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A Survey of Road Accident Reporting and Driver's Behavior Awareness Systems: The Case of Tanzania

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Abstract—**Road traffic accidents are a leading cause of death in developed and developing countries. It has been shown that road accident reporting systems could reduce their effects by minimizing response time and mapping road accident-prone areas. This paper provides an overview of the systems and applications for road accident reporting and drivers' behavior awareness. A field survey, conducted in Dar es Salaam region in Tanzania, investigated the current state of road traffic accident reporting. Findings showed that the main means of reporting road accidents were physical reporting and police emergency phone calls. The absence of alternative means for reporting road accidents causes information delay and lack of precise accident location for the emergency first responders. This paper concludes by proposing a mobile application system for road accident reporting and drivers' over-speed awareness, in order to improve road safety in developing countries.**

Keywords-road traffic accidents; road accident reporting; smartphone sensors; road safety; driver's behavior; awareness

I. INTRODUCTION

Road traffic accidents are the 8th global leading cause of death, with 1.35 million deaths and up to 50 million injuries in 2016 [1] with the death and injury rates are higher in developing than in developed countries [2]. Strong enforcement of road safety laws, public awareness campaigns, smart road design, and safer vehicles have been determined as ways of reducing road traffic accidents [1]. In Tanzania, road traffic accidents have high rates of morbidity and mortality [3]. The country has high rates of road accidents, with a traffic fatality rate of 32.9 per 100,000 people, pointing out the necessity for further improvements in road safety measures [1]. The factors of road traffic accidents related deaths and injuries in Tanzania have been categorized as human, mechanical, or road/infrastructure condition related. Among human factors, overspeeding was found to be the major cause of road traffic accidents [4]. Underreporting of road traffic accidents is a challenge, as it leads to untrustworthy data [5]. It is also pervasive in many parts of the world and results in giving lower priority to road safety compared to other public health challenges. Moreover, Tanzania lacks road accident reporting systems, apart from emergency call numbers which are mostly unreliable and sometimes unavailable [1]. Various measures were imposed to prevent road traffic accidents and improve safety in Tanzania, for instance road safety regulations such as speed-limit laws, obligatory seat-belt and helmet use, and strict laws regarding driving under the influence. Road traffic accident victims' chances of survival increase with the immediate availability of pre-hospital emergency services [6]. This implies that response time reduction is needed in order to improve healthcare delivery in road accident emergencies. The reporting of traffic accidents could also be utilized for mapping accident hotspot (black spot) areas, notifying drivers and other road users to be more careful when accessing them.

In a post-crash situation, usually the bystanders/witnesses contribute to the initiation of the emergency care, by either providing first aid or calling for help. This study aims to reduce road accidents both passively, through enabling drivers to observe speed limits by enhancing their driving over-speed awareness, and actively by enabling timely reporting of road accidents to minimize rescue time response. As Tanzania has 43.5 million mobile phones and 23.1 internet users [7], this paper proposes a mobile application system for road accident reporting and drivers' over-speeding behavior awareness that will enable road users to report road accidents and over-speeding drivers to traffic police officers, using smartphones' built-in sensors such as GPS receivers and cameras. To achieve these objectives, a literature review was conducted on related studies for drivers' behavior awareness and road traffic accident reporting. A field survey was also conducted in Dar es Salaam, using questionnaires, interviews, document reviews, and observation to evaluate the current state of reporting road traffic accidents and drivers' over-speeding behavior awareness.

II. RELATED WORK

The review of related studies on systems and applications for drivers' behavior awareness and road traffic accidents' reporting showed that the existing systems are categorized as in-vehicle and smartphone sensor based systems.

A. In-vehicle Sensor-based Systems

Many vehicle built-in systems have been implemented to increase road safety and reduce accidents' occurrence. Since 2018, all new cars sold in the European Union embed the in-vehicle eCall system for the detection and reporting of accidents to emergency services [8]. Its main disadvantage is

the difficulty to install it in older cars, which are widely used in developing countries. e-NOTIFY is a similar proposed system, using an On-Board Unit (OBU) that utilizes in-vehicle sensors to automatically detect and report accidents to the nearest Control Unit and nearby vehicles [9]. OBU device obtains information from in-vehicle sensors in order to transmit the accident's information, utilizing Vehicle-to-Vehicle (V2V) and Vehicle to Infrastructure (V2I) communications. The main disadvantage of this system is its costly installation. Authors in [10] proposed an android-based mobile application system that detects and reports vehicle accidents through an On-Board Diagnostic (OBD II) which collects vehicle information such as GPS, accelerometer, airbag triggers, and vehicle speed data. OBD II is a second generation OBD that diagnoses the vehicle electrical system to detect vehicle problems. The mobile application is able to detect an accident by calculating G-force estimates or detecting airbag triggers through a smartphone connected to an OBD II, using Bluetooth to receive data from the vehicle's internal bus. When an accident is detected, it is reported to emergency services through email or SMS. Authors in [11] implemented a driving styles platform, based on neural networks, to define the driving style of each user and the type of road the vehicle is moving. The developed android application utilized the OBD-II Bluetooth connection to collect vehicle information such as speed, acceleration, engine revolution per minute, throttle position, and vehicle's geographical location. OnStar is another vehicle built-in system implemented by General Motors that utilizes in-vehicle sensors to detect road accidents and inform emergency services [12]. This system is vehicle dependent as it can be installed only on General Motors' vehicles.

B. Smartphone Sensor-based Systems

Authors in [13] presented a Context-based Driver Score (CDS) model to score driver's behavior based on a context including road quality, weather, and time of day. The study aimed to improve Usage-Based Insurance (UBI) products by including the context of the driver, which was mostly ignored by insurance companies. Data collected from smartphone sensors were used to model vehicle maneuvers and their interaction with the road. In [14], a system similar to eCall but using a mobile device was presented, which detected accidents and sent notifications to emergency services or contacts. WreckWatch, a client-server system proposed in [15], utilized smartphones in road accident detection to reduce traffic congestion and emergency responders' notification time. Moreover, this study discussed some major challenges for accident detection using smartphone sensors. Authors in [16] developed a traffic management system using crowd-sourced smartphone GPS sensor data and other parameters, such as traveling time and distance, recommending alternative route paths for shorter traveling time or less fuel consumption. The system utilized only the GPS sensor, and only drivers were involved in collecting driving data. Another study developed a smartphone-based platform collecting low-cost and long-term naturalistic data for Vulnerable Road Users (VRUs) [17]. The LogYard smartphone application was developed for recording high-quality data from a large number of users for off-line analysis, addressing privacy and integrity issues of the participants. Authors in [18] proposed a system using the internal accelerometer and GPS of a smartphone to enhance the existing safety features on a road, in order to increase drivers' awareness, classifying road condition types and drivers' driving patterns. Another study surveyed smartphone-based sensing in vehicles for Intelligent Transport System Applications [19], identifying certain advantages of using smartphone-based instead of in-vehicle sensing. Among the advantages, smartphone-based sensing links driving behavior to an individual driver rather than a vehicle of which the driver may be unknown. It also provides connectivity without any additional equipment and has low installation cost. Authors in [20] proposed the use of smartphones to automatically detect road accidents in order to increase road safety and reduce the time to call for help, specifically for cyclists as they are among the most VRUs. The study used accelerometer, gyroscope, and GPS sensors logged data to develop an algorithm for accident detection, but the algorithm and data were proprietary. In [21], an accident detection and reporting system based on the Internet of Things (IoT) was presented. An android application was developed to collect smartphone sensor data and process them on a cloud infrastructure to detect an accident. The study focused ways to reduce the significant false positive rates for automatic accident detection found in previous studies. Waze is a crowd-sourcing mobile application providing real-time traffic information for road users. In addition, it provides other services such as reporting of various road incidents, and it also collects anonymous users' speed and GPS locations for its service improvements [22]. This mobile application does not send these road incident reports to authorities, the information are mainly used for informing drivers. RAC is another mobile traffic application, based in the UK, enabling users to share and view various road incidents, route planner, shortest route, and traffic news services [23].

C. Characteristics of Road Accident Reporting Systems

Road accident reporting systems and applications have the following characteristics:

- Accident report content: The report includes automatic user location retrieval through an embedded GPS sensor. It also includes simple forms that collect road accident data in text, photo, video or audio, with more emphasis in the text format. Most accident reporting systems embed the Minimum Set of Data (MSD) of the accident information in reports [24].

- Usability: Mobile applications and systems for road accident reporting need to be attractive and simple in design in order to be easy to use.

- Interaction: Given the road accident situation, the user interaction with mobile application systems for reporting road accidents needs to be quick and intuitive [25].

III.   METHODOLOGY

A field survey was conducted in the region of Dar es Salaam, Tanzania, to determine the overall situation regarding the reporting of road traffic accidents to the traffic police authorities. The survey involved two groups: traffic police officers and road users (citizens).

A. Study Area

Dar es Salaam is Tanzania's largest city with five districts: Kinondoni, Ilala, Temeke, Ubungo, and Kigamboni. The region's 2016 projected population was 5,465,420, based on the 2012 census [26]. Dar es Salaam was chosen as a study area because of its high population and its effect on the high usage of roads for land transportation. According to the national government report of 2015, Dar es Salaam also had the highest number of road traffic accidents [27].

B. Sample Size and Sampling

Yamane's simplified formula was used to obtain the sample sizes [28]. This formula is widely used in statistics for sample size calculations. The formula is expressed as:

$$n = \frac{N}{1+N(e^2)} \quad (1)$$

where n is the sample size, N is the population size and e is the acceptance sample error. The acceptance sample error was defined as 0.1, and the population size for Dar es Salaam was 4,364,541. On the other hand, the population size for traffic police officers in Dar es Salaam was estimated to be 1300 [29]. Through Yamane formula, sample sizes of 93 and 100 for traffic police officers and road users (citizens) were used respectively. Simple random sampling was used for data collection from responders who were willing to complete the survey. The survey was conducted in three traffic police stations: Traffic Police Headquarters (HQ), Oysterbay station, and Urafiki station in Ilala, Kinondoni and Ubungo districts respectively. The survey aimed to determine means, challenges and information collected on road accident reporting.

C. Data Collection Methods

This research collected both quantitative and qualitative data utilizing questionnaires, structured interviews, and observation methods.

1) Questionnaires

Two different structured questionnaires were utilized and given to traffic police officers and road users.

- The questionnaire for the traffic police officers consisted of demographic questions about age and gender, the means used to receive road accident reports, the challenges faced in responding to road accidents, and the kind of collected information during road accident reporting.

- The questionnaires for the road users consisted of demographic information about age, gender, and level of education, the source of help provided at the accident scene, awareness of existing mobile applications for road accident reporting, and the attitude towards the use of mobile application systems for road accident reporting.

2) Interviews

Interviews were used to obtain detailed answers and opinions from the responders. Interviews were also taken from senior traffic police officers who failed to complete the questionnaires for various reasons. Some road users were also interviewed in order to determine their attitude on road traffic

accident reporting and the feasibility of using a mobile application system.

3) Observation

The survey also involved first hand observation of road traffic accidents on the roads of Dar es Salaam. One of the observed incidents was a motorcycle and car accident. This accident was not reported, as the victims of the accident were only slightly injured without needing help to visit hospital facilities, and there was not a simple mechanism for road accident reporting to traffic police apart from traditional methods, such as telephones and physical reporting. Road accident observation obviously occurred only by chance and not by systematic monitoring.

D. Data Analysis

Analysis on collected data was conducted using Python programming language and spreadsheet software programs because of their simplicity and the availability of various data analysis libraries.

IV. RESULTS AND DISCUSSION

A. Causes of Road Traffic Accidents in Tanzania

Several studies found that human factors constitute the main reason of road traffic accidents, with over-speeding being the leading factor [30]. In Tanzania, 74% of the accidents that happened in 2010 were caused by human factors [4]. Other factors include vehicle/mechanical and road conditions. Table I shows the causes of road accidents, where some of the human causes include excessive speed, overtaking, and driving while intoxicated (DWI). Reckless driving, which is driving with excessive speed for a given road/traffic condition, consisted about 57% of all accident causes [4]

B. Speed Limits for Road Safety

The methods for enforcing speed limit laws in Tanzania include the use of speed radar guns and the Vehicle Tracking System (VTS) installed in public transport buses to limit driving speeds to the regulated 80km/h outside urban and 50km/h in urban areas [31]. Table II shows the road speed limits for different vehicle types.

TABLE I.   MAJOR CAUSES OF ROAD CRASHES (SUMATRA, 2017)

Causes of road crashes		Contributory percentage (%)	
		2000-2005	2010
Human factors	Reckless driving	54	57
	Over-speeding	8	9
	Improper overtaking	7	8
	DWI	3	0
	Overloading	5	n.a
Mechanical factors		16	12
Road conditions		7	14
TOTAL		100	100

C. Road Traffic Accident Reporting

Road traffic accidents are mainly reported by bystanders/witnesses. The responsible authorities for post-crash response include Traffic Police, Insurance Companies, Ministry of Health and Social Welfare, and Fire and Rescue Services [4].. The current approach to road accidents' reporting

in Tanzania is through phone calls, physical reporting to the traffic police officers, and sharing of information through social media such as Instagram and WhatsApp.

TABLE II.   SPEED LIMITS IN TANZANIA

Vehicle type	All cars	Buses and coaches(less than 12m in length), goods vehicles(less than 3.5tn in weight)
Built-up area	50km/h	50km/h
Urban area	50km/h	60km/h
Single carriageways	Not stated	80km/h
Dual carriageways	Not stated	80km/h

Source: Road Traffic Act, 1973 [31]

D. Field Survey Results: Traffic Police Officers' Response

The results obtained from data analysis of the collected responses from traffic police officers are shown below, by section.

1) Responders' Demographic Characteristics

As noted in Table III, 79% of traffic police officer responders were male and 21% were female. The high number of male responders was due to the fact that most of the traffic police officers are male. On the other hand, 63% of the responders aged between 31-40 years, 29% between 41-50 years, and 8% between 21-30 years.

TABLE III.   DEMOGRAPHIC CHARACTERISTICS OF TRAFFIC POLICE OFFICER RESPONDERS

Demographic characteristics	Responders	Percentage (%)
Gender		
Male	73	79
Female	20	21
Age groups (years)		
21-30	7	8
31-40	59	63
41-50	27	29

2) Means Used to Receive Road Accident Reports

The study aimed to determine the time efficiency of the means used for reporting road accidents to traffic authorities. As noted in Figure 1, most road accident reports were received through telephone calls (62%). Bystanders' physical reporting for road accidents was found to be 28% of all responses. Physical reporting from victims had a frequency of 10%. These results show that there are still some challenges in reporting accidents to responsible authorities, such as dealing with increased response times and underreporting. Therefore, there is a need for alternative road accident reporting tools that will aid road users in immediate and effective reporting.

3) Challenges Faced in Responding to Road Accidents

Traffic police officers responding to road accidents identified several challenges in timely assisting road accident victims to avoid preventable injuries and deaths. As shown in Figure 2, information delay was noted to be the most important challenge in responding to road accidents with 43%. Other challenges included accident location accuracy (38%), false information (13%), and lack of transport (6%). These findings

signify that road users may fail to report road accidents on time due to the limitations of the existing methods. An alternative mobile application tool could enable road accident witnesses to easily report the accident with its accurate location using a smartphone's GPS sensor.

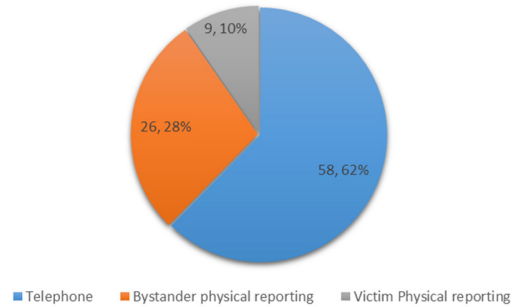**Means for Road Accident Reporting**

Fig. 1.   Means for road accident reporting.

Challenges faced in responding to road accidents
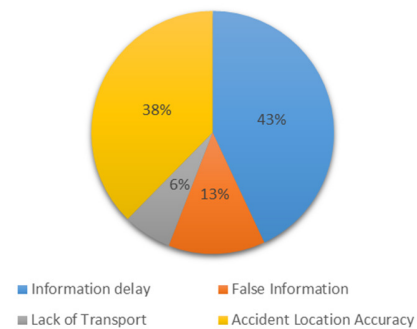

Fig. 2.   Challenges faced in responding to road accidents.

4) Collected Information

Traffic police officer responders were asked about the necessary information collected during road accident reporting. This question aimed to determine the road accident details that should be reported by a mobile application. Figure 3 shows the obtained results.

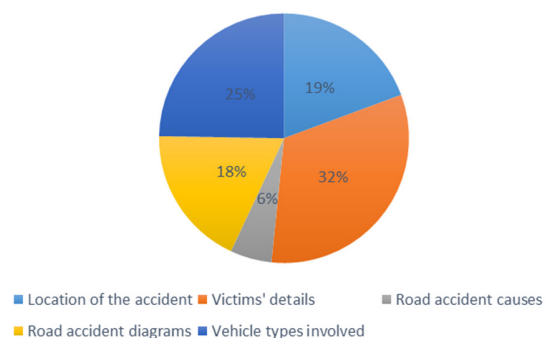**Information collected during road accident reporting**

Fig. 3.   Information collected during road accident reporting.

Victims' details were addressed as the most frequently collected information (32%), followed by the vehicle types involved (25%), the location of the accident (19%), the road accident diagrams (18%), and the accident's causes (6%). As the information about a road accident is mainly collected from the witnesses' point of view, there are high chances for false information. Road accident report systems providing information such as accident's location using a GPS sensor would help to face this challenge.

E. Field Survey Results: Road User Responses

After analyzing the data collected using questionnaires from road users, the following results were obtained.

1) Responders' Demographic Characteristics

The responder's demographic characteristics can be seen in Table IV.

TABLE IV.   DEMOGRAPHY OF COMMUNITY RESPONDERS

Demographic Characteristics	Responders	Percentage (%)
Gender		
Male	64	64
Female	36	36
Age groups (years)		
20 or younger	5	5
21-30	43	43
31-40	32	32
41-50	12	12
51 or older	8	8
Education level		
Completed sec school only	17	17
Completed more than sec school	68	68
Didn't complete sec school	15	15

2) Source of Help Provided in the Accident Scene

As depicted in Figure 4, the majority of the responders (75%) indicated that accident witnesses provide help in the accident scene, while 23% indicated the traffic police officers, and only 2% indicated the hospital facilities for medical assistance.
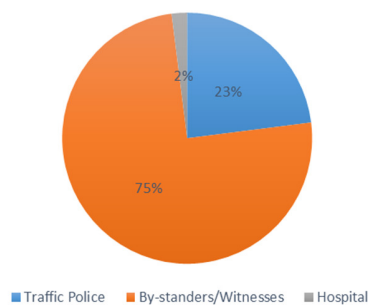

Fig. 4.   Sources of help provided in the accident scene.

This indicates that if bystanders had alternative means, they could possibly request for help from additional sources.

3) Awareness of Existing Mobile Applications

Almost all responders were unaware of any existing mobile applications for reporting road accidents. Only one responder was aware of such an application, but the mentioned application was used for road traffic monitoring and was no longer available. The lack of any other alternative means points out the need for a road accident reporting mobile application.

4) Attitude Towards a Mobile Application System

The vast majority of the responders had a positive attitude on the advantages of a mobile application system for road accident reporting and drivers' over-speeding behavior awareness as can be seen in Figure 5. Only 2% responded that such a mobile application will not help in notifying the responsible authorities on time.
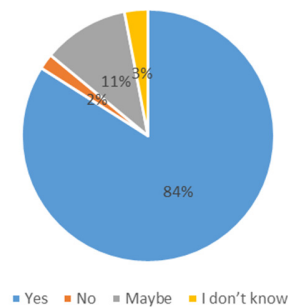

Fig. 5.   Attitude toward a mobile application for reporting road accidents and driver's over-speeding awareness.

F. Proposed Solution

To address the challenges faced by the current road accident reporting systems in Tanzania, this study proposes a mobile application system, by which road users could report road traffic accidents to traffic police authorities. The proposed mobile application system would also let road users be aware of their driving over-speeding behavior by utilizing data retrieved from the GPS sensor. The system would report road accidents to the nearest traffic police station with the assumption that the users (drivers, passengers or pedestrians) are witnesses. The system could also enable the continuous collection of smartphone sensor data, such as accelerometer, gyroscope, and GPS for the development of more robust automatic road accident detection and reporting algorithms. The mobile application system should feature the necessary required information for reporting road accidents. Images captured using smartphone cameras could be considered as a way to determine the type of vehicles involved, and provide some insight into the accident's causes, while GPS sensors would retrieve the location of the accident automatically.

V. CONCLUSION AND FUTURE WORK

A. Conclusion

Smartphone-based road accident detection and reporting systems can provide innovative solutions to improve drivers' awareness on road safety and save lives in road traffic accidents. Despite being more portable and relatively inexpensive in comparison with in-vehicle sensor-based

solutions, smartphone sensor-based solutions face various challenges, such as more false positive occasions very likely to happen with smartphone-based accident detection compared to systems implemented with in-vehicle sensors, the reliability of smartphone sensors, and the availability of wireless network links. Since Tanzania lacks alternatives, apart from the police emergency number, a mobile application for reporting road accidents could deal with the current challenges faced by the traffic police authorities in receiving accident reports, reducing the time needed to provide help to the victims.

B. Future Work

The short-term goal is to develop a mobile application system that would report road accidents to the nearest traffic police station through crowdsourcing road users (drivers, passengers, and pedestrians) to report accidents as witnesses. The mobile application system would also utilize smartphone's GPS sensor to increase road safety consciousness, by notifying both drivers and passengers when exceeding speed limits. In addition, the system would continuously collect smartphone accelerometer and gyroscope sensors' data in order to develop robust automatic detection and reporting algorithms, as the long-term goal of the study. The collected data may help reducing the false positives of already developed systems. Future research work should involve the design, development, and validation of the proposed system in order to evaluate if the proposed solution will aid and increase the reporting of road accidents to the authorities.

REFERENCES

[1] WHO, "Global status report on road safety 2018," World Health Organization, Geneva, Switzerland, 2018.

[2] G. A. Ali, "Traffic accidents and road safety management; a comparative analysis and evaluation in industrial, developing and rich-developing countries," presented at the 29th Annual Southern African Transport Conference, Pretoria, South Africa, Aug. 2010, Accessed: Jun. 25, 2020. [Online]. Available: https://repository.up.ac.za/handle/2263/14865

[3] R. Boniface, L. Museru, O. Kiloloma, and V. Munthali, "Factors associated with road traffic injuries in Tanzania," *The Pan African Medical Journal*, vol. 23, no. 46, Feb. 2016, doi: 10.11604/pamj.2016.23.46.7487.

[4] NAOT, "Performance Audit Report On The Management Of Traffic Inspections And Speed Limits 2012," National Audit Office of Tanzania, Dar es Salaam, Tanzania, 2012.

[5] A. Detho, S. R. Samo, K. C. Mukwana, K. A. Samo, and A. A. Siyal, "Evaluation of Road Traffic Accidents (RTAs) on Hyderabad Karachi M-9 Motorway Section," *Engineering, Technology & Applied Science Research*, vol. 8, no. 3, pp. 2875–2878, Jun. 2018.

[6] O. A. Abdellah, M. M. Aborokbah, and A. O. Elfaki, "Improving Pre-hospital Care of Road Traffic Accident's Victims with Smartphone Technology," *International Journal of Interactive Mobile Technologies (iJIM)*, vol. 12, no. 2, pp. 130–141, Mar. 2018.

[7] TCRA, "Quarterly Communications Statistics: July-September 2019, Operators Submissions," Tanzania Communications Regulatory Authority, Tanzania, 2019.

[8] EU, "eCall: Time saved = lives saved | Digital Agenda for Europe" European Commission, 2018.

[9] M. Fogué, P. Garrido, F. J. Martinez, J.-C. Cano, C. T. Calafate, and P. Manzoni, "Automatic Accident Detection: Assistance Through Communication Technologies and Vehicles," *IEEE Vehicular Technology Magazine*, vol. 7, no. 3, pp. 90–100, Sep. 2012, doi: 10.1109/MVT.2012.2203877.

[10] J. Zaldivar, C. T. Calafate, J. C. Cano, and P. Manzoni, "Providing accident detection in vehicular networks through OBD-II devices and Android-based smartphones," in *2011 IEEE 36th Conference on Local Computer Networks*, Oct. 2011, pp. 813–819, doi: 10.1109/LCN.2011.6115556.

[11] J. E. Meseguer, C. T. Calafate, J. C. Cano, and P. Manzoni, "DrivingStyles: A smartphone application to assess driver behavior," in *2013 IEEE Symposium on Computers and Communications (ISCC)*, Jul. 2013, pp. 535–540, doi: 10.1109/ISCC.2013.6755001.

[12] GM, "OnStar In-Vehicle Safety and Security." General Motors, . https://www.onstar.com/us/en/home/ (accessed: Jun. 25, 2020).

[13] A. Walcott-Bryant *et al.*, "Harsh brakes at potholes in Nairobi: Context-based driver behavior in developing cities," in *2016 IEEE 19th International Conference on Intelligent Transportation Systems (ITSC)*, Nov. 2016, pp. 675–681, doi: 10.1109/ITSC.2016.7795626.

[14] J. Smolka and M. Skublewska-Paszkowska, "A method for collision detection using mobile devices," in *2016 9th International Conference on Human System Interactions (HSI)*, Jul. 2016, pp. 126–132, doi: 10.1109/HSI.2016.7529620.

[15] C. Thompson, J. White, B. Dougherty, A. Albright, and D. C. Schmidt, "Using Smartphones to Detect Car Accidents and Provide Situational Awareness to Emergency Responders," in *Mobile Wireless Middleware, Operating Systems, and Applications*, Berlin, Heidelberg, 2010, pp. 29–42, doi: 10.1007/978-3-642-17758-3_3.

[16] J. Gonçalves, J. S. V. Gonçalves, R. J. F. Rossetti, and C. Olaverri-Monreal, "Smartphone sensor platform to study traffic conditions and assess driving performance," in *17th International IEEE Conference on Intelligent Transportation Systems (ITSC)*, Oct. 2014, pp. 2596–2601, doi: 10.1109/ITSC.2014.6958106.

[17] L. Sandsjö, B. A. Sjöqvist, and S. Candefjord, "A Concept for Naturalistic Data Collection for Vulnerable Road Users Using a SmartPhone-based Platform," presented at the The 24th International Technical Conference on the Enhanced Safety of Vehicles (ESV), Gothenburg Sweden, Jul. 2015.

[18] M. Fazeen, B. Gozick, R. Dantu, M. Bhukhiya, and M. C. González, "Safe Driving Using Mobile Phones," *IEEE Transactions on Intelligent Transportation Systems*, vol. 13, no. 3, pp. 1462–1468, Sep. 2012, doi: 10.1109/TITS.2012.2187640.

[19] J. Engelbrecht, M. J. Booysen, G.-J. van Rooyen, and F. J. Bruwer, "Survey of smartphone-based sensing in vehicles for intelligent transportation system applications," *IET Intelligent Transport Systems*, vol. 9, no. 10, pp. 924–935, Dec. 2015, doi: 10.1049/iet-its.2014.0248.

[20] S. Candefjord *et al.*, "Using Smartphones to Monitor Cycling and Automatically Detect Accidents: Towards eCall Functionality for Cyclists," presented at the International Cycling Safety Conference 2014, Göteborg, Sweden, Nov. 2014.

[21] F. Bhatti, M. A. Shah, C. Maple, and S. U. Islam, "A Novel Internet of Things-Enabled Accident Detection and Reporting System for Smart City Environments," *Sensors*, vol. 19, no. 9, Jan. 2019, Art. no. 2071, doi: 10.3390/s19092071.

[22] Waze, "Driving Directions, Traffic Reports, and Carpool Rideshares." Waze https://www.waze.com/waze (accessed Jun. 25, 2020)

[23] RAC, "RAC Mobile Traffic Apps | RAC | RAC Drive." RAC. https://www.rac.co.uk/drive/travel/driving-in-the-uk/mobile-apps/ (accessed Jun 25, 2020).

[24] S. R. Sontakke; A. D. Gawande, "Crash Notification System for Portable Devices," *International Journal of Advanced Computer Technology (IJACT)I*, vol. 2, no. 3, pp. 33–38, Jun. 2013.

[25] M. Romano, T. Onorati, I. Aedo, and P. Diaz, "Designing Mobile Applications for Emergency Response: Citizens Acting as Human Sensors," *Sensors*, vol. 16, no. 3, Mar. 2016, Art. no. 406, doi: 10.3390/s16030406.

[26] "2016 Tanzania in Figures," National Bureau of Statistics, Dar es Salaam, Tanzania, 2017.

[27] "Crime and Traffic Incidents Statistics Report: January - December 2015," Tanzania Police Force, Dar es Salaam, Tanzania, 2016.

[28] T. Yamane, *Statistics: An Introductory Analysis*, 2nd ed. New York, NY, USA: Harper International, 1967.

[29] G. G. Lukumay *et al.*, "Provision of post-crash first aid by traffic police in Dar es Salaam, Tanzania: a cross-sectional survey," *BMC Emergency Medicine*, vol. 18, no. 1, Nov. 2018, Art. no. 45, doi: 10.1186/s12873-018-0199-9.

[30] M. Touahmia, "Identification of Risk Factors Influencing Road Traffic Accidents," *Engineering, Technology & Applied Science Research*, vol. 8, no. 1, pp. 2417–2421, Feb. 2018.

[31] "The Road Traffic Act," Government of Tanzania, 1973, pp. 1–71.