UNIVERSITY OF NAIROBI

COLLEGE OF BIOLOGICAL & PHYSICAL SCIENCES

SCHOOL OF COMPUTING & INFORMATICS

MOBILE BASED SYSTEM FOR REPORTING ROAD ACCIDENTS TO ENABLE LOCAL FIRST AIDERS RESPOND TO EMERGENCIES IN KENYA

BY

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(P53/65552/2013)

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A project report submitted in partial fulfillment of the requirements for the award of Masters of Science in Distributed Computing Technology of the University of Nairobi.

April, 2019

DECLARATION

This project is my original work and, to the best of my knowledge, this research work has not been submitted for any other award in any University.

Callo Mocheche Simion: ____________________ Date: ________________

(P53/65552/2013)

This project report has been submitted in partial fulfillment of the requirements for the Master of Science Degree in Distributed Computing Technology of the University of Nairobi with my approval as the University supervisor.

Dr. A.M .Kahonge: ______________________________ Date: ________________

School of Computing and Informatics

DEDICATION

To my dear husband Dr.Onyancha and our children Perpetua, Benedict and Benjamin, you're great first aiders. Do your best to save a life and make the world a better place. God will reward you.

ACKNOWLEDGEMENT

My very sincere appreciation to Dr.Kahonge and Dr.Abade for all support in my research project. Many thanks to the staff members of Red Cross Society of Kenya for their insight and support to the success of this project. Also my appreciation to Mr. Sabul for support and training me in Java and MySQL to ensure successful system development.

Last but not least, a big thank you to my manager Anne Mukami and FCR team for your patience and support.

ABSTRACT

Road accidents in Kenya claim approximately 3000 lives every year and leave a number of people with serious injuries or lifetime disabilities. To save lives after an accident is an issue that needs rapid response by the emergency service bodies. This has been a challenge in Kenya as there is no well-coordinated way of reporting accidents and deploying emergency personnel. Despite the fact that there are numerous emergency service providers more often the challenge has been to report to the nearest service provider as there is no way for the person at the accident scene to know where to report to. The frequency of road accidents is on the rise in Kenya with many accidents going noticed by witnesses but unreported or reported late. One main reason is lack of a simple and reliable medium of reporting directly to the concerned parties. A unified way is not available for most witnesses to report.

The aim of this work was to investigate weaknesses in the current system of reporting road accidents and response by first aiders with interest to provide a more significant solution. A study was conducted on Red Cross Society staff and members of the public on their experience and opinion on the current manual system. An investigation of the most common methods used for reporting road accidents was done and the results indicate that most respondents are not confident that the current system ensure minimal response time to road accidents. The current system is not efficient enough since some accidents end up being reported and responded to very late. From the survey, it was noted that there is need for applying technology in reporting road accidents and responding by first aiders.

In this study, a road accidents reporting system was developed. A mobile cum web app was created and used to report accidents. Relevant parties can get alerts through the app and action immediately to save lives. Location information is supported by the app and depends on a smartphone inbuilt GPS module. Also the progress of the reported accidents can be checked in the system. The development of the system followed a waterfall system development life cycle (SDLC) and was implemented by use of prototypes. The results obtained during the study especially at testing, indicate that the developed system if used properly will make reporting and response to road accidents almost real –time and easy. It will also increase number of accidents reported since anyone with a smart phone can just report by inputting a single entry then submitting. Many lives may be saved due to very fast response to road accidents in Kenya with improved coordination of first aiders and integrated communication.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

1.0 Background

A road accident involves personal (physical) injury occurring in the public highways and footways whereby at least one road vehicle/motorcycle or a vehicle colliding with a pedestrian is involved and is reported to the traffic police within 30 days (REF). Post-crash response includes all activities done as soon as a road accident occurs up-to but not including hospitalisation of victims. Such activities include emergency rescue, prehospital medical care and transport.

Road accidents can happen everywhere and result in severe injuries and even death of victims. Normally, when road accidents occur in Kenya, road users attempt to rescue victims and contact relatives of the victims, emergency rescue services through hotlines, posts on Facebook and Twitter to ensure quick response to save lives. Sometimes, the emergency rescue services' hotlines get too busy and also getting contacts of relatives from victims' phones may be difficult in case of unconsciousness or locked phones. Posts on Facebook and Twitter can only be received when mobile users are online and the intended recipient may take long before receiving the information.

Kenya government has developed many strategies including Integrated National Transport policy 2009, National Transport and Safety Authority (NTSA) installation and embracing ICT solutions to enforce safety on Kenyan roads. However, Kenya continues to struggle with challenge of road crashes (Mose & Gachanja, 2017). According to NTSA, the situation on the roads is getting worse with an increase in road accident fatalities in 2015, 2016 and highest in 2017. Thus, calling for dynamic multiple approaches to road safety and implementation gaps.

Kenya is currently among the developing countries with highest rates of deaths related to road accidents (Kulova, 2016). According to (WHO, 2015), an estimate of 3,000 to 13,000 people perish through road accidents yearly. Some of these deaths occur due to various risk factors associated with handling the after-crash injuries. The risk factors include: lack of appropriate pre-hospital care, delay in detecting crashes.

With the increase of mobile phones in Kenya, there is an opportunity for reporting accidents just in time to enable first aiders respond before paramedics take over. According to the current statistics, the total number of mobile subscribers rose to 38.9 million increasing mobile penetration to 88.2 %.(CAK, 2017).This implies that most of the population travels with their mobile phones and communicate constantly. There is an opportunity of reporting accidents using mobile phones and also unleashing the untapped potential of first aiders to respond to accidents that occur within their localities.

Studies worldwide have confirmed that some deaths are potentially preventable and severe injuries are manageable in a large proportion of victims of road crashes if they get appropriate pre-hospital care. In this regard, Kenya needs accurate and objective data system which is integral to 5 stakes of road safety: managing roads safely, safer roads and mobility, safe inspected vehicles, observing road precautions and improvement in responding to crashes. In fact, focus on post-crash response is one of the goals within the Global Plan for the Decade of Action for Road Safety (WHO, 2011).

1.1 Problem Statement

Road accidents can happen anytime and everywhere to anyone in Kenya and this calls for concerted efforts to curb them. According to NTSA, road crashes affect everyone regardless of status in society especially those in age between 20 to 44 years. There is no convenient way to report road accidents nor a unified efficient coordination to enable local first aiders to respond to the accidents just in time in Kenya. There exist various emergency rescue service organisations like St. Johns Ambulance, Red Cross, AMREF Flying doctors and AAR among others. However, these services are located far at specific regions and ambulances are often tied to serving patients in respective hospitals. Sometimes the ambulances delay on the way or even end up not reaching destinations due to poor roads, traffic jams and congestions and unstructured location addresses. Road accident victims wait for too long in pain or end up losing lives in deaths which could otherwise be avoidable (Soro & Wayoro, 2017) . This is due to the fact that ambulances take too long to reach the accidents scene and untrained road users mishandle victims in attempt to rescue them (Soro & Wayoro, 2017). According to WHO's Global status report on road safety 2015, the attention of physical damages after an accident has happened is extremely time-sensitive: delays of time of response can result in losing a life which could have otherwise be saved.

Many systems have been developed for escalating emergencies to relevant authorities but they've not yet embraced the potential of first aiders who are normally within the localities of accident scenes. There is need to report road accidents as soon as they occur and enable first aiders within the locality of such accidents to respond before formal health care givers arrive to take over. Pre-hospital care can reduce risks of death in injured people by 25 %(WHO, 2016). This is due to the fact that haemorrhage control and safe positioning improves safety in absence of ambulance transport.

1.2 Main Objective

The main objective was to develop a mobile and web based system to be used by eyewitnesses for reporting road accidents to enable first aiders to respond to such emergencies within their localities just in time.

1.2.1. Specific Objectives

i. To investigate the existing technological methods used for reporting road accidents.
ii. To evaluate the weaknesses and challenges of current technological methods used for reporting road accidents
iii. To design , develop, test and deploy a prototype mobile based/web based system for reporting road accidents

1.3 Research Questions

This study focused on developing a mobile based system for reporting road accidents to enable first aiders to respond to accidents within their localities. Therefore, by the end of the research the following questions were answered:

i. What are the current methods used for reporting road accidents?
ii. How can the mobile based system be used for reporting road accidents?
iii. How do related models function?
iv. How can road users be sensitized to use the system in reporting road accidents?
v. How can the feedback of the developed solution be used to improve the system?

1.4 Justification

The mobile based system will be used by eyewitnesses to report road accidents to enable victims get timely first aid and a matched transport for medical attention. Thus, the system will assist concerned authorities to track and reduce severity of injuries from road accidents through timely first response. Even the most sophisticated emergency care system is ineffective if bystanders fail to recognise an accident and don't know how to call for help (WHO, 2016).In fact, simple systems with mobile phones and well-designed protocols can greatly improve care

1.5 Significance

The proposed mobile based system will take emergency response to road accidents to the next step. It will help minimise delays in responding to save lives of road accidents' victims in Kenya.

1.6 Scope of the Study

This research work involved development of a mobile/web based system to enable eyewitnesses report road accidents just in time. The target population included: road users, first aiders and Kenya Red Cross Paramedics.

1.7 Assumptions

i. The target population has 24 hour operational mobile phones
ii. Availability of database with updated details of first aiders, ambulance and paramedics.
iii. The use of Smartphones by all actors
iv. First aiders will respond to emergencies within their localities.

CHAPTER 2: LITERATURE REVIEW

2.0 Overview

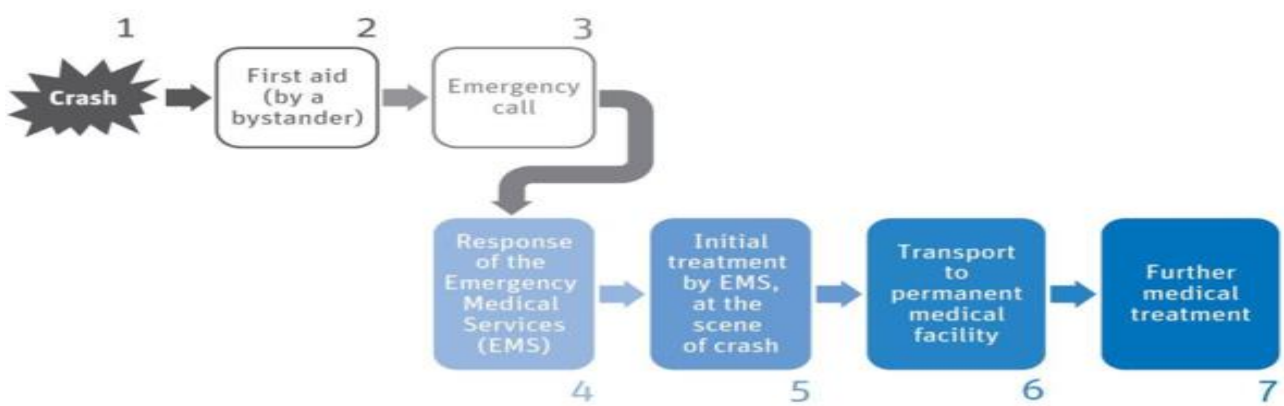
This chapter will highlight the trend of Kenyan road accidents and discuss technological efforts in place to address them .It will also provide details of other studies and works done towards addressing road accidents safety and other emergencies.

2.1 Road Accidents

Many actions have been implemented to limit instances of road accidents and minimize incidences of injuries whenever accidents happen. However, most of these efforts have proved futile in curbing road accidents. For example, the requirement of safety seat belts installation in all vehicles in Kenya, failed due to poor management and fraudulent law enforcement agencies (traffic police). Road transportation in Kenya is the most prevailing with 93% of passengers and cargo traffic (Matheka et al,2015).Kenya is one of the leading countries in the world with the highest rates of road accidents. NTSA reports indicate that about 3,000 Kenyans die from road accidents annually. However, according to (WHO, 2015) between 3,000 and 13,000 people die through road accidents yearly. According to NTSA, road crashes affect everyone regardless of status in society especially those in age between 20 to 44 years. NTSA Report, 2016 indicates that most of fatal crashes occur between 1700 hours and 2200 hours with peak hour being 2000 hours. Highest fatalities occur on Saturday followed by Sunday (NTSA, 2016). The emergency services are never available whenever accidents happen, if the emergency services were available, a good number of deaths would be prevented (European Transport Safety Council, 1999). Ordinarily, road accidents are observed to occur during the peak hours. This is when many people are through their daily routines and may be available to rescue accident victims if called upon or if alerted. Volunteer first aiders within the vicinity may attend to road accident victims as they wait for paramedics to take over the rescue mission. (European Transport Safety Council, 1999), notes that most of these demises arise as a consequence of airway obstruction which could be fixed by lay-bystanders trained in first-aid. Study finding by (Soro & Wayoro, 2017) revealed that a reduction by 5 minutes in response time raised possibility of dying by 24% and 30% correspondingly for roads and motorways accidents. Sánchez-Mangas et al. (2010) studied the consequences of swift medical responses to the scenes of road-traffic accidents in Spain. In this research, it was observed that a ten minute decrease in the medical response time can be related to a one third decrease in the likelihood of death from road-traffic calamities.

(Vanderschuren & Mckune, 2014), analysed the possibility that rural road accident victims are able to receive suitable medical care within the, so called, Golden Hour. It was noted that people in need of trauma care after a road accident are most likely to live on if they are given definitive care within the first hour after the accident (i.e. the Golden Hour). Thus, a post-crash tool is effective tool to reduce traffic related death toll. Due to insufficient Emergency Medical Services (EMS) in Kenya, many damaged victims reach in hospital by private means, including car, truck, or taxi (Wachira & Smith, 2013). St. John Ambulance and Red Cross are the only public providers of emergency medical services in Kenya. Private EMS plays limited roles since they are generally situated in Nairobi and only attend patients who can afford to pay.(Benjamin Wachira a,*, Ian B.K. Martin,2011)

Figure 1 : Post Crash Chain of Events **Source: Hakkert et al. (2007).**



The diagram above represents a typical post-crash chain of events on road accidents.

The risk factors involved in road safety in developing countries such as Kenya include delayed emergency services, lack of unified communication between relevant parties and limited health insurance to all citizens. Post-Crash Emergency response can be described as the sub-set of undertakings including emergency rescue, pre-hospital medical care and transport activities conducted instantly following a road crash (WHO, 2016). Emergency response activities are considered to end when the victim is transported to hospital (Wall , et al., 2014).

Kenya government has developed many strategies to curb road accidents including Integrated National Transport policy 2009, NTSA installation, joining United Nations Decade of Action for Road Safety (2011-2020); and using ICT solutions. However, Kenya continues to face the challenge of road crashes. Most recently, the President ordered withdrawal of NTSA personnel from traffic law enforcement on public roads, which could enhance their focus on coordination and planning for road safety.

There are other initiatives by NGOs including equipping matatu drivers by ASIRT Kenya (road safety advocacy group) with the knowledge and first aid skills. Training matatu drivers in trauma first aid and crash prevention may hasten the response to, and reduce the morbidity and mortality from road injuries. So far, about 30 matatu drivers completed the training. This calls for a dynamic approach in policy response implementation gaps more regularly, as well as reviewing the overall effectiveness of road safety strategies and targets.

2.2 Mobile Coverage in Kenya

During the last quarter of 2016, Communication Authority of Kenya (CAK) report indicates that the number of mobile subscriptions increased to 38.9 million both prepaid and post-paid with an 88.2% penetration rate in the country (CAK, 2017). However in rural areas where access to internet is not available, the most common phones are the normal feature phone. Kenya has one of the best mobile phone network coverage. With the zero rating of tax on mobile phones penetration rate has grown tremendously covering most of the country. Smartphone dissemination in Kenya has increased to more than 60 per cent of the populace over the past five years courtesy of the inflow of affordable phones.

This is confirmed in a statement by Jumia Business Intelligence and GSMA Mobile titled: White Paper 2017: Trends from the Kenyan Smartphone and E-Commerce Industry, released on Wednesday. The report revealed that the exponential evolution of smartphone consumers was due to a fall in average price of the devices. Chinese products have created better competition. The average price of a smartphone has more than halved from the Sh23,100 in 2013 to Sh9,700 in 2016 with the lowest priced X-Tigi P3 smartphone being sold on Jumia for Sh2,799 tremendously covering most of the country.

Figure 2 : Mobile subscription and penetration in Kenya (CAK, 2017)

2.3 Related Work

(N.Njuguna, M. Kahonge and K. Miriti, 2012) developed a Web Application and GPS Integration in Motor Vehicle Accident Detection. They integrated impact sensors, GPS, GIS, GSM, Electronic Database System, internet and web programming to automate their system for sensing and reporting accidents in Nairobi-Kenya. They later recommended further research on Accident reporting by authorized users through mobile phones and Instant accident alert to specific mobile phones including the police and other emergency services.

(Derdus & Ozianyi, 2014), developed CrashData, a smartphone-based application for road accident data collection in Kenya .The system enables police to collect data digitally instead of keying information manually into forms P41. Using the CrashData application, data are sent to a central database for storage and can be recovered by the same system. The CrashData focuses more on collecting information than savings lives first. The proposed system will prioritise savings lives followed by collection of data.

(Nirbhavane & Prabha, 2014) , developed an accident monitoring system using wireless application with use of heart rate monitoring device. The application (based on android platform) send GPS data with remote server and emergency situation location information to appropriate authorities like hospitals, relatives and traffic police in case of traffic accident in India.

(Thompson, et al., 2010) discussed challenges in detecting car accidents and how smart phone-based accident recognition (WreckWatch) can reduce overall traffic congestion and increase the preparedness of emergency responders. They argued WreckWatch can recreate an accident founded exclusively on the data collected from the smartphone. This system was developed in the USA, wherein the environmental, economic and social factors in USA are different from Kenya.

Similar work was also attempted by (Zhao,Y,2000) who developed an Intelligent Transportation System (ITS), which uses sensor networks to monitor traffic situations and make modifications to upturn safety and lessen overcrowding on transportation networks .These systems sum total cars to determine speed and crowding, as well as sense ice build-up and other menaces .

2.3.1 Nduru App

(Thomas, K,2012) developed ‘NDURU’ a mobile application that enables people to report accidents, reckless drivers, dangerous vehicles and other high road risks in Kenya. The application is available on the Nokia S40 platform and also has an SMS version. It also allows users to report corrupt police officers and flag situations that can lead to an accident before they do. A Kenyan application is giving road users the chance to take responsibility of their welfare through their mobiles in an endeavour to challenge the high number of mortalities on the country's roads. Founder and developer of Nduru App, Thomas Kioko told HumanIPO: "Kenya is among the many developing nations that have no all-inclusive and adequately scoped safety laws relating to fundamental risk factors. The government has tried to enforce hefty fines to try and reduce road accidents but it hasn't worked."

He noted NduruApp provides a podium where motorists in public service vehicles are able to check how fast their vehicle is moving and get speed warnings on their mobile phones.

"Motorists will obtain alerts if the vehicle they are traveling in is over-speeding," he said. "The speed is locally stored in the mobile phone and the user can later forward the data if they do not have an internet connection. The application provides a step-by-step first aid guide. This will help in administering first aid to the injured victims before the emergency services land."

Kioko observed that NduruApp was using mobile platform to allow road users to air their views and distresses regarding road safety, and was distinguished from the Ma3Route service by its concentration on that rather than traffic updates.

2.3.2 Ma3Route

Ma3route generates data on road traffic patterns and accidents in Kenya to improve mobility experience of the people in major cities. It has more than 500,000 daily users who access the platform newsfeeds either through native mobile apps, the web, twitter or Facebook (Paul, 2017).

The users make use of crowdsourced data generated by citizens while on transit. Following a report by the National Transport and Safety Authority (NTSA), which indicated that pedestrians form an overwhelming majority of traffic accident related deaths in Kenya. Ma3route provide information on the nature and location of accidents to policy makers. The policy makers use Ma3Route data for policy making and enforcement to reduce road carnage. For example, in the cases where pedestrians avoid using footbridges, government can introduce fines or deploy traffic officers in known accidents prone areas.(Agunbiade, 2016). The main use of Ma3route information include policy making and improving mobility of road users but not rescuing services. This is because the information is not intended for first aiders and rescue services in time. The proposed system will focus on calling for rescue services for road accidents victims the soonest and also improve mobility. This is because road accidents affect mobility. Thus, the sooner road carnages are attended and cleared from the road , the earlier the roads get ready for use by all road users again.

2.3.3 Google Live Traffic Alerts

Google provides live traffic alerts in Kenyan roads through google maps 'mobile app when it is in navigation mode. The app provides updates on upcoming congestion, and expected delay in traffic using a specified route. It also suggests alternative routes which the user can follow on depending on expectations provided. Google live traffic alerts is based on Waze. Waze is the most popular community-based traffic and navigation app in the world. Waze is centered on crowdsourced data from the community. It gathers complementary map data and information on traffic, accidents, police traps, blocked roads and weather conditions from community of active users. Waze evaluates all traffic information to provide Wazers with the most ideal route to their terminus. Wazi map is applicable in many countries. (Klosowski, 2016; Osamuyi, 2016). Clearly, the main concern of Waze is ensuring road users drive through the most appropriate routes. It does not concern itself with calling for help to rescue accidents victims.

All of the above systems have not focused on reducing response times to rescue accident victims. None of the works above has considered engaging the nearest first aiders to address delay of paramedics for immediate help. For example, NDURU provides text notes on first aid, it is not practical for people to read notes and apply practical in the panic mode of accident.

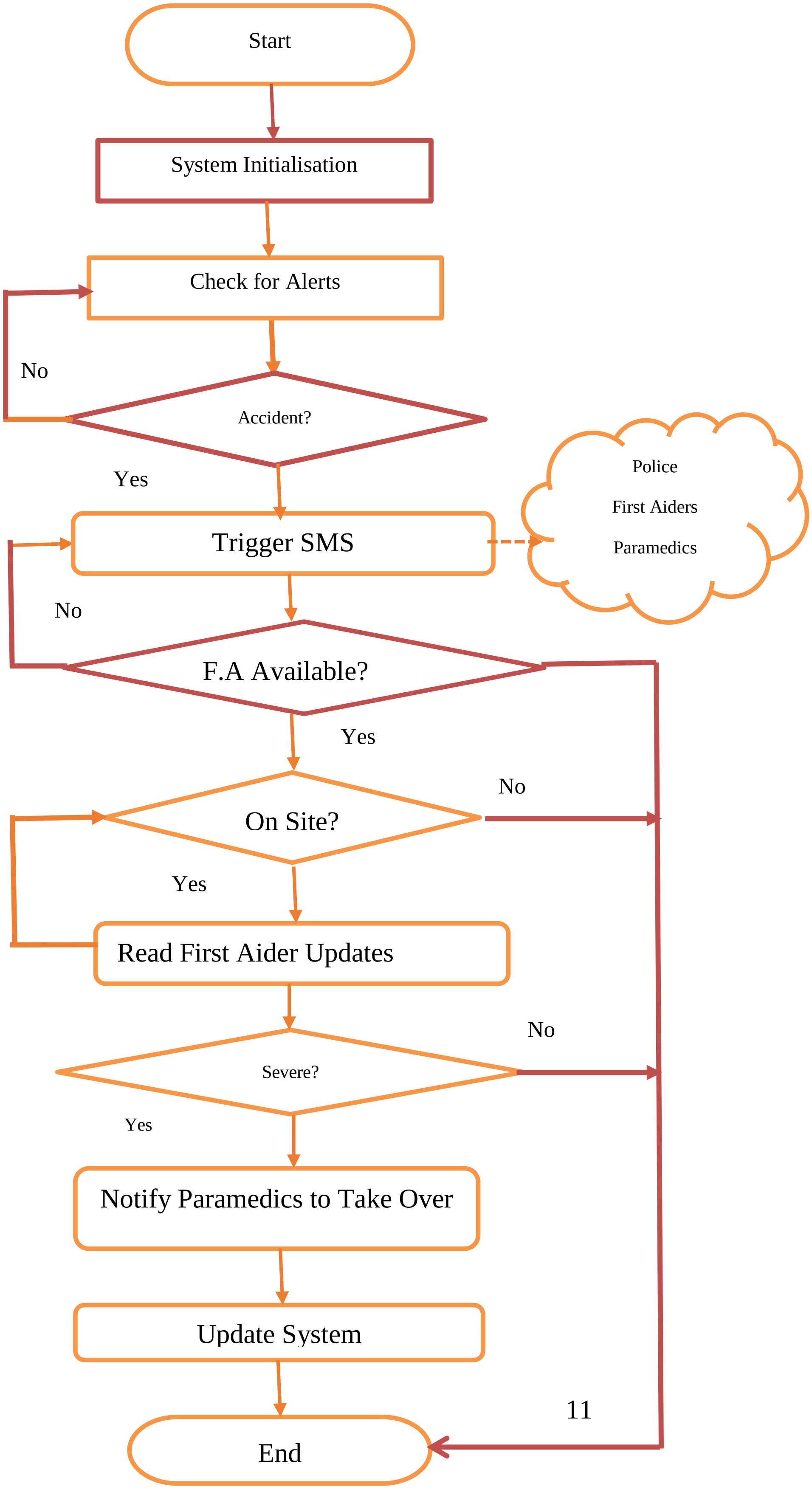
2.4 Smartphones Systems for Emergency Systems

Literature of various emergency reporting systems in other countries was done and revealed that developed countries use smartphones systems for emergency management applications. For example, the AppLERT android based mobile application enables users to report incidents and disasters for instant saving in Phillipines. Fire Ready(FR): fire notices and information system, alerts users of fire dangers in affected area and sends photographs of bushfire activity. User must create specify their regions in order to get specific location warnings on a user's device when incident occurs. Warnings are issued by emergency service to provide advice to the public and such information displays on the application.

Federal Emergency Management Agency (FEMA): FEMA application contains awareness information on various emergency situations and disasters. It has an interactive checklist for emergency kits and a plan for emergency meeting locations. FEMA is mainly applicable in emergency alertness and preparation that what are the general ways the public can embrace pre and post-disaster . Other include HelpMe,Sahana Foss, Great Call, Quake SOS,My Disaster Droid,CCTV, Saper , Automatic Car Notification among others.

2.5 Operational Flow Chart

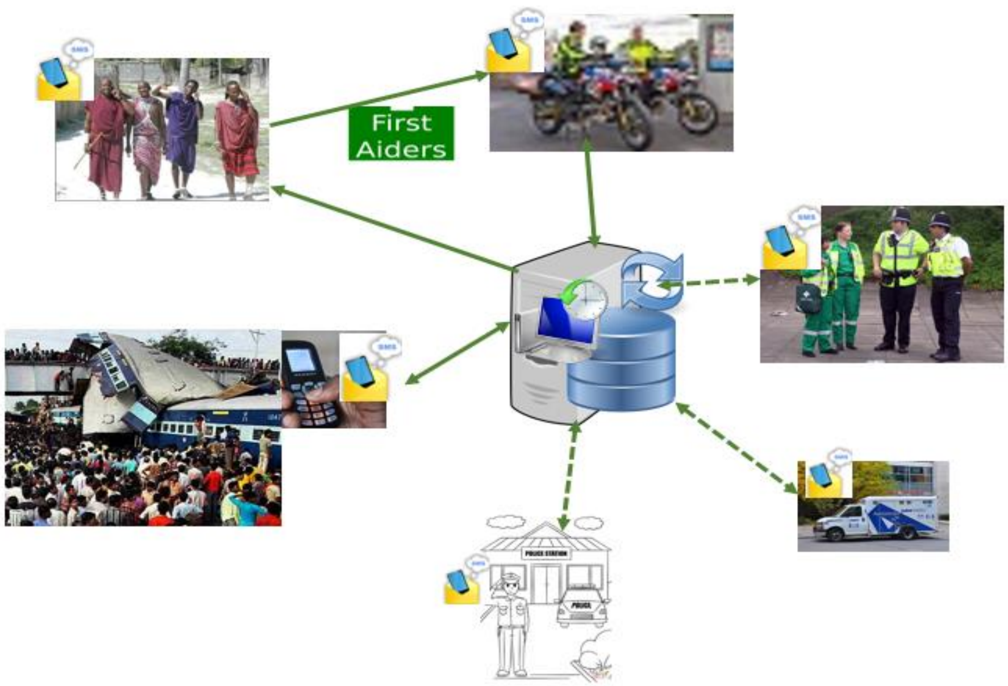
Figure 3: Operational Flow Chart



2.6 The System Architecture

The system was designed to allow effortless information distribution and increase awareness of the activities done by other teams in post-crash response. The system provides various mechanisms such as identifying accident location and time of occurrence generate sms alerts to relevant parties (police, paramedics and local first aiders) and maintain database. Parameters that affect emergency response effectiveness include: total road length, rural road total length and response time (Wall , et al., 2014).

Figure 4: The Proposed System Architecture

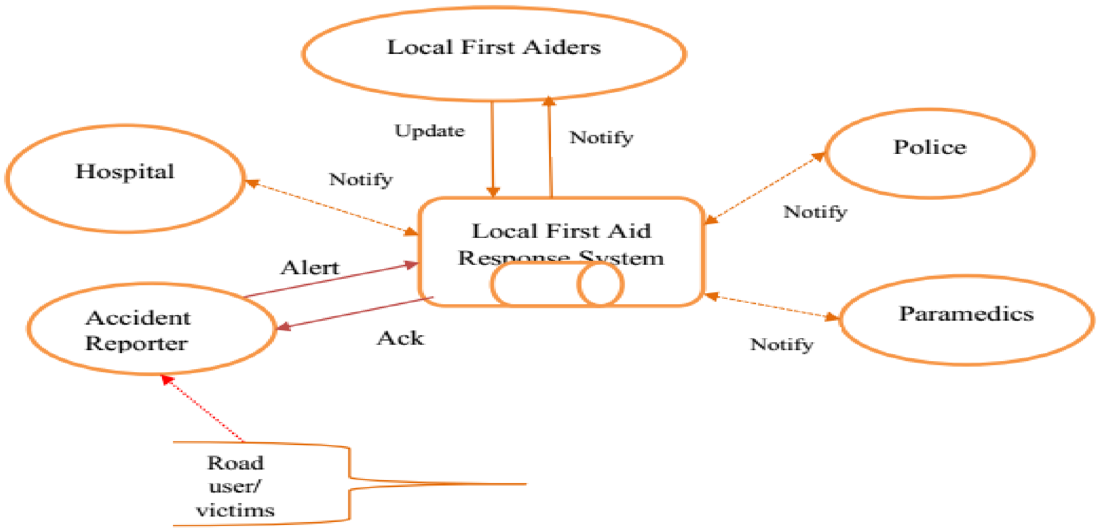


The system has capability of receiving accident sms alerts from road users or conscious accident victims then automatically send notifications to designated local first aiders, paramedics and police stations. The system's main focus is on local first aiders since it will be a complementary system to bridge communication and delay gap in handling road accident emergencies. All relevant details of first aiders, paramedics and police contacts are maintained in a database. The database is refreshed at specific intervals to ensure regular updates.

2.7 Conceptual Architecture

The following conceptual model represents the researcher's view of the research problem and solution.

Figure 5: Perceived Conceptual Architecture



CHAPTER 3: RESEARCH METHODOLOGY

3.0 Overview

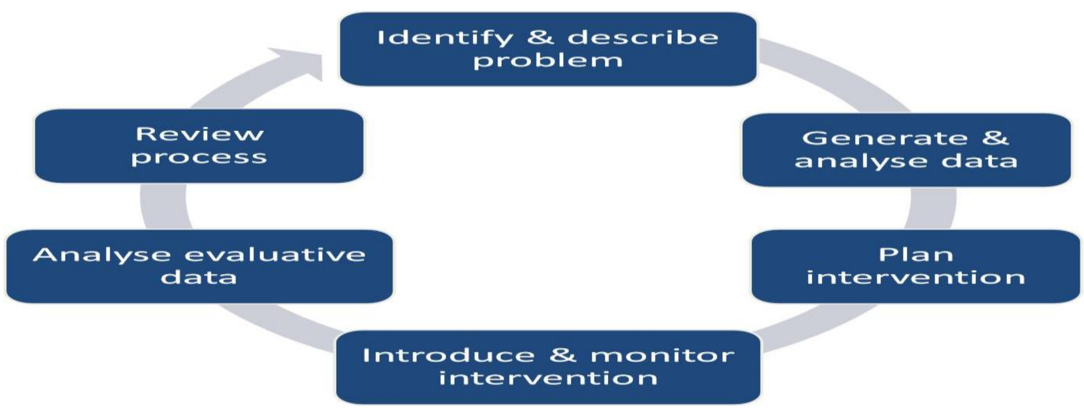
This chapter discusses the research design and system development methodology that was applied in the research project.

3.1 Research Design

This study engaged intervention research which involves knowledge development, knowledge utilization, design and development. Intervention refers to any strategic activity intended to produce systematic positive change in an individual by adjusting a condition, method or situation in their life and/or environment (Holosko, 2016).

An intervention describes any instance of interfering with typical practice. Intervention research can be efficacy and/or effectiveness research. Efficacy checks whether the intervention works under ideal conditions and effectiveness checks whether the intervention works under real-life conditions (Martiniuk, et al., 2010) . Similarly, (Holosko,2015) defines intervention research as an organised study of purposive change approaches characterized by both the design and development of interventions. Design involves the description of an intervention. This includes defining the magnitude to which interference is defined by explicit practice ideologies, objectives and actions.

Figure 6: The Process of Intervention Research

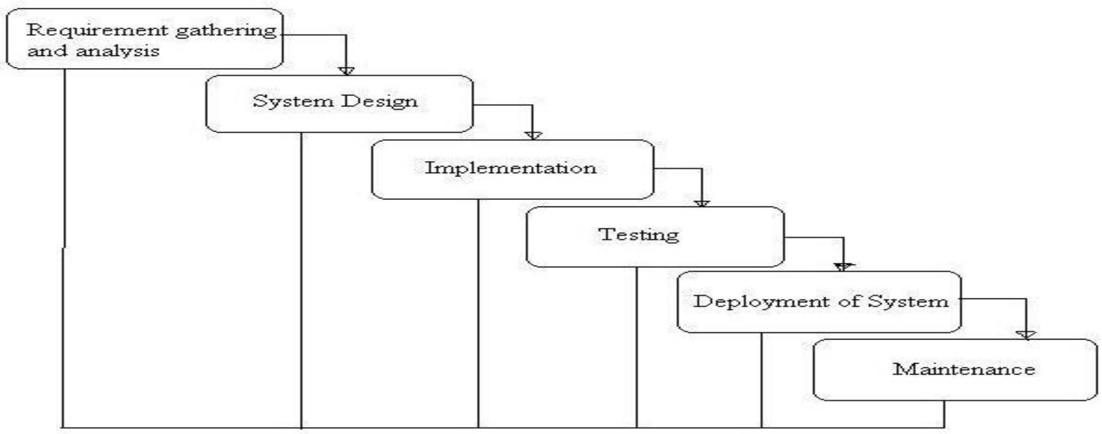


This research sought to understand how road accidents are reported in Kenya and how response to such accidents happens and what can be done to improve reporting and response to road accidents.

3.2. System Development Methodology

The development of the road accident reporting system adopted the waterfall system development life cycle process. Systems Development Life Cycle (SDLC) comprises of an exhaustive plan defining how to develop, maintain, interchange and modify or augment particular software. System developers follow specific steps to ensure relevant software for a given user need. The SDLC process includes steps to determine user needs and requirements to ensure successful and efficient systems development.

Figure 7: Waterfall Model



The research adopted SDLC waterfall model given the fact that it is simple and easy to use. It is also easy to manage since each phase has specific deliverables and a review process. Waterfall model is procedural and follows steps to capture all the user requirements. In waterfall model key issues are considered before the design of the software, the end product software created is of high quality. SDLC ensures that controls of the software are stable to achieve proper documentation. Waterfall model is appropriate for minor projects where requests are very well comprehended. This research project being a small one with known specific user needs, then waterfall model was the most appropriate model to adopt. Waterfall model has one main disadvantage: Once a system is in the testing phase, it is very challenging to go back and change something that was not well-thought out in the conception period. Thus, all user needs must be considered before development of system. The researcher ensured thorough completion and confirmation of one milestone before the next was started.

3.3 System Development Life Cycle Stages

The following are the general steps that were followed during System development Process in this research.

Requirements Gathering and Analysis: In this stage, researchers attempted to answer the following general questions: Who was going to use the system? How would they use the system? What data should be captured into the system? What data should be output by the system? After requirement assembly, the requirements were analyzed for their validity and the possibility of incorporating the requirements in the system development. Road users were selected randomly to give their views on how road accidents are reported in Kenya and challenges faced when reporting such accidents. The selected road users also were asked to provide views on system design to enable them report road accidents easily. Also Red Cross paramedics and general first aiders were reached for information on system design and functionality. The information was gathered through Questionnaires using Delphi technique and face to face interviews on the Red Cross paramedics and first aiders in Nairobi County. Delphi technique was embraced since the study depended mainly on expert opinions to address problem. The main aim of Delphi is to find a steadfast solution to a problem from a group of subject matter experts. (Latif, et al., 2016)

System Design: At this stage, the researcher designed the system by factoring in views from the road users, first aiders and paramedics on capabilities of the system to enable users report, respond to and escalate road accidents just in time. The system design specifications served as input for coding and execution. During system design, the researcher and preselected testers came up with the Test strategy including what to check and how to test. The researcher preselected some of the road users, paramedics and first aiders initially interviewed, to use the system and confirm functionality.

Implementation and Coding: This phase was the main focus for the developer and the longest phase of the software development life cycle. The system was developed as an Android App in Java Environment with SMSLib for SMS functions and MySQL for database services. It also involved development of Web portal with primefaces and embraced SOA. During implementation, all system problems were identified and fixed by system developer before progressing to system testing

Testing: After the code is developed it is tested against the requirements to make sure that the product is actually solving the needs addressed and gathered during the requirements phase. During this phase all types of functional testing like unit testing, integration testing, system testing, acceptance testing and non-functional testing were done. The researcher selected and trained some of the road users, Red Cross paramedics and first aiders initially interviewed, to use the system prototype and confirm functionality. Any problem and /or challenge identified by respective users was reported to the system developers for resolution. The users were asked to test the prototype again and again until each of them was satisfied with the outcome.

Deployment: After successful testing, the new or improved system is delivered to the users for their use. Any system problems are identified and fixed during the process before final deployment. All system problems were resolved and confirmed by users and system developer in the final testing. However, the system developed being a system prototype just to proof a concept, final deployment was not applicable.

Maintenance: The objective of maintenance is to ensure that user needs are sustained and hardware and software upgrades take place as and when required. User training also continues so as to ensure that they fully understand how the system works and are comfortable performing their roles in the system. The system developed in this research was only a prototype to demonstrate the reality of concept. Therefore, maintenance was beyond the scope of this research project.

3.4 Sample Size and Target Population

Population is the collection of all that fit in into a given specification while a sample is a smaller assembly gotten from the available population. (Mugenda and Mugenda, 1999).Sampling provides meaningful information about the population being represented.

There are many health facilities and emergency response providers in Kenya. They include: AAR, AMREF, St. John Ambulance, Flying doctors and Red Cross Society of Kenya and various hospitals. St. John Ambulance and Red Cross were formed under parliament Acts to serve all Kenyans. They carry out pro-active and responsive disaster-related events, including search and rescue, first aid services and evacuation, crowd control and fire-fighting. Red Cross society of Kenya offers similar and even more functions to the public in collaboration with other emergency service providers, the target population for the research was limited to Kenya Red Cross Society paramedics, first aiders and randomly selected road users due to time constraints and limited finance. Also, the Red Cross society of Kenya had confirmed their willingness to support and provide credible data for use in this research. The study focused on understanding the challenges which road users and first aiders face when reporting accidents which they witness and response to such accidents respectively. For the sake of this study, every Kenyan was considered a stakeholder in the system since road accidents can happen to anyone regardless of age, race, career or geographical location .In this regard, road users were picked randomly and only those who had smartphones and could speak in English qualified for face to-face interview. For Red Cross paramedics and first aiders, the information was gathered mainly through Questionnaires using Delphi technique.

3.5 Data Collection

The research instruments used for data collection in this research included: questionnaires, documents analysis and face to face interviews. These helped in determining system requirements and design considerations.

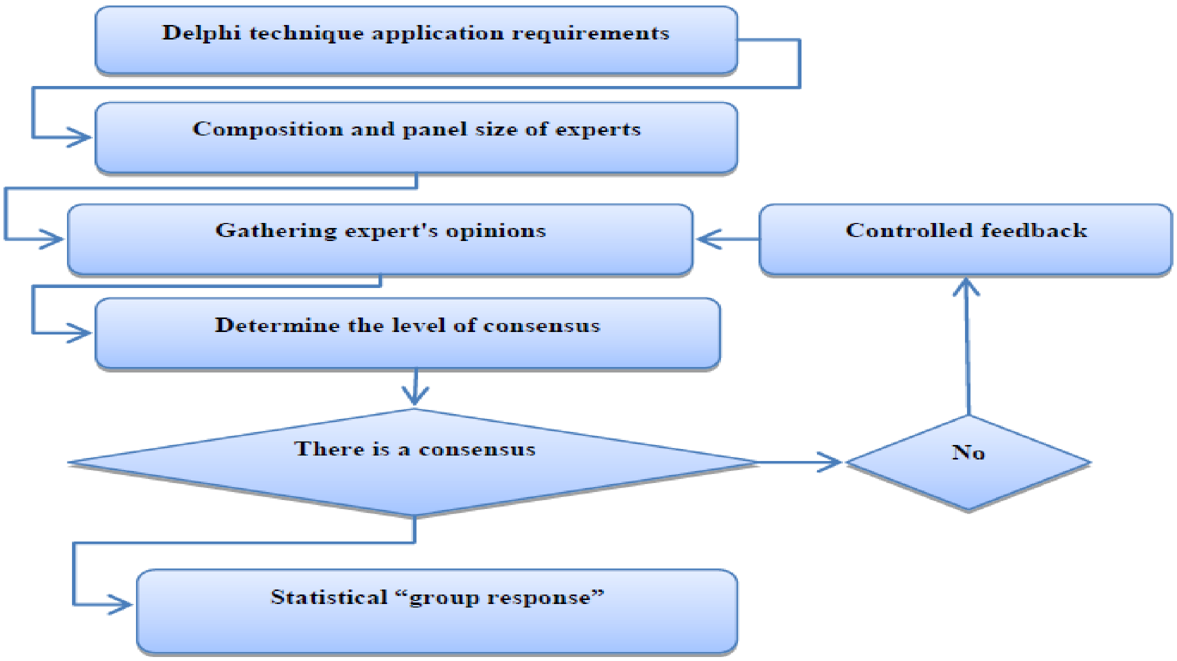
3.5.1 Delphi Questionnaires

The questionnaires comprised of structured questions giving the respondents the liberty to elaborate their opinions where applicable. The reliability and validity of the data collected through questionnaires was checked by doing a test run with a few respondents to gauge their understanding and interpretation of the questions. The information was gathered through questionnaires using Delphi technique with the Red Cross paramedics and first aiders in Nairobi County. Delphi technique was embraced since the study depended mainly on expert opinions to address problem. The objective of Delphi is to obtain a reliable response to a problem from a group of subject matter experts (Avella, 2016).

Steps of Delphi

In Delphi, experts answer questionnaires in two or more rounds (Habibi, et al., 2014). Numerous sequences of questionnaires are sent out and unknown replies are accumulated and shared within the group after each round. The problem is recognized and a set of questions are constructed concerning to the problem so that the answers to these questions would produce resolutions to the problem.

Figure 8: Theoretical Framework of Delphi Technique



Preliminary round: The round one form was distributed to panel experts for pilot testing. Modifications were made based on the remarks and suggestions received. The first form consisted of overall open ended questions (appendix 1) for the respondents to fill out their replies for each question. The comments along with the statistical results were used to formulate the 2nd questionnaire and the latter was fed back to the respondents as sum-ups.

The 2nd round questionnaire (appendix 2) consisted of 33 specific agreement statements. Statements that had consensus in round one were not included in the next round of the Delphi, but some were used to frame new questions to get additional facts. A 9-point Likert agreement scale was used to gauge the strength of a subject's agreement with a clear statement (1 for absolute disagreement while 9 represented total agreement).

The 3rd round questionnaire (appendix 3) consisted of 3 more specific statements for the respondents to completely disagree or agree. The circulation and gathering of the questionnaire to the professionals was done via email .Examination of the answers was done by looking at the statistical using Microsoft Excel and qualitative data provided by the respondents.

Planning of the 2nd written round: The questionnaire for round two was based on the outcomes and remarks of the participants in the round one. The replies were clustered into 3 brackets (1 to 3 totally differ, 4 to 6 nor agree/nor disagree and 7 to 9 fully agree). Consent was confirmed if 75 % or more of the responses fell in one of the 3 brackets. Questions which had reached consensus were not included. The respondents' comments were also used to formulate questions and questions which caused misunderstanding where rearticulated or removed. Analysis of the 2^{nd} round questionnaires was done in the same way as the first. Analysis of the 3^{rd} (final) round was done to provide conclusion of the opinions from respondents.

3.5.2 Face to Face Interviews

Face to face interviews helped us get clarification on ambiguous questions and answers. Face to face Interviews was carried out and helped us to discover how people think and feel about a road accident reporting systems in Kenya. That is "what the road users' opinion is on using their mobile phones to report road accidents and for first aiders to be alerted about road accidents in their localities". Face-to-face interviews have a distinctive benefit of assisting interviewers to create a relationship with the respondents and their collaboration. Such interviews provide opportunity for researchers to seek clarity on ambiguous answers.

Road users were selected randomly to give their views on how the system should be designed to enable them report road accidents easily. For the sake of this system every Kenyan is a potential user of the system since anyone may be involved in road accident and anyone can witness road accident and report to enable victims get rescued in time. Also Red Cross paramedics and general first aiders were reached to provide information to enable system design and functionality. The information was gathered through face to face interviews on the Red Cross paramedics and first aiders who would have confirmed willingness to provide vital information. They were interviewed on the requirements of such a system in regard to usability, reliability and effectiveness.

3.6 Data Analysis

Data analysis helps the researcher making sense of the collected data. Data collected from face to face interviews was analysed qualitatively in order to obtain direct feedback from the users and determine the design of the system to be developed for reporting road accidents. Raw data collected through interviews and questionnaires needs to be processed and analysed to make sense. The Processing include: Editing of data to detect and correct errors, identifying omissions, Coding of closed-ended questions for efficient analysis; Classification of data in order to come-up with significant relationship; and tabulation of the data to facilitate the analysis. Data from the questionnaires was analysed using quantitative data analysis method using Excel spread sheet software. This is because Excel has the ability to consolidate and envisage the replies easily in many ways including generating comparative graphs and charts. This output enabled decision making on the outcome and understanding of whether /or not and how solutions provided will be of importance to the users and community at large.

3.6.1. Qualitative Analysis

Qualitative analysis will involve analysing data which cannot be quantified including data collected using open-ended questions and interviews. Analysing data collected from different respondents i.e road users, Red Cross Paramedics and first aiders in a systematic way in order to draw useful conclusions and make recommendations. Phrases or words from different respondents were studied to identify similarities and differences and establish a pattern.

3.6.2 Quantitative Analysis

Quantitative analysis applied on analysing closed-ended questions that had predefined responses and could be assigned numerical values. This assisted us in getting statistics for describing distribution of measurements using few indices.

CHAPTER 4: RESULTS AND DISCUSSIONS

4.0 Overview

This chapter provides findings and interpretations of the study whose main objective was to develop a mobile based system for use by eyewitnesses for reporting road accidents to enable first aiders to respond to such emergencies within their localities just in time. The main objective was split into the following specific objectives: -

i. To investigate the current technological methods used for reporting road accidents.
ii. To evaluate the weaknesses and challenges of current technological methods used for reporting road accidents
iii. To design , develop a prototype mobile based system for reporting road accidents
iv. Test and validate the prototype with the users

The results for each specific objective are discussed as follows.

4.1 Current Technological Methods for Reporting Road Accidents in Kenya

The research embraced face to face interviews to investigate the current technological methods used for reporting road accidents in Kenya. The available road users were selected randomly but only those who had smartphones and could speak in English qualified for face to-face interview. 100 respondents out of 130 were interviewed and they provided comprehensive information regarding road accidents reporting systems in Kenya. From the interview, it was clear that most people had witnessed road accidents, some had attempted to report and others had never reported accidents. The following table shows the methods of reporting road accidents by selected road users.

Table 1: Current methods of reporting road accidents by road users in Kenya

Method of reporting/	Not Reporting	Calling Relatives of Victims	Calling Hotlines			Social Media		
			Police	Red Cross	St.Johns	Facebook	Tweeter	WhatsApp
No of road users out of 100	5	18	51			26		

The table above indicates that the most popular method of reporting road accidents is by calling hotlines, followed by posting on social media and least is calling relatives. It is clear that the road users don't have a specific app for reporting road accidents.

4.2 Current Technological Methods for Reporting / Receiving Reports on Road Accidents in Kenya

The study involved brief preliminary interviews and 3 rounds of Delphi questionnaires to understand methods engaged in reporting and receiving reports on road accidents by first aiders and paramedics.

4.2.1 Interview and Delphi Round One Results

There was approximately 90% response to the questionnaire in round one i.e 40 out of 42 panelists responded. From Round 1 results, most of the first aiders had been involved in being informed of accidents and responded to accidents. Findings indicate that the most common ways of reporting and /or receiving reports on road accidents by first aiders and paramedics include: Call centre receiving alerts via hotline number, social media, Organization branches, National police, and ambulance providers and via HF/VHF radio frequencies for the organization. HF radios cover 1000km while VHF radio cover 30km. Each branch of Red Cross Kenya has a VHF radio for communications.

The study also revealed that call centres receive 3 to 10 reports about road accident occurrences daily depending on:

- Weather of the day
- Day of the month i.e Fridays and weekends of end month.
- School opening and closing days due to rush
- Festive seasons Easter and Chrismas holidays: Tired PSV drivers
- Hotspot areas and black spots.
- Pedestrians , motorists and passengers

The road accidents are normally categorized depending on cause of accidents, Severity of accidents and contents of vehicles involved in accidents i.e toxic substances and explosives.

The following communication channels are engaged in getting reports on road accidents in Kenya: Phone call on 1199 and 0800720577 , HF and VHF radio , mass media i.e TV, social media including: M-Salama , KenyaRedCross, Ma3Route, RoadAlertsKE, EMS-Kenya, NDOCKenya (National Disaster Operations Centre), St.Johns Ambulance, KenyaTraffic, FloodKenya, Hootsuite, stream from all social networks, google, tweet. Red Cross also monitors all counties and WhatsApp groups link with organisation's mobile number to get accident reports.

4.3 Evaluation of Current Technological Methods for Receiving /Reporting Road Accidents

The second objective was to evaluate the weaknesses and challenges of current technological methods used for reporting road accidents. This was achieved as follows:

Calling relatives: This normally applicable when an accident victim is conscious and can provide contacts of relatives. This poses a challenge in cases where relatives are far away from accidents scene hence take long time to reach and may not be first aiders who can aid them before taking them to hospital. The relatives may panic on getting news about road accidents by their loved ones.

Calling hotlines and Posting on social media are common methods of reporting accidents. The main challenge here lack of relevant information regarding accidents. Relevant information include: Exact physical location of accident scene, number of deceased and victims in accidents and names of accident location. Posting on social media may not get acknowledgement that the report has been responded to.

Challenges involved in reporting and receiving reports on road accidents include Communication channels are not known by every potential reporter, Location description difficulties, Poor network coverage, No formal address to remote places (see Delphi Round Two Results).

4.3.1 Delphi Round Two Results

All findings and results are summarised in the following headlines:

i. **Factors which determine how soon first aiders/paramedics reach accident scene**

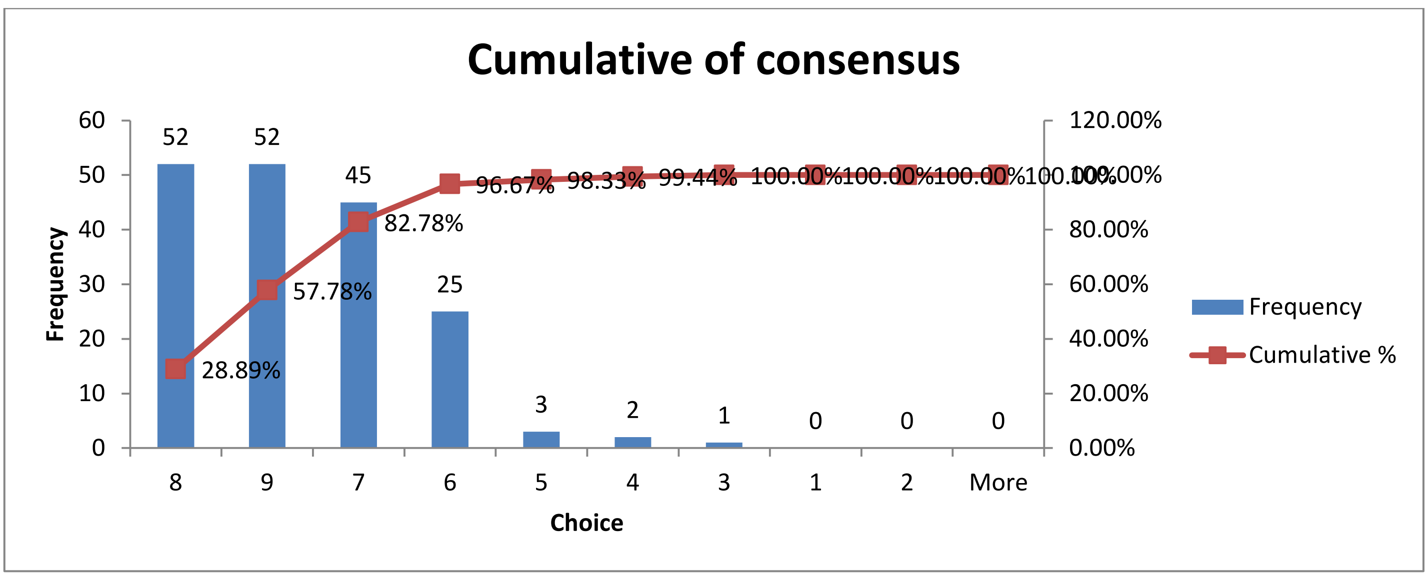
The results in Table 2 and Figure 9 indicate that the factors which determine how soon first aiders/paramedics reach accident scene include: Distance in which the accident occurred from town centre, road networks on the region, condition of the road surface, terrain of accident location and time taken for road network identification to locate accident scene.

Table 2: Factors affecting how soon first aiders/paramedics reach accident scene

1	Question/Statement	Mode of Consensus	General Positive/ Negative Consensus	Remarks	Pursue to Round 3

a	Distance in which the accident occurred from town centre	Strongly Agree	80.56%	Consensus achieved	No
b	Road networks on the region	Strongly Agree	86.11%	Consensus achieved	No
c	Condition of the road surface	Strongly Agree	83.33%	Consensus achieved	No
d	Terrain of accident location	Strongly Agree	83.33%	Consensus achieved	No
e	Time taken for road network identification to locate accident scene	Strongly Agree	86.11%	Consensus achieved	No
			82.78%		

Figure 9: Consensus on Factors affecting how soon first aiders/paramedics reach accident scene



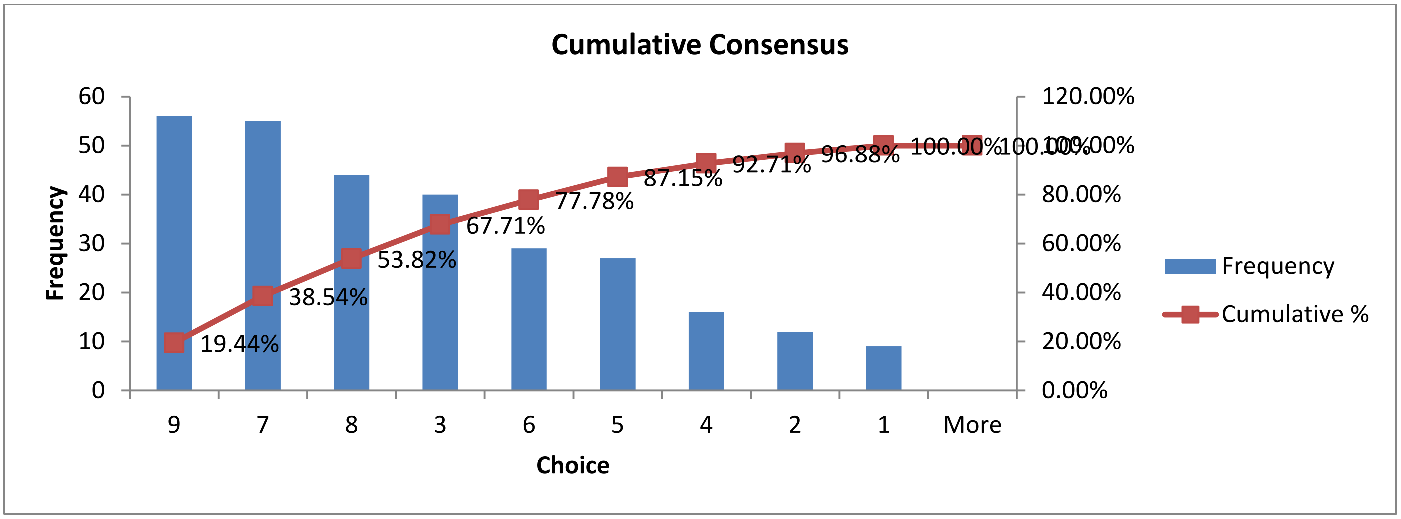
ii. Challenges faced when reporting/receiving reports road accidents in Kenya

The results in table 3 and figure 10 below indicate the challenges faced when reporting/receiving reports road accidents in Kenya. They include communication channels are not known by every potential reporter, Location description difficulties, Poor network coverage, No formal address to remote places. Language barrier was not a challenge to most first aiders (see table 3). The factors which didn't reach consensus were pursued to round 3.

Table 3: Challenges faced when reporting/receiving reports road accidents in Kenya

	Question/Statement	Mode of Consensus	General Positive/ Negative Consensus	Remarks	Pursue to Round 3
a	Language barrier	Strongly Disagree	80.56%	Consensus achieved	No
b	Reporters are not updated that the accident has been responded to	Agree	61.11%	Consensus not achieved	Yes
c	Lack of airtime for reporters to call or sms details of an accident.	Agree	66.67%	Consensus not achieved	Yes
d	Communication channels are not known by every potential reporter.	Strongly Agree	86.11%	Consensus achieved	No
e	Location description difficulties	Strongly Agree	80.56%	Consensus achieved	No
f	Poor network coverage	Strongly Agree	86.11%	Consensus achieved	No
g	No formal address to remote places	Strongly Agree	88.89%	Consensus achieved	No
h	Some callers panic hence unable to give clear details about an accident.	Agree	55.56%	Consensus not achieved	Yes
			77.78%		

Figure 10: Challenges faced when reporting/receiving reports road accidents in Kenya



iii. Challenges faced by first aiders when responding to road accidents

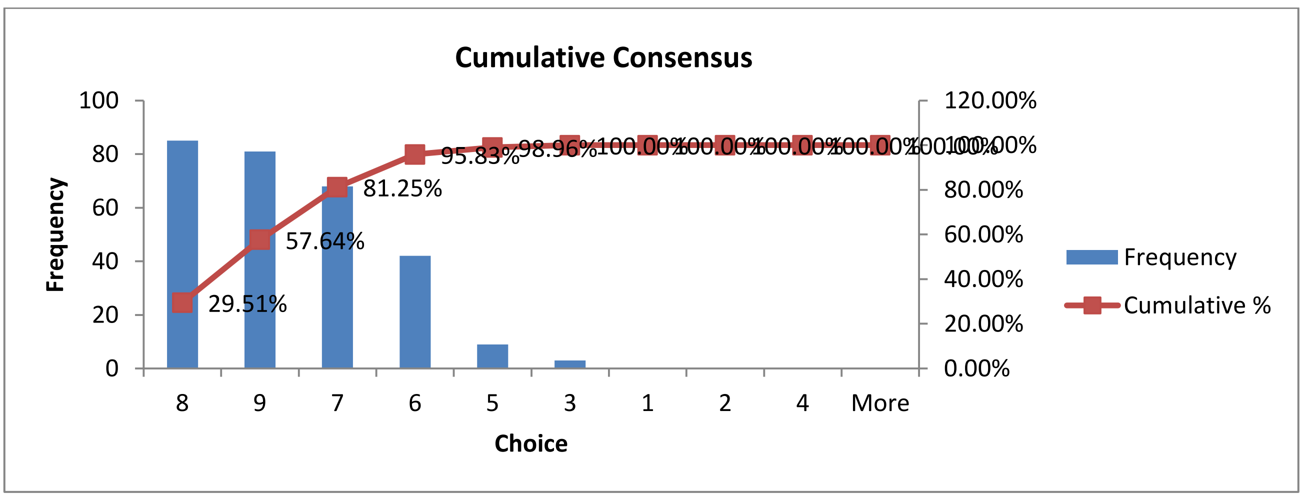
The responses from the first aiders (Table 4 and Figure 11) confirmed that challenges faced by first aiders when responding to road accidents include: Distance of accident scene from dispatch centre or organisation branch offices, Number of ambulances available to handle situation, Terrain and state of the roads leading to accident scene i.e rough and fine surface roads, Traffic jam and road congestions, Time of the day i.e peak or off peak, day or night as shown in the table and figure below.

Table 4: Challenges faced by first aiders when responding to road accidents

	Question/Statement	Mode of Consensus	General Positive/ Negative Consensus	Remarks	Pursue to Round 3
a	Number of ambulances available to handle situations.	Strongly Agree	83.33%	Consensus achieved	No
b	Distance of accident scene from dispatch centre or organisation branch offices.	Strongly Agree	80.56%	Consensus achieved	No
c	State of the roads leading to accident scene i.e rough and fine surface roads.	Strongly Agree	83.33%	Consensus achieved	No
d	Terrain of the accident scene and roads	Strongly	86.11%	Consensus	No

	leading to accident scene.	Agree		achieved	
e	Ignorance of drivers assuming that ambulances are not carrying casualties.	Strongly Agree	77.78%	Consensus achieved	No
f	Traffic jam and road congestions.	Strongly Agree	80.56%	Consensus achieved	No
g	Poor weather especially rainy seasons	Strongly Agree	77.78%	Consensus achieved	No
h	Time of the day i.e peak or off peak, day or night.	Strongly Agree	80.56%	Consensus achieved	No
			81.25%		

Figure 11: Challenges faced by first aiders when responding to road accidents



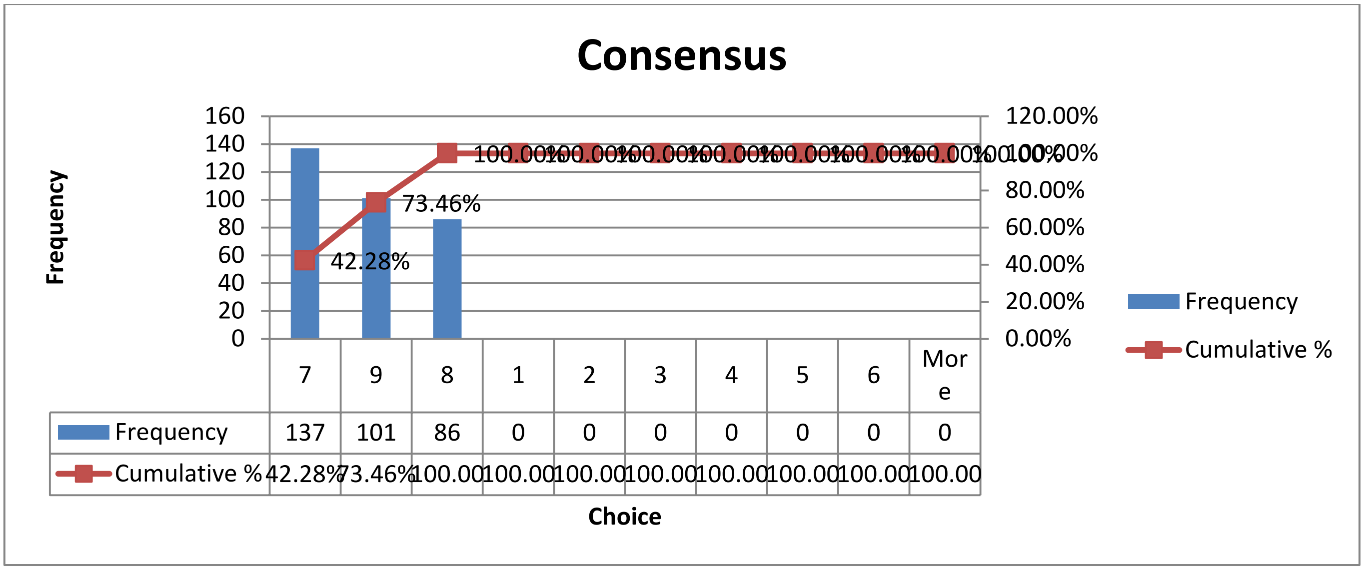
iv. Basic Features and Capabilities

All first aiders and road users unanimously agreed that the following basic features and capabilities (table 5 and figure 12) should be integrated into the mobile/web based system to address the challenges faced in responding to road accidents in Kenya.

Table 5: Basic features and capabilities to be integrated into the system

	Question/Statement	Mode of Consensus	General Positive/ Negative Consensus	Remarks	Pursue to Round 3
a	App should be installable in a mobile phone to report any accident.	Strongly Agree	80	Consensus achieved	No
b	App should pin point location of the reporter being the accident scene.	Strongly Agree	90	Consensus achieved	No
c	App should name location of the reporter being the accident scene.	Strongly Agree	80	Consensus achieved	No
d	App should indicate details of road network map	Strongly Agree	85	Consensus achieved	No
e	App should send alerts to the nearest first aiders, police, hospitals and EMR.	Strongly Agree	80	Consensus achieved	No
f	The system should synchronize all alerts, updates and maintain details of accident rescue progress until completion	Strongly Agree	85	Consensus achieved	No
g	Both system and app should function 24 hours daily.	Strongly Agree	90	Consensus achieved	No
h	The system should automatically deploy first aiders to the scene immediately an accident is reported.	Strongly Agree	85	Consensus achieved	No
i	The system should broadcast alerts to all parties in time	Strongly Agree	85	Consensus achieved	No

Figure 12: Basic features and capabilities to be integrated into the system



v. Suggestions to improve Reporting and Response to Road Accidents in Kenya

Both road users and first aiders suggested that to improve reporting and response to road accidents in Kenya: campaigns on how, where and when to report accidents should be done regularly (see table 6)

Table 6: Suggestions to improve Reporting and Response to Road Accidents in Kenya

	Question/Statement	Mode of Consensus	General Positive/ Negative Consensus	Remarks	Pursue to Round 3
a	Campaign and display the app on mass media to report accidents and make the app toll free to report road accidents	Strongly Agree	80	Consensus achieved	No
b	Create awareness on how, where and when to report accidents in Kenya.	Strongly Agree	90	Consensus achieved	No
c	Create awareness that ambulances use siren when carrying and going for casualties.	Strongly Agree	80	Consensus achieved	No

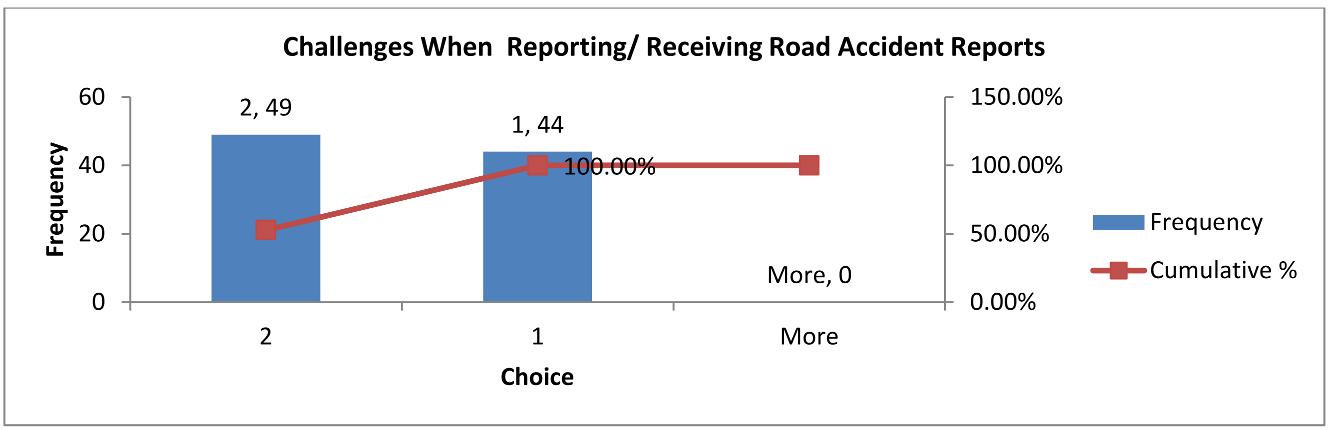
4.3.2 Delphi Round Three Results

In round 3, it was agreed that reporters are not updated that the accident has been responded to. All first aiders indicated that lack of airtime and reporters panic were not real challenges faced when reporting/receiving reports road accidents in Kenya (see table 7 below).

Table 7: Challenges faced when reporting/receiving reports road accidents in Kenya.

2	Question/Statement	Mode of Consensus	General Positive/ Negative Consensus	Remarks	Pursue to Round 4
No. b)	Reporters are not updated that the accident has been responded to.	Agree	58.06%	Consensus achieved	No
No. c)	Lack of airtime for reporters to call or sms details of an accident.	Disagree	54.84%	Consensus achieved	No
No. h)	Some callers panic hence unable to give clear details about an accident.	Disagree	61.29%	Consensus achieved	No
		52.69%= Disagree ,47.31%= Agree			

Figure 13: Challenges faced when reporting/receiving reports road accidents in Kenya.



Overall Results

From the Round 1,2 and 3 results above, it is very necessary and urgent to develop a mobile app to enable road users report road accidents and first aiders respond to accidents within their localities. Modern technologies like mobile and web Apps are not yet embraced.

CHAPTER 5: SYSTEM DESIGN AND PROTOTYPE DEVELOPMENT

5.0 Overview

This chapter explains the system design and prototype development applicable in this research project.

5.1 System Functional Requirements

Functional requirements capture the envisioned performance of the system. This behaviour may be communicated as services, tasks or functions the system is required to accomplish. The anticipated system should allow for the following operations:

a) Any road user to login in and report a road accident
b) User to receive a confirmation that accident has been reported successfully
c) Registration of new users : paramedics , first aiders and administrators
d) Registration of Help points i.e hospitals and police stations.
e) Access on mobile app for all users and web for police, first aiders and administrators
f) Send alerts to first aiders about deployment areas.
g) Create web based database and update all events

5.2 Non-functional Requirements

The following are the key non-functional requirements of the system.

a) The system should not allow unauthorized users to register and modify accident records.
b) The central server has to be provided at secured area and made constantly available
c) The system must be simple and easy to be used by all its potential users
d) The system ought to execute as projected. Given the essential input, it should give the anticipated output.
e) The system should be extendable or scalable to future needs
f) The system should be available and in good state at whatever time it is required.
g) All constituents should be available and integrity of data should be warranted.
h) The degree of failure should be very minimal.
i) The system should be consistent in all of its functions.

5.3 System Inputs and Output

The system has 4 important actors as users – the reporter, system administrator and the first aiders and police. With the application any road user can send an alert to trigger the system to send broad-cast messages to local first aiders, police and paramedics. Name of the physical location of accident is send to the local first aiders in form of sms. To police and paramedics, information such as name, the physical address and the nature of the emergency is given. In summary, the inputs of the system will include alert from road user / victim and also update messages from local first aiders and paramedics. The outputs of the system include information to first aiders, police and paramedics.

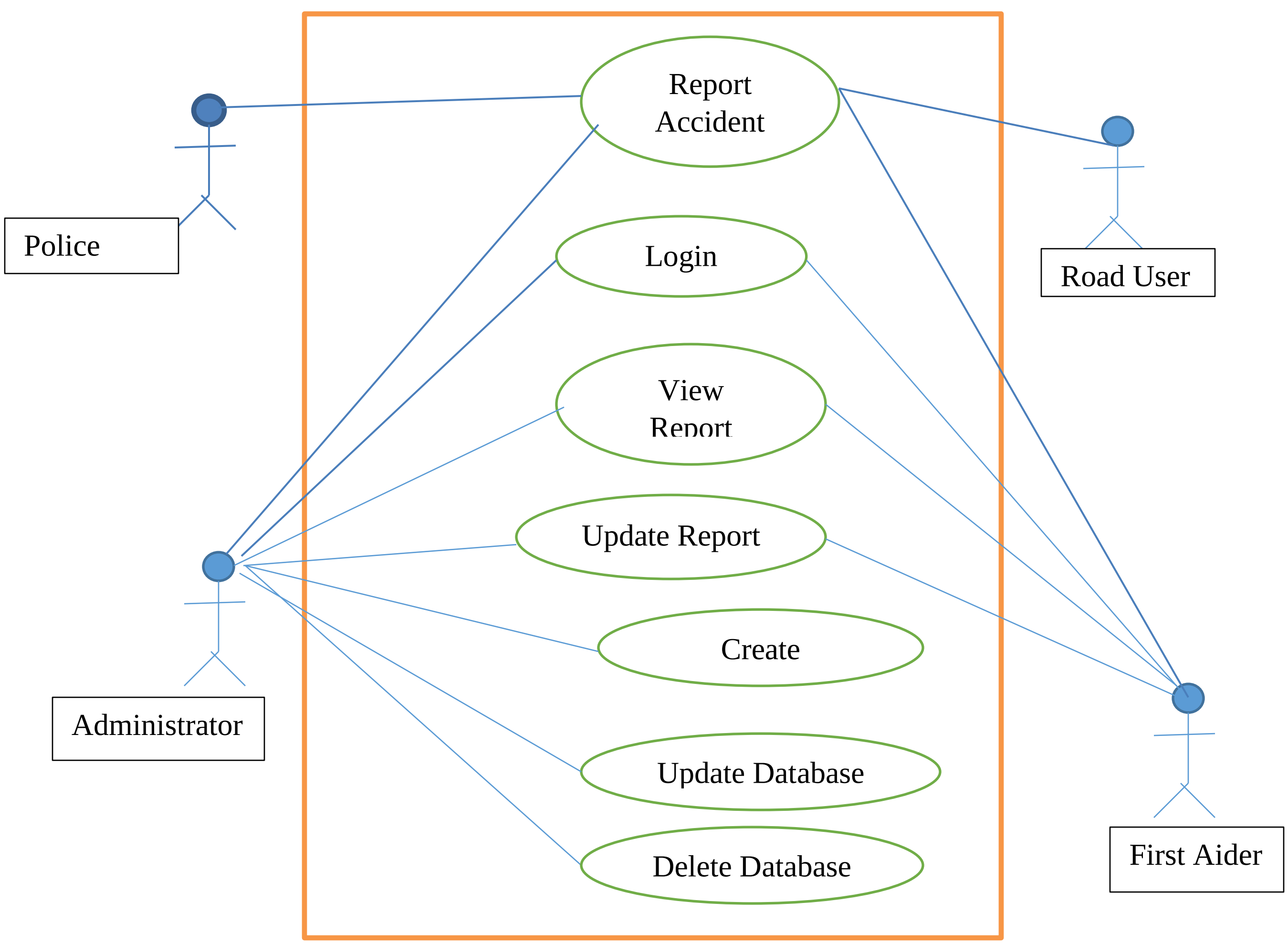
The system comprises of a database with 4 tables. One table contains details for first aiders: Full names, Mobile contacts, current residence location.

Table consists: Locations of Police stations and contacts of police and another Table has: Range of geographical coordinates of physical locations with corresponding local names and Mobile contacts of respective hospitals.

5.4 Use Case Diagram

A Use Case model captures Use Cases and relationships between actors and the system. It describes the functional requirements of the system, the manner in which outside entities (actors) interact at the system boundary, and the response of the system. The use case diagram is illustrated below:

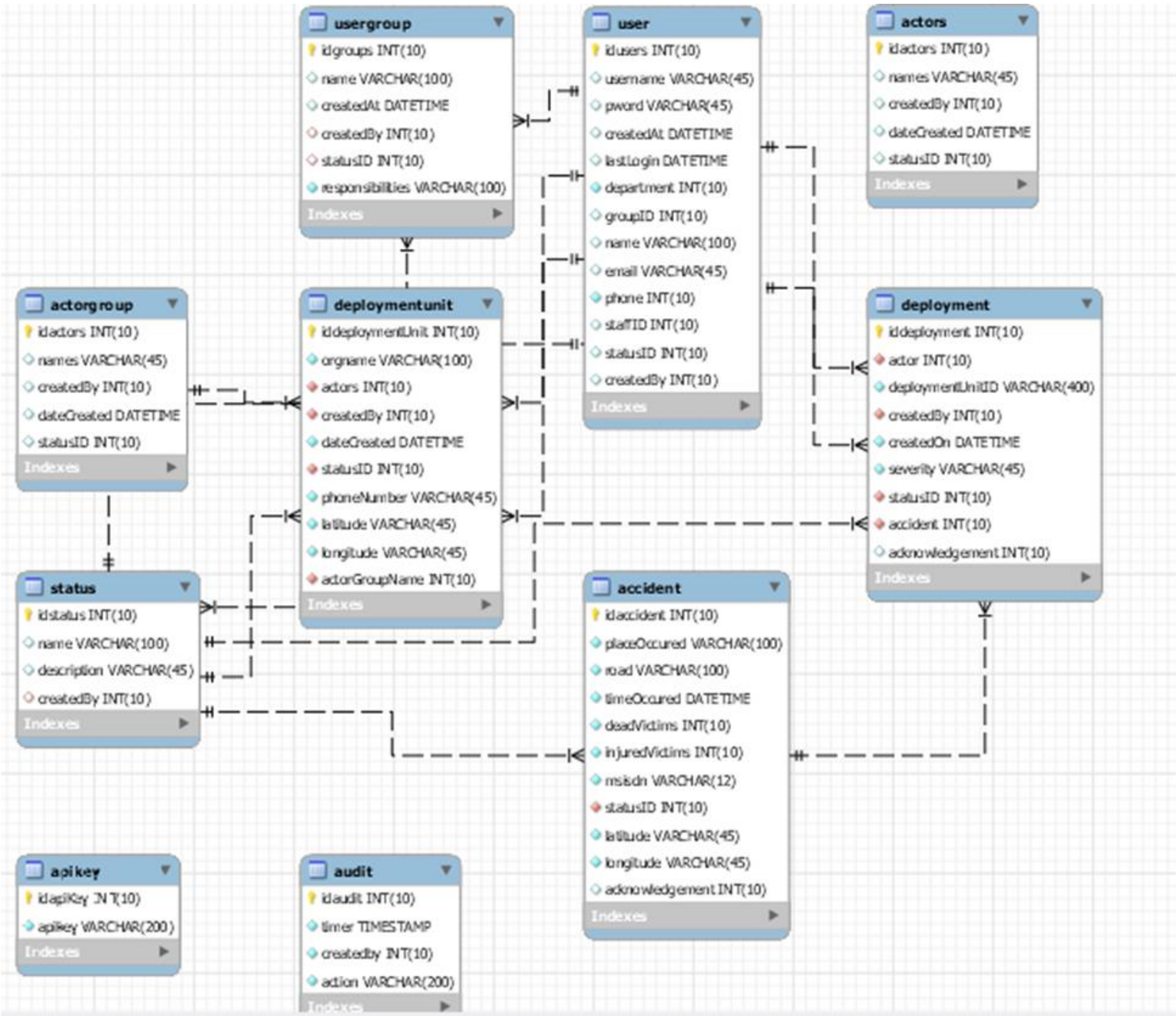
Figure 14 : Use Case Diagram



5.5 Class Diagrams

Class diagrams are used to define the organization of a system in terms of classes, attributes, operations, and association of objects in the class.

Table 8: The Database Schema



5.6 Implementation Technology

The system was developed as an Android App in Java Environment with SMSLib for SMS functions and MySQL for database services. It also involved development of Web portal with primefaces and embraced SOA. The system implementation technologies are discussed as follows:

5.6.1 Android Operating System

This is the greatest widespread mobile phone operating system in the world nowadays. Selecting this platform with Java language for execution of the system implies that more people are expected to have access to it therefore making it more beneficial.

5.6.2 Mysql Database Management System

MySQL is the most prevalent Relational Database Management System due to the following reasons:

Open Source- It is free and can be used by anyone without any license or authorization.

Easy, Fast and High Performing -This Database is easy to use and it operates very fast.

As it is essentially a improved version of SQL, a general understanding of SQL is enough to work proficiently with MySQL

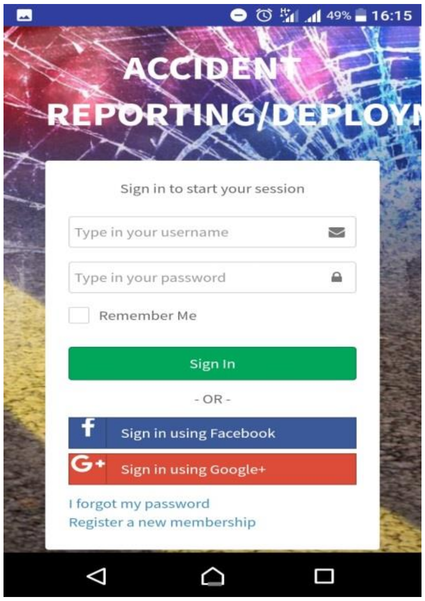
Cross Platform Supports - It can be connected with all major Operating Systems in addition to Windows without a loss of performance. It also runs with various development interfaces like JDBC, ODBC, Pearl,Python, PHP and C++ . This is mainly because the development APIs that are unified with it.

Memory Factor- MySQL checks memory leaks thus facilitating efficient resolutions for information storage.

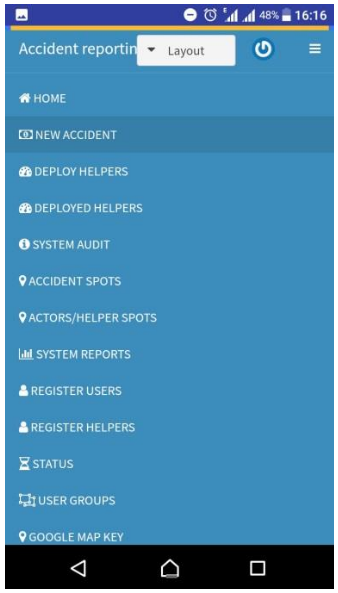
Data Security - MySQL secures the stored data. This makes this database system safe and reliable as in popular cloud solutions such as Microsoft Azure. An unauthorized access to data is not possible since, it is secured with encrypted database passwords. Special authority and rights are subjected only to authorized entry.

5.7 Main Interfaces

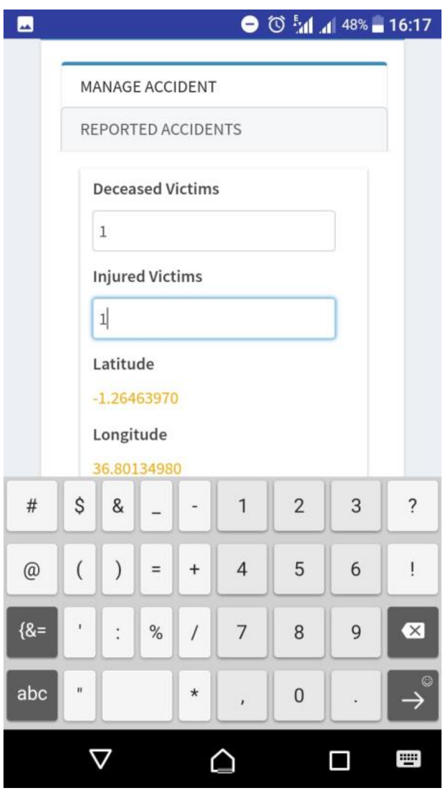
Login Screen



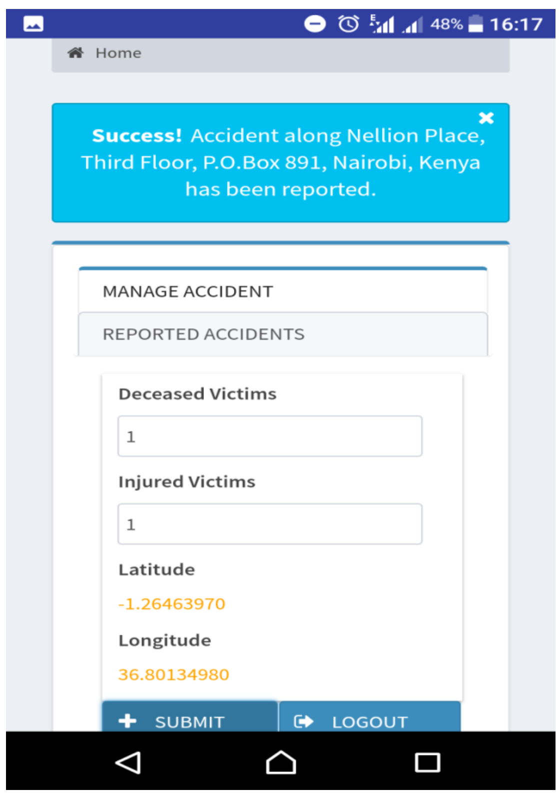
Main Menu



Reporting Screen



Successful Reporting



CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.0 Overview

The findings of this study concur with studies in other countries concerning need for using technology to report and respond to road accidents. Kenya is gradually embracing technology but quite on a low key note especially in handling emergencies. These results should be a wakeup call for us to embrace available technology resources in solving our own problems.

6.1 Fulfilment of the Research Objectives and Questions

The research objectives can be confirmed to have been fulfilled given that all research questions were answered as follows:

i. What are the current methods used for reporting road accidents?

Based on the interviews and questionnaires responses obtained during the study, the following methods are used by ordinary road users for reporting road accidents in Kenya: Phone calls, social media i.e twitter, Facebook, WhatsApp and calling centre via hotline numbers. Other agencies like Red Cross organization branches, National police and ambulance providers report road accidents via HF/VHF radio frequencies and mass media apart from phone calls and social media. These methods have challenges which have been discussed in this report. It is clear that there is no fully functional application for reporting road accidents by road users. Literature of various emergency reporting systems in other countries was done and revealed that developed countries use smartphones systems for emergency management applications.

ii. How can the mobile based system be used for reporting road accidents?

From the research findings, mobile based system can be used for reporting road accidents to address challenges including: unknown communication channels, Location and naming difficulties, tracking time of reporting and indicate help points for first aiders. The system will enable road users report accidents and automatically indicate location and name of accident scene, time of occurrence and surrounding help points like police stations, hospitals and first aid kiosks.

iii. How do related models function?

Literature of various emergency reporting systems in other countries was done and revealed that developed countries use smartphones systems for emergency management applications. For example, the AppLERT android based mobile application lets user to escalate occurrences and tragedies for speedy rescue in Phillipines. Fire Ready(FR) is a fire warnings and information system, acquaints users of fire hazards in affected area and sends photographs of bushfire activity. Federal Emergency Management Agency (FEMA) is an application with awareness information on various emergency circumstances and disasters. It has an interactive worksheet for emergency kits and a plan for emergency meeting locations. **Systems developed in Kenya for emergency situations include:** CrashData which is a smartphone-based application for road accident data collection in Kenya .The system enables police to collect data digitally instead of keying information manually into forms P41. A 'NDURU' is a mobile application available on the Nokia S40 platform that enables people to report accidents, reckless drivers, dangerous vehicles and other high road risks in Kenya. Ma3Route generates data on road traffic patterns and accidents in Kenya to improve mobility experience of the people in major cities. Google Live Traffic Alerts provides live traffic alerts in Kenyan roads through google maps 'mobile app when it is in navigation mode. The app provides updates on upcoming congestion, and expected delay in traffic using a specified route.

vi. How can road users be sensitized to use the system in reporting road accidents?

The research findings on user sensitization regarding usage of the system in reporting road accidents in Kenya include mainly: Campaigning and displaying the app on mass media and social media to influence road users to use it in reporting road accidents whenever they happen. Another way of sensitisation suggested was creating awareness on how, where and when to report accidents in Kenya i.e training road users on how to report road accidents and first aiders on how to acknowledge and respond to reported accidents using the app. Last but not least, making the app toll free to enable road users report road accidents without incurring cost of purchasing data bundles and airtime. Once the use of the app is declared free, every person with a phone can report accident.

vii. How can the feedback provided be used to improve the system?

The feedback provided include expected features and capabilities which the developed system should have in order to address challenges faced on reporting and responding to road accidents in Kenya. The feedback indicated that the App should be installable in a mobile phone to report any accident. It should pin point location of the reporter being the accident scene. It should name location of accident scene and send alerts to the nearest first aiders, police and paramedics. It also synchronize all alerts, updates and maintain details of accident .The system should automatically deploy first aiders to the scene immediately an accident is reported. The system was developed factoring in all feedback given by road users and first aiders on how it should work to making reporting and responding very fast.

6.2 Development of a Mobile/web Based Reporting System

The study was concluded effectively with the development of a mobile based application model as was anticipated in the key objective. The application has the proficiency to report road accidents with specifications of coordinates and names of accident scenes. The project research was undeniably a great opening to reveal the potential of an invention using the readily accessible and broadly established mobile technology and the internet. The outcomes gotten from assessment of the prototype show that projected consumers embrace this solution in an optimistic mode, even giving important criticism on the improvements that should be accomplished to leverage on it more.

6.3 Impact of the System Usage in Kenya

From the results obtained during the study especially at testing, indicate that the developed system if used properly will make reporting and response to road accidents almost real –time and easy. It will also increase number of accidents reported since anyone with a phone can just report by inputting a single entry then submit. Many Lives may be saved due to very fast response to road accident in Kenya. Coordination of rescue team will improve since both web based and app systems will be integrated for unified communication.

6.4 Recommendations

It is recommended that the system that has been developed as a prototype should be augmented and be implemented to report road accidents and any other accident in Kenya. The application will then give chance to any road user with a smartphone to report a witnessed accident and enable first aiders respond promptly. An Application Programming Interface (API) should also be provided in future to other platforms to intensify perceptibility and accessibility of the application. The Kenyan emergency response services should promote this system by making if toll free i.e no data charges involved when reporting and responding to road accidents using the App. This will ensure reporting and responding to most accidents as they happen in Kenya.

6.5 Future Works

Though, the Mobile app system has tried to implement most of the functional requirements required and defined for the system, there are some more additional tasks to be addressed and others to be handled extensively as it has been learned from related systems or products being used in other countries.. If more resources are available, we can implement this using cloud computing techniques and also include voice recording as a future work.

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APPENDIX 1: BUDGET AND PLAN

4.0 Research Project Budget

Item	**Description**	**Amount(Kshs.)**
Project Personnel	Data Collection assistants	10,000
Administrative Support	Approval fees for necessary authorization and support to conduct research	5,000
Travel	During data collection	15,000
Tools and equipment	Computers, data collection and analysis tools	50,000
Miscellaneous	For emergency use	10,000
Grand Total		90,000

Source of Funding: Self

4.1 Research Project Schedule

TASK	**TIME(Weeks)**
Project Proposal	5
Data Collection	4
Data Analysis	3
Prototype Design	3
Prototype Development	6
Final Report	3

APPENDIX 2: DELPHI ROUND 1 EMAIL QUESTIONAIRE

Dear Panelist,

Thank you for agreeing to participate in this research project. Your participation will be completely confidential and you will remain completely anonymous throughout this process. The data gathered within this survey will not be not be subject to any public disclosure and is for use only as part of a MSc research project.

The research project aims to investigate the current methods of reporting road accidents, identify challenges and provide solution. The following survey is stage 1 of a Delphi questionnaire. This is designed to obtain your personal opinion relating to the key issues related to this study. The Delphi process involves questioning you on three distinct sessions:

Round One: General open ended questions will be submitted to you requiring your response. These are attached for you to reply to now.

Round Two: At a later date (Tentatively after 2 weeks): Your answers and those from the other panellists from round One will be summarised and formulated into a series of more specific questions that you will be asked to respond to.

Round Three: Round 2's questions will be submitted to you again but this time you will also be able to see the average reply of the other panellists and you will then be asked if you would like to adjust your answer from the Round Two or not.

The identity of all panellists will remain confidential at all times. Please reply to each one but do not feel limited in the length or style of your answers.

A reply to this by email is fine.

Thanks for your assistance,

Callo Mocheche Simion.

APPENDIX 3: DELPHI ROUND 1 QUESTIONNAIRE:

Appendix 1: First Aiders' perspective on road accidents in Kenya

1. How do you get information about road accidents' occurrence?

   ----
2. How frequent do you get reports about road accident occurrences?

   ----
3. When road accidents are reported to you, how soon do you get to the accident scene?
   a. In urban setting

   ----
   b. In rural setting

   ----
4. What categories of road accidents do you respond to?

   ----
5. What factors do you consider in categorisation of road accidents?

   ----
6. What communication channels/systems do you use for getting reports about road accidents?

   ----
7. What communication systems do you use in responding and /or coordinating first aiders to road accidents scenes?

   ----
8. Briefly explain how you coordinate first aiders in response to road accidents.
   (a) Steps of emergence response to road accidents i.e chain of activities from the time an accident is reported to time of complete first aid.

   (b) How do you get first aiders available to respond to road accidents once they happen?

   (c) What determines the number of paramedics and /or first aiders to deploy to road accidents scene?

(d) How do you know how many first aiders actually get to road accidents scene, in case of no ambulances? Briefly explain how.

----

9. Kindly list challenges faced when receiving reports on road accidents.
   a. In urban setting

   ----

   b. In rural setting

   ----

10. Kindly list challenges faced when responding to road accidents.
   a. In urban setting

   ----

   b. In rural setting

   ----

11. Do you think a mobile/web based system can help to address the above challenges?

----

   a. If No, please suggest what can be done to address the above challenges.

   ----

   b. If Yes, briefly discuss features and capabilities which should be incorporated into the mobile/web based system to address the above challenges
   ----
   ----

12. Are you are willing to be involved in testing phase of the system?

----

13. Are you are willing to use the system once it is developed?

----

14. Please indicate remarks, if any regarding road accidents in Kenya.

Thank you for your cooperation.

APPENDIX 4: DELPHI ROUND 2 QUESTIONNAIRE

Dear Panelist,

Welcome and thank you for accepting to participate in round two of the questionnaire.
Please provide an answer to each statement and make comments on any issue you wish.
We use a 9-point Likert scale for rating the answers; please choose only one score of the *agreement* scale for each question.

15. There are various factors which determine how soon first aiders/paramedics reach accident scene.

Please state to what extent you agree with the following statements

	Response time is determined by :	**Completely disagree**			**Do not agree/nor disagree**			**Completely agree**		
		1	2	3	4	5	6	7	8	9
a	Distance in which the accident occurred from town centre									
b	Road networks on the region									
c	Condition of the road surface									
d	Terrain of accident location									
e	Time taken for road network identification to locate accident scene									

Comments:

----

16. The following are challenges faced when reporting/receiving reports road accidents in Kenya.

Please state to what extent you agree with the following statements

		Completely disagree			Do not agree/nor disagree			Completely agree		
		1	2	3	4	5	6	7	8	9
a	Language barrier									
b	Reporters are not updated that the accident has been responded to									
c	Lack of airtime for reporters to call or sms details of an accident.									
d	Communication channels are not known by every potential reporter.									
e	Location description difficulties									
f	Poor network coverage									
g	No formal address to remote places									
h	Some callers panic hence unable to give clear details about an accident.									

Comments:

----

17. The following are a summary of challenges faced when responding to road accidents.

Please state to what extent you agree with the following statements

		Completely disagree			Do not agree/nor disagree			Completely agree		
		1	2	3	4	5	6	7	8	9
a	Number of ambulances available to handle situations.									
b	Distance of accident scene from dispatch centre or organisation branch offices.									
c	State of the roads leading to accident scene i.e rough and fine surface roads.									
d	Terrain of the accident scene and roads leading to accident scene.									
e	Ignorance of drivers assuming that ambulances are not carrying casualties.									
f	Traffic jam and road congestions.									
g	Poor weather especially rainy seasons									
h	Time of the day i.e peak or off peak, day or night.									

Comments:

----

18. The basic features and capabilities below should be incorporated into the mobile/web based system to address the challenges faced in responding to road accidents in Kenya.

Please state to what extent you agree with the following statements

		Completely disagree			Do not agree/nor disagree			Completely agree		
		1	2	3	4	5	6	7	8	9
a	App should be installable in a mobile phone to report any accident.									
b	App should pin point location of the reporter being the accident scene.									
c	App should name location of the reporter being the accident scene.									
d	App should indicate details of road network map									
e	App should send alerts to the nearest first aiders, police, hospitals and EMR.									
f	The system should synchronise all alerts, updates and maintain details of accident rescue progress until completion									
g	Both system and app should function 24 hours daily.									
h	The system should automatically deploy first aiders to the scene immediately an accident is reported.									
i	The system should broadcast alerts to all parties in time									

Comments:

----

19. The following are general suggestions to improve reporting and response to road accidents in Kenya.

Please state to what extent you agree with the following statements

		Completely disagree			Do not agree/nor disagree			Completely agree		
		1	2	3	4	5	6	7	8	9
a	Campaign and display easy to remember numbers to report accidents.									
b	Create awareness on how, where and when to report accidents in Kenya.									
c	Create awareness that ambulances use siren when carrying and going for casualties									

Comments:

Thank you for your cooperation.

APPENDIX 5: DELPHI ROUND 3 QUESTIONNAIRE

Respondent Cover Note:

You recently assisted the second round of my research with your opinions on challenges and solutions to responding to road accidents in Kenya. This is the final round of the research and the questions will take you no longer than 1 minute to complete. Please read each statement and then delete 1 of the 2 boxed options below it leaving your option of 'agree' or 'disagree'. A short note is provided with each question to let you know what the general opinion was in the previous round.

No.2	Statement	
From No. b)	Reporters are not updated that the accident has been responded to.	
Choice	Agree	Disagree

Note : In the last round of questions, 61.11% of respondents agreed with this.

No.2	Statement	
From No. c)	Lack of airtime for reporters to call or sms details of an accident.	
Choice	Agree	Disagree

Note: In the last round of questions, 66.67% of respondents agreed with this.

No.2	Statement	
From No. h)	Some callers panic hence unable to give clear details about an accident.	
Choice	Agree	Disagree

Note: In the last round of questions, overall consensus was split but favoured agreement 55.56%.

Thank you for your cooperation.

APPENDIX 6: TIMELINE OF THE DELPHI STUDY

Date	**Event**
18/09/2018	Request for input for Delphi rounds from panelists
19/09/2018	Request for comments from Red Cross ERS coordinators on draft questionnaire
21/09/2018	Invitation letter sent out to participate in the Delphi (dataset, n=42 panelists)
23/09/2018	Reminder to reply to invitation sent out
29/09/2018	Distribution of round 1 questionnaires +cover letter to the Delphi panel (42 panelists accepted)
06/10/2018	First Reminder sent out to those who didn't reply
14/10/2018	Second Reminder sent out to those who didn't reply
23/10/2018	Collection and reception of replies from panellists
04/11/2018	Analysis of round 1 results and formulation of round 2 questionnaire (n=40)
12/11/2018	Distribution of round 2 questionnaires (n=40)
14/11/2018	Reminder done
16/11/2018	Collection of round 2 results
17/11/2018	Analysis of round 2 results and preparation of round 3 questionnaires.
20/11/2018	Distribution of round 3 questionnaires (n=36)
22/11/2018	Reminder done
23/11/2018	Reception and Analysis of round 3 results and conclusion(n = 32)

APPENDIX 7: SAMPLE CODES

REPORT ACCIDENT VIEW

```
<?xml version="1.0" encoding="UTF-8"?>
<ui:composition xmlns="http://www.w3.org/1999/xhtml"
        xmlns:p="http://primefaces.org/ui"
        xmlns:h="http://java.sun.com/jsf/html"
        xmlns:f="http://java.sun.com/jsf/core"
        xmlns:ui="http://java.sun.com/jsf/facelets"
        template="#{layoutMB.layout}">
  <ui:define name="head-end">
    <ui:param name="renderBreadCrumb" value="true"/>
  </ui:define>
  <ui:define name="title">
  </ui:define>
  <ui:define name="body">
    <div class="box box-primary">
      <p:panel id="spanel">
        <h:panelGrid columns="1">
          <p:growl id="msgs1" sticky="true" showDetail="true" />
          <p:tabView  styleClass="si-icon-16x16 si-icon-edit"   style="background: transparent; width: 100%; height:
100%; border: 0" >
            <p:tab title="MANAGE ACCIDENT" >
              <h:form id="activityForm" style="width: auto" >
                <h:panelGrid columns="1" >
                  <p:panelGrid columns="4" columnClasses="ui-grid-col-2,ui-grid-col-4,ui-grid-col-2,ui-grid-col-4"
                      layout="grid" styleClass="ui-fluid card">
                 <p:outputLabel value="Deceased Victims"/>
                 <p:inputText type="number"  style="width:200px"   value="#{acc.accident.deadVictims}" />
                 <p:outputLabel value="Injured Victims"/>
                 <p:inputText  type="number"  style="width:200px"   value="#{acc.accident.injuredVictims}" />
                 <p:outputLabel value="Latitude"/>
                 <inputText   style="width:200px; color: orange" value="#{acc.accident.latitude}" id="latitude"/>
                 <p:outputLabel value="Longitude"/>
                 <inputText   style="width:200px; color: orange" value="#{acc.accident.longitude}" id="longitude"/>
                    <p:messages for="userForm"  showDetail="true" />
                  </p:panelGrid>
                  <h:panelGrid columns="8">
                    <p:commandButton value="SUBMIT"  icon="fa fa-plus" class="find-me" styleClass="btn-
primary"  action="#{acc.createAccident()}"/>
                    <p:commandButton value="LOGOUT"   action="#{acc.logout}"  icon="fa fa-sign-out"
styleClass="btn-primary" />
                  </h:panelGrid>
                </h:panelGrid>
                <p:remoteCommand name="setLang" process="@this" partialSubmit="true"
actionListener="#{acc.setlatLong}" />
              </h:form>
            </p:tab>
            <p:tab title="REPORTED ACCIDENTS">
              <h:form id="accidentForm" style="width: auto" >
                <p:dataTable var="accident" value="#{acc.accidentList}"
                       paginator="true" rows="10"
                       style="background: transparent; font-size:11px"
                       id="activitysTable"
```

REPORT ACCIDENT CONTROLLER

```
public String createAccident() {
        try {
            Apikey apiKey = (Apikey) em.createQuery("select a from Apikey a").getSingleResult();
            System.out.println(latitude);
            System.out.println(longitude);
            System.out.println("the key" + apiKey.getApikey());
            GeoApiContext context = new GeoApiContext().setApiKey(apiKey.getApikey());
            com.google.maps.model.LatLng latlng = new com.google.maps.model.LatLng(Float.parseFloat(latitude),
Float.parseFloat(longitude));
            GeocodingResult[] results;
            results = GeocodingApi.reverseGeocode(context, latlng).await();
            accident.setLatitude(latitude);
            accident.setLongitude(longitude);
            getUtx().begin();            getAudit().setAction("reported accident " + getAccident().getPlaceOccured() +
getAccident().getRoad());            getAudit().setCreatedby(1);            getAudit().setTimer(new Date());
            getEm().persist(getAudit());            getEm().persist(accident);            em.flush();
            deploy(accident, accident.getStatusID(), accident.getStatusID().getName(), accident.getLatitude(),
accident.getLongitude());            getUtx().commit();
            FacesContext.getCurrentInstance().addMessage(null, new FacesMessage(FacesMessage.SEVERITY_INFO,
"Success!", "Accident along " + getAccident().getRoad() + " has been reported."));
            setAccident(new Accident());
        } catch (Exception ex) {
            FacesContext.getCurrentInstance().addMessage(null, new FacesMessage(FacesMessage.SEVERITY_ERROR,
"Error!", ex.getMessage()));            ex.printStackTrace();       }        setAccident(new Accident());    return null;            }
        public String deploy(Accident accident, Status status, String severity, String latitude, String longitude) {
        try { Float latitude2 = Float.parseFloat(latitude) + Float.parseFloat("0.2");
            Float longitude2 = Float.parseFloat(longitude) + Float.parseFloat("0.2");
            System.out.println("passed longitude " + longitude2);
            System.out.println("passed latitude " + latitude2);
            System.out.println("passed accident " + accident);
            System.out.println("passed status " + status);
            deploymentunitList = em.createQuery("select d from Deploymentunit d where d.latitude <= '" + latitude2 + "' and
d.longitude <= '" + longitude2 + "'").getResultList();
            for (Deploymentunit d : deploymentunitList) {
                deployment.setStatusID(new Status(1));
                deployment.setAcknowledgement(0);
                getEm().persist(deployment);
                FacesContext.getCurrentInstance().addMessage(null, new FacesMessage(FacesMessage.SEVERITY_INFO,
"Success!", deployment.getDeploymentUnitID() + " deployed successfully."));            }
                    setDeployment(new Deployment());
        } catch (Exception ex) {
            ex.printStackTrace();            FacesContext.getCurrentInstance().addMessage(null, new
FacesMessage(FacesMessage.SEVERITY_ERROR, "Error!", ex.getMessage()));    } setDeployment(new Deployment());
return null;    }      public void setlatLong() {        try {
            String latitude =
FacesContext.getCurrentInstance().getExternalContext().getRequestParameterMap().get("latitude");            String
longitude = FacesContext.getCurrentInstance().getExternalContext().getRequestParameterMap().get("longitude");
setLatitude(latitude);
            setLongitude(longitude);
                    FacesContext.getCurrentInstance().addMessage(null, new
FacesMessage(FacesMessage.SEVERITY_INFO, "Success!", accid.getPlaceOccured() + " " + accid.getRoad() + "
Updated successfully."));
       }        accid = new Accident();
        return null;    }
```

REPORT ACCIDENT MODEL

```
@Entity
@Table(name = "accident") @XmlRootElement @NamedQueries({
   @NamedQuery(name = "Accident.findAll", query = "SELECT a FROM Accident a"),
   @NamedQuery(name = "Accident.findByIdaccident", query = "SELECT a FROM Accident a WHERE a.idaccident =
:idaccident"),
   @NamedQuery(name = "Accident.findByPlaceOccured", query = "SELECT a FROM Accident a WHERE
a.placeOccured = :placeOccured"),
   @NamedQuery(name = "Accident.findByRoad", query = "SELECT a FROM Accident a WHERE a.road = :road"),
   @NamedQuery(name = "Accident.findByTimeOccured", query = "SELECT a FROM Accident a WHERE
a.timeOccured = :timeOccured"),
   @NamedQuery(name = "Accident.findByDeadVictims", query = "SELECT a FROM Accident a WHERE
a.deadVictims = :deadVictims"),
   @NamedQuery(name = "Accident.findByInjuredVictims", query = "SELECT a FROM Accident a WHERE
a.injuredVictims = :injuredVictims"),
   @NamedQuery(name = "Accident.findByMsisdn", query = "SELECT a FROM Accident a WHERE a.msisdn =
:msisdn"),
   @NamedQuery(name = "Accident.findByLatitude", query = "SELECT a FROM Accident a WHERE a.latitude =
:latitude"),
   @NamedQuery(name = "Accident.findByLongitude", query = "SELECT a FROM Accident a WHERE a.longitude =
:longitude")})
public class Accident implements Serializable { private static final long serialVersionUID = 1L;    @Id
   @GeneratedValue(strategy = GenerationType.IDENTITY)
   @Basic(optional = false)    @Column(name = "idaccident")    private Integer idaccident;    @Basic(optional = false)
   @NotNull    @Size(min = 1, max = 100)    @Column(name = "placeOccured")    private String placeOccured;
   @Basic(optional = false)    @NotNull    @Size(min = 1, max = 100)    @Column(name = "road")    private String road;
   @Basic(optional = false)    @NotNull    @Column(name = "timeOccured")   Temporal(TemporalType.TIMESTAMP)
   private Date timeOccured;    @Basic(optional = false)    @NotNull    @Column(name = "deadVictims")    private int
deadVictims;    @Basic(optional = false)    @NotNull    @Column(name = "injuredVictims")    private int injuredVictims;
@Basic(optional = false)    @NotNull    @Size(min = 1, max = 12)    @Column(name = "msisdn")    private String
msisdn;    public Accident(Integer idaccident, String placeOccured, String road, Date timeOccured, int deadVictims, int
injuredVictims, String msisdn, String latitude, String longitude) {
       this.idaccident = idaccident;        this.placeOccured = placeOccured;        this.road = road;        this.timeOccured =
timeOccured;        this.deadVictims = deadVictims;        this.injuredVictims = injuredVictims;        this.msisdn = msisdn;
       this.latitude = latitude;        this.longitude = longitude;    }    public Integer getIdaccident() {        return idaccident;
   }    public void setIdaccident(Integer idaccident) {        this.idaccident = idaccident;    }    public String
getPlaceOccured() {        return placeOccured;    }    public void setPlaceOccured(String placeOccured) {
       this.placeOccured = placeOccured;    }    public String getRoad() {        return road;    }
   public void setRoad(String road) {        this.road = road;    }
   public Date getTimeOccured() {        return timeOccured;    }
   public void setTimeOccured(Date timeOccured) {        this.timeOccured = timeOccured;    }
   public int getDeadVictims() {        return deadVictims;    }
   public void setDeadVictims(int deadVictims) {      this.deadVictims = deadVictims;   }
   public int getInjuredVictims() {        return injuredVictims;    }
   public void setInjuredVictims(int injuredVictims) {    this.injuredVictims = injuredVictims;    }
   public String getMsisdn() {       return msisdn;    }
   public void setMsisdn(String msisdn) {        this.msisdn = msisdn;    }
   public String getLatitude() {        return latitude;    }
   public void setLatitude(String latitude) {        this.latitude = latitude;    }
   public String getLongitude() {        return longitude;    }
   public void setLongitude(String longitude) {        this.longitude = longitude;    }
   public Status getStatusID() {        return statusID;    }
   public void setStatusID(Status statusID) {        this.statusID = statusID;    }
   @XmlTransient    public Collection<Deployment> getDeploymentCollection() {
{        return "com.amon.db.Accident[ idaccident=" + idaccident + " ]";    }  }
```