Emergency Ambulance Service Scheme and e-Call in Road Traffic Accident Rescue Operation

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Abstract:

Death from road traffic accidents trauma is a major challenge in the developing countries of the world; Nigeria inclusive. This study deemed it apt to examine the effectiveness of the Emergency Ambulance Service Scheme (EASS) under the Federal Road Safety Corps in the rescue and management of road crash victims in the Federal Capital Territory (FCT) Nigeria and the need for e-call adaptation in the system. The study uses a total of 121 and 440 questionnaires administered to Zebra crew members and motorists respectively using cluster and random sampling technique. The study revealed that the level of awareness of the existence of the Abuja Zebra crew ambulance services is still very poor and that most accident victims are been conveyed to the hospital via private or public vehicles. It also revealed that road safety Zebra crew is still operating below the GOLDEN HOUR given by global standard as within 1 to 20 minutes of the crash. The study therefore developed an add-on e-call system to be hosted by FRSC headquarter for effective rescue operation that are scalable to the national and international levels.

Keyword: Accident, Ambulance, e-call, Emergency, Road Crash, Road Safety, Trauma.

1. Introduction

In any environmental hazard and disaster especially road crash, the trauma outcome has been a major public health problem worldwide (Peden, 2005). Trauma accounts for more than 16,000 deaths daily that causes above 312 million casualties annually seeking medical attention. It is the usual cause of death amongst people under 40 years of age who are economically viable in term of human power. Furthermore, several thousand with non-fatal injuries ends up with disabilities, Ugbeye (2010).The incidence of fatal Road Traffic Crash (RTC) in developing countries is higher especially in sub-Saharan Africa (WHO, 2002)

It has been observed that most deaths occurring within the first hour of injury is usually as a result of severe brain and cardiovascular injury with minimal treatment value. Deaths which occur from airway obstruction and external bleeding both are preventable by simple First Aid measures, Ashaolu (2010). Measures taken in developed countries to mitigate the

complication of trauma are engineered into a seamless, efficient and cost effective system, which ensures that the incidence of trauma related illness is to a bearable level.

In Nigeria with over 160 million people, in 2006, the Federal Road Safety Corps (FRSC) reported that there were 9,114 road traffic crashes resulting in 4,944 deaths or 55 deaths per 10,000 registered vehicles and about161 deaths per 100,000 are of RTC. Study also reveals that an audit of emergencies surgical operation carried out at the University of Ilorin Teaching Hospital alone showed that 68.4% of the 2455 casualties admitted in the Accident and Emergency Department had trauma cases that are related to injuries sustained in RTC. Also, according to the FLA Foundation, in every 6 second, someone is killed or maimed on the world road, especially in developing countries. For instance, three persons lost their lives while two others were seriously injured after a vehicle plunged into a bridge at Ushafa, along Dutse-Bwari expressway in Bwari Area Council of the Federal Capital Territory (FCT).

In spite of the involvement of Federal Road Safety Corps in the rescue and management of road crash victims in the Federal Capital Territory (FCT), road crashes have persisted to increase with more deaths being recorded in recent times, Ayo et al (2014). According to Olagunju (2011), people within accidents scenes do not know how to triage victims in terms of degree of injuries. Several lives that could have being saved had been lost due to challenges of roads network and substandard materials/tools used by rescue agents. FRSC (2010) reported that over 100 people die and 200 to 400 are injured each year in road crashes in Abuja. In order to ensure prompt response to crash victims, Emergency Ambulance Service Scheme (EASS) was established to provide response within twenty (20) minutes to post crash victims, (FRSC Zebra Quality Manual, 2012).

Although the government and other agencies have been embarking on series of public awareness on the importance of road safety standard adherence in Abuja Municipal Area Council (AMAC) in conjunction with various seminars and workshops organized most especially by the FRSC and National Emergency Management Agency (NEMA) to stem down road traffic hazards in the country and in Abuja in particular. The spate of RTC is still daunting the government and the citizenry as the FRSC goal of 3.2 deaths per 10,000 vehicles by 2020 is still like a mirage, hence the need for this study.

1.1 Review of Relevant Literature

WHO Africa fact (2013) reveals that African Region has the highest road fatality rates of all the world's regions and that Postcrash care is inadequate or lacking in many countries. In 2010, concerned about the very high and increasing burden of road traffic crashes around the world, the United Nations General Assembly adopted Resolution 64/255, which proclaimed 2011–2020the Decade of Action for Road Safety. The goal of the Decade is to reduce the increasing trend in road traffic deaths, and to save an estimated 5 million lives over the period. The African Region remains the least motorized of the six world regions, but suffers the highest rates of road traffic fatalities, with 37 of 44 surveyed countries having death rates well above the global average of 18.0 deaths per 100 000 population. While the regional average is 24.1 deaths per 100, 000 population, for the 19 countries in the middle-income category, covering 44% of the Region's population, the rate is 27.8 deaths per 100 000 population. By comparison, the global average for middle-income countries is 20.1 deaths per 100 000 population.

In 2013 alone, the World Health Organization estimated worldwide traffic deaths to be 1.25 million. Top countries high traffic-related death rates include: Libya, Thailand, Malawi and Liberia (Table 1)

Table 1. Highest Rates of Highway Accident Deaths in the World

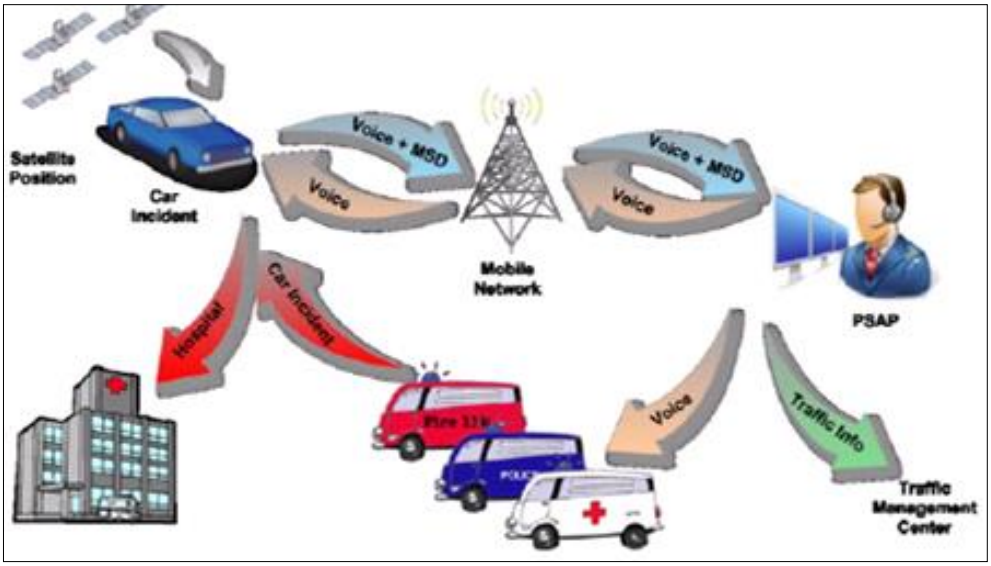
Rank	Country	Traffic Related Mortalities Per 100,000 People
1	Libya	73
2	Thailand	36
3	Malawi	35
4	Liberia	34
5	DR Congo	33
6	Tanzania	33
7	Central African Republic	32
8	Rwanda	32
9	Iran	32
10	Mozambique	32

In Nigeria, the road traffic crashes record given by FRSC on various states of the federation from 2007-2012 reveals that out of a total reported cases of 37,272, Abuja rank fifth with fatal RTC recorded cases of 611 after Ogun, Kaduna, Kano and Lagos state, (FRSC Policy, Research and Statistics, 2013).

1.2 Emergency Response and e-calls Services

Emergency is defined as "a sudden, unexpected occurrence, involving a clear and imminent danger, demanding immediate action to prevent or mitigate loss of, or damage to, life, health, property or essential public services. Emergency includes such occurrences as fire, transportation accident, flood, earthquake, or other soil or geologic movements, as well as such occurrences as riot, accident, or sabotage." (California Environmental Quality Act 21060.3)

As illustrated in Fig. 1 an emergency procedure involves many essential components and providers involved in rescue operations. The coordination between components and providers directly influence the services provided in an emergency response (Yang, 2006). Response time is defined as the time it takes for an emergency vehicle to arrive at the scene upon receiving the emergency call at the station. It is the sum of the preparation time and the travel time (Bradley *et al.,* 1998). According to Walderhaug*et al.,* (2008), Na *et al.* (2010), and Beul.,Mennicken., Ziefle., Jakobs., Wielpütz., Skorning and Rossaint (2010), ICT and telemedicine concept in an emergency situation required a well-integrated system.



MSD = minimum set of data e.g Vehicle Location , PSAP = Public Safety answering point
Figure 1 *ICT Based Ambulance Services.* Source: Alan Steven (2012)

eCall is a combination of an In Vehicle System (IVS), a device with a GSM cell phone and GPS location capability, and a corresponding infrastructure of Public Safety Answering Points (PSAPs), Veera and Krishnaiah (2013). eCall system assumed vehicles would be equipped during the production process with emergency sensors and communication modules, which, if the predefined emergency conditions are registered, will automatically dial the emergency centre and convey exact information regarding place of the accident, vehicle identification (registration number and VIN), its type as well as initiate the voice connection allowing the call centre personnel to gather additional data on the accident details, therefore, reaching optimal decision as to the parameters of the rescue operation.

Getting an immediate alert in the event of an accident and knowing the exact location of the crash site is of major importance in cutting response time by 50% in rural and 40% in urban areas. On Europe's road network alone in 2010, about 31,000 people were killed and 1.5 million injured in about 1.15 million traffic accidents. eCall projects is expected to save hundreds of lives in the European Union each year, and to mitigate the severity of tens of thousands of injuries. Quicker arrival at the accident scene will also allow faster clearance of crash sites, thus reducing the risk of secondary accidents, decreasing congestion times, cutting fuel waste and lowering CO2 emissions. In hard financial terms, the EU's economic loss, caused by road accidents, amounts to more than €130 billion per year. If all cars were equipped with the eCall system, several billion of Euros could be saved every year. It is expected that as from 31 March 2018, car manufacturers will have to equip all new models with an in-vehicle technology that will communicate with the 112-based eCall interoperable service containing information such as current position and prior-to-crash speed, type of vehicle, VIN, VRN, number of passengers travelling, etc.. The infrastructure for the eCall system should be in place by 1 October 2017 and its use will be accessible to all consumers and free of charge, (Council of the European Union, 2014).Technology of today makes it relatively easy and straightforward to measure linear and angular accelerations of the vehicle chassis to estimate its full state in the 6DOF space, (Bouler, et. Al 2006, Ericsion, 2013).

The eCall service is provided by a chain of components. However, certification cannot apply to the whole eCall chain but rather to isolated systems. Three types of device or systems are considered to go through eCall standardization, being provided by different vendors and use with a different context:

i. In-vehicle systems (IVS)
ii. Mobile networks
iii. Public Safety Answering Points PSAP

These different types of systems need a specific certification processes and will therefore be the three-targeted types of eCall systems for certification. It is likely that millions of IVS from hundreds of suppliers are likely to reach the market in the next Year. Therefore, the IVS is one of the key targets for the eCall certification. The personnel of the emergency call centre should be able to accept notifications in more than one language

1.3 Impact of Efficient Ambulance Services

Researches into the impact of improved response times have been conducted to determine efficiency (Pell *et al.,* 2001; Ball, 2005; Heath and Radcliffe, 2007; Dewar, 2001). A significant improvement in the survival rate of victims of heart attack for instance, was identified ranging from 6% to 8% when response time improved from 15 minutes to 8 minutes. It was argued, therefore, that improving response times to 5 minutes from an average of 15 minutes could more than double survival rates. Whilst response times are clearly important, efficiency also concerns what happens at the scene. Patients of the London Air Ambulance service were found to arrive at hospital later than a comparable land ambulance case as crews were spending longer at the scene, conducting more intensive management of the patient, patients were triaged to hospitals with appropriate skills etc. (Nicholl *et al.,* 1995). Similarly, a study of cases of cardiac arrest, found that paramedics tends to spend longer time at the scene than ambulance technicians using basic techniques and semi-automatic defibrillators. This implies that paramedics were making use of their skills and thus delaying the ambulance from starting its journey to the hospital. Such delay might be at the expense of the patient, Guly*et al.* (1995).

It has become necessary to continue to develop the skills of ambulance crews and paramedics through increasingly high level education and training, which will enable them to engage in safe and reliable triage activity on the scene, as well as provide a wider range of treatment (Ball, 2005). Marks *et al.* (2002), therefore, also noted the widespread introduction of priority based dispatch systems. These form a kind of 'triage' system designed to match urgency of response to the clinical needs of patients, using structured protocols and systematic questioning of callers (Nicholl *et al.,* 1999). In contrast, O'Cathain*et al.* (2002) found that emergency medicine dispatch systems fulfilled a previously unmet need for general advice and resulted in higher caller satisfaction than before. However, Gray and Walker (2008a) argued that computer aided dispatch systems, despite their usefulness, should be augmented by a system which used extended skills paramedics to triage as alternative pathways.

In London and the West Midlands, Dale *et al.*,(2004) examined the feasibility of using telephone assessments for low priority (category C) calls to identify the patients less likely

to require A&E care or hospital admission, as a response to the persistent growth in demand for emergency ambulance care. The findings of the study supported the view that telephone assessment, triage and advice to non-urgent callers offered a safe alternative to the dispatch of an emergency ambulance.

1.4 Aim and Objectives of the Study

This study is aimed at assessing the effectiveness of the FRSC Zebra in road accident management in Abuja metropolis and the need for the adoption of eCall system in rescue operations through the following objectives:

i) examine the human capacity and infrastructure base of the scheme,
ii) assess their mode of operation and efficiency, and
iii) design an eCall based rescue operation for the scheme.

2.0 Methodological Approach

The study area; geographically, the Federal Capital Territory (FCT) lies between latitude 8^0 25' and 9^0 20; North of the equator and longitude 6^0 45; and 7^0 39; East of the Greenwich meridian, with a land area of about 7315 square kilometre, see Fig. 2. The unofficial metropolitan population of Abuja is well over 3,000,000, but the population as at 2012 is 2,245,000 making it the fourth largest urban area in Nigeria after Lagos, Kano and Ibadan.

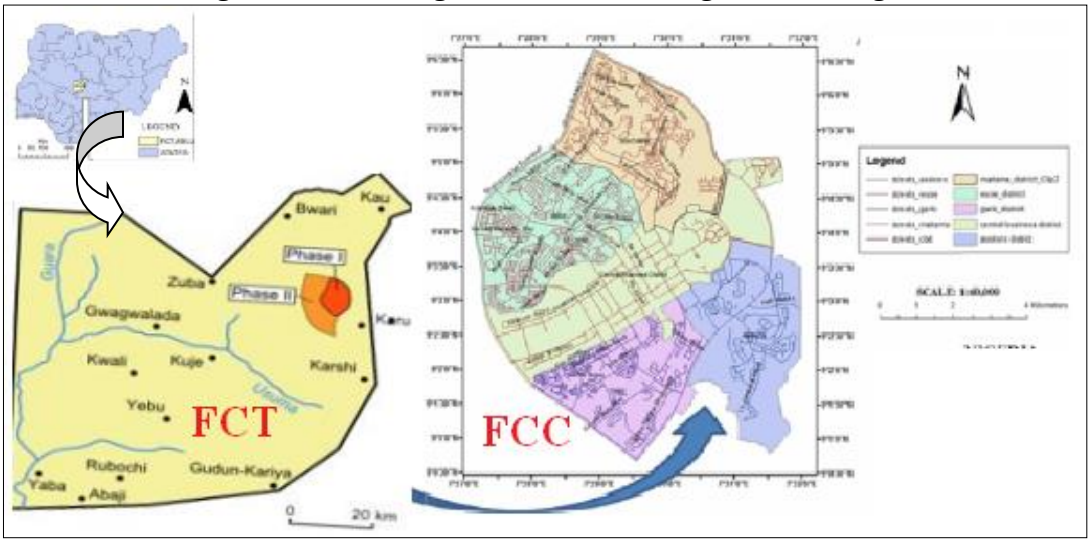


Fig. 2; *Study Location, FCT-Nigeria.*
Source: Adapted from Ayo et al (2014)

2.1 Sources of Data

The whole work started with recognizance survey of the study area to identify the location and operation of the existing Zebra crews. A total of 121 structured questionnaires were administered to Zebra crews of the FRSC as displayed in table 2.

Table 2. Estimated Population of Zebra(s) in the Study Area

Name of Zebra and Location	No. of Questionnaire
Zebra 1, Area 10 Garki	18
Zebra 2, Central Area	15
Zebra 3,Kukwaba	18
Zebra 4, Gwarinpa1	18
Zebra 12, Kugbo	17
Zebra 8, Giri Junction	18
Zebra 6, Yangoji	17
Grand Total	**121**

Source: Researcher's Field Work, (2019).

The existing emergency toll free line call (112 CALL – FRSC, 0700 – 2255 – 3772) was assessed to determine efficiency and response time, while the data collected from both the ZEBRA crew and the targeted road users were analysed using both Statistical Package for Social Science version (SPSS 16.0) and Microsoft Excel to analyse the data.

2.2 Development of the Proposed E-Call System.

The basic operation flow of the proposed Emergency Call (E-Call) System is as depicted in Figure 3. Characteristically, the operation process of the eCall System starts with the initializing of the unit which entails the power on and the initialization of all onboard Sensors.

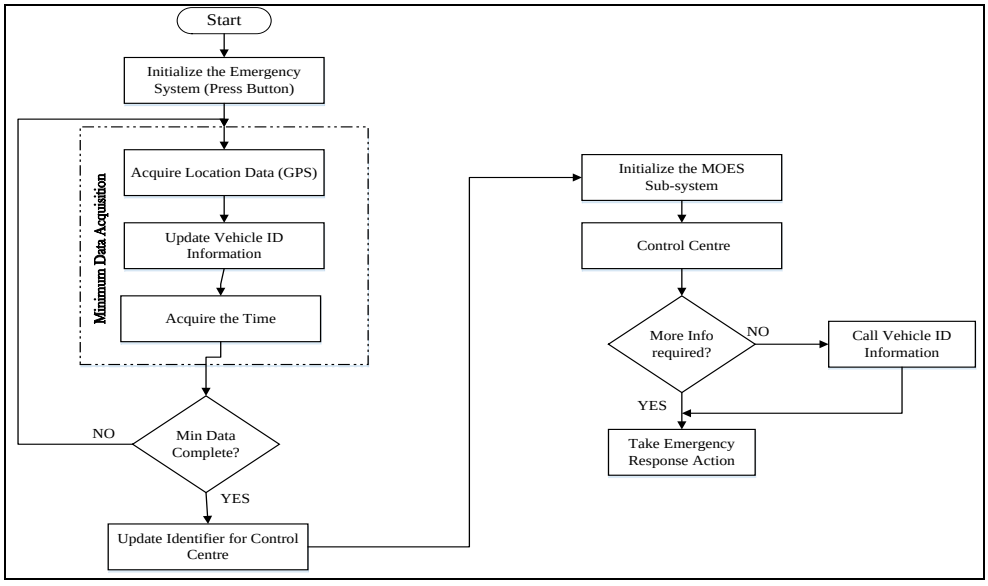


Figure 3: Flow of Operation of the E-Call System.

It involves acquiring network parameters and mobile network operators scanning stage for Handover decision and execution of the decision arrived at scanning and decision stage as

discussed in by Aibinu et al (2006ab). The Simplified block diagram of the system is as shown in Figure 4a and b.

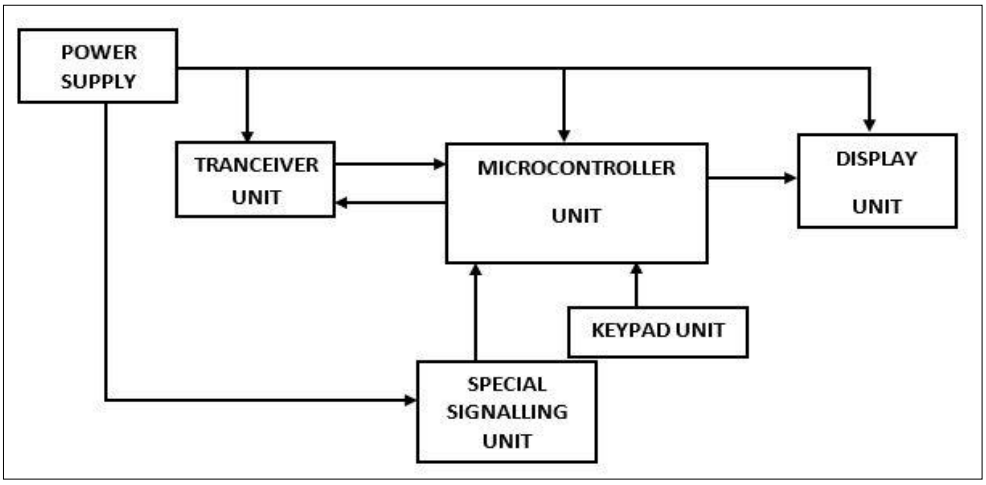


Figure 4a A simplified block diagram of the Emergency Call System

The description of the basic components of the eCall System namely; the Power Unit; the Transceiver Unit; Microcontroller Unit; Display Unit; Keypad Unit and Special Signalling Unit are presented as follows;

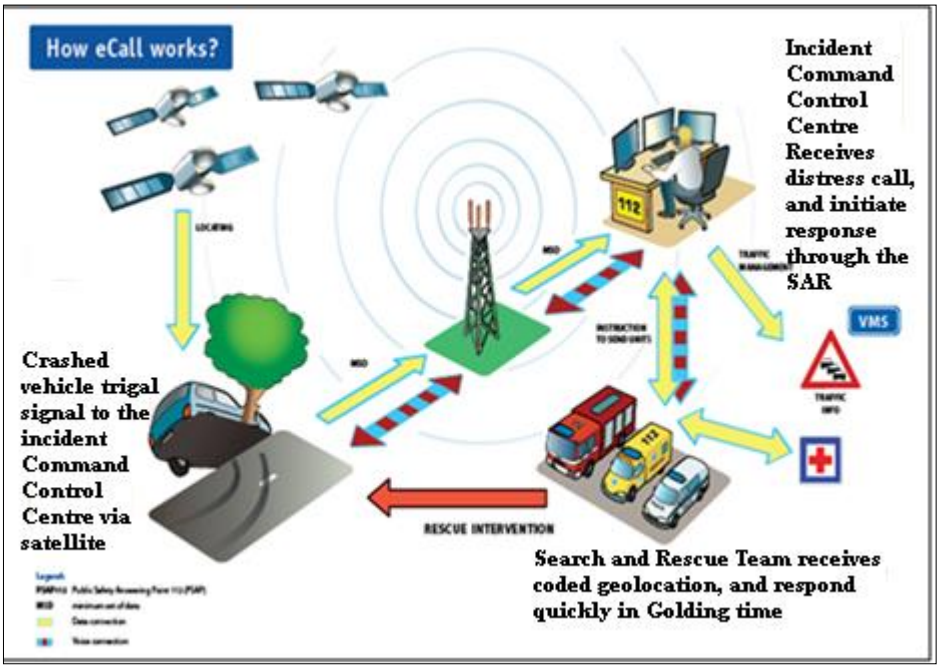


Figure 4b. The e-Call Architecture Design

2.2.1 The Keypad Unit

This unit was used to mapped unique codes (which are combinations of digits 0-9) to each of the emergency numbers of interest. This enables a call to be initiated to the emergency

number by simply dialling its corresponding unique code. The total number of mappings that is enabled by the proposed system depends on the desired digit combination and its computed using (3). The unit comprises of a 4x4 alphanumeric keypad that is interfaced with the Microcontroller unit. The four rows of keypad i.e. rows 1, 2, 3 and 4 are connected to Arduino pins 38, 40, 42 and 44 while the four columns of the keypad i.e. columns 1, 2, 3 and 4 are connected to Arduino pins 46, 48, 50 and 52 respectively. The characters on the keypad comprise of digits 0-9, letters A-D as well as the '*' and '#' symbols as seen in the complete circuit diagram of Figure 5.

$$ {}^{n}C_{r} = \frac{n!}{r!(n-r)!} \qquad (3) $$

Where, r is the digit unique code and n are the set of digits from 0-9.

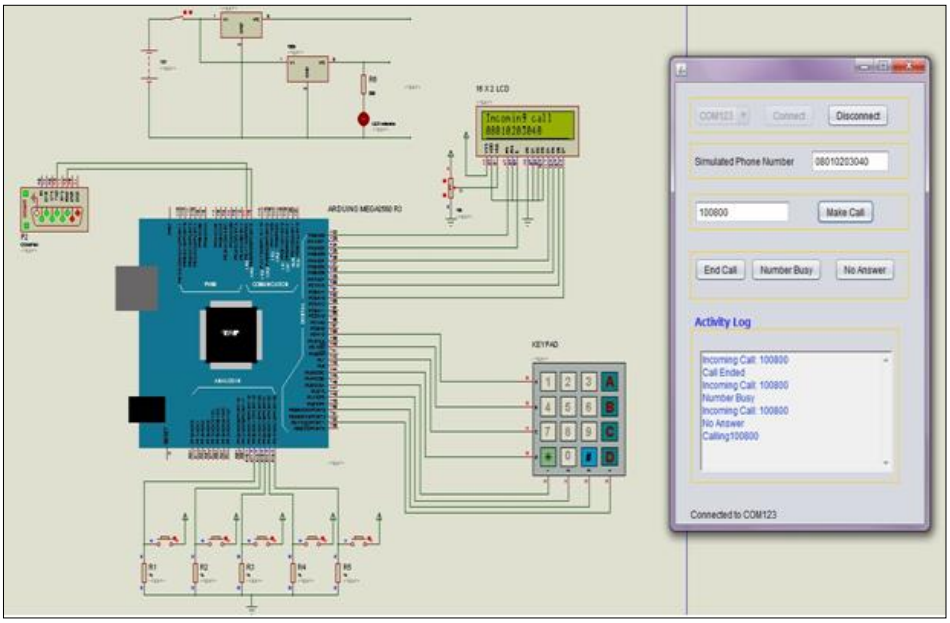


Figure 5: The simulated design of the e-Call System.

3.0 Results

3.1 Ambulance Equipment

The list of ambulance equipment as highlighted in table 3 reveals that out of 11 items of standard ambulance equipment, only 5 items meet the required UN standard. This corroborated the findings of Solagberu *et al*, (2002) that from four teaching hospitals in Southwest Nigeria, it was observed that out of all the emergency cases of 1,996 RTC traumas, only 172 had any form of pre-hospital first-aid. The ambulance couldn't have assisted much when there was no adequate equipment.

Table 3. Ambulance Equipments in Abuja FRSC zebra scheme

S/N	Name of Equipment	No. available	Standard No. Required	Deficit
1.	Personal Protective Equipments			
	Gloves: Sterile (5-8) each	2 pairs	4 pairs	2 Pairs
	Clean (pairs unisize)	4 pairs	12 Pairs	8 Pairs
	Disposable Bags (Biohazard)	1	6	5
2.	Stretcher	1	2	1
3.	Scoop	1	2	1
4.	Spinal Board (adult and child) each	1	1	0
5.	Quick Extricating Device	1	1	0
6.	Cardiac Monitor/Defibrillator	1	1	0
7.	Oxygen therapy equipment	2 cylinders	4 cylinders	2 cylinders
8.	Aspirator (suctioning) equipment	1	1	0
9.	Airway maintenance equipment	1	2	1
10.	Laryngeal Mask Airway	6 Paris	12 Pairs	6 Pairs
11.	First Aid Box	1 set	1 set	0

Source: Field Survey, (2016)

3.2 Arrival at Accident Scene

During road traffic accidents, the road safety zebra crew has a specific time to arrive at the accident scene. Based on the questionnaire administered to zebra crew, 58% of the total respondents reveal that the crew arrives at the accident scene within 1-20 minutes, 21%, 12% and 8% of the total respondent shows that the road safety zebra crew arrived at the accident scene within 21-40 minutes, 41-1hour and more than an hour respectively. In terms of global best practices, 1-20 minutes is the maximum acceptable range of time that road traffic accident zebra crew should arrived at accident scene.

3.4 Level of safety agencies' response to emergency calls

In term of equipment for distress calls, it is obvious that the existing system has no eCall infrastructure as the level of response to emergency calls in table 4 reveals that 47.4% are by the Road Safety Zebra crew, 24.1% are of National Emergency Management Agency, 20.4% are of FCT Police Command, and 28.2% are from Nigeria Security and Civil Defence Corps. This implies that NEMA, Police and NSDC were also involved in road traffic rescue operation in Abuja Municipal Area Council without proper coordination.

Table 4**.** Emergency agencies' response to rescue operation

Agencies	Frequency	Percentage (%)
NEMA	84	24.1
Police	71	20.4
Civil Defence Corps	98	28.2
Road Safety	165	47.4
Others	18	5.2
Total	**348**	**100.0**

Source: Field Survey, (2019)

3.5 Level of Awareness about Zebra Crew in Abuja Municipal Area

In term of awareness of the existence and operation of Zebra Crew in Abuja Municipal Area Council by motorist, out of the 440 respondents from major motor parks sampled, about 284 are aware of Zebra crew services while the remaining 156 respondents are not aware of Zebra crew services in the area. This implies that the level of awareness of road safety emergency Zebra crew in the study area is just fair. Among those that are aware, 28.9% have directly benefited, while 65% have benefited indirectly from Zebra crew services.

3.6 Transportation of Accident Victims to the Hospital

While assessing the means of conveying RTC victims to hospital, 310 of the respondents which represent 70.5% of the total sampled reveals those road traffic accident victims were transported to the hospital by commercial/private cars while 25% and 4.5% claimed that road traffic accidents were transported to the hospital using road safety ambulance and police ambulance respectively. This implies that there is no change from the earlier studies of not adhering to global standard in terms of conveyance of RTC victims to the hospital.

4.0 Discussion and findings

It is essential to arrive at every RTC scene with the appropriate equipment; which is the basic professional standard required of all Ambulance scheme and an expectation of the victims and their relatives. An eCall is an emergency voice call, initiated manually or automatically from a vehicle to a Public Safety Answering Point (PSAP), supplemented by up to 140 bytes of incident related data. The Minimum Set of Data (MSD) has been defined to includes the Global Navigational Satellite System (GNSS) derived location and vehicle direction of travel, the Vehicle Identification Number (VIN) and other information to enable the emergency response teams to quickly location and provide medical and other lifesaving assistance to the accident victims. Should the MSD not be transmitted or received for any reason, or if the PSAP is not equipped with the necessary eCall equipment (eCall modem / server), the accident victims and PSAP operator may still converse using the In-Vehicle System (IVS) audio equipment.

The 3rd Generation Partnership Project (3GPP) has specified the eCall service telecommunications requirements, data transmission protocols and network signalling aspects for Release 8. The in-band modem used to transfer the MSD from the vehicle to the PSAP, following the establishment of a 112 or other emergency voice call, has been specified by 3GPP TSG SA4. Table 5 show the list of African countries with uniform emergency ambulance toll number “112”.

Table 5. African countries with common emergency call number (112)

State	Police	Ambulance	Fire
Angola	113	112	115
Benin	117	112	118
Burundi	117	112	118
Burkina Faso	17	112	18
Cameroon		112	
Equatorial Guinea	114	112	115
Guinea-Bissau		112	
Mayotte		112	
Namibia		112	
Nigeria		112	
Sao Tome and Principe		112	
Seychelles		112 or 999	

Once the System onboard sensors are initialized, they continually acquired and monitor the minimum data for transmission to the control centre whenever required. The minimum data for the purpose of this design is limited to the Geographic Position System (GPS), Location (the Latitude and Longitude of the current position of the vehicle); the Time of transmission; and the Vehicle Identification (ID) Information (the Registration Details, type of Vehicle).

Upon the quest to initiate an E-call, the user of the system is expected to press first button on the System as depicted in Figure 2. Once the button is pressed the Control Centre is updated with the minimum data of the user via the developed Multiple Operator Enable Sim (MOES) Sub-system of the E-Call System. However, the system has the capability of embedding more sensors for additional data acquisition.

Characteristically, in Nigeria and other developing countries within this sub-region the availability of Mobile Communication Systems Network is still subjective as the coverage of all operators does not cut across all areas. Thus, to address this issue of network availability, the MOES Sub-system have been developed at the Advanced Engineering Research and Innovation Laboratory of the Federal University of Technology Minna Nigeria. Note that, the development of Embedded-Multiple Operators Enabled SIM (E-MOES) capable of initiating handover across different Mobile Network Operator (MNO) as presented in Aibinu et al (2006, a and b). The developed system handles the integration of Multiple SIM cards on the MOECS.

The summary of findings from this research work is as given below;

i. Some of the Abuja Zebra crew do arrive at accident scene within 41 to 60 minutes which fall short of global best practices of within 1-20 minutes.
ii. Most accidents victims were transported to the nearest hospital by commercial/private carsto hospital within Abuja instead of ambulances.

iii. In term ofZebra crew composition,staffing is highly disproportion in term of specialties, only 3 medical doctors in all. In term of best practices, minimum of two (2) medical doctors and 18 health workers including a driver are to be stationed in each location to ensure adequate first line response to accidents victims (Pell *et al.*, 2001).
iv. Most RTC victims lost their lives due to late arrival of rescue operators which can be attributed to lack of information or misinformation.
v. No vehicle is presently equipped with eCall facilities in the country and neither is there any national policy on eCall programme where there are no infrastructure to drive the embattled speed limit device scheme proposal of the FRSC.

4.1 Conclusion

This study that assesses the effectiveness of Emergency Ambulance Service Scheme in Abuja Municipal Area Council (AMAC), is juxtaposed with the global best practice of a minimum response time of 1 – 20 minutes. This is a challenge to African countries and particularly Nigeria where her capital territory has the highest fatality rate of road traffic crashes of 33.48 crashes per 10,000 vehicles and 13.86 deaths per 100,000 of the population for the first three quarters of 2013 (January to September), **(**Semiu 2013). A situation where most accident victims are still been conveyed to the hospital via private or public vehicles is ethically unacceptable. There is much to be done at the national, state and NGOs levels in addressing the ugly trend.

There is therefore the need Nigeria and African countries to embrace and fully implement the eCall and speed limit devices with up-to-date infrastructure in order to trail with the global smart city crusade as opine by Ibidapo, (2014).

4.2 Recommendations

The following recommendations were made based on the findings of this research work:

i. Ask the mobile network operators to set up their networks in a way that they correctly transmit automatic emergency calls generated by cars as in Fig. 4.
ii. Government through the relevant agencies should ensure that all mobile operators adopt the "Teleservice 12" such that emergency calls will be routed over any available network so as to achieve the regional ITS Action Plan in Figure. 6.
iii. Nigeria and other African countries to set a deadline for the installation of eCall and speed limit devices in all vehicles within their territory.
iv. Introduction of eCall as standard option in all new vehicle types approved for importation.
v. Since the Zebra ambulance operation has not met the GOLDEN HOUR given by global standard of within 1 to 20 minutes of the crash, it is recommended that the organization should increase the number of zebra crew with modern equipments.

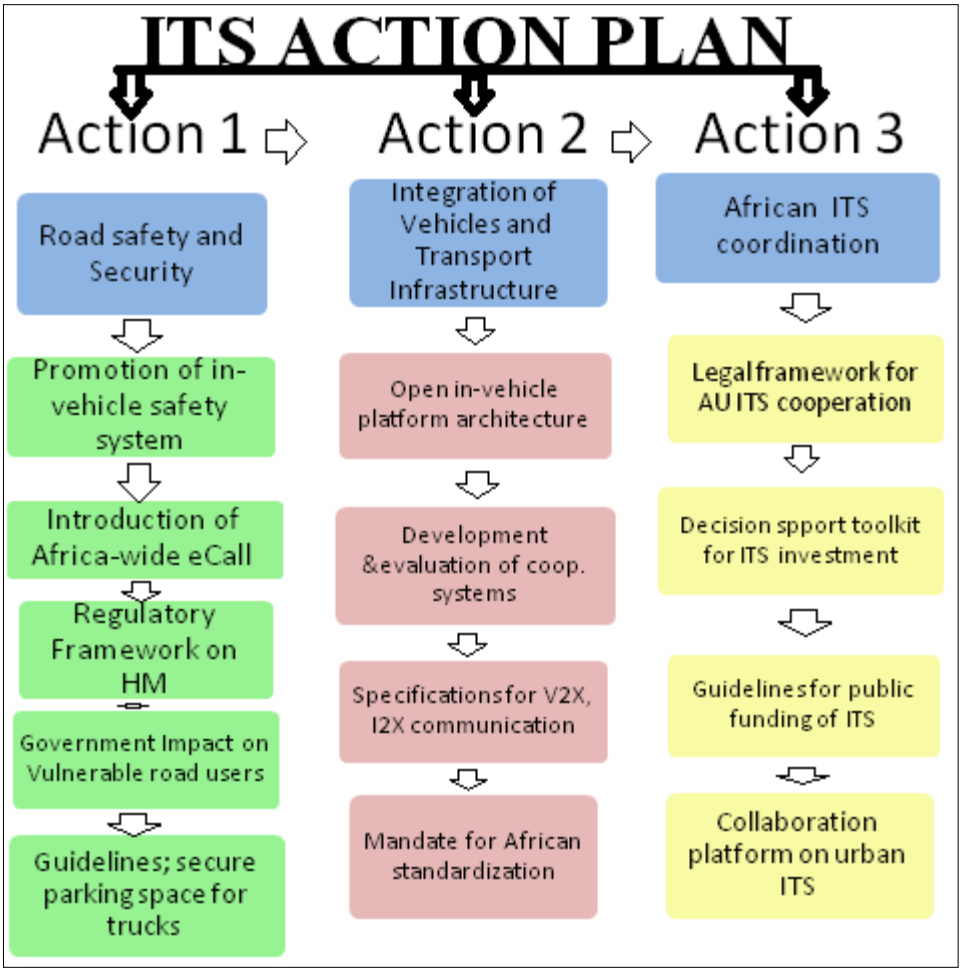


Figure 6. Action plan for project implementation.

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