Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 00 (2018) 000–000

Transportation Research Procedia

www.elsevier.com/locate/procedia

World Conference on Transport Research - WCTR 2019 Mumbai 26-31 May 2019

Challenges with Human Factors in Road Traffic Safety, and The Need for Reasonable Degrees of Automation

Adekunle Mofolasayo[a]

117-1757 Cunningham Way,SW Edmonton, T6W 3B5, Canada, mofoladek@live.com

Abstract

Human factors play a huge role in road traffic safety. Research has found that more than 90% of traffic crashes occur due to some form of human error. Improving road user behavior has been the major strategy that has been emphasized for improving road traffic safety. Meanwhile, despite the efforts on training, and testing for drivers, global status of road traffic safety is still alarming. In the effort to improving road traffic safety, there is need to pay adequate attention to factors that can help minimize the impact of human error, or at least ensure that implications of human error do not result in undesirable consequences on the road. This study evaluates how factors such as driver distraction, fatigue, driving under the influence of drugs and alcohol, and outside objects affects the driver. The need for reasonable degrees of automation to help reduce impacts of human factors in road safety, and recommendations aimed at providing a widespread support for these automation systems in the driving task is presented. Given the advancement in automobile technology at this age, it is recommended that minimum vehicle standards be increased to incorporate features that can help minimize the impacts of human error in driving.

Peer-review under responsibility of WORLD CONFERENCE ON TRANSPORT RESEARCH SOCIETY.

Keywords: Road traffic safety; Human factors; Vehicle standards; Automation; Collision avoidance systems; Transportation policy.

1. Introduction

Human factors play a huge role in road traffic safety. Research has found that more than 90% of road traffic crashes occur because of some form of human error (NHTSA &USDOT, 2015; Durić, & Miladinov-Mikov, 2008). The ability to perceive and adequately react to an urgent issue during the driving task is dependent on a range of factors. Roess, Prassas & McShane (2011) noted that perception and reaction times increase with factors such as fatigue, presence of drugs, and or alcohol in the driver's system, age, and complexity of the reaction. Meanwhile, a driver that is distracted would have travelled some distance before realizing an issue that needs attention on the road. A driver that is fatigued may fall asleep behind the wheels. Research has also found that presence of drugs and alcohol in the system of road

Peer-review under responsibility of WORLD CONFERENCE ON TRANSPORT RESEARCH SOCIETY

users are detrimental to road traffic safety. This report reviews how some human factors contribute to safety issues on the road and provide suggestions on way forward to greatly reduce the negative impact of human factors on traffic safety.

2. Driver fatigue

Driver fatigue has been found to be one of the major factors that negatively impact road traffic safety. Jamroz & Smolarek (2013) identified driver fatigue, sleep restriction and falling asleep while at the wheels as some of the major factors that contributes to accidents on the road. Various researchers have presented figures that indicated that driver fatigue is a significant contributor to traffic crashes. Fletcher, McCulloch, Baulk, & Dawson (2007) identified driver fatigue as a critical aspect of public health that is responsible for 10 – 40% of road crashes. The European transport safety council report (2001) on the role of driver fatigue in commercial road transport crashes also noted that driver fatigue has been identified as a significant factor that contributes to about 20% of road crashes, with surveys showing that over 50% of long haul drivers have fallen asleep at some point behind the wheels.

Interacting factors that contributes to fatigue has been identified as time that is available for rest and continuous sleep, length of continuous work and daily duty, the arrangement of duty with rest and sleep within every 24-hour cycle (Brown, 1994). The Royal Society for the Prevention of Accidents [ROSPA] (2001) indicated that there will be impairment of performance if sleeping is less than 4 hours per night. Alertness, concentration, vigilance, and reaction time, a critical element for safe driving is reduced by sleepiness. The causes of accidents as noted by de Mello et al (2013) includes: Sleep disorders, hours of work driving, alcohol and drug abuse, higher levels of sleepiness, higher levels of stress, fatigue, lapses of attention, OSAS associated with alcohol, higher body mass index (BMI), and sleep medication. Aworemi, Adegoke, Oyedokun, & Adewoye (2010) also noted that sleep deficit, stress, duration of driving, and alcohol have a significant contribution to driver fatigue, at 5% and 10% significant levels.

It is generally recognized that fatigue does not only results from prolonged activities. Socioeconomic, psychological, and other environmental factors that affect the body and the mind also cause fatigue (Brown, 1994). While the contributing factors to fatigue as stated by Brown (1994) are valid, there may be need for more research into how other factors that may cause undesirable stress for various people lead to various forms of fatigue, absent mindedness, and eventually accidents on the road. Although some recommendation that should minimize the impact of driver fatigue has been made in the literature, driver fatigue remains a challenge on the roads. The strategies given by de Mello et al (2013) to prevent crashes includes naps, caffeine intake, physical exercise, break to rest, healthy nutritional habits, restorative sleep, phototherapy, reducing working hours at the wheels, and treatment of sleep disorders. To guard against driver fatigue, among other things, Aworemi et al recommends avoiding driving when ill, sleepy, or taking medication, and planning journey to incorporate regular rest breaks. At least 15 minutes of rest every 2 hours was recommended. Aworemi et al, further recommended that people should avoid embarking on a long drive after working for a full day. While this recommendation is good, it may be difficult to enforce. Typically, law enforcement officers do not stop drivers to ask if they are fatigued/tired, or if they have taken a good rest after some work before embarking on a journey. Except it reflects in the driving that the driver is not fit for driving, a driver may not be stopped if the driver does not break any other law. But this does not mean that some people on the road are not sleepy or tired. Will any law enforcement officer dissuade people from traveling home to see their family after a long work day? What if people claim they are not fatigued before a traffic crash? Radun & Radun 2009 noted that lack of reliable testing, and blurred concept of fatigue makes it very difficult to make fatigue an operationalized component of criminal or traffic law.

de Mello et al 2013 noted that some behavioral psychometric, and physiological test that are being used increasingly to evaluate the impact of fatigue on driver performance includes polysomnography, actigraphy, oculography, the maintenance of wakefulness test, etc. Evaluating the issue of fatigue, sleepiness behind the wheels and the need for a reasonable degree of automation to help human drivers avoid traffic crashes, some important questions to ask includes:

- Is it possible for humans to completely eradicate various stressors that may result in driver fatigue?
- Could there be some undiagnosed medical conditions, or emotional issues that could result in more likelihood of sleepiness behind the wheels for various people?

- Will it not be an invasion of people's privacy if anyone tries to monitor or confirm the amount of sleep that a driver has had before getting behind the wheels?
- Is there a universal agreement on the amount of rest that everyone needs, to avoid fatigue or sleepiness behind the wheels?"
- Is it possible to enforce a universal plan for work and rest?

de Mello et al, in the study about "sleep disorders as a cause of motor vehicle collisions" cited studies that indicated that sleep disorders like insomnia, narcolepsy, Obstructive Sleep Apnea (OSA), etc. are associated with excessive sleepiness, cognitive deficits, and fatigue symptoms like reduced driving skills; and these have been linked to increase risks of highway accidents and fatalities. de Mello et al also recommended that all disorders that produce excessive sleepiness should be investigated and monitored to reduce accidents, associated injuries, and loss of lives on the highway. Even if a driver is well rested, it is also not going to be an easy task for law enforcement officers to know what point a driver needs a break from driving in order to avoid falling asleep. If we all agree that it is not possible for humans to provide adequate answers to the above questions without intruding on the private lives of people, and if we all know that some reasonable autonomous motor vehicle technologies exist that can help the driver in reducing the likelihood of a crash, then we should all be able to come to a consensus on improving the minimum standards of all motor vehicles to have these reasonable level of automation, to keep people safe on the roads. Given the various level of autonomy that is presently available, a discussion about what can be referred to as a reasonable degree of autonomy for driver operated motor vehicles is included in a later section of this study.

Brown (1994) has noted that fatigue is not adequately recognized and reported as cause of road accidents, and that the effects of fatigue begins mostly from irregular working hours, and not only from the time spent while driving. It cannot be disputed that various personal issues exist in the lives of various drivers, and it will be very difficult for law enforcement officers in various municipalities to monitor and ensure that people take adequate rest before going behind the wheels, without intruding on people's privacy. Without great foresights and welcoming of technologies that can ensure that this human limitation does not result in traffic crashes, and its associated consequences, the sad statistics of traffic fatalities on the roads, globally may not see a significant decline. It is good to note that a fatigued driver that is asleep behind the wheel, may neither see the vehicle speed on the dashboard, nor any other warning systems that various vehicles may have. An important question that needs appropriate answer from us all is, "for innocent road users, whether it be vulnerable road users, (pedestrians, bicyclists, etc.) or other motorists, should the consequence of any fatigue driver bring these innocent people to an untimely death?". Knowing that road traffic crashes does not discriminate between the young and the old, the rich and the poor, the politician or the farmer, there is need for a concerted effort in implementation of legislations that can help humanity overcome the pertinent challenge of road traffic crashes. No one in human wisdom can say with all certainty that he, or she will never be in contact with a driver that is going through some form of fatigue that may result in road traffic accident.

3. Distracted Driving

Distracted driving is a serious issue in road traffic safety. The center for disease and control prevention, as well as NHTSA have classified distracted driving into 3 main categories. These includes: visual, a situation in which the eyes are taken off the road; manual, a situation in which the hand is taken of the wheels, and cognitive, a situation in which the mind is taken off driving. Foss & Goodwin (2014) classified 3 types of distraction into physical tasks, auditory or visual diversions, and cognitive activities, and further noted that some forms of activities like texting can include 3 types of distraction (physical, visual, & cognitive), given that both eye, mind, and hands can be engaged in the distracting operation. The potential risk to road safety due to exponential growth in mobile phone use in the society has become a matter of concern for policy makers. The proportions of drivers using mobile phones while driving has also increased. Although it may not be an easy task to ascertain the exact impact of the use of mobile phones on crashes, some studies have indicated that drivers who use cell phone while driving are 4 times more likely to be involved in a crash (WHO & NHTSA, 2011). Meanwhile, various municipalities have instituted distracted driving laws. For example, the Canadian Automobile Association (CAA) indicated that 10 provinces in Canada has some form of distracted driving laws.

From the enforcement point of view, out of the 3 main forms of distraction that was mentioned above cognitive distraction in which the mind is taken off driving will be the most challenging as it is not possible (with human reasoning) to discern what goes on in another person's mind with all certainty. Except someone begins to swerve on the road, a law enforcement officer may not know that the mind of the driver is already off the driving task. People certainly have things to think about. Someone that does not have a job may be thinking about how to get a job while behind the wheels. Someone that has a business may be thinking about how to make the business bigger. If someone's mind is off the road, the alertness to things going on in the immediate vicinity of the road may be considerably reduced. Some of the questions that will help in addressing the issue behind distracted driving are:

- Does the world have any technology to discern absent mindedness in driving?
- Can anyone stop a human mind from wandering thoughts?
- Can anybody be certain of the exact point in which the mind will wonder off the driving task to a dangerous extent?
- Who should bear the consequence of this absent mindedness on the road?

It is no doubt that humans need to travel from one place to the other to attend to daily needs. Giving the above-mentioned human limitations, to evaluate the need for a reasonable degree of autonomy, we all need to be sincere in answering this question: 'does anyone (either rich or poor, influential or non-influential, novice or learned) deserve to be a victim of distracted driving?' AAA foundation for traffic safety believes that needless death can be eliminated by improving understanding of how physical and mental distractions causes impairment for drivers, and by educating the public on avoidance of distractions. However, considering the length of time that road traffic safety has been an issue for humanity at large, can we say that enough education and awareness has not been created about avoiding distraction? Can we say that law enforcement agencies are not doing a good job to prevent distracted driving? The issue of distracted driving is serious in various places around the globe. For example, the center for disease and control prevention noted that every day in the United States more than 1000 people are injured, and 9 people are killed in crashes that are reported as involving distracted driver. This means that in a 30-day month, 270 people die on the road while more than 30,000 people are injured in this kind of crashes. This consequence is certainly more than outcome of some diseases or terrorist attacks in some places. There is an urgent need to attend to this crisis that has faced humanity at large for a long time. The injury, and property damages also have their effects on the economy. It is not possible to give a price to the loss of lives, and the emotional trauma that people may go through when traffic crash results in fatalities.

3.1. Evaluation of distance travelled while being distracted

Figure 1.0 is used to illustrate the amount of distance which may be travelled at various speeds while being distracted. Given that:

$$Speed = distance/time \quad (1)$$

The distance travelled by an object moving at a certain speed is represented as:

$$Distance = Speed * Time \quad (2)$$

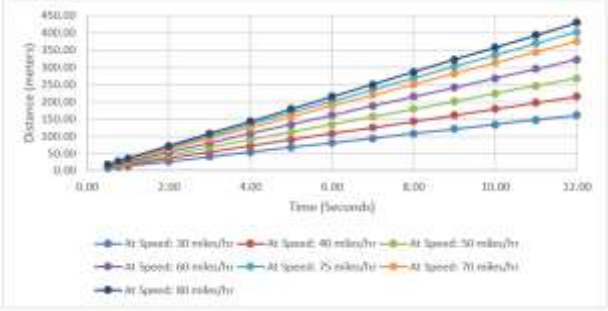

Fig. 1. Illustration of distance travelled by objects in motion at various speeds.

The centre for disease and control (CDC) noted that at 55mph, a driver that is texting or reading a text, whose eyes is off the road for about 5 seconds would have travelled a distance that is long enough to cover a football field. From figure 1, it is obvious that the longer the period of distraction the longer the driver will travel without giving a proper attention to the driving task. For figures 1.0 and 2.0, note that 1 mile = 1609.34 meters (Metric conversions). Within the period of distraction, traffic crashes that may result in both property damage, injury and even fatality could have occurred. Meanwhile, it is known that the computer system cannot be distracted in the way humans are. Looking at the numbers of fatalities that occur around the globe from distraction's point of view, it is no doubt that automation systems that are able to help ensure that this human limitation does not result in traffic crashes will be helpful for humanity at large.

3.2. Perception-reaction time (PRT), and total stopping distance

During the driving task, the foot does not get on the brake immediately the eye perceived an issue that warrants a reaction. The American Association of State Highway and Transportation Officials [AASHTO] (2004) noted that 2.5s is considered adequate as a brake-reaction time, as it exceeds 90th percentile of reaction time for drivers. However, it was also noted that while some drivers have less reaction time, most complex conditions during driving tasks require higher reaction time. Various other braking reactions times exist for different situations. In simple braking operations, the perception reaction time (PRT) is said to begin when the driver first perceived an event that warrants a braking action and terminates when the foot is applied on the brake (Roess, Prassas & McShane, 2011). AASHTO's recommendation of 2.5 s for normal braking operations was used for figure 2.0. Note that the illustration in figure 2 represents only the expected reaction distance (equation 3), with an assumption of 2.5s for break-reaction time. The expected total stopping distance can be calculated using equation 7. The human factor here is dependent on how quickly the human driver can react to a hazard on the road at a given speed under the prevailing road and weather conditions.

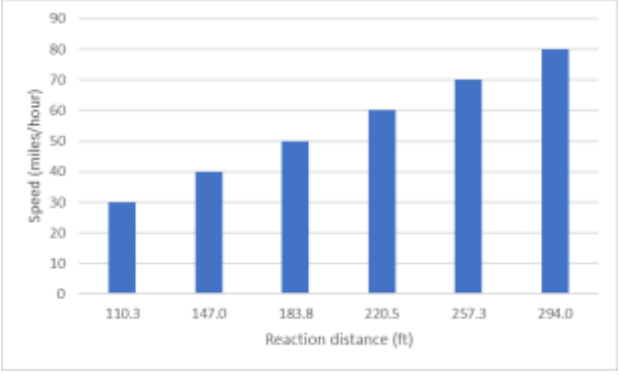

Fig. 2. Reaction distance at varying speed.

Roess, Prassas & McShane, 2011 defined the reaction distance as the perception reaction time multiplied by the speed of the vehicle. For normal braking operations:

Reaction distance $$d_{rc} = 1.47 * V_{in} * t \quad (3)$$

Where t (secs) is the AASHTO recommended (time) standard for braking reactions, V_{in} is the initial speed of the vehicle $(mile/hour)$. From equation 3, and figure 2, it is obvious that the reaction time will increase with speed. Meanwhile the vehicle does not stop immediately after the break is engaged. AASHTO (2004) shows the approximate braking distance for vehicles traveling at the design speed of the road, with a relationship between the deceleration rate and the Speed:

Braking distance $$(d_{bk}) = 1.075 * {V_d}^2/a \quad (4)$$

Given that d_{bk} is the approximate braking distance in (feet), V_d is the design speed (mph), and a is the deceleration rate (ft/s^2). AASHTO (2004) expressed the total stopping sight distance as the addition of the distance travelled during the reaction time and the distance travelled during the braking process.

Thus, for a vehicle travelling at the design speed of the road:

$$\text{Total Stopping Distance} = (1.47 * V_d * t) + (1.075 * {V_d}^2/a) \quad (5)$$

When considering the effects of grade, with the braking system resulting in a change of speed, Roger, Elena, & William (2011) included the final speed in the equation for braking distance:

$$\text{Braking distance } (d_{bk}) = ({V_{in}}^2 - {V_{fn}}^2)/30(F \pm 0.01G) \quad (6)$$

Thus, total stopping distance when considering the effect of grade will be expressed as follows:

$$\text{Total Stopping Distance (ft)} = (1.47 * V_{in} * t) + [({V_{in}}^2 - {V_{fn}}^2)/30(F \pm 0.01G)\,] \quad (7)$$

Where F is the coefficient of skidding or forward rolling friction (a/g), g is the acceleration due to gravity, V_{in} and V_{fn} are the initial and final speed of the vehicle, and G represents the grade (%).

3.2.1. The challenge in bringing the vehicle to a stop after perception of hazardous event

Apart from the fact that distraction increases the distance travelled before a driver becomes aware of an issue that warrants braking operations, to reduce the total stopping distance after the driver becomes aware of the issue that needs attention, from equation 5, it is obvious that the major factors that determines the total stopping distance includes:

- The perception reaction time,
- The speed of the vehicle, and
- The deceleration rates

It may take a distracted driver a longer time to perceive a potential hazard that warrants a reaction. Equation 6 shows that in addition to the speed of the vehicle, the effect of grade and the coefficient of skidding or forward rolling friction also play a role in the braking distance.

3.3. Recommendations to reduce the total stopping distance from PRT analysis of braking operations

Knowing that the total stopping distance is crucial in road traffic safety, and that it is highly desirable to bring a vehicle to a stop before a collision with an object, the following recommendations are made:

- Ensure maintenance and enforcement of appropriate speed limit (giving a consideration for the grade of the road, weather conditions, and friction forces between the tires and the road surface)
- Promote research in technologies that can greatly increase deceleration rate at operating speeds of vehicles
- Incorporate reasonable autonomous systems that can automatically detect and react to an issue that needs an action during the driving task.

Recall, figure 2 illustrated the reaction distance that the vehicle could have travelled with a perception reaction time of 2.5s. Reduction of this reaction distance could mean that the vehicle will be able to stop before crashing into an object or even human. Giving that computer systems handle multiple processes faster than humans, it is envisaged that autonomous systems will bring the reaction time in driving closer to zero, when a hazard is detected on the road. However, note that even if autonomous systems are incorporated that can bring the reaction time close to zero, before the vehicle stops, there is still a challenge with the braking time. As a result, even when all vehicles on the road have autonomous systems to detect hazardous situations, factors such as speed of the vehicle, friction factors, the grade of the road, the deceleration rate of the vehicle will still have an impact on the possible distance that can be travelled

before the vehicle finally stops. Hence, there will be need for continuous education of people in various municipalities as regards the realities of the braking distance of vehicles.

Improvement in engineering controls to protect vulnerable road users in various communities is also recommended. This may include construction of more guard rails, depending on need in various places, gates/barriers to restrict vulnerable road users from accidentally getting in the way of high speed vehicles, etc. For example, an inexperienced cyclist that is having trouble stopping a bike at an intersection may be restricted from going into the intersection by a gate. Continuous road safety audit is also recommended which may be able to detect things such as the need for overhead bridges for pedestrians. Continuous road safety audits should also be able to identify other measures to improve traffic safety. Examples may include the need for improvement of roadway lighting systems in dark hours, improvement of road surface conditions, removal of any barrier that may obstruct the view of drivers, especially at intersections etc.

3.4. Effects of outside objects on driver performance

Distraction from outside object is also a huge factor that negatively impacts road traffic safety. Decker et al (2015), on a review of the impact that billboards have on driver's visual behavior noted that external distraction seem to account for at least 6 - 9% of motor vehicle collisions in which distraction was a factor. Decker et al also noted that considerable evidence exists to show that about 10 – 20% of all glances at billboards were $\geqslant$ 0.75s. Young & Mahfoud (2007) on a study about the effect of roadside advertisement on driver distraction noted that conservative estimates put external distractors as responsible for up to 10% of all accidents; and although roadside advertisements are designed to attract attention, the industry does not acknowledge their potential threat to road safety. Young & Mahfoud also noted that roadside advertising showed a detrimental effect on lateral control, increased eye fixations, and mental work load, and can even draw attention away from more relevant road signage in some places. Exercise of prudence was recommended when placing or authorizing road side advertisements.

Edquist (2008), noted that increasing amount of visual information like advertisements by the roadside create a visual clutter in the environment. Edquist further classified visual clutters into 3 categories: situational clutter (other road user, and vehicles that the driver interacts with), designed clutter (traffic control systems like, road signs, markings, etc.), and built clutter (signage that is not installed by traffic authorities, and other roadside developments). Billboards were found to have significant effects on the speed, ability of drivers to follow directions given on the road signs, and eye movements. While the driver speed reduced with billboards, their ability to follow road signs becomes slower, and comes with more errors, the amount of time spent looking at the roadside at the expense of paying proper attention to the road also increased. The distraction from visual clutter in the driving environment is certainly hazardous for road users. In evaluation of the issue of outside objects on driver performance with the issues described here, it is important to sincerely address these questions;

- How can the issue of visual clutter in the driving environment be addressed?
- Do we have a true statistic of all traffic crash that occurred because the driver was distracted by outside objects or people?
- Should any municipality come up with a law that completely prohibits advertisement on the roadside?
- What impact is an application of a reasonable degree of autonomous motor vehicle technology expected to make on improvement of road traffic safety in this regard?

Roberts, Boddington, Rodwell, & Jorgensen (2013) noted that there is considerable variation in the criteria for management of advertising devices used by the roadside in various jurisdictions. The income derived from outdoor advertising, especially on high volume corridor also creates a challenge.

4. Driving under the influence of drugs and alcohol

Driving under the influence of drugs and or alcohol is another dangerous human factor in road traffic safety. Kuypers, Legrand, Ramaekers, & Verstraete (2012) in a study aimed at assessing the risk of having a traffic accident after using single drugs, alcohol or a combination, and determine concentrations in which the risks significantly

increased, in addition to other findings noted that alcohol in general caused an increased risk of crash. Cannabis (in general) also resulted in increased risk of accidents. At a concentration of 2ng/mL of THC accident risk was found to be four times the risk of the lowest concentration of THC. Bradford (2017) identified THC as "tetrahydrocannabinol", a chemical that is responsible for most of the psychological effects of Marijuana. The National Institute of Drug Abuse (2017) referred to THC as a mind altering chemical delta-9-tetrahydrocannabinol that is contained in Marijuana (Cannabis Sativa). THC is said to have capabilities to change thinking, induce hallucinations, and cause delusions (Bradford, 2017). Cannabis has been identified as the 2nd most impairing drug that is used in the world, after alcohol. The risk of being involved in a crash is said to be doubled when the blood alcohol level is between 0.05 – 0.08 %, and at blood alcohol level of 0.24 %, the risk of crash increases to more than 150-fold (Brubacher, 2011). Road transportation safety will surely be in greater trouble if more people get on the road with significant amount of THC or alcohol that can affect their normal thinking process, perception and reaction time. Sewell, Poling, & Sofuoglu (2009) noted that while cannabis and alcohol cause acute impairment of many driving related skills in a dose-related way, the effect of Cannabis vary more between people than they do with alcohol, because of differences in smoking techniques, tolerance, and absorptions of THC.

Law enforcement for transportation operations is such that should guaranty safety for every road user. When evaluating the need for automation systems in driving operations with the issue about driving under the influence of drugs and alcohol, some important questions to consider includes:

- Is it possible for law enforcement officers, 100% of the times to apprehend the offenders before they cause a havoc on the road?"
- Does any road user deserve to be the victim of any driver whose reasoning may have been affected by THC or by Alcohol effect?
- What effect is an application of a reasonable degree of autonomous motor vehicle technology expected to bring on the effort to minimize the potential impact that any impaired driver (that may have not been caught by law enforcement officer) may bring to the entire community?

5. Major emphasis of road safety approach and proposed way forward

Improving road user behavior has been the major strategy that has been emphasized for road traffic safety (Ran Naor Foundation for advancement of road safety research, 2007). While efforts to improve road user behavior may include things like driver training, and re-training, public education, enforcement of traffic laws, etc., with the amount of traffic fatalities that still occur on the roads in various jurisdictions, does this mean that people do not have adequate driver-training before they get a driving license? Are the driver-licensing officers not doing adequate jobs? We certainly cannot put a blame on the driver licensing officials. As illustrated in this study, there is no doubt that humans have some serious limitations that contribute to traffic crash. If it is known that relying on the hope of improving road user behavior alone has not improved road traffic safety to the desirable extent worldwide, certainly, it is time to expand the major strategy beyond the realm of hoping to improve road user behavior. A review and upgrade to the minimum vehicle standard is recommended. It will be desirable to see implementation of minimum vehicle standards that has various levels of automation to help ensure that human errors do not result in negative consequences for various road users. Mofolasayo (2018) recommended that at a minimum, vehicle standards should be increased to ensure that all vehicles on the road have auto brake systems to prevent both frontal and backward collisions. Such auto brake systems should be capable of detecting objects in the trajectory of the moving vehicles, and efficiently reduce speed to prevent collision. Such collision avoidance systems will go a long way to reduce road traffic crashes and its associated consequences globally. If properly enforced, such collision avoidance system should also help deter/prevent the use of automobiles as weapons of mass destruction for unsuspecting vulnerable road users. While addressing a question about if the autonomous vehicles will completely replace human drivers, as raised in the Federal Automated Vehicle Policy by USDOT & NHTSA (2016), Mofolasayo (2018) suggested that pilot projects be done in various communities to validate the efficiency of the autonomous systems. If there are no accidents at all while autonomous vehicles are on the road, this may form the basis for adoption of full autonomous vehicles on a large scale. It is no doubt that all traffic crashes require a thorough investigation to determine the cause, and create lesson

learned for future improvement. Continuous, and rigorous investigations of any traffic crash involving vehicles with autonomous systems is recommended to ensure that the cause of any system failure is identified, and information about necessary improvement of the technology is openly shared with all automobile manufacturers. It will be a good idea to ensure that all automobiles have not only the system that can report the present fault in the vehicles, but also a system that can track the repairs, and maintenance that has been done on the vehicles. Such a system will be helpful during investigation of any traffic crash that involves vehicles with autonomous systems. If there is a foul play, in which someone has tampered with a safety feature before a crash, the recommended improvement in vehicle design should be able to show that record.

At this time, it is known that not everyone appears to be comfortable with a full autonomy for roadway vehicles. Daziano, Sarrias, & Leard (2017) on a study that evaluates if consumers are willing to pay to let cars drive for them noted that semiparametric random parameter logit estimate indicates that there is an approximately even-split between, no demand, modest, and high demand for automation. Daziano, Sarrias, & Leard also found that average household is willing to pay a significant price for automation (about $3,500 for partial automation and $4,900 for full automation); the preference for automation is very diverse. While some people are not willing to pay for the technology, a considerable portion of the sample is willing to pay more than $10,000 for full automation technology. Kyriakidis, Happee, & de Winter (2015) in their research about public opinion on automated driving also found that public opinion about autonomous driving is diverse. 69% of people believe that automated driving will reach 50% market share by 2050. While some people welcome the idea of fully automated driving, another large portion of people are of the opinion that autonomous driving will not provide an enjoyable experience and are not willing to pay for it. Kyriakidis, Happee, & de Winter 2015 also noted that main concerns that were raised about autonomous driving includes software hacking / misuse, data transmitting issue, legal, and safety. Mofolasayo (2018) in his presentation slides on the evaluation of potential policy issues when planning for autonomous vehicles proposed ways by which these concerns may be addressed. These includes ensuring that system exist that will both promptly inform users, and refuse to work in autonomous mode when data breach has been identified, ensuring that means to switch to manual driving exists when data breach has been identified, not implementing full autonomous systems on a large-scale basis if it has not been tested and safety verified in all weather conditions in various municipalities, etc.

From the analysis of human factors evaluated so far, there is no doubt that humans need a reasonable degree of automation in driving operations to avoid serious challenges that are posed by human factors. There appears to be a great need for more public education about human limitations in driving operations, its impact on humanity at large (as reflected in the global statistics for road traffic fatalities), and the need for a reasonable degree of autonomy in driving of automobiles. There is need to determine what a reasonable degree of autonomous motor vehicle technology is to get everyone on the same page with improvement efforts for road traffic safety operations.

5.1. What is a reasonable degree of autonomy for roadway motor vehicles?

The above question is one that is expected to evolve from one generation to another. It may also be affected by the advancements in technological innovations in the transportation industry. Firstly, it is good to know that it will not be a wise idea to have a technology that can save lives, and not put it to good use. In this age, humanity at large has grown to see innovative technologies that can help humans better monitor the driving environment (or at least complement human efforts), and also take necessary actions to bring the vehicle to a stop to avoid traffic crash. If this technology can help save lives, and drastically reduce the traffic fatalities on the roads globally, why should anyone be against it? One of the things that has been mentioned in previous research is about ‘enjoyable experience of manual driving operations’ (Kyriakidis, Happee, & de Winter, 2015). If what is presently considered an enjoyable experience in the driving operations contribute greatly to 1.25 million fatalities on the roads (globally) every year, then humanity at large needs to answer the important question, “is this so-called enjoyable experience a reasonable one, considering the amount of traffic fatalities”? It is very obvious that humans have great limitations which previous road traffic safety efforts have not been able to overcome. It is high time that humanity at large arose in one accord to say ‘no’ to transportation systems that do not guarantee safety of all road users. Good sense of judgement needs to be applied in

this situation. We already have technologies that can help in monitoring of driving environment, and initiate crash prevention action in good time. Let us use it. We already have technologies that can detect objects in the trajectory of moving vehicles, and stop in good time, or make adequate maneuver to avoid collision. Let us use it.

Six of the most common new technologies as mentioned by IIHS & HLDI and referenced by Mofolasayo (2019) includes: autobrake, forward collision warning, blind spot detection, adaptive headlights, lane departure warning, and lane departure prevention. Given various technological innovations in motor vehicle designs in present day, a reasonable degree of automation will be the use of automatic technologies that has been adequately tested (in an open and unbiased way) in all weather conditions (including hazardous weather conditions; such as severe winter (extreme cold, & snow), rain, fog, etc., and the safety capabilities has been verified to ensure safety of people in their daily commute. Mofolasayo (2019) prepared 'a research guide for using the efficiency of technological innovations in automobiles to establishing unbiased policies for improvement of minimum safety standards for driver operated motor vehicles.' This report recommends that researchers in various jurisdiction give a fair opportunity to test reasonable autonomous technologies in motor vehicles to determine which technology is ripe to be mandated as minimum standards to improve road traffic safety in various jurisdictions globally. Insurance Institute for Highway Safety (IIHS) and Highway Loss Data Institute (HLDI) noted that crash avoidance features are rapidly entering the vehicle fleet. While some technologies are optional in some vehicle, there are some technologies that are standard for some vehicles. After open and unbiased testing of these technologies on a large scale, it is recommended that efficient technologies be mandated and enforced as a standard for all motor vehicles. It is known that the world has also witnessed the advent of full autonomous motor vehicles. Mofolasayo (2018) presented a study that evaluates some potential policy issues when planning for autonomous vehicles. Implementation of full autonomous vehicles on a large scale in any community will depend on the efficiency of such vehicles. It is no doubt that weather conditions and roadway conditions are not the same in various communities globally. The evaluation processes for full autonomous motor vehicles will have to be done in all weather and roadway conditions in every community to verify its safe-use under the prevailing road and weather conditions of the community. It is known that the operations of computers are limited to the algorithms for which it has been pre-programed. Given various factors that interact during the driving operation, various scenarios could exist on the road. Full autonomous vehicles will need to be able to perform efficiently in all these conditions to be certified as safe for use (in a large scale in any community) under those situations.

Knowing that system failure sometimes occurs, it is better to still have human drivers that can take over the driving operations in any situation where there is a safety related issue with automatic features. Responsible drivers in the vehicles should still be able to manually apply the brakes when there is need for it. The responsible driver in the vehicle should also have the ability to control the steering as need be. The availability of manual driving operations in the vehicles should not be made to have a capacity to override the automatic braking systems that is designed to prevent frontal and backward collisions in the trajectory of the moving vehicle. Automobile designs in which an immobilizer system works directly with the autobrake system is recommended. If the autobrake system is faulty, or has been tampered with, the vehicle should not work. With a technology like this, the world should expect to see a great reduction in collisions on the road. Let us remember that it is possible to design automobiles in a way that people cannot use the vehicles as a weapon. If some vehicles are on the road without reliable collision avoidance systems, in any situation where there is no adequate room for maneuver, and there is an impending collision from a vehicle that does not have collision avoidance systems, even vehicles who have collision avoidance system may not be able to escape a collision with such vehicles that do not have collision avoidance systems. This shows the need to aim at a system where all vehicles on the road will have reliable collision avoidance systems. A motion like this should be a good compliment to any community with a good security system. *'Every road user deserves a safe commute, without fear that someone may use automobile as a weapon to kill them'* Mofolasayo (2018). The suggestion that indicated that 'it is better to still have human drivers behind the wheels in vehicles that have automated features in-case of system failure' does not mean that full autonomous vehicles should not be used. Various purposes exist for which full autonomous motor vehicles are desired, but they have to be operated only under the conditions that their safe-use has been tested and certified. Mofolasayo (2019) noted that efficiency of technological innovations that can help driver monitor the driving environment, warn the driver, or take good actions to avoid a collision should be individually evaluated, whilst technologies that best guarantee safety need to be selected as minimum standard for all roadway motor vehicles. Efficiency of full autonomous motor vehicles may be compared to the efficiency of driver-operated

motor vehicles that have high level of autonomous motor vehicle technologies as a standard practice. When a human driver is operating a vehicle with efficient autonomous technologies, such as the common new technologies that were mentioned, autobrake (to prevent collision), lane departure warning, etc., this does not relieve the human driver of the responsibility to control the vehicle. If an autonomous vehicle technology fails to perform as expected, the human driver has the responsibility to ensure a safe operation of the motor vehicle, e.g. applying the brake when it is necessary. A proactive approach to test the efficiency of these technologies to improve minimum standard of driver operated motor vehicles has been proposed by Mofolasayo (2019). The above-mentioned research guide by Mofolasayo (2019) to evaluate the efficiency of autonomous motor vehicle technology is a good resource for this.

6. Removing barriers to improving road traffic safety

If the world truly wants to see a change in the trend for traffic crashes, there is certainly a need to put all politics, and hope of financial gain from any system aside, and ensure that safety is truly a first priority in transportation systems. In the effort to remove barriers to improving road traffic safety, major questions to evaluate includes:

- If the world continue with the existing policies in the transportation sector, are we going to see a drastic change in fatalities on the road worldwide? If the answer is no, the next question is:
- Do humans have natural ability to make everyone's mind focused on the driving task through increased enforcement, and not be involved in any form of distraction whether visual, manual or cognitive? If the answer is no, the next question is:
- Do humans already truly have technologies that are able to help ensure that human limitations as described does not result in negative consequences as has been in the past? If the answer is yes, the next question will be:
- What can be done to bring this technology into full implementation to help reverse the trend in road traffic crashes, and the associated consequences?

It is no doubt that since no one can confidently say that humanity has a system that can make people concentrate on the driving task at all times, there is certainly a need for some autonomous system that can ensure that human errors does not result in dangerous consequences. Note that even if systems are implemented that warn drivers about impending danger, there is still a need for the driver to be in a reasonable state of mind to be able to properly respond to such an alert. Will such alert be efficient for fatigue drivers or for someone who is driving under the influence of drugs or alcohol? Will such alerts stop a terrorist? If everyone has agreed that humans need autonomous systems like automatic braking system, and other automatic crash prevention systems, the next question to address will be "what are the limiting factors that may create resistance to implementing technologies that are aimed at improving safety for people on the roads globally, and how can this be resolved"? Some of the crash avoidance features listed by the Insurance institute for highway safety (IIHS) & Highway loss data institute(HLDI) includes auto brake, adaptive headlight and blind spot detection, lane departure prevention, forward collision warning, etc.

It is not a happy thing to see a traffic crash in which some fellow human beings have lost their lives. If we ask people that have witnessed (or heard about) an accident scene (with sad consequences) if they would love to support a technology that could help prevent the loss of life on the road. The reasonable answer will be yes. But if we ask these people what their support for the technology will be, if the technology has a potential to dangerously affect the economic well-being of their community; probably, at this point, the question may be going to a seemingly tough area for some people. Normally people will not want anything to affect the source of their income. It is known that movement of vehicles from one place to the other does not come without other factors that have implications on economy in various places around the world. To adequately address the issue of road traffic safety, there is also a need to address the economic implications for people in various region. While there is concern about road traffic safety, there are also other concerns like release of toxic gases into the atmosphere from various exhaust pipes. Although it will be good to find a way to address all the concerns in a way that brings positive results for all, knowing that it may be somewhat challenging to implement changes that will make everyone happy at this time, it will be a good idea to address the issues one after the other.

According to world health organization (WHO) on the top ten causes of death, road traffic injuries was rated among the top 10 causes of death (killing 1.3 million people, 76% of this are boys, and men), just before tuberculosis (1.4 million), diarrhea (1.4 million), diabetes (1.6 million), lung cancer, including bronchus and trachea cancers (1.7 million), lower respiratory infections (3.2 million), heart diseases and stroke (15 million deaths) in 2015. Although there are other causes of death globally that exceeds that of road traffic injuries, road traffic fatality is one that can be drastically reduced and eliminated by having effective changes to transportation system design and the related policies. Because some autonomous technology systems in transportation that can help ensure that some human error during the driving task does not result in negative consequences are associated with other advanced technology that does not require the use of fossil fuel, to eliminate potential barriers in achieving improved road traffic safety, there is need to implement systems that will first assure those who make a living from sales of fossil fuel that the goal is not aimed at adversely affecting the economy of such communities or nations. McCauley (2017) in his writing about why electric vehicles and autonomous vehicles are linked noted that autonomous vehicle's future is dependent on cost-effectiveness of electric vehicles. But the statistics that was given does not show that all autonomous vehicles are electric vehicles.

It is known that fossil fuel resource in an area can be depleted after continuous mining over a long period of time. Petroleum Technology Research Centre (PTRC) described a project (that occurred between 2000 – 2012) that studied carbon dioxide injection and storage into 2 depleted oil fields in south-eastern Saskatchewan. The injected CO_2 is used for enhanced oil recovery. PTRC also noted that operators of oilfield in West Texas have been injecting Carbon dioxide into oil fields for a long time now. Knowing that world's deposits of fossil fuel is not an infinite reserve, while the resource is being wisely extracted for daily use, there is a need to also ensure continuous support for development of technologies that can use renewable energies. For example, it will not be good to wait until the reserves for fossil fuel remains as little as a year's worth before the world begins to explore production of vehicles that can use alternate energy on a large scale. This knowledge should be enough to bring those who mine natural resources for the benefit of humanity at large, and those who develop technologies that will be of good use to humanity (when the fossil deposit begins to show a significant depletion rate) together as partners in achieving breakthrough for mankind both in the energy and safety aspect of the transportation industry. While it will not be advisable to adopt a strategy that may send an economic shock to any nation, it will also not be good for anyone to try to go against plans for a long-term sustenance because of the perceived effect on present financial situation.

Allowing for a gradual adjustment to economic situations while improving road traffic safety will be good. Instead of having a view point that somewhat associate automobiles that have good level of autonomy with automobiles that does not require the use of fossil fuel, a good collaboration with those who have high expertise in producing automobiles with advanced technologies to help ensure that human limitations do not result in negative consequences will be good. In the face of depleting non-renewable energy, in various municipalities, and the concern about possible economic shock from a drastic change to technologies that use non-renewable energy, it may be good to explore a quota system in which there will be a certain percentage of vehicles that are made to use non-renewable energy for a pre-determined length of time, while each manufacturer also has a quota for vehicles that use renewable energy. The quotas may be periodically adjusted depending on the need and global concerns. However, the vehicles (either the ones that use fossil fuel or the ones that rely completely on renewable energies should all have a reasonable level of autonomous system) to ensure adequate crash avoidance. The quota system described above is aimed at giving various economies the opportunity to adjust and have a smooth transition with global technological developments, and long-term realities of non-renewable resources.

6.1. Overcoming potential fears from loss of revenue from fuel tax

Another potential economic challenge is the revenues that comes in through fuel tax. If taxes from fuel forms a major source of resource for road maintenance, and construction of new roads, without a viable alternative for the fuel tax, government support for technologies that provide transportation services without the need to use fossil fuel may not be very strong. Meanwhile, various governments that may want to encourage technologies that provides transportation alternative with a consideration of long-term realities of non-renewable energies may allow systems

that will greatly favor consumers that have vehicles that use renewable energy technologies. For example, if vehicles with non-renewable energies becomes affordable for everyone in a community, and the government makes a legislation that allows all those who buy that vehicle to not have to pay any road user fee (for maintenance of road) for a considerable number of years, there may be a rush to switching to vehicles with non-renewable technologies, and this probably may result in an economic shock for nations whose economies have heavily relied on oil (fossil fuel) for quite a while. With a mind to make room for adjustment, and create a unanimous support for automakers who have specialties in highly automated vehicle technologies (that can help improve safety on the roads) with renewable energy technologies (that may help reduce fears from potential realities of non-renewable resources), and automakers who make vehicles that use fossil fuel, it will be a good idea to consider adoption of other systems that makes all road users pay a fair share of the cost of using the roads. The use of road user charge system as described by Kirk & Levinson (2016) which involves assessing owners of personal vehicles on a per-mile basis for distance driven may be adopted. The mileage-based road user charges system has also been used in various places, including road user charge on both trucks and automobiles in New Zealand, road user charges on trucks in Switzerland, Austria, and Germany. Small scale experiments of this system both on state and local levels has also been conducted in the United States (Kirk & Levinson 2016). Mofolasayo (2018), also recommended that efforts should be made to implement systems that can automatically capture, and report vehicle mile traveled by all vehicles (in a road usage finance system), in all jurisdictions, for periodical billing system. This will ensure that electric powered autonomous vehicles can pay their fair share of road maintenance fees.

News from National Conference of State Legislators [NCSL] (2017) through USDOT FHWA's program on Surface Transportation System Funding Alternatives (STSFA) also indicated that there is interest in alternative revenue mechanism for Highway Trust Fund. This interest in alternative funding for surface transportation is surely a good step to ensure that government can take a neutral stand between conflicting interests of anyone who may favor blind exploration of fossil fuel without thought of the future, and those who are trying to ensure that the world is prepared for future realities of non-renewable energy. Any effort to make any government stay on fuel tax as a sole source of funding system for maintenance of roadways may be seen as trying to make the government stay in a biased position, and favor development of the fossil fuel sector over other sectors. (Note: The fuel tax system may not be good for revenue generation for road maintenance by the time a considerable portion of vehicles in the traffic stream use alternative forms of energy that does not require fuel tax). No government should decide to stay in a position that may generate a conflict of interest in this way. Rather, governments in various jurisdictions should show the interest and effort to move to a neutral position as regards source of revenue for the government. While providing due encouragement for those who mine natural resources for daily use, those who focus on preparing humanity for future realities of the use of non-renewable energy in the transportation sector should also receive due encouragement. Recall that this is aimed at creating a mutual understanding and support by all parties, to the extent that everyone will be supportive of adopting technologies that is expected to improve transportation safety for all. It is also good to remember that a lot of automobiles on the road at this time are still supported by fossil fuel.

7. Improvement in road traffic safety: few examples

Measures to improve road traffic safety has been implemented in various places. While some acknowledgeable improvements have been made, so far, no country is yet to record zero fatality on road traffic safety within a year. Places with low road traffic accidents as presently presented on world health rankings include: Micronesia, Sweden, Kiribati, United Kingdom, Netherlands, Switzerland, Denmark, Norway, Spain, Japan, Singapore, Israel, Iceland etc. (World health rankings). As early as 1997, the Swedish parliament has a plan to eradicate road fatalities and injury (Vision zero). Sweden's roads have achieved a record of the world's safety roads, with 3 of every 100,000 dying on the roads each year (The Economist, 2014). A report about traffic and road conditions in Micronesia indicates that speed limits are very low: in most places speed limits are 20 miles per hour, and 15 miles per hour when children are present in school zones (Country reports).

Sung & Rios (2015) on a report on how South Korea has drastically reduced road deaths noted that comprehensive policies played a major role in reduction of children's death from road and traffic injuries. Among other things, transport safety acts, guidelines, and regulations were thoroughly revised, and complemented as need be. Run-red and

speeding cameras were installed on road sides, there was improvement in transportation infrastructures such as new pavements, guardrails, and speed controls for various hazardous locations. As tactics to discourage high-risk behaviors and drunk driving, driver's license issuing programs were reviewed. Penalty for violating traffic laws in school zones was more severe than in other areas. Campaigns were held to promote road safety. Road safety also attracted considerable political support. Within a 22-year period, 1992 (1566 death of kids) to 2014 (53 deaths of kids), south Korea witnessed almost 97% reduction in traffic fatalities for children under 14 years. While the general population witnessed 59.1% reduction in death from road crash (a reduction from 11,460 to 4,762 deaths from road traffic crash over the 22-year period).

8. Pathway to having a smooth transition in transportation policy to reversing deadly trends in road traffic safety

For individual jurisdictions who wish to see improvement in traffic safety, the following processes may be followed:

Engaging with the community

- Create more awareness about the severity of road traffic safety, and the need to take urgent action.
- Allow the general populace to contribute to the proposal for improvement of road traffic safety.
- Have a team of experts review the suggestions from the community and rate the suggestions.
- Select the best proposal to improve road traffic safety in your community (lessons learned from other places with great improvement in road traffic safety may be taken into consideration).
- Use established statistics from research, good reasoning, engineering judgement, and adequate logic to defend the selected proposals.
- Ensure that the decisions are not affected by bias for economic gains or various lobbyist groups.

In analyzing safety improvement suggestions from the community, criteria significance (weights) may be assigned to various suggestions based on evidence-based research on effectiveness of the proposals. Podvezko (2009) in a report on 'application of AHP technique' indicated that a lot of theoretical and practical methods of determining the significance of criteria exist. While pairwise comparison of criteria is widely used, the so-called Analytical Hierarchy Process (AHP) is the most well-known. One of the limitations mentioned for the AHP process is contradicting expert estimates. While it is a good thing to carry the community along in decisions of safety improvements, this study recommends the use of evidence-based research. If needed, sample trial of various safety improvement suggestion may be evaluated to determine their effectiveness.

If research findings indicate that all suggestions received from a certain community will likely not yield much positive result, a good education of residents in the community as regards effectiveness of various road safety improvement policies is recommended.

8.1. Using research records as a defense for policy improvements

This study has evaluated various limitations of humans in driving operations. It is known that technologies already exist to help ensure that some human errors while driving does not result in negative consequences. After an open and unbiased testing of these innovative technologies on a large scale, and evidence-based research results are available to back up the decision for policy improvements, to see effective implementation of a policy that can bring about a good change, the following recommendations may be used in various municipalities:

- Call a meeting with the executives of all car manufacturers in the community.
- Showcase the newest standards of collision avoidance features that can drastically reduce traffic collisions.
- In the presence of all, ask to know if there is any of the car manufacturing company that is unable to produce vehicles that meet the standards for the desired collision avoidance systems, regardless of the form of energy that is used to power such a vehicle.
- Ensure adequate compensation for those who came up with a technology that is beneficial to all and have that technology available for use by everyone to improve road traffic safety for all.

- Provide adequate help for any car manufacturer who does not have the technology or facility to meet up with the desired standard. This may be in the form of collaboration with manufacturers that have the desired technology.
- Ensure unbiased, and continuous testing of all the desirable technologies under every condition that a driver may see on the roads.
- Make a legislation that raise the minimum vehicle standards for all vehicles on the road in that jurisdiction.
- Make a legislation that disallows vehicles that does not meet the desirable standards from being imported into the country.
- Establish a deadline in which all vehicles on the road in that country or jurisdiction must have the minimum standard that is specified.
- Ensure that adequate centers exist that will check to confirm that all vehicles in each municipality meet the minimum vehicle standards for automatic collision avoidance systems.
- Refuse to renew vehicle license for any vehicle that does not meet the minimum vehicle standard for collision avoidance systems on the road.
- Ensure a legislation that mandates everyone in the municipality to either upgrade their vehicles to meet the minimum standard for collision avoidance systems or get rid of such vehicles from the community. (A fine may be instituted for violation of the legislation).
- Ensure adequate enforcement which may include periodic search of any property that has a vehicle that does not meet up with the minimum standards for collision avoidance systems and get rid of such vehicles.

While there is news about notable achievements in reduction in traffic crashes with policy improvements in some municipalities, there is still need to put in more effort to achieve more improvement in road traffic safety in all jurisdictions globally.

- A concerted effort is needed (cooperation between all nations on improvement to transportation safety).
- Open sharing of knowledge on what has resulted in positive achievements (improvement) in road safety in various municipalities on a constant basis is recommended
- There is a need to legislate an increase to the minimum safety standard for all motor vehicles on the road
- There is a need to ensure that all manufacturers of motor vehicles every are aware of the increased minimum safety standards for motor vehicle. Enforcement of these increased standard is recommended
- There is a need to create a sense of global accountability for road traffic safety for people in all jurisdiction. This should be strictly motivated by the intention to improve road traffic safety in all communities globally
- There is a need to set a timeline for various nations to come up with adequate legislation, and enforcement of legislations aimed to improve road traffic safety.

This report has provided an evaluation of human factors in driving operations and discussed the need for a reasonable degree of automation in driving operations. The report also includes a discussion about what will be good to consider as a reasonable degree of automation in driving operations. In defining what a reasonable degree of automation will be for motor vehicles, this report indicates that a reasonable degree of automation will be the use of automatic technologies that has been adequately tested (in an open and unbiased way) in all weather conditions (including hazardous weather conditions; such as severe winter (extreme cold, & snow), rain, fog, etc., and the safety capabilities has been verified to ensure safety of people in their daily commute. Given various human limitations (which present driver training and law enforcements has not been able to eradicate for many years) that affects driving operation, and the fact that no country in the world is yet to achieve zero fatalities on the road within a year, it is high time for the world to explore breakthrough idea to turn around from what presently appears to be an unending journey with road traffic fatalities. The need to welcome reasonable degree of autonomous motor vehicle technologies to ensure that human limitations in driving of motor vehicles does not lead to negative consequences has been discussed in the report. This report recommends adequate testing of the technologies on a large scale in every community, in an open and unbiased way. This report also recommends that technologies that are found to be efficient in improving traffic safety be made as minimum standards for all motor vehicles on the road. A periodic and consistent review of the status of transportation safety standards, and subsequent improvements to the standards is recommended in every community globally.

Conclusion and recommendations

With the trend in the road traffic fatalities globally, the world is certainly overdue for an improvement in the minimum standards for vehicles on the road. This study provides a review of some human factors that results in road traffic crashes and recommends ways to achieve a positive turn around in road traffic safety for various municipalities around the globe. Findings from previous literatures were discussed to emphasize the reality of challenges with human factors in the driving operations. This report also includes some recommendations that is hoped to help humanity at large achieve a breakthrough in the effort to reducing road traffic crashes and the associated property damage, injuries and fatalities. Among other things, the discussion in this study illustrates human challenges with fatigue, sleepiness behind the wheels, distraction while driving, driving under the influence of drugs and alcohol. From review of human factors, it is evident that errors associated with human factors presents a real challenge to improving transportation safety. This study supports the fact that challenges with human factors in driving operations presents a real threat to improvement in road traffic safety.

It is known that a mixed opinion exists when it comes to the issue about implementation of autonomous driving. Meanwhile, if it is known that certain technologies are able to help human drivers improve road traffic safety, it is reasonable that those technologies be given a fair chance for open evaluation and testing in various municipalities. This study defines a reasonable level of autonomy (to help human drivers reduce the chance of traffic crash) as the use of automatic technologies that has been adequately tested (in an open and unbiased way) in all weather conditions (including hazardous weather conditions; such as severe winter (extreme cold, & snow), rain, fog, etc., and the safety capabilities has been verified to ensure safety of people in their daily commute. A good reference on ‘a research guide for using the efficiency of technological innovations in automobiles to establishing unbiased policies for improvement of minimum safety standards for driver operated motor vehicles’ has been mentioned in the study. After fair and unbiased evaluation of reasonable autonomous motor vehicle technologies, this study recommends a consensus effort to improve the minimum standards of motor vehicles in every jurisdiction to include innovative autonomous technologies that are found to be efficient. To ensure that everyone is carried along in the effort to improve traffic safety, the report provides a proposal to engage with the community, ensure public education, and use evidence-based research in making decisions to improve road traffic safety. Recognizing that the energy that supports transportation system is a factor that may affect its acceptance, this study proposed a system to ensure that presumed economic impact of certain technologies does not obstruct the effort to improve road traffic safety.

While there is news about notable achievements of reduction in traffic crashes with policy improvements in some municipalities, there is still need to put in more effort to achieve more improvement in road traffic safety in all jurisdictions globally. This report noted that:

- A concerted effort is needed (cooperation between all nations on transportation [road traffic] safety)
- Open sharing of knowledge on what has resulted in positive achievements (improvement) in road safety in various municipalities is needed
- There is a need to legislate an increase to the minimum safety standard for all motor vehicles on the road
- There is a need to create a sense of global accountability for road traffic safety for people in all jurisdiction This should be strictly motivated by the intention to improve road traffic safety in all communities globally
- There is a need to set a timeline for various nations to come up with adequate legislation, and enforcement of legislations aimed to improve road traffic safety.

The fact that no country in the world is yet to achieve zero fatalities on the road within a year further corroborates the need to improve on automation systems and ensure legislation that promotes the use of systems that are designed to ensure that human limitations in driving of motor vehicles does not lead to negative consequences. After adequate testing of the innovative autonomous technologies that are aimed at improving road traffic safety, on a large scale in every community, this report supports the notion that technologies that are found to be efficient in improving road traffic safety be mandated as minimum standards for all motor vehicles on the road in all municipalities.

The proposal presented to engage with the community in the effort to improve road traffic safety and to ‘use research records as a defense for policy improvement’ may be transferred to a world standard for managing road traffic safety. A periodic and consistent review of the status of transportation safety standards, and subsequent improvements to the standards is recommended in every community globally.

References

AAA foundation for traffic safety. “Distracted Driving” https://www.aaafoundation.org/distracted-driving Accessed 7/19/2017

American Association of State Highway and Transportation Officials (2004). “A Policy on Geometric Design of Highways and Streets” (5th Edition). Washington DC.

Aworemi J. R., Adegoke A-A. I., Oyedokun A. J., & Adewoye J. O., (2010). “Efficacy of Drivers’ Fatigue on Road Accident in Selected Southwestern States of Nigeria”. International Business Research. Vol. 3, No. 3; July 2010.

Bradford A., (2017). “What is THC”. Live Science. https://www.livescience.com/24553-what-is-thc.html Accessed 6/28/2017

Brown I. D., (1994). “Driver Fatigue”. Human factors, 1994, 36(2), 298-314

Brubacher J. R., (2011). “Cannabis and motor vehicle crashes”. British Columbia Medical Journal (BCMJ), Vol. 53, No. 6.

Canadian Automobile Association (CAA) “Distracted Driving laws in Canada”. https://www.caa.ca/distracted-driving/distracted-driving-laws-in-canada/ Accessed 6/27/2017

Center for disease and control prevention (CDC). https://www.cdc.gov/motorvehiclesafety/distracted_driving/index.html Accessed June 29, 2017.

Country Reports-Travel Edition. "Traffic and road conditions in Micronesia". https://www.countryreports.org/travel/Micronesia/traffic.htm Accessed 2019/04/27.

Daziano R. A., Sarrias M., & Leard B., (2017). “Are consumers willing to pay to let cars drive for them? Analysing response to Autonomous vehicles”. Transportation Research Part C 78 (2017) 150–164.

de Mello M. T., Narciso F. V., Tufik S., Paiva T., Spence D. W., BaHammam A. S., Verster J. C., & Pandi-Perumal S. R., (2013). “Sleep Disorders as a Cause of Motor Vehicle Collisions”. International journal of preventive medicine. V.4(3); 2013.

Decker J. S., Stannard S. J., McManus B., Wittig S. M. O., Sisiopiku V. P., & Stavrinos D., (2015). “The Impact of Billboards on Driver Visual Behavior: A Systematic Literature Review”. PMC. NCBI. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4411179/ Accessed 6/30/2017

Durić P., & Miladinov-Mikov M. (2008) “Some characteristics of drivers having caused traffic accidents”. Med Pregl. 61(9-10):464-9. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/19203062 Accessed 12/28/2017

Edquist J., (2008). “The Effects of Visual Clutter on Driving Performance”. Accident Research Center. Monash University. Doctor of Philosophy - Thesis. Retrieved from https://www.tml.org/legal_pdf/Billboard-study-article.pdf Accessed 6/29/2017

European Transport Safety Council, Brussels (2001). “The role of driver fatigue in commercial road transport crashes”. http://etsc.eu/wp-content/uploads/The-role-of-driver-fatigue-in-commercial-road-transport-crashes.pdf Accessed 06/21/2017

Fletcher A., McCulloch K., Baulk S. D., & Dawson D., (2007). “Countermeasures to driver fatigue: a review of public awareness campaigns and legal approaches”. Centre for Sleep Research, University of South Australia. Australian and New Zealand Journal of Public Health. 2005 Vol. 29 No. 5. https://doi.org/10.1111/j.1467-842X.2005.tb00229.x

Foss R. D., & Goodwin A.H., (2014). “Distracted Driver Behaviors and Distracting Conditions Among Adolescent Drivers: Findings from a Naturalistic Driving Study”. Journal of Adolescent Health. Volume 54, Issue 5

Insurance Institute for Highway Safety (IIHS) & Highway Loss Data Institute (HLDI). "Crash avoidance features by make and model". Retrieved from https://www.iihs.org/iihs/ratings/crash-avoidance-features. Accessed 2019/04/25

Jamroz K., & Smolarek L., (2013). “Driver Fatigue and Road Safety on Poland’s National Roads”. International Journal of Occupational Safety and Ergonomics (JOSE) 2013, Vol. 19, No. 2, 297–309. Retrieved from http://archiwum.ciop.pl/59813 Accessed 6/21/2017

Kirk R. S., & Levinson M., (2016). “Mileage-Based Road User Charges”. Congressional Research Service. https://fas.org/sgp/crs/misc/R44540.pdf Accessed 6/28/2017

Kuypers K. P. C., Legrand S-A., Ramaekers J. G., & Verstraete A. G., (2012). “A Case-Control Study Estimating Accident Risk for Alcohol, Medicines and Illegal Drugs” PLOS Medicine. https://doi.org/10.1371/journal.pone.0043496.

Kyriakidis M., Happee R., & de Winter J.C.F. (2015). “Public opinion on automated driving: Results of an international questionnaire among 5000 respondents”. Transportation Research Part F: Traffic Psychology and Behaviour. Volume 32, July 2015, Pages 127-140. https://doi.org/10.1016/j.trf.2015.04.014.

McCauley R., (2017). “Why Autonomous and Electric Vehicles Are Inextricably Linked”. Retrieved from http://www.govtech.com/fs/Why-Autonomous-and-Electric-Vehicles-are-Inextricably-Linked.html Accessed6/30/2017.

Metric Conversions. http://www.metric-conversions.org/length/miles-to-meters.htm Accessed 6/29/2017

Mofolasayo A., (2018). “Evaluation of potential policy issues when planning for autonomous vehicles”. Presentation Slides at The Proceedings of the 53rd Annual Conference. Canadian Transportation Research Forum. Gatineau, Quebec, June 2018.

Mofolasayo A., (2018). “Evaluation of potential policy issues when planning for autonomous vehicles”. Proceedings of the 53rd Annual Conference. Canadian Transportation Research Forum. Gatineau, Quebec, June 2018.

Mofolasayo A., (2019). ‘A research guide for using the efficiency of technological innovations in automobiles to establishing unbiased policies for improvement of minimum safety standards for driver operated motor vehicles.’ Proceedings of the 53rd Annual Conference. Canadian Transportation Research Forum (Accepted). Vancouver, May 2019.

National Conference of State Legislators [NCSL] (2017). “Road Use Charges”. http://www.ncsl.org/research/transportation/road-use-charges.aspx Accessed 6/28/2017

National Highway Traffic Safety Administration (NHTSA). “Policy Statement and Compiled FAQs on Distracted Driving” http://www.nhtsa.gov.edgesuite-staging.net/Driving+Safety/Distracted+Driving/Policy+Statement+and+Compiled+FAQs+on+Distracted+Driving Accessed June 29, 2017

National Highway Traffic Safety Administration (NHTSA) & USDOT (2015). “Critical Reasons for Crashes Investigated in the National Motor Vehicle Crash Causation Survey” Retrieved from https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812115 Accessed 6/29/2017

National Institute of Drug Abuse (2017). “Marijuana”. https://www.drugabuse.gov/publications/drugfacts/marijuana Accessed 6/28/2017

Petroleum Technology Research Center (PTRC). “Weyburn-Midale - The IEAGHG Weyburn-Midale CO2 Monitoring and Storage Project”. Retrieved from https://ptrc.ca/projects/weyburn-midale Accessed 6/28/2017.

Podvezko V., (2009). "Application of AHP Technique". Journal of Business Economics and Management. 10:2. DOI: 10.3846/1611-1699.2009.10.181-189

Radun I., & Radun J. E. (2009). “Convicted of fatigued driving: Who, why and how?”. Accident Analysis and Prevention 41 (2009) 869–875.

Ran Naor Foundation for advancement of road safety research (2007). “Road traffic safety research and education in Israel”. Retrieved from http://www.rannaorf.org.il/webfiles/files/Road%20traffic%20safety%20research.pdf Accessed 7/5/2017

Roberts P., Boddington K., Rodwell L., & Jorgensen D., (2013). “Impact of Roadside Advertising on Road Safety – Austroads Research Report” Austroads Publication No. AP-R420-13. Retrieved from http://scenic.org/storage/PDFs/austroads%20research%20report%20on%20impact%20of%20roadside%20advertising%20on%20road%20safety.pdf Accessed 6/29/2017

Roess R. P., Prassas E. S., & McShane W. R., (2011) “Traffic Engineering – Fourth Edition”. Pearson Higher Education Inc. NJ.

Sewell R. A., Poling J., & Sofuoglu M., (2009). “The effect of Cannabis compared with Alcohol on driving” PMC. US National Library of Medicine. National Institute of Health. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2722956/ Accessed 6/28/2017.

Sung N. M., & Rios M., (2015). World Economic Forum. “How South Korea has dramatically reduced road deaths”. World Bank. Retrieved from https://www.weforum.org/agenda/2015/06/how-south-korea-has-dramatically-reduced-road-deaths/ Accessed 6/28/2017

The Economist (2014). "Why Sweden has so few road deaths". https://www.economist.com/the-economist-explains/2014/02/26/why-sweden-has-so-few-road-deaths Accessed 04/27/2019.

The Royal Society for the Prevention of Accidents (ROSPA). (2001) “Driver fatigue and road accidents. A literature review and position paper”. Retrieved from https://www.rospa.com/rospaweb/docs/advice-services/road-safety/drivers/fatigue-litreview.pdf Accessed 06/21/2017

US Department of Transportation (USDOT) & National Highway Traffic Safety Administration (NHTSA) (2016). “Federal Automated Vehicles Policy. Accelerating the Next Revolution in Roadway Safety”. Retrieved from https://www.transportation.gov/sites/dot.gov/files/docs/AV%20policy%20guidance%20PDF.pdf Accessed 02/25/2017

World health organization (WHO). “The top 10 causes of death”. http://www.who.int/mediacentre/factsheets/fs310/en/ Accessed 6/27/2017

World Health Organization(WHO), & NHTSA. (2011) “Mobile Phone use: A growing problem of driver distraction”. Retrieved from http://www.who.int/violence_injury_prevention/publications/road_traffic/distracted_driving_en.pdf Accessed 6/21/2017.

World Health Rankings. "Road traffic accidents". https://www.worldlifeexpectancy.com/cause-of-death/road-traffic-accidents/by-country/ Accessed 2019/04/27.

Young M. S., & Mahfoud J. M., (2007). “Driven to distraction: Determining the effect of roadside advertisement on driver attention”. Ergonomics Research Group, School of Engineering and Design, Brunel University. Retrieved from http://www.reesjeffreys.co.uk/reports/Roadside%20distractions%20final%20report%20%28Brunel%29.pdf Accessed 6/29/2017.