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What is the optimal design of a Mountain Rescue Patient Assessment Smartphone Application?

Rita Darcy

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in partial fulfilment of the requirements for the degree of

Master of Science in Health Informatics

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Declaration

I declare that the work described in this dissertation is, except where otherwise stated, entirely my own work, and has not been submitted as an exercise for a degree at this or any other university. I further declare that this research has been carried out in full compliance with the ethical research requirements of the School of Computer Science and Statistics, Trinity College Dublin.

Signed: _____

Rita Darcy

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24th June 2016

Abstract

The purpose of this study is to explore what is the optimal design of a patient assessment Smartphone application that will be used by Mountain Rescue team members. It is proposed that a suitably designed application could assist Mountain Rescue team members in conducting and recording a patient assessment during a callout.

A review was conducted of existing First Aid and Mountain Rescue apps. A Smartphone app was discovered that assists with patient assessments in remote emergency care situations, called the NOLS (National Outdoor Learning School) SOAP (Subjective, Objective, Assessment and Plan) Note Smartphone application. This application could potentially be used in Mountain Rescue.

Three research studies were conducted. The first was a questionnaire that focused on the current functionality of the NOLS SOAP Note app to identify required functionality of a patient assessment app. The second study involved interviewing selected Dublin & Wicklow Mountain Rescue Team members who have both Mountain Rescue and healthcare experience, to ascertain the data that should be recorded during a patient assessment, and the information that should be transferred during a handover. The author used the feedback from the studies to develop a prototype app. The final study was an evaluation of the prototype app.

The feedback received from the first two studies was used in the design of a prototype app. The prototype app was deemed by the research participants to have a high level of usability and scored closely to the NOLS SOAP Note app usability score.

The design of the prototype app was an iterative process. The screen mock-ups used to define the screen layouts, were created using a tool called Ninja Mock. The prototype app was developed using the Xamarin development environment using the C# language. The prototype app was deployed using Dropbox.

It is recommended that the IMIST-AMBO handover protocol is used by Mountain Rescue team members when handing over a patient to paramedics. It is also recommended to involve stakeholders in the design process. The resulting prototype app is functional, but further development is required to optimally design a patient assessment app for Mountain Rescue.

Acknowledgements

I would like to sincerely thank my supervisor Mary Sharp for providing advice and support throughout the year.

I would like to thank the members of the Dublin & Wicklow Mountain Rescue Team for participating in my research studies, for sharing their invaluable insight and knowledge with me, and for supporting my ideas. All the team members give up a considerable amount of their time to support Mountain Rescue, so I really appreciate the additional time that they gave to this project.

Many thanks are due to my friend Maebh Ni Fhalluin who assisted by proof reading this document and providing valuable suggestions.

Finally, thanks to my classmates who have provided encouragement and support over the last two years.

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Abbreviations

Term	Definition
ABC	Airway, Breathing, Circulation
AED	Automated External Defibrillator
AGS	An Garda Siochana (Irish Police Force)
AMBO	Allergies, Medication, Background, Other Information
API	Application Program Interface
APK	Android Application Package
ASHICE	Age, Sex, History, Injuries or Illnesses, Condition, ETA
AVPU	Alert, Verbal, Pain responsive, Unresponsive
BSI	Body Substance Isolation
CFR	Cardiac First Responder
CPG	Clinical Practice Guidelines
CRUD	Create, Update and Delete statements
DWMRT	Dublin & Wicklow Mountain Rescue Team
EFR	Emergency First Responder
EMT	Emergency Medical Technician
EU	European Union
GCS	Glasgow Coma Scale
GCS	Glasgow Coma Scale
GUI	Graphical User Interface
HSE	Health Services Executive
ICAR	International Commission for Alpine Rescue
ICG	Irish Coast Guard
ICT	Information Communication and Technology

Term	Definition
IDE	Integrated Development Environment
IMIST	Identification of patient, Mechanism of injury or medical complaint, Injuries or information related to complaint, Signs, Treatments and Trends
IT	Information Technology
MOI	Mechanism of Injury
MRI	Mountain Rescue Ireland
NACC	National Ambulance Control Centre
NOLS	National Outdoor Leadership School
PC	Personal Computer
PCR	Patient Care Report
PHECC	Pre-Hospital Emergency Care Council
PSNI	Police Service of Northern Ireland
REC	Remote Emergency Care
SAMPLE	Symptoms/ Signs, Allergies, Medications, Past pertinent medical history, last intake, event
SOAP	Subjective, Objective, Assessment and Plan
SQL	Structured Query Language
SRS	Software Requirements Specification
SUS	System Usability Scale
UI	User Interface
US	United States (of America)
XAML	Extensible Application Markup Language

The term ‘app’ is used in this document as a shortened version of ‘Smartphone Application’

Chapter 1 Introduction

1.1 Introduction

This first chapter provides background information on Mountain Rescue in Ireland and a typical search and rescue scenario is explained. Details are provided on the various first aid training courses and standards that are used in Mountain Rescue. The problems that occur in patient assessment are explored, which provide a motive for this study. The research question is stated, followed by the smaller research questions that when answered will assist in answering the overall research question. An overview of the research plan is given, followed by an overview of the overall dissertation.

1.2 Background

1.2.1 Mountain Rescue in Ireland

Mountain Rescue Ireland (MRI), is an organisation that represents 12 Mountain Rescue teams across the island of Ireland that was founded in 1965, and celebrated 50 years of existence in 2015 (MRI 2015b). The primary role of MRI teams is to search for and rescue people in the hills and mountains of Ireland, but rescue teams are also involved in searching for missing persons, providing swift water rescue, assisting in air crashes in remote environments and providing support in severe weather conditions (MRI 2015a). The Mountain Rescue teams are tasked by An Garda Siochana (AGS) or the Police Service of Northern Ireland (PSNI) and since 1986 MRI teams have officially provided a 999/112 rescue service (MRI 2015a). The rescue service is provided 24/7 by volunteer members. MRI teams work closely with other rescue services and organisations such as the Irish Coast Guard (ICG), the Health Services Executive (HSE), Coillte and the National Parks.

Table 1-1 Mountain Rescue Teams in Ireland

1	Donegal Mountain Rescue Team
2	Dublin & Wicklow Mountain Rescue Team
3	Galway Mountain Rescue Team
4	Glen of Imaal Mountain Rescue Team
5	Kerry Mountain Rescue Team
6	Mayo Mountain Rescue Team
7	Mourne Mountain Rescue Team
8	North West Mountain Rescue Team
9	Search and Rescue Dog Association of Ireland (SARDA)
10	Sligo/Leitrim Mountain Rescue Team
11	South Eastern Mountain Rescue Association (SEMRA)
12	Tramore Cliff and Mountain Rescue Team

The author is a current full team member of the Dublin & Wicklow Mountain Rescue Team (DWMRT) with over 5 years' experience in participating in search and rescues.

MRI is a member of the International Commission for Alpine Rescue (ICAR), and MRI hosted the ICAR congress convention in Killarney, Co. Kerry in October 2015 where over 400 delegates from 33 countries attended (ICAR 2015).

All the MRI teams strive for professionalism in providing rescue services, by training to a high level and continually keeping up to date with current best practice rescue techniques and rescue technologies. The majority of rescue team members have passed the Mountain Skills Assessment awarded by Mountaineering Ireland and have obtained a minimum first aid qualification. Volunteer members all have full time jobs, with only a minority working professionally in medical or emergency services.

1.2.2 Typical Search and Rescue

A typical search and rescue will last for a number of hours. It generally takes team members about 30 minutes to an hour to reach the rendezvous point, and then additional time is required to get to the actual casualty site by foot or by transport and foot. If the location of the patient is unknown, it could take several hours to search for the patient. It generally takes about 20 minutes to assess, treat and package the patient to prepare them for a stretcher carry-out. There are many factors involved in a callout so the expected length of a callout can be very unpredictable. Mountain Rescue team members responding to a callout have to be prepared to spend at least 12 hours on the mountain, and be prepared for the occasional all-nighter.

A typical search and rescue involves some or all of the below steps:

- AGS/ PSNI tasks the relevant Mountain Rescue team(s) by calling the callout officer(s) and explains the details received from the 999/112 distress call.
- The callout officer sends out text messages to team members providing a brief description of the incident and a rendezvous meeting point.
- Team members confirm their availability by text message and/ or by WhatsApp message.
- A Mountain Rescue van/ vehicle is deployed to a roadside location near to the incident site and a 'base' is established. A senior team member takes on the role of 'Incident Commander'.

- Team members report into the base and the Incident Commander assigns members into groups of 5 or 6 people called a party. A party leader is assigned. A party leader assigns roles to the other team members:
    - Medic – will provide first aid treatment to casualty if required
    - Comms – responsible for radio communications
    - Navigator – responsible for navigating to and from the incident location
    - Scribe – assists the medic and writes down patient assessment notes
    - Gofor- assists the party leader
- The party will be asked to search for the casualty in a specific area or will be given details of the casualty's location.
- The party may be asked to bring additional equipment such as a stretcher, casualty bag (similar to a sleeping bag), vacuum mattress (used to support and stabilise the casualty), first aid kit, oxygen and Entonox.
- The party find the casualty and the medic assesses the casualty. If required, first aid is provided to the casualty and a patient assessment is conducted.
- The patient may be put onto a stretcher and carried down by rescue team members to a HSE ambulance or to a site where the ICG helicopter can safely winch the casualty from. A brief handover is conducted at this point. In theory the patient assessment details are written down and a duplicate copy is given to the awaiting paramedic/ coast guard member.
- A debrief is conducted once the incident is over and all team members have returned safely to base.

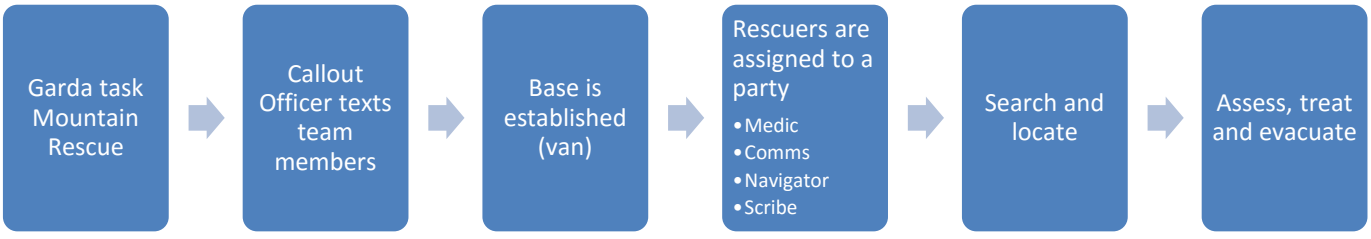


Figure 1-1 Typical Search and Rescue scenario

1.2.3 Callout Statistics

The Dublin & Wicklow Mountain Rescue Team work closely with the Glen of Imaal Rescue Team on nearly every callout. Overall the two teams are the busiest in the country with on average of over one callout a week since 2011 as can be seen in Figure 1-2.

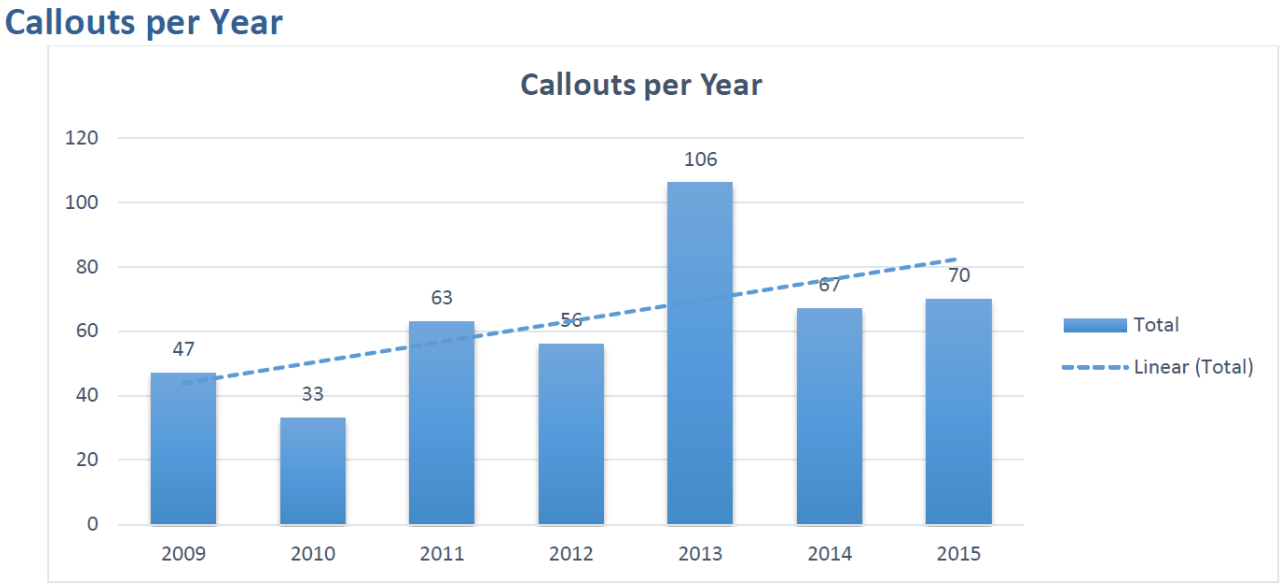


Figure 1-2 Number of DWMRT callouts per year (DWMRT 2016)

The injuries typically treated by the teams are lower leg injuries as seen in figure 1-3.

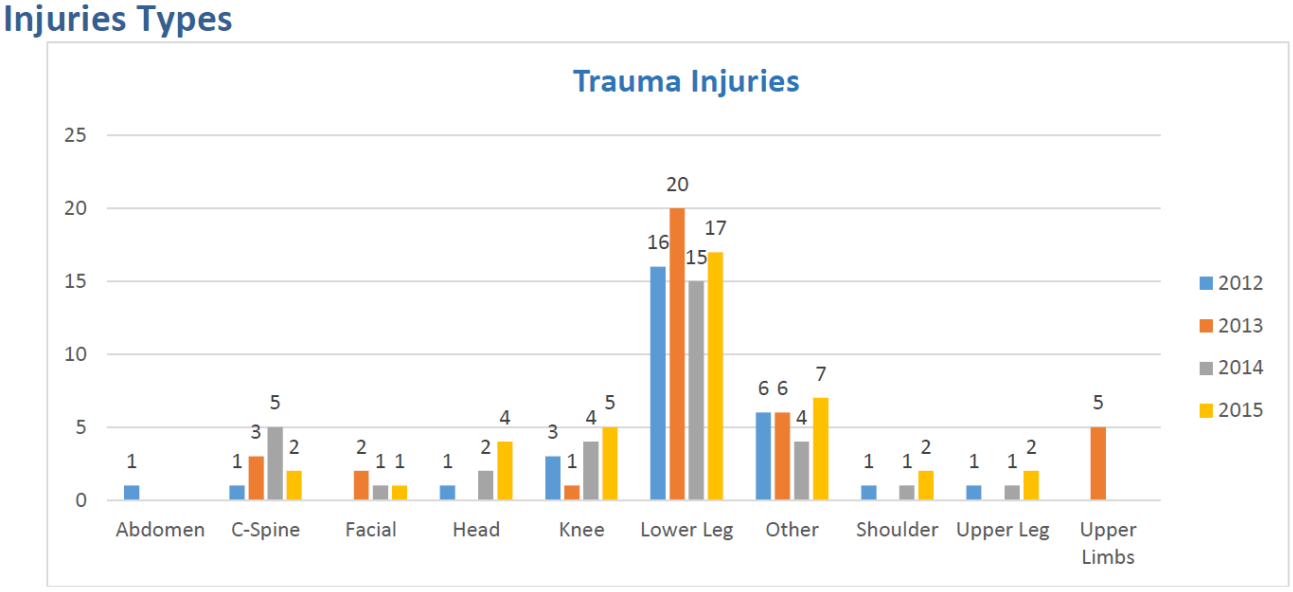


Figure 1-3 Type of injuries treated by DWMRT at callouts by year (DWMRT 2016)

As seen in figure 1-4 the evacuation method varies from a full stretcher carry-out to an awaiting HSE ambulance, a stretcher carry to an awaiting ICG helicopter, or a direct handover to the ICG helicopter. A handover is conducted by Mountain Rescue personnel each time a patient is transferred to either the HSE ambulance or to the ICG helicopter, so approximately 30 patient handovers are conducted each year.

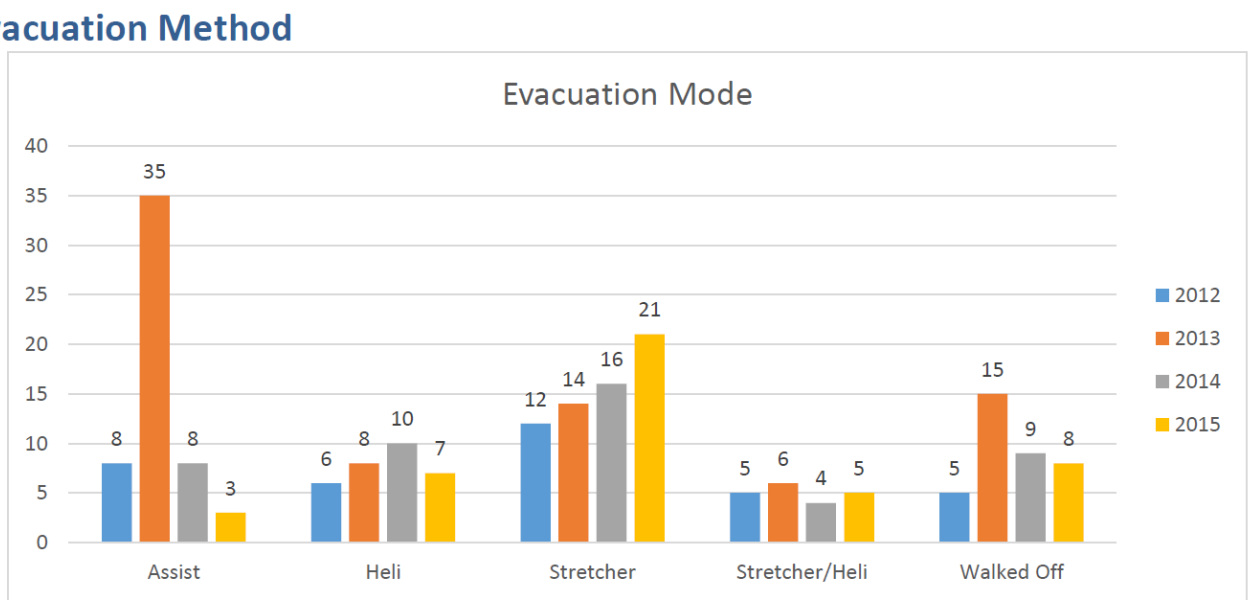


Figure 1-4 The method of evacuation used by DWMRT at callouts by year (DWMRT 2016)

1.3 First Aid Standards

1.3.1 PHECC

The Pre-Hospital Emergency Care Council (PHECC) was established in 2000 (PHECC 2012) in Ireland and the council is an independent statutory agency that is responsible for setting standards for pre-hospital emergency care education and training (PHECC 2011). PHECC publish clinical practice guidelines, which provide information on how to provide care for pre-hospital emergencies by trained volunteers and professionals who are classified as either

Responders

- Cardiac First Response (CFR)
- Occupational First Aid
- Emergency First Response (EFR)

Or Practitioners

- Emergency Medical Technicians (EMT)
- Paramedics
- Advanced Paramedics
- Nurses and Doctors

1.3.2 REC

Remote Emergency Care (REC) is a not for profit certificating body and training company that provide courses that focus on providing first aid in remote and wilderness areas. Their courses are approved by Mountaineering Ireland and include REC Level 2 which focuses on practising first aid in the outdoors and REC Level 3 which includes outdoor first aid and training in Automated External Defibrillators (AED) (REC 2016).

1.3.3 WEMSI

The Wilderness Emergency Medical Services Institute (WEMSI) is a voluntary organisation that provides education in wilderness medicine and focuses on patient assessment, patient treatment and incident management. WEMSI run Wilderness First Responder, Wilderness EMT and Wilderness Physician courses annually in Ireland (WEMSI 2016).

1.3.4 Training standards in MRI

In general Mountain Rescue team members are trained to PHECC CFR level although some teams have trained team members to EFR level. Some teams focus on REC qualifications for example DWMRT expect all team members to be trained to REC Level 3. Qualifications need to be renewed on a 2 to 3 yearly basis depending on the course.

1.4 Problems in Patient Assessment in Mountain Rescue

The author has identified problems in recording data during patient assessments, transferring patient data to paramedics and recording patient data for later statistical analysis and record keeping. In particular, the problems identified in conducting patient assessments in Mountain Rescue include that it is difficult to write and treat at the same time, the weather conditions can be formidable, the assessments may occur in the dark, and although a rescue team member may be designated as a 'scribe' to assist the medic they may disappear to get equipment or help with another part of the operation.

Other problems include the difficulties in writing with first aid gloves on, legibility of handwriting, there may be distractions such as an incoming helicopter, or there may be multiple casualties to assess and treat.

Another factor to consider is that although team members are trained to a high level in first aid, in general they do not get to practice first aid on a daily basis.

1.5 Research Question and Study Aims

1.5.1 Research Question

The main research question of this study is *'What is the optimal design of a Mountain Rescue Patient Assessment Smartphone Application?'* It is envisaged that an optimally designed Smartphone application will help to reduce the problems associated with recording patient assessment details. The author has developed a Smartphone application prototype as part of this study.

This study expands on research conducted as part of a Human Computer Interaction group project the author participated in, which resulted in a paper called 'The potential of using voice recognition in patient assessment documentation in Mountain Rescue' (Darcy et al. 2015).

1.5.2 Study Aims

The aims of this study were to

1. Investigate what patient assessment Smartphone applications already exist that could be of benefit to Mountain Rescue teams.
2. Evaluate similar patient assessment Smartphone applications.
3. Determine which patient assessment details are already recorded by Mountain Rescue teams.
4. Determine what is the pertinent information required for patient handovers to paramedics.
5. Determine what is the pertinent information required for MRI for legal and statistical purposes.
6. Determine what is the pertinent information required to be stored in a patient assessment tool for decision making and record keeping.
7. Evaluate if implementing a patient assessment Smartphone application can assist in treating patients.
8. Evaluate if implementing a patient assessment Smartphone application can assist in data transfer, collection and storage.
9. Investigate what functionality would support the user of the Smartphone application.
10. Investigate if voice recognition could be successfully used as part of the application functionality in particular.
11. Investigate how to optimally design the Smartphone application to be used in conditions that Mountain Rescuers work in.

1.5.3 Proposed Smartphone App Functionality

Before research was carried out for this project the following functionality was proposed for a patient assessment Smartphone application.

- Prompt user to carry out assessments
    - Situation Report, ABC, Sample History, Vital Signs, Pain Scale
- Record
    - Voice and convert to notes
    - Diagnosis, Treatment
    - Location and Weather
    - Medication given and equipment used
- Alert
    - Monitor changes in patient's condition
- Transfer data
    - Send info to Mountain Rescue base and paramedics
- Display
    - Trendlines
    - Patient summary data

1.5.4 Expected Benefits

It is expected that the author's Smartphone application prototype app will record patient assessment details fully and comprehensively. It is anticipated that the data will be sent onto the Mountain Rescue base and that the data will assist the incident commander in making decisions such as what equipment to send to the scene, what evacuation method is required and what medication to use.

Ideally the application will establish baselines and trends for the patient's condition which will be beneficial to the paramedic during handover.

1.6 Overview of the Research

The first part of the research was to conduct a literature review to find out if similar projects have been conducted in the area of Smartphone applications used in patient assessment in Mountain Rescue. The literature review provides background information on Smartphone technology and pre-hospital care. An investigation was carried out to determine what applications are currently used by Mountain Rescue teams and to ascertain what patient assessment or first aid applications are openly available to the public.

Interviews were conducted with paramedics to ascertain the level of detail that would assist them during patient handovers from Mountain Rescue teams and to ascertain the pertinent information required for callouts, legal and statistical purposes.

As part of the research a survey was sent out to MR team members asking them to evaluate an existing patient assessment Smartphone application.

The author used the findings from the research to optimally develop a prototype application that could support the patient assessment process in Mountain Rescue. Rescue team members were asked to provide feedback following use of the prototype app by answering a short questionnaire.

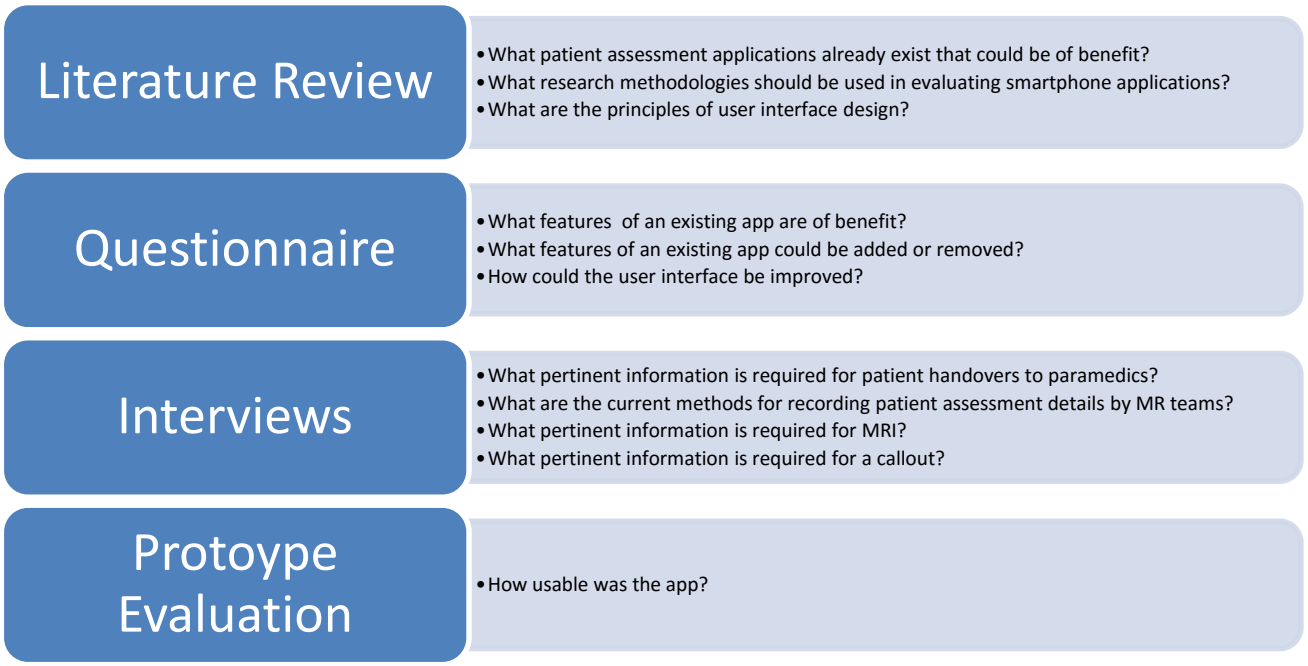


Figure 1-5 Research plan summary

1.7 Overview of the Dissertation

This dissertation is split into six chapters, with several appendices at the end of the document. Figure 1-6 provides a pictorial view of the work done to complete this thesis.

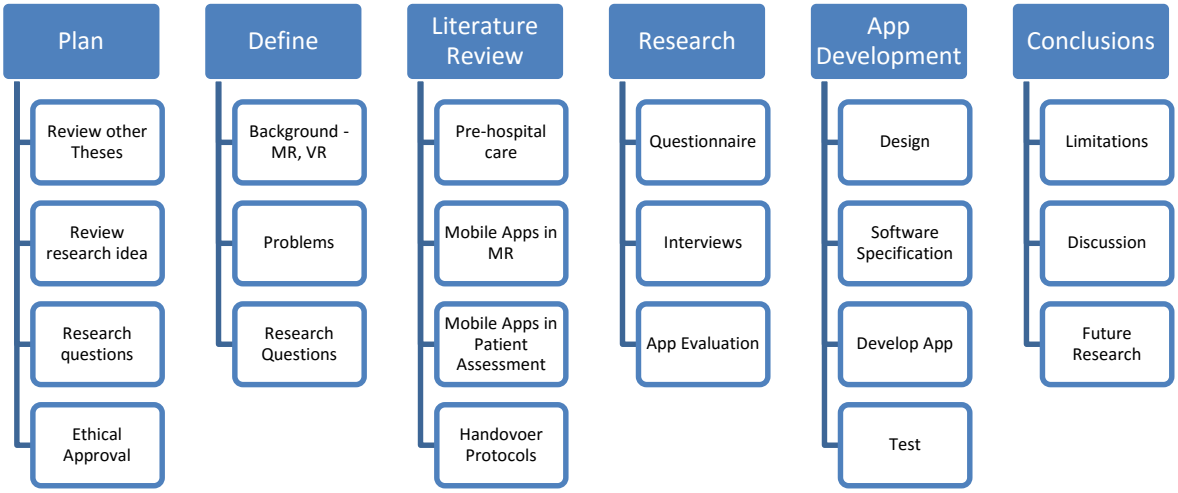


Figure 1-6 Dissertation work breakdown structure

The initial chapter of the dissertation provides background information on Mountain Rescue and First Aid standards in Ireland, introduces the problems posed in patient assessment in Mountain Rescue and identifies the research question and the study aims.

The second chapter is a literature review of mobile technology, software as a medical device, and pre-hospital care guidelines, and details are provided on relevant Smartphone applications that are used in First Aid and Mountain Rescue, and handover protocols.

Chapter 3 explains the research methods used in three studies undertaken as part of this thesis, a questionnaire based on the evaluation of a pre-existing patient assessment app, interviews of healthcare professionals involved in Mountain Rescue and a final short questionnaire based on the evaluation of a prototype app developed as part of the thesis work. Chapter 4 documents the analysis of the results found from the various research studies.

Chapter 5 explains how a prototype app was developed based on information obtained from the literature review and from the analysis of the research studies. Details are also provided on the architecture of the prototype and how it was developed. The final chapter concludes by detailing the strengths and limitations of the overall study, recommendations for future research and the author's reflections on the study.

Chapter 2 State of the Art

2.1 Introduction

This chapter starts with the search strategies used to find information on the current state of the art in the area of patient assessment Smartphone applications in Mountain Rescue. The current growth of mobile technologies and the European Union (EU) legislation on software applications as medical devices are explored. The current best practice guidelines in practising first aid are given, followed by Smartphone applications that are used in first aid or in Mountain Rescue. The chapter concludes noting that there are very few papers in the selected research area.

2.2 Search Strategy

To provide background information on mobile technology, news reports, papers, websites and ComReg quarterly papers were used to find relevant details. To find out the current legal situation in relation to software as a medical device the EU guidelines and directives were consulted. The books 'Wilderness Medicine' and 'Casualty Care in Mountain Rescue' were referred to extensively to provide information on pre-hospital care. The author planned to develop an application to work on Android Smartphones so when searching for current first aid and Mountain Rescue applications, only Android applications were considered, and these were found on the Google App Store website.

The author tried to find papers on voice recognition in Mountain Rescue, rescue services and in patient assessment but found very few relevant papers.

Table 2-1 Phrases used in searching for literature

Search term	**Stella (Trinity College Dublin Library Search Engine)**
'voice recognition' AND' 'Mountain Rescue'	Nothing relevant
'speech recognition' AND' 'Mountain Rescue'	Nothing relevant
'voice recognition' AND 'rescue services'	Nothing relevant
'voice recognition' AND 'patient assessment'	Nothing relevant
'voice recognition' AND 'emergency services'	Through walls communication for medical emergency services
'smartphone application' AND 'patient assessment'	Nothing relevant
'Mountain Rescue'	Satellite-Based Technologies in Use for Extreme Nocturnal Mountain Rescue Operations: Several books titled 'Mountain Rescue'

2.3 Mobile Technology

Motorola were the first in the world to demonstrate a portable cellular system and phone prototype in 1973, but it took a further 10 years before they got approval to release the world's first handheld cell phone, the DynaTAC 8000X in September 1983 (Motorola Solutions 2015). By 2005, ComReg in Ireland reported that the number of mobile phones in Ireland had exceeded the current population (RTE News 2005).

The primary uses of mobile phones were initially to make and receive phone calls, and to send text messages. However, ComReg (Commission for Communications Regulation) in Ireland report that although Irish people sent nearly 1.5 billion texts in Q1 in 2016 this is approximately a 14% decrease on the same quarter in the previous year as seen in Figure 2-1. In fact, data usage volumes (internet uploads and downloads) have risen drastically by nearly 60% (Commission for Communications Regulation 2016). This highlights the shift in usage of mobile phones from sending text messages to internet usage.

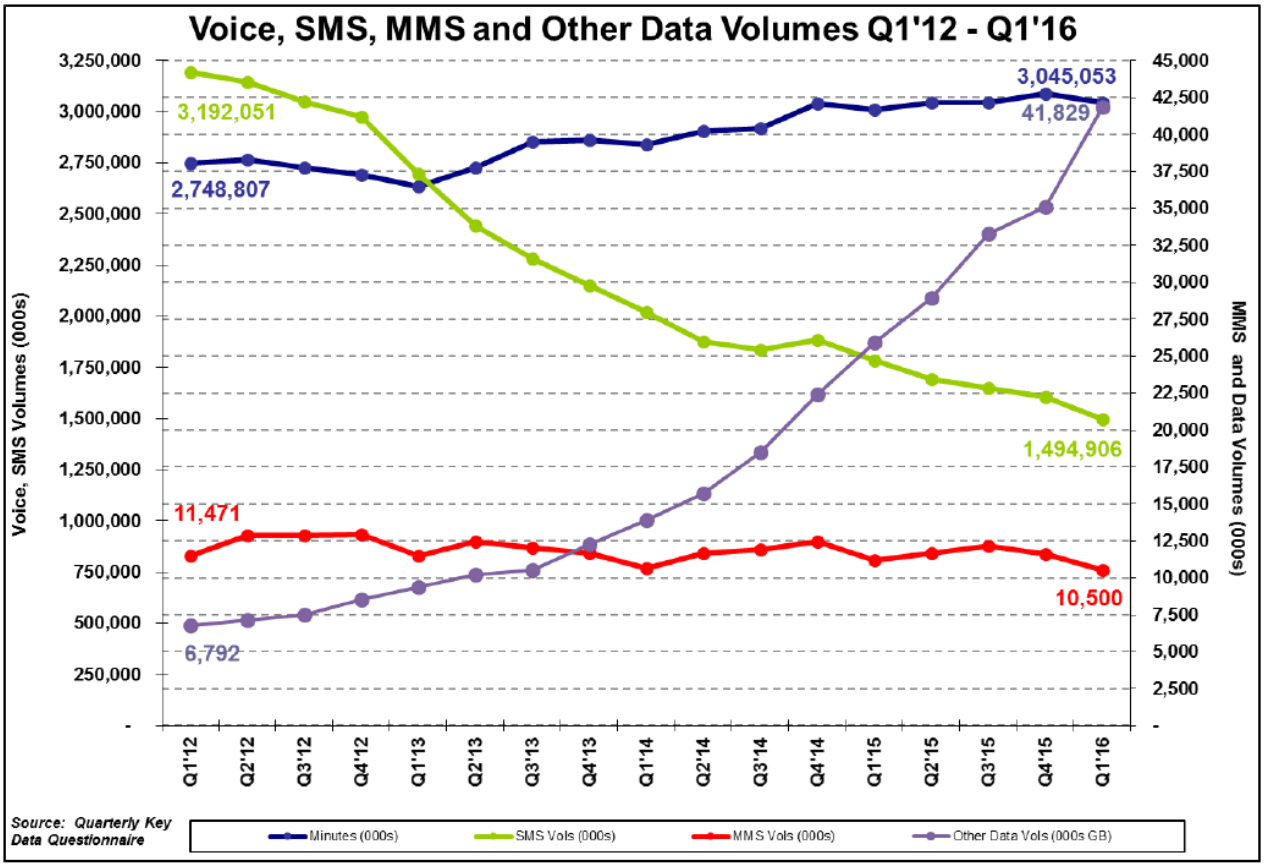


Figure 2-1 Mobile Volumes (Commission for Communications Regulation 2016)

According to research conducted by StatCounter, a company that specialises in website visitor analysis, one third of web access in Ireland is from mobile devices and there is a decrease in usage of Personal Computers (PCs) to access the internet from 77% to 56% in the last two years (Weckler 2015). This highlights the shift in using PCs to mobile devices for accessing the internet.

Mobile phones have evolved to Smartphones that incorporate multiple functions and can now be used to access the internet, as a games console, as a camera or video camera, navigate using the internal GPS, and watch videos or TV (Watts 2012). There is no longer a need to purchase a separate camera, GPS device, or music player as all the functionality can be found within a Smartphone.

2.4 Software as a Medical Device

The European Commission have published a series of guidelines to help answer questions on the application of EU legislation to medical devices. The guidelines document MEDDEV 2.1/6 refers specifically to the qualification and classification of stand-alone software, which is software not deemed to be integrated into a medical device.

A medical device is considered to be an '*instrument, apparatus, appliance, software of other article, whether used alone or in combination, including the software intended by its manufacturer to be used specifically for diagnostics and or therapeutic purposes*' (European Commission 2012).

If stand-alone software is considered to be a medical device under the guidelines, then rules of the medical device directives may apply and the software will have to carry the CE marking. However, software that is used for storing patient results that are transferred to healthcare providers is not deemed a medical device.

Referring to Figure 2-3, the developed prototype Smartphone application does not fall under the classification of a medical device as it will be used to store and communicate data but it will not be used to specifically provide benefit to patients.

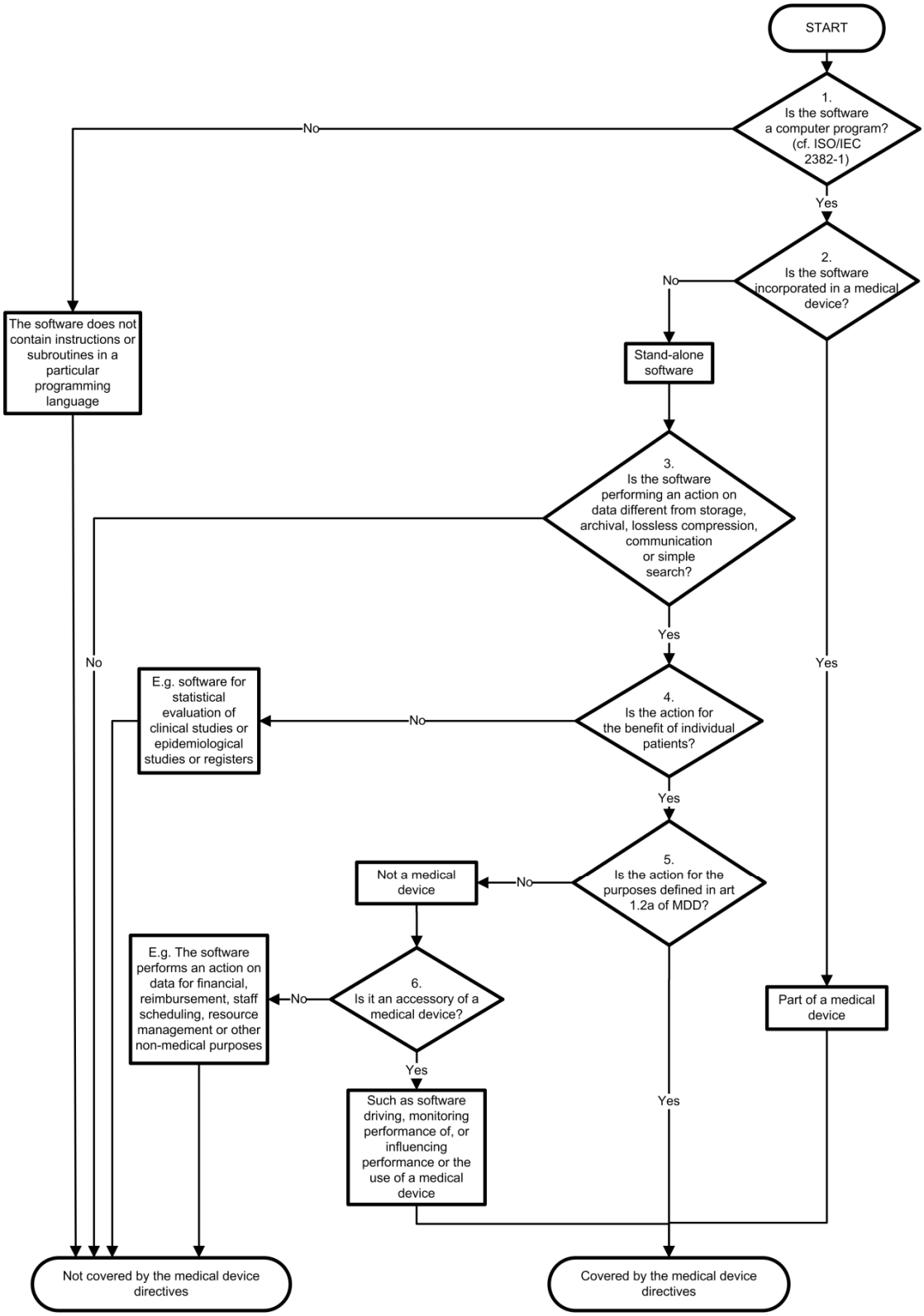


Figure 2-2 Software as a medical device decision tree (European Commission 2012)

2.5 Pre-hospital care

2.5.1 PHECC Clinical Guidelines

The PHECC Clinical Guidelines refer to care principles that when implemented should reduce risk and help to avoid errors in treating patients. The care principles are to ensure that the scene is safe and that adequate standard infection controls are implemented (e.g. wear gloves), identify number of patients and condition of patients and call 999/112 with a situation report, ensure patients have adequate ABCs (Airway, Breathing and Circulation), control external bleeding, record vital signs and manage conditions. The other care principles include ensuring that the patient is in the most comfortable position or posture, that the patient is kept warm, and to provide reassurance to the patient (PHECC 2012). Ideally details should be recorded on an Ambulatory Care Report (ACR) or on a Patient Care Report (PCR).

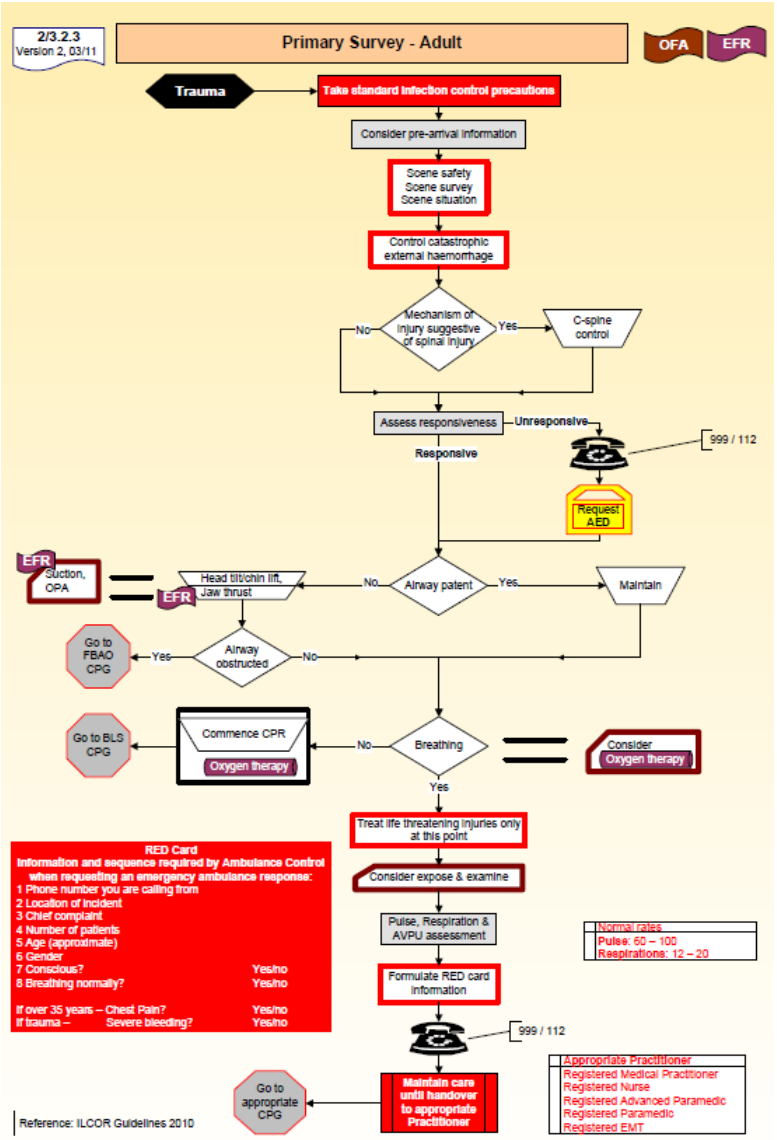


Figure 2-3 PHECC Primary Survey (PHECC 2012)

The care principles focus on what happens if there is nearby help, but not on what happens if there is a delay in transferring the patient to an advanced practitioner such as in a Mountain Rescue callout situation.

2.5.2 First aid in Mountain Rescue

A term used frequently in first aid in Mountain Rescue is 'scene safe, gloves on'. It is important that the rescuer assesses the situation before they approach a patient as they need to be aware of potential dangers to their own life such as rock fall, avalanche or cliff edge risks. (Schimelpfenig 2012) also recommends that the rescuer should only enter the scene if they consider it safe to, and when entering the scene, they should try to determine the mechanism of injury (MOI) e.g. has the patient fallen from a height, and the rescuer should protect against infection by implementing body substance isolation (BOI) precautions. All rescuers are required to wear medical gloves when touching a patient for medical assessment.

They are multiple acronyms used within first aid. These are used as prompts to remind rescuers what steps to follow in a logical order. The following text refers to variations of DR. ABCDEF which can refer to Danger, Response, Airway, Breathing, Circulation, Deformity, Exposure, and Fractures.

If the patient is conscious, verbal consent should be asked for before treating a patient. If the patient is unresponsive the rescuer should try to wake up the patient by talking to them or by looking for a pain reaction (Ellerton 2006). The next steps followed are to start the 'primary survey' or 'initial assessment' and to check for the ABCs (Airway, Breathing and Circulation). If the casualty's airway is blocked the obstruction should be removed taking spinal precautions if a cervical spine injury is suspected, if there is no breathing basic life support should be started, and if there is external bleeding this should be stopped by applying direct pressure with dressings to the wound (Ellerton 2006). Once the basic ABCs are confirmed to be stable, then the rescuer continues to check for disability or deformities such as obvious broken bones.

In a Mountain Rescue situation patients are treated for what are known as the three hypos – hypo-hydration, hypoglycaemia, and hypothermia. The patient should be protected from 'E' the environment by placing a mat under the patient, opening up a storm shelter (bothy/ bivvy) over the patient and rescuers, changing the patient's clothes if wet or putting more clothes onto the patient, and providing food and hot drinks if appropriate. 'E' also stands for Expose and Examine, and the rescuer should check inside clothes for blood loss or abnormalities.

The next stage is to carry out a more focused exam or 'secondary survey'. At this stage it may be worthwhile considering moving the patient to a safer or easier location to work in. A full examination

is carried out where the medic's senses such as look, feel, smell and listen are used to systematically check from head to toe. If the patient is alert then the patient is asked to the let the rescuer know if they experience any pain during the examination, and if the patient is unconscious the rescuer looks out for reactions to pain. Vital signs are then measured to record level of responsiveness AVPU (Alert, Verbal, Pain Responsive, Unresponsive), heart rate, skin colour, temperature, respiration rate and pupils (Schimelpfenig 2012). The initial set of readings can be used as a baseline and they can highlight problems for example shock. If the patient has a chief complaint or they notice pain during the examination the acronym OPQRST is used to learn more about the pain, O – onset, P – provokes, Q – quality, R – radiates/ region/ referred, S – severity, T- time/ trend (Schimelpfenig 2012).

A SAMPLE history should also be carried out to find out more about what happened before and during the event that led up to the incident, and to ascertain other factors that may affect the treatment and care of the patient. The chief S - symptoms are already established from examining the patient, so then the rescuer finds out about A – allergies, M – medications, P – past medical history from, L – last intake and E – the event leading up to the incident from talking to the patient if possible. If the patient is unconscious the rescuer will check for a medical bracelet in the hope to find out more information, or if other people are at the scene ask them for more details.

Ideally a second person will be on scene to write down the observations and details when the medic is assessing and treating the patient. The notes will also contain an assessment of the patient and any interventions made such as splinting the leg or administrating oxygen. Some Mountain Rescue teams use the PHECC PCR to record the details on. One copy is given to the HSE paramedic during handover and the carbon copy is kept for Mountain Rescue team records. However, the PCR is a very large paper document that can be difficult to write on especially in the dark or in adverse weather conditions.

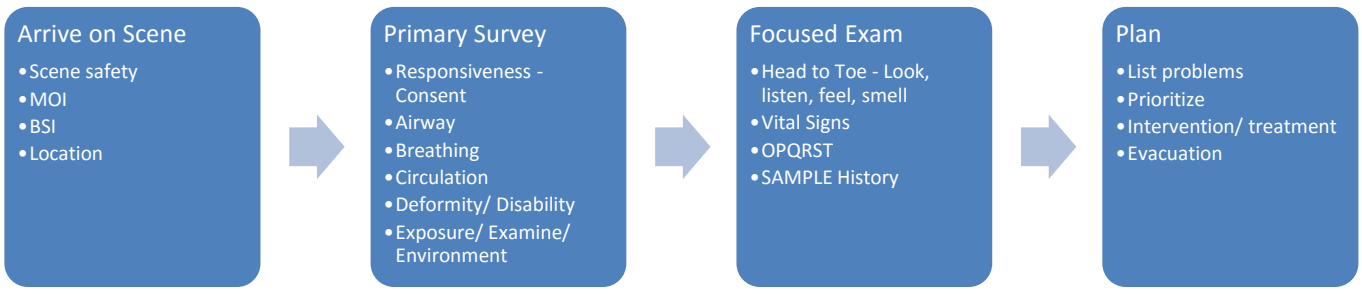


Figure 2-4 Summary of steps taken in assessing and treating a patient in Mountain Rescue

2.6 First Aid Apps

The below Table 2-2 lists commonly used Smartphone applications used for first aid training and education.

Table 2-2 First aid and PHECC Smartphone applications

Search term	Name	Purpose
First Aid	St John Ambulance First Aid	This app lists various conditions and gives details on how to provide first aid for both adult and children. (St John Ambulance 2015)
	First Aid by Irish Red Cross	This first aid app provides information on approximately 20 common first aid scenarios from allergic reactions to meningitis to unconscious not breathing. The app aims to teach users what to do in case of an emergency and some simple tests are included to test the user's knowledge. (Irish Red Cross 2015)
	RCSI MyHealth	This app lists various health conditions and illnesses and gives details on sign and symptoms, preventive measures and general advice on how to treat the conditions. Contact details are listed for all hospitals in Ireland, and for various emergency and support services in Ireland. (RCSI 2015)
	WebMD for Android	This is an American app which lists conditions and symptoms, drugs and treatments and general first aid information. Users can also use the app to scan their pill bottle which creates a repeat prescription which is sent to Walgreens. (WebMD 2015)
	iTriage	This app is similar to WebMD but also allows users to search for conditions and symptoms using speech recognition. The user can also store their own personal medical data. (iTriage 2015)
PHECC	PHECC Field Guide	This app is specifically aimed at Emergency Medical Services and provides detailed medical information and assists trained workers to calculate medical dosages. (Pre-Hospital Emergency Care Council 2011)
	PHECC Responder Alert	This app allows registered users to record when a responder has attended an incident for record purposes. (Pre-Hospital Emergency Care Council 2012)

The below Table 2-3 lists applications used for patient handover, measuring vital signs and recording patient assessment details.

Table 2-3 Patient handover and patient assessment applications

Search term	Name	Purpose
Patient handover	ISBAR Patient Handover	This is used within hospitals to do handovers for multiple patients. (Ranesys 2015)
Patient Assessment	SOAP Note	This app was produced for the Wilderness Medicine Institute, National Outdoors Leadership School (NOLS). The purpose of the app is to record patient details in wilderness settings. (National Outdoor Leadership School 2015)
	Patient Tracker	
	Notes & Orders: Medical Tool	
	iMedDoc EMR	
Vital Signs	iCare Health Monitor	This app uses the camera on the phone to measure and record blood oxygen levels, blood viscosity, heart rate and blood pressure. By blowing on the phone's microphone, lung capacity can also be measure. No external devices are required to do the measurements. (iCareFit Studio 2015)
	Medrills: Vital Signs and Monitoring Devices	How to assess vital signs are taught using this app. Medrills provide a series of training apps in instructing users in first aid and in more advanced paramedic skills. (Medrills 2015)

2.6.1 NOLS SOAP Notes

Whilst investigating the current state of the art first aid Smartphone applications, the application 'NOLS SOAP Notes' was found, and this application meets many of the desired functional requirements for a patient assessment Smartphone application to be used in Mountain Rescue. The SOAP (Subjective, Objective, Assessment and Plan) Notes is provided free of charge, by the US National Outdoor Leadership School (NOLS), the same training institute that published the book 'Wilderness Medicine' which is a reference book for the REC and WEMSI courses. Sample screenshots from the application are shown in Table 2-4 and Table 2-5.

Table 2-4 SOAP Notes sample screenshots - Subjective details

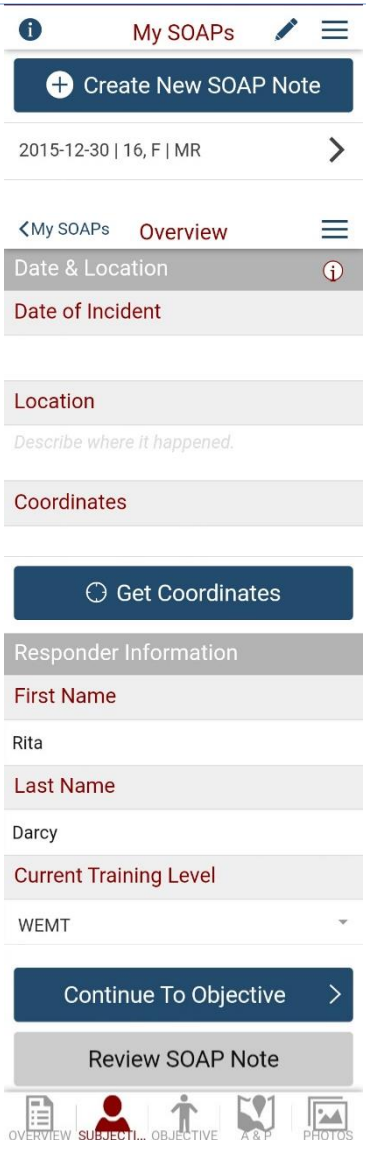
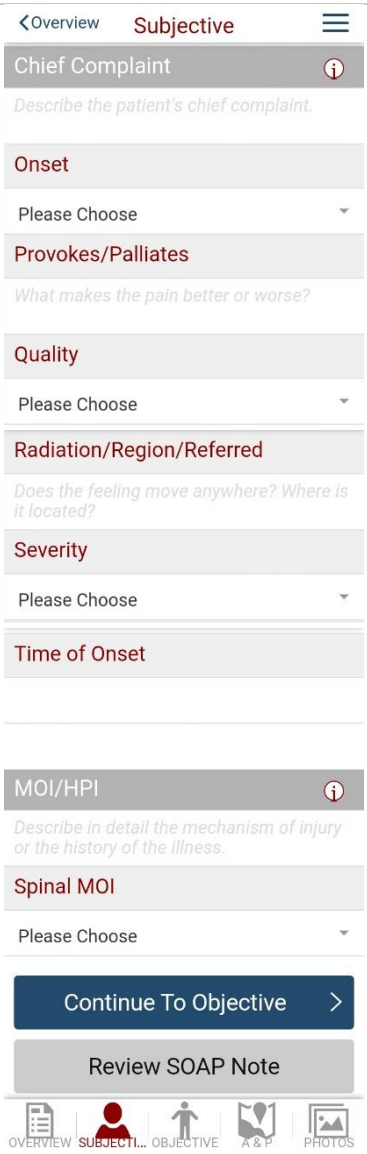
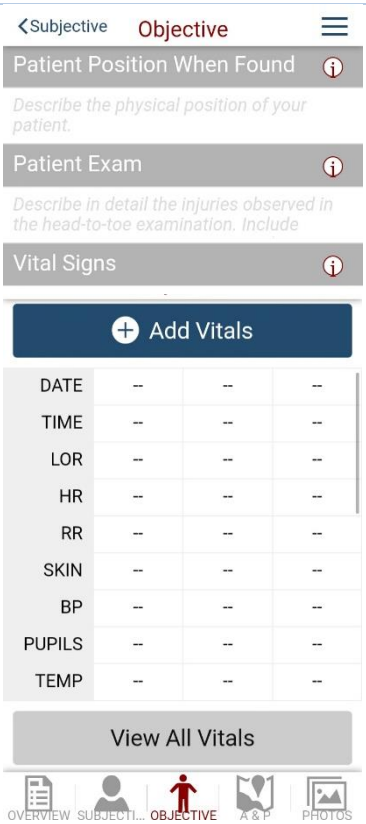
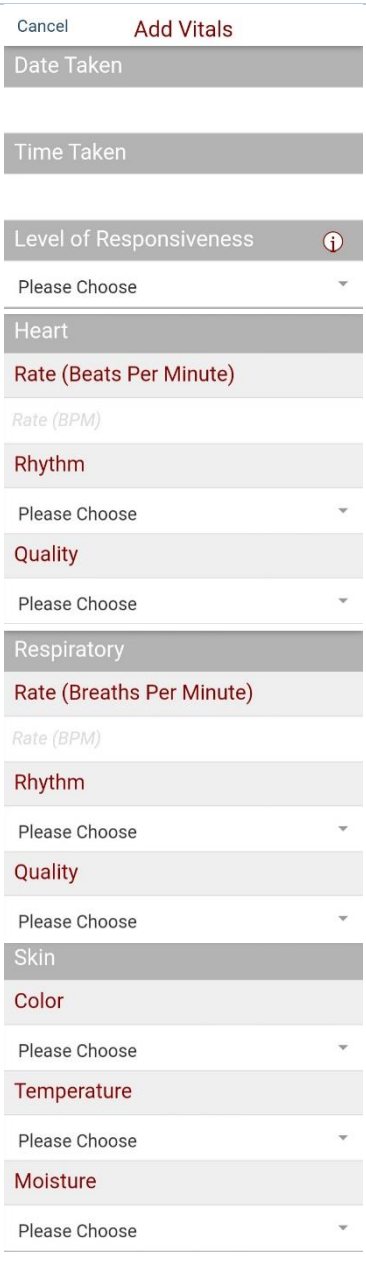
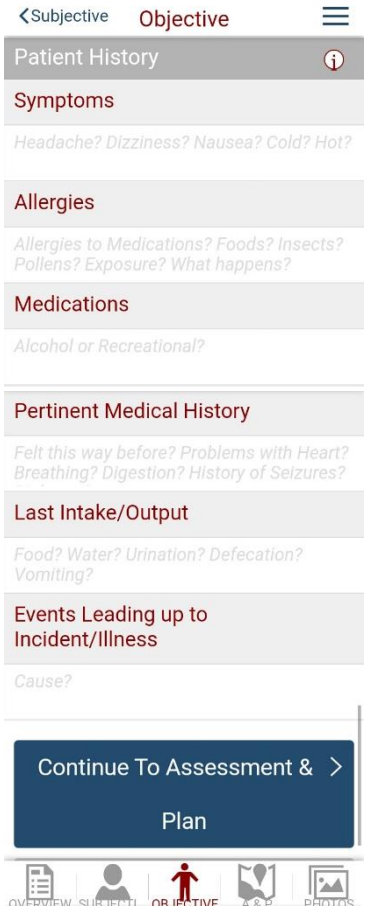
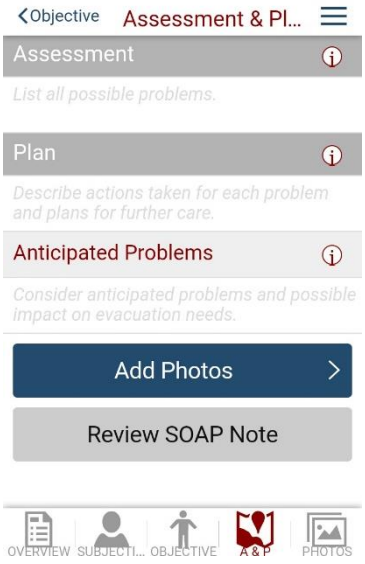
New SOAP Note	Overview	Subjective
		

Table 2-5 SOAP Notes - Objective details and Sample history

Objective	Vitals	SAMPLE
		

2.7 Apps used in Mountain Rescue

The majority of rescue team members use Smartphones. Listed below in Table 2-6 are commonly used Smartphone applications that are used by some or all rescue team members that have Smartphones (Darcy & Mounsley 2015).

Table 2-6 Smartphone applications used by Mountain Rescue team members in Ireland

Purpose	Application	Details
Communication	WhatsApp	WhatsApp is a messaging app that allows messages to be sent to one or more people in a group. Text, images, video and sound recordings can be shared. There is an initial cost of 89 cents per year, but after that the cost of sending messages is free if the user is using free Wifi. The Dublin & Wicklow Mountain Rescue Team use the app for finding out availability to callouts and for organising training events, and for general group information purposes.
	Fire Alert 2	This app allows users to set a unique sound, screen display and vibration pattern for when a certain text e.g. 'callout' is received in a text message. The app can override the silent mode on the phone and it can convert texts to voice which is useful for when team members are driving to callouts.
Navigation	ViewRanger	ViewRanger is a freely available GPS app, but users can pay extra for more details maps. The app shows current location on a map and allows for plotting way points. Users can also share their location with other users using the Buddy Beacon functionality.
Ropework	CMC Rescue Field Guide	This is a mobile version of the paper-back book and provides information on how to set up ropes safely for rescue situations.
Search	Lost Person Behaviour	This a mobile version of the paper-back book and provides details on where to find casualties depending on the incident type, age of the casualty and mental state of the casualty. The information is based on research conducted in the US.
	Send my Position	This app picks up the current user's co-ordinates and the user can send the position details to another person using any other messaging app such as gmail, WhatsApp, Facebook messenger.
	Journal.ie	The Journal.ie is provides news reports on missing persons.
Weather	Met Eireann	This app provides local and national weather forecasts, including rain radar readings.
	YR - Norwegian site	This is a popular app for weather forecasts as it provides local forecasts, and a graph of the weather for the upcoming days.
	Windy Ty	This app gives a visual representation of current and expected wind and rain.

2.8 Handover Protocols

In general, if a patient is treated by Mountain Rescue personnel they are handed over to an awaiting HSE or ICG paramedic. This handover usually takes about 1 minute to conduct.

'Clinical handover refers to the transfer of information from one health care provider to another when either a patient has a change of location of care, and/ or when the care of or responsibility for that patient shifts from one provider to another.' (PHECC 2016)

The Ambulance Service in New South Wales in Sydney, Australia devised a standardized protocol for the communication of information during an ambulance to Emergency Department handover, called the IMIST-AMBO protocol following a 'video reflexive ethnography study' (Iedema et al. 2012). This protocol is now being used in Ireland by pre-hospital emergency care clinicians and emergency department nurses and doctors (PHECC 2016).

The handover process involves active listening. Using the protocol, the paramedic uses a structured approach for communicating pertinent information, and the Emergency Department staff know what to expect when receiving the message – specific patient details in a specific order.

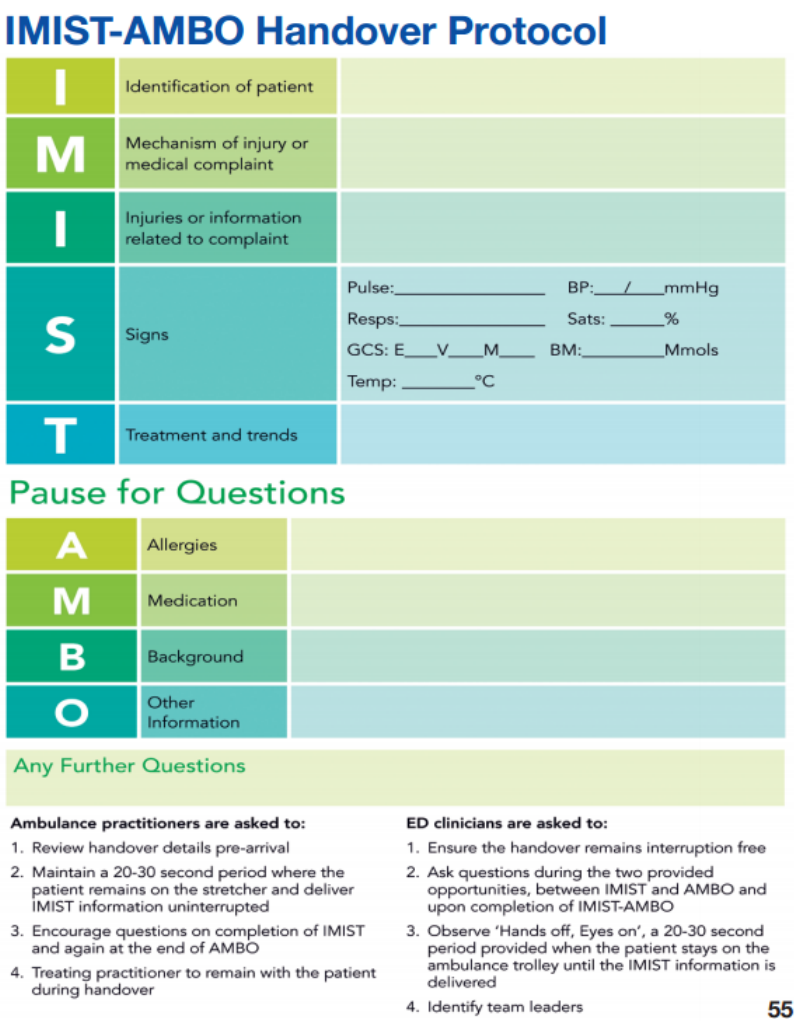


Figure 2-5 IMIST AMBO protocol

2.9 Conclusion

There are limited papers published in the area of patient assessment, Smartphone applications and voice recognition in Mountain Rescue. However, there are clear guidelines on how a patient assessment should be conducted, what data should be recorded and how the data should be communicated during a handover.

After extensive research only one Smartphone application was found that has similar functionality to the proposed prototype, the NOLS SOAP Notes app. This highlights that this study is in a relatively unique research area.

Chapter 3 Research Methodology

3.1 Introduction

Three research studies were conducted as part of this dissertation as per Figure 3-1. The first study was the creation of an online questionnaire, that asked DWMRT team members to review the previously discovered NOLS SOAP Note app. The purpose of this questionnaire was to find out what functionality was required, and what functionality could be better designed when developing a new improved patient assessment app.

To find out what data should be recorded in a patient assessment app, interviews were conducted with DWMRT team members who also work professionally in healthcare. After reviewing the feedback from the questionnaire and interviews, a prototype app was developed and DWMRT team members were asked again to provide feedback using a simple online questionnaire.

Ethical approval was sought from the Trinity College Dublin Research Ethics Committee to proceed with all three studies.

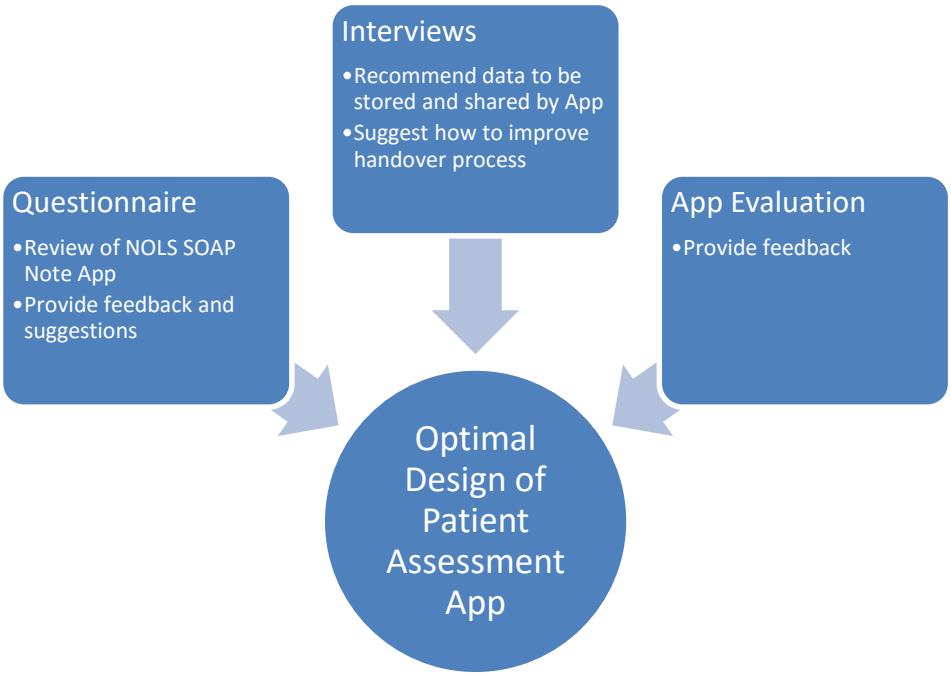


Figure 3-1 Overview of Research Methodology

3.2 Study Group

The group that were asked to participate in the various studies were team members of the Dublin & Wicklow Mountain Rescue team. It is a requirement of the team that members are a minimum of 21 years of age and are either employed or self-employed when joining. All full team members are proficient in First Aid and hold a minimum qualification of REC Level 3. All full team members own a Smartphone and they receive callout information by both texts and WhatsApp messages. There are approximately 40 full team members at any one time on the team.

New recruits are called probationary team members and in general have both mountaineering and first aid experience. It takes approximately 1 year to become a full team member following successfully passing navigation, rope-work, first aid, and hill skills assessments.

Associate team members are previous full team members, who have stepped down from being a full team member but who occasionally assist the team when major incidents occur. They may attend team training sessions and are still required to keep up their first aid qualifications.

The participants selected are therefor from a known population. See Appendix D Ethical Approval for the questionnaires and interview questions used as part of the research.

3.3 Questionnaire Method

Innovation is not necessarily the creation of a brand new product, in most cases it is done ‘ as the incremental enhancement of existing products’ (Norman 2013). As part of the Literature Review, the NOLS SOAP Note App was discovered on the Google Store, which allows a user to record patient assessment details using a set of checklists or forms. An online questionnaire was devised to ascertain participants’ feedback after using the SOAP Note app, to aid in designing the prototype app.

The participants were asked to create a ‘Note’ (fill in a set of patient assessment details) using the app, to send an email from the app after they had fully entered in the ‘Note’, and to then fill in the questionnaire. An analysis was carried out on the emails sent by the participants, to evaluate how much functionality the participant actually used.

There was a mix of open and closed questions in the questionnaire so the survey was both quantitative and qualitative in nature. The questionnaire was created using Qualtrics, an online survey software tool, freely available to current Trinity College Dublin students. The opening page contained an information sheet and informed participants of the purpose of the study. The initial question in the questionnaire required the participant to confirm if they had read the informed consent form and that they agreed to participate in the study. If participants selected not to consent, the survey ended. Other than the first question, none of the questions were mandatory. The participants were also given the option of not participating in the study after completing the last question.

The questionnaire link was sent to the secretary of the Dublin & Wicklow Mountain Rescue Team and he sent an email to all team members requesting them to participate in the questionnaire study. The link to the survey was also posted on the team's internal forum website.

The questionnaire was broken down into six sections:

1. Background
2. Smartphones
3. System Usability Scale
4. App Evaluation
5. App Functionality
6. Patient Assessment App

3.3.1 Background

The participants were asked how many years' experience they had in Mountain Rescue and First Aid, what their First Aid qualifications were and what type of team member they were.

3.3.2 Smartphone Use

The participants were asked about their experience of owning a Smartphone, what type of phone they use, what First Aid Apps they already used, if their Smartphone is waterproof, if they had used voice recognition beforehand and if they carry a Smartphone during callouts. These questions were asked to ascertain if the participant would be likely to use a Smartphone during a callout.

3.3.3 System Usability Scale

A common way of evaluating an app is to use the System Usability Scale, which is a simple list of 10 questions devised by the Digital Equipment Corporation (Brooke 1996). This tool is widely used, and the results from these set of questions were compared to the results of the prototype app evaluation.

3.3.4 App Evaluation

A series of questions were devised based on design principles. According to Norman, 'good design takes care, planning, thought, and an understanding of how people behave' (Norman 2013).

Preece et al. (2015) describe a product with good interaction design as 'easy to learn, effective to use and providing an enjoyable user experience'. The overall experience, ranging from positive to negative, of using a product may determine if the user will use the product again. Participants were asked to report on their overall experience of using the application ranging from 'Terrible' to 'Delightful'.

Preece et al. (2015) define the goals of usability as 'effective to use, efficient to use, safe to use, having good utility, easy to learn, easy to remember how to use'. A few of the questions directly pertain to usability and ask would you use the app, who would you recommend to use the app and when should the app be used.

In the book 'The Design of Everyday Things' Donald Norman (2013) proposes seven principles of design; discoverability, feedback, conceptual model, affordances, signifiers, mappings, and constraints all of which contribute to the overall experience of using a product.

Discoverability refers to being able to find out what a product can do, and how it works and functions (Norman 2013). A product that is well designed allows the user to figure out for themselves the functionality of the product without having to refer to a manual or a training guide. A few of the questions refer to navigation and whether or not the user was able to spot the timer functionality for assistance in recording vital signs.

Feedback is the communication of results following an action e.g. what information is returned when a button is pressed (Norman 2013). Getting a response back in a timely manner provides reassurance that the user used the product correctly. A question is asked if the app responded quickly enough.

A conceptual model is a representation of a system. The NOLS SOAP Note app is essentially a conceptual model of a patient assessment notebook with pre-printed pages for recording patient information and vital signs.

Affordance is the relationship between the properties of an object and the person using it (Norman 2013). The opening question in the questionnaire asks if the user has sent an email following using the app. The app affords the possibility of sending an email but only if the user is capable of sending an email using the standard 'Share' functionality on a Smartphone.

Norman describes a signifier as 'any perceivable indicator that communicates appropriate behavior to a person'. Signifiers are essentially clues that inform the user how to use an object such as the simple 'Push' sign on a door that signifies to a person that the door should be pushed instead of pulled. A progress bar was added into the online survey to signify or show participants their progress in answering the questionnaire. A list of symbols and their intended meanings are provided in the questionnaire to verify if the participant understood the expected behavior of the icons.

Mapping is the 'relationship between controls and their actions' (Norman 2013). An example of mapping is the steering wheel on a car, by turning the steering wheel there is a relationship to how the car moves.

Constraints or the imposing of limitations forces user behavior (Norman 2013). Within the questionnaire itself constraints are used for certain questions, only allowing the responder to move onto another related question if they have given a specified answer e.g. if the responder answers 'Yes' to the question 'Did you make any errors or mistakes filling in the SOAP Note' they move to the next question otherwise if they answer 'No' they skip the following questions until the end of the section.

Another factor that will influence a persons' decision to use a product is if they make a lot of errors using the product. They might have the tendency to blame themselves, when really it could be the result of poor design (Norman 2013). The participant was asked if they made any mistakes filling in the SOAP Note in the app, and if so what were the errors and was it possible to correct the errors.

3.3.5 App Functionality

The participants were provided with a list of the features in the SOAP Note app and were asked to determine if the features were necessary or if the features were well designed.

3.3.6 Patient Assessment App

Participants were asked in the questionnaire what features would they like to see in a newly developed app, and what factors or concerns would prevent them from using a patient assessment app during a Mountain Rescue callout.

3.4 Interview Method

A semi-structured interview was conducted with selected team members of the Dublin & Wicklow Mountain Rescue team. Those selected were those with both Mountain Rescue and professional healthcare experience. A list of questions was prepared in advance that contained both open and closed questions that allowed for both quantitative and qualitative research. See Appendix D Ethical Approval for the list of questions asked.

Participants were given an information sheet in advance, and they were asked to sign an informed consent form in advance of the interview.

The interview questions were broken down into 5 sections:

1. Background
2. Smartphone use in your role in Mountain Rescue
3. Smartphone use in your role in Healthcare
4. Mountain Rescue Callout
5. Patient Care Report Form
6. Patient Handover at a Mountain Rescue Callout

3.4.1 Background

The participants were asked simple questions about their number of years' experience in Mountain Rescue and in Healthcare. The questions were asked to ascertain their level of experience in both areas.

3.4.1 Smartphone use in your role in Mountain Rescue

The participants were questioned as to which Apps had they used beforehand in Mountain Rescue and if they carried a Smartphone during callouts. This was to understand if they already had experience in using Apps in Mountain Rescue and if they had familiarity with Apps in general.

3.4.2 Smartphone use in your role in Healthcare

The participants were questioned as to which Apps had they used beforehand in Healthcare and if they carried a Smartphone during work. This was to understand if they used a Smartphone during their working hours, as this would allow Mountain Rescue personnel send information directly to these individuals during a callout.

3.4.3 Mountain Rescue Callout

The participants were asked about the pertinent information recommended to be recorded by Mountain Rescue personnel at a callout involving a patient, how often the patient should be reassessed and what information is required for handover. The participants were also questioned on what data should be stored after a callout, and on the patient assessment process. The questions were asked to ascertain what data should be recorded in a patient assessment app.

3.4.4 Patient Care Report Form

The Patient Care Report (PCR) form (See Appendix C Patient Care Report Forms) is provided by PHECC and is used by paramedics. It also used occasionally by Mountain Rescue medics during the handover of a patient to a paramedic. The participants were asked about what they like and disliked about the form, and if it was appropriate for use in Mountain Rescue situations. The questions were asked to see if a newly developed app should record information as per the current paper PCR form.

3.4.5 Patient Handover at a Mountain Rescue Callout

The final set of questions were only asked of those participants who work as paramedics or advanced paramedics. The questions focused on what information is required for handovers and how the process could be improved by possibly using the IMIST – AMBO protocol.

3.5 App Evaluation Method

Based on the feedback and suggestions from both the questionnaire and the interview questions, and from information obtained from the Literature Review, a prototype app was developed.

Members of the Dublin & Wicklow Mountain Rescue Team were requested to test and evaluate the prototype app. After testing the newly developed app they were asked to evaluate the app using the System Usability Scale (SUS).

All the questions were closed, with participants having to select an answer ranging from 'Strongly Disagree' to 'Strongly Agree'. The quantitative questionnaire was created using Qualtrics, an online survey software tool, as used per the questionnaire study.

The SUS questionnaire was used again as it allowed for comparison of results of the NOLS SOAP Note app with the newly developed prototype app.

3.6 Ethical Considerations

The author of the dissertation is a full team member of the Dublin & Wicklow Mountain Rescue Team. The author informed participants to be full and honest when participating in the studies.

3.7 Conclusion

Developing questions about a pre-existing app provided a good framework to determine required functionality. Reviewing design principles was also beneficial in formulating relevant questions to find out the optimal design of an app.

Designing interview questions to be answered by subject matter experts was a concise way of finding out the relevant data required to be stored by an app. Using both questionnaires and interviews provided a more rounded approach to ascertaining knowledge and feedback.

Chapter 4 Analysis of Results

4.1 Introduction

An email was sent to the secretary of the Dublin & Wicklow Mountain Rescue Team following receiving ethical approval on April 13th, requesting team members to participate in the questionnaire and interview studies. Information about the research studies was given to team members at the team training weekend that ran from 15th to 17th April 2016. In total 19 questionnaires were filled in from April 20th to April 30th 2016, and 5 interviews were conducted from 19th April to 27th April 2016, two of which were conducted in person and three were conducted over the phone. Following development of a prototype app, DWMRT members were asked to test out the app and answer a short questionnaire. The results can be found in Appendix E Research Results.

An analysis is provided for each of the research studies, and the chapter concludes with lists of suggested data and functions for a patient assessment app.

4.2 NOLS SOAP Note app Email Results

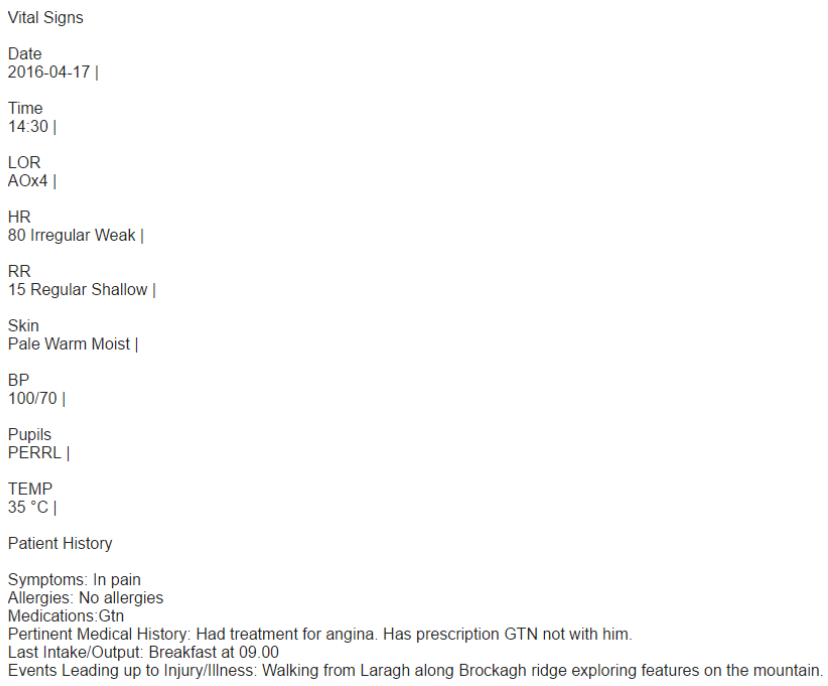
Participants were requested to create a full patient assessment report or 'Note' using the NOLS SOAP Notes app, and then to send on the report/ note to the author's email address using the app's Sharing function. The purpose of this exercise was primarily to ensure that the participant had used the functionality on all screens of the application. The participants did fill in the majority of the patient assessment note as seen in the resulting emails that were sent from the app. See Appendix E Research Results.

One participant noted that they were unable to send on the email. For an email to be sent the user must already have email software set up on their phone. Validation could be added to the app to check if email has been set up on a phone.

The emails received were in various formats. Some emails were just plain text, whilst some contained headings and formatted tables. Some of the emails contained a line at the bottom saying 'Sent from iPhone' or 'Sent from my Galaxy Smartphone'. It was found that the emails sent from an iPhone contained more formatting and were easier to read. It was not anticipated that the type of Smartphone device used would affect the formatting of the shared email. *See Figures 4-1 and 4-2.*

Some participants used acronyms such as ‘Hx’, ‘lwr’ and ‘NKDA’ or shortened words such ‘evac’ and ‘heli’ which may not be understood by the recipients of the email. If the app was being introduced to a group of first aiders it is recommended that agreed terminology is used that is understood by all users of the app and the resulting emails.

When multiple answers were given to a question a new line was created instead of the answer being concatenated. If the data from the email was being transferred to another system this could cause problems as the fields would not match up.



Vital Signs

Date
2016-04-17 |

Time
14:30 |

LOR
AOx4 |

HR
80 Irregular Weak |

RR
15 Regular Shallow |

Skin
Pale Warm Moist |

BP
100/70 |

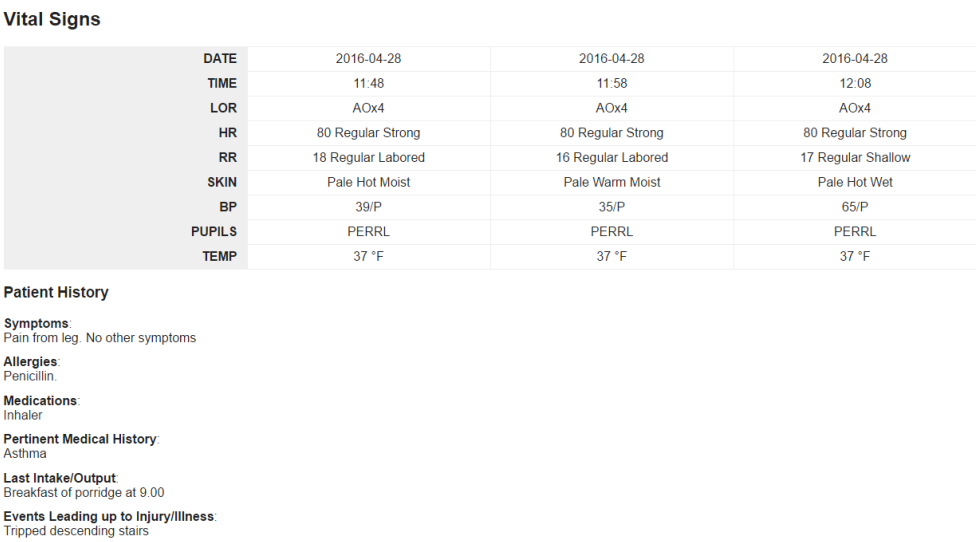
Pupils
PERRL |

TEMP
35 °C |

Patient History

Symptoms: In pain
Allergies: No allergies
Medications:Gtn
Pertinent Medical History: Had treatment for angina. Has prescription GTN not with him.
Last Intake/Output: Breakfast at 09.00
Events Leading up to Injury/Illness: Walking from Laragh along Brockagh ridge exploring features on the mountain.

Figure 4-1 Sample email from a Samsung Galaxy (Android) phone



Vital Signs

DATE	2016-04-28	2016-04-28	2016-04-28
TIME	11:48	11:58	12:08
LOR	AOx4	AOx4	AOx4
HR	80 Regular Strong	80 Regular Strong	80 Regular Strong
RR	18 Regular Labored	16 Regular Labored	17 Regular Shallow
SKIN	Pale Hot Moist	Pale Warm Moist	Pale Hot Wet
BP	39/P	35/P	65/P
PUPILS	PERRL	PERRL	PERRL
TEMP	37 °F	37 °F	37 °F

Patient History

Symptoms:
Pain from leg. No other symptoms

Allergies:
Penicillin.

Medications:
Inhaler

Pertinent Medical History:
Asthma

Last Intake/Output:
Breakfast of porridge at 9.00

Events Leading up to Injury/Illness:
Tripped descending stairs

Figure 4-2 Sample email from an iPhone

4.3 NOLS SOAP Note app Questionnaire Results

4.3.1 Method

The questionnaire was hosted online using Qualtrics software. A report was generated based on the inputted results using Reporting 2.0 on the Qualtrics website. Two reports were generated, a Word document and an Excel document. The Excel document only contained the questions asked and did not contain any data. The questions were therefore copied into an excel sheet and the answers were typed in manually to this new excel sheet by referring to the answers in the Word report. For more complex questions, the data was downloaded individually into the newly created excel sheet and graphs and table of results were created. The data export and report functions in Qualtrics were found to be very limited in functionality, and a considerable about of time was spent exporting data and reformatting it to provide useful information. *See Appendix E Research Results.*

4.3.2 Background

Participants were asked about their number of years' experience in Mountain Rescue and First Aid. This was to confirm that the participants had sufficient experience and knowledge to be able to fill in the questionnaire competently. It was found that 90% of the participants have over 5 years' experience in First Aid so the majority are knowledgeable of patient assessment (See Figure 4-3).

58% of participants hold a REC 3 qualification, and 5 participants are at PHECC EMT level or higher.

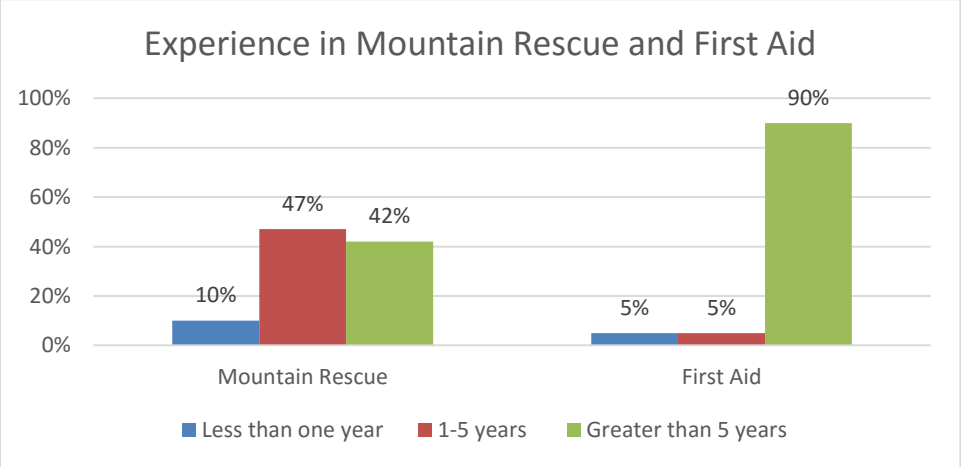


Figure 4-3 Experience in Mountain Rescue and First Aid

4.3.3 Smartphone Use

The participants were asked a series of questions in relation to personal Smartphone use. It was found that 100% of participants own a Smartphone, 53% of which are Android and 42% of which are iPhones, and one participant owns a Blackberry (See Figure 4-4). All participants carry a Smartphone during a Mountain Rescue callout, and they either have a waterproof phone or a case to protect their phone (See Figure 4-5). Some participants have used the glove mode functionality on their phone but the majority have found this functionality to be ineffective. 42% have used voice recognition beforehand using either Google Voice or Apple Siri.

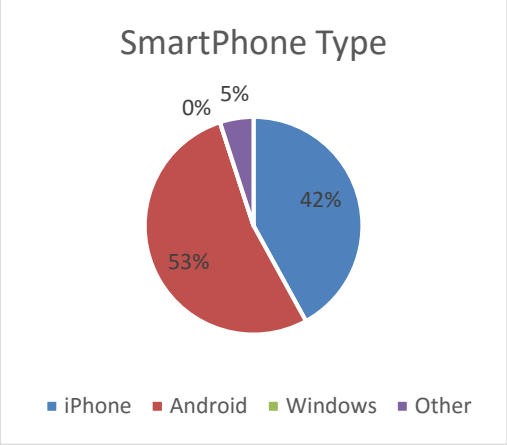


Figure 4-4 Type of Smartphone owned by team member

Although the author developed a prototype app to be used for Android Smartphones only, if the app were to be released it should also be developed to work for iPhones as well, as otherwise a huge section of potential users could not use the app.

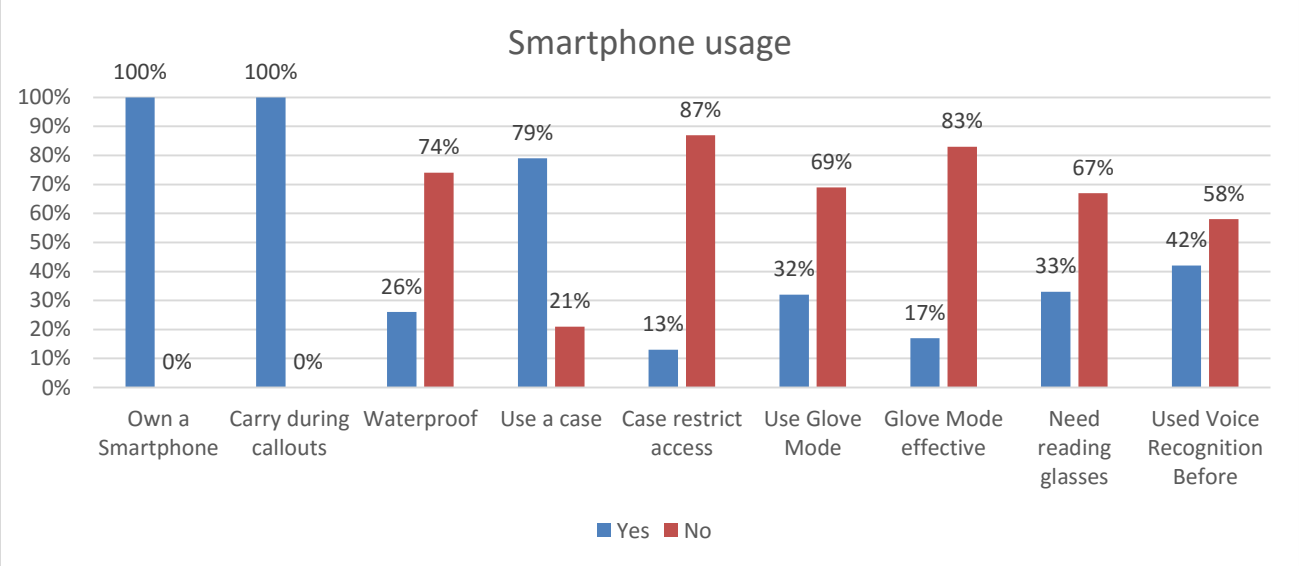


Figure 4-5 Smartphone related answers

Participants have used other first aid apps such as the PHECC Field Guide, the PHECC EFR CPG, Irish Red Cross app, Medicare and the RCSI MyHealth app.

4.3.4 System Usability Scale

Participants were asked to give their feedback on the NOLS SOAP Note app after creating a patient assessment note and sharing it by email. The System Usability Scale was used to assess the app's usability. The average result returned was 83.6 which is high as anything above 68 is considered above average (US Department of Health and Human Services 2016). The SUS overall result is displayed in Figure 4-6.

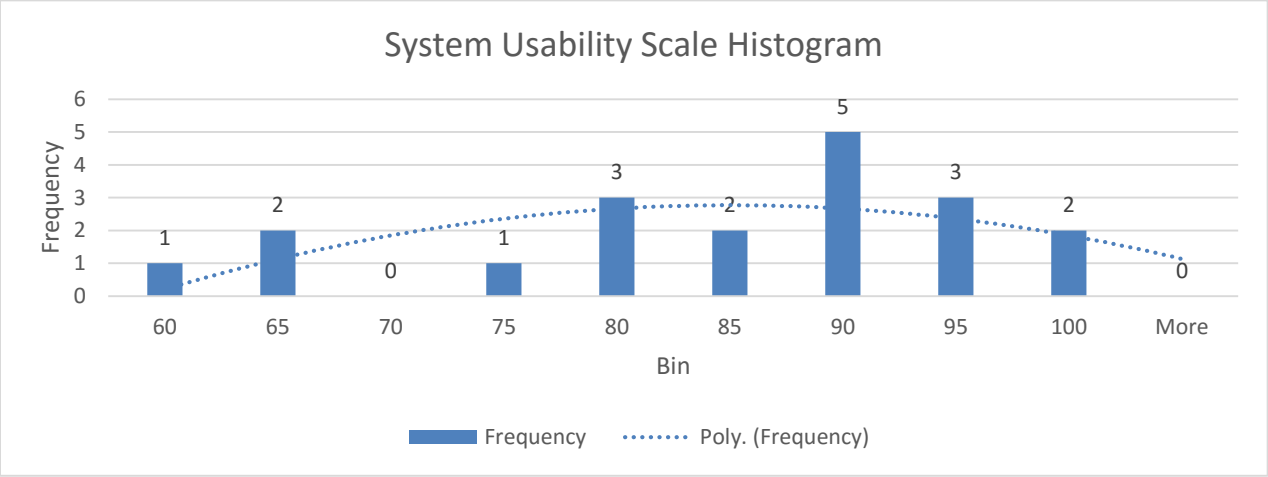


Figure 4-6 System Usability Scale Histogram

This finding was also backed up by asking participants how they described their overall experience of using the app, with the majority of users reporting that they found it 'good'. (See Figure 4-7)

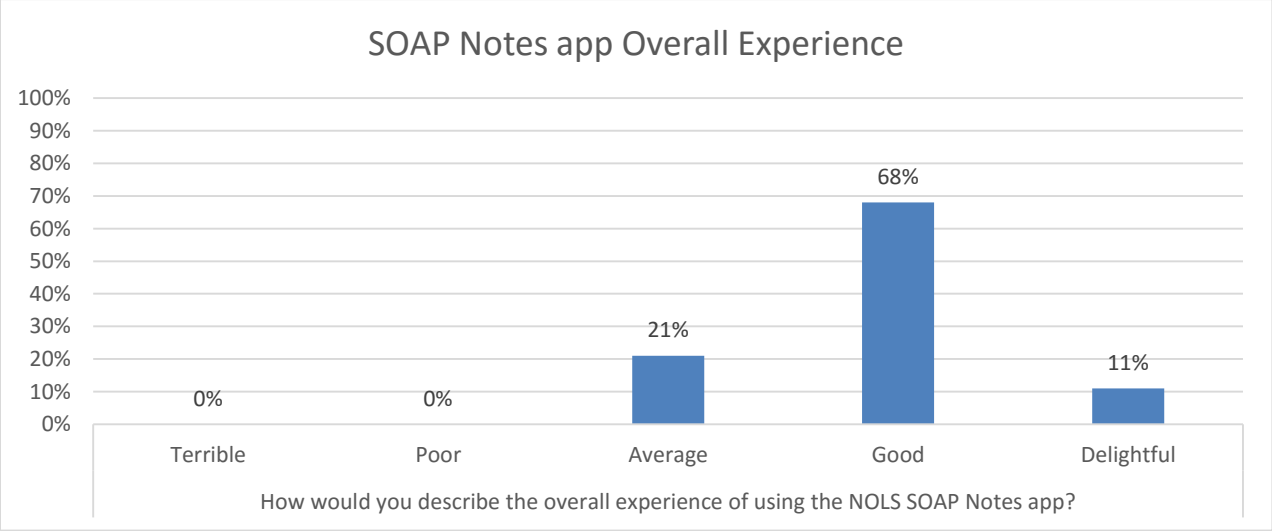


Figure 4-7 NOLS SOAP Note app Overall Experience

Overall the participants liked using the app but there is still room for improvement.

4.3.5 App Evaluation

Only 2 of the participants used the NOLS SOAP Note app previously. 74% of participants responded that they would 'Probably yes' or 'Definitely yes' use the app during training. However, only 21% of participants would 'Probably yes' use the app during an actual Mountain Rescue callout. This suggests that the app would be useful for training purposes, but that there are limitations with the app that would prevent users from using it during a callout. (See Figure 4-8)

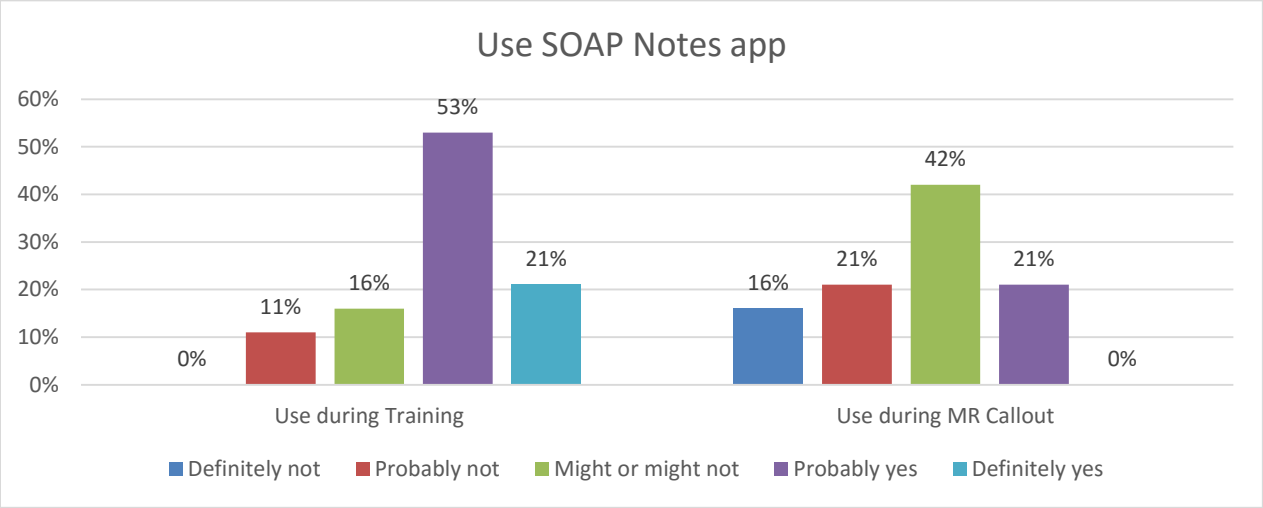


Figure 4-8 Use of app at training and at Mountain Rescue callouts

The majority of participants recommended that the Scribe should use the app (See Figure 4-9), and that it should be used either during the assessment or at intervals (See Figure 4-10).

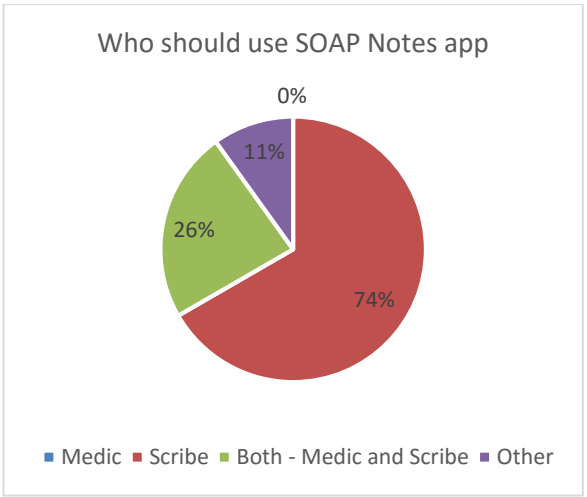


Figure 4-9 Who should use the app?

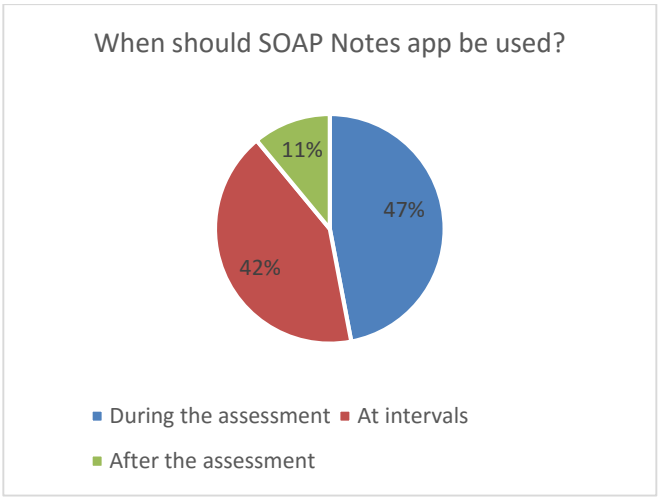


Figure 4-10 When should the app be used?

For an app or any product, it is more likely to be used if it is well designed. As previously discussed, Don Norman has suggested 7 design principles that include

- discoverability – the ability to find and follow functionality
- feedback – to receive a response
- affordances – for the product to enable the user to do something
- signifiers – to use symbols to represent items (Norman 2013)

Although participants found it easy to navigate through the pages (See Figure 4-11), 68% of them did not discover the timer functionality, 22% found it did not agree that it was easy to add in Vitals and 27% did not agree that it was easy to view that the system was in edit mode (See Figure 4-12).

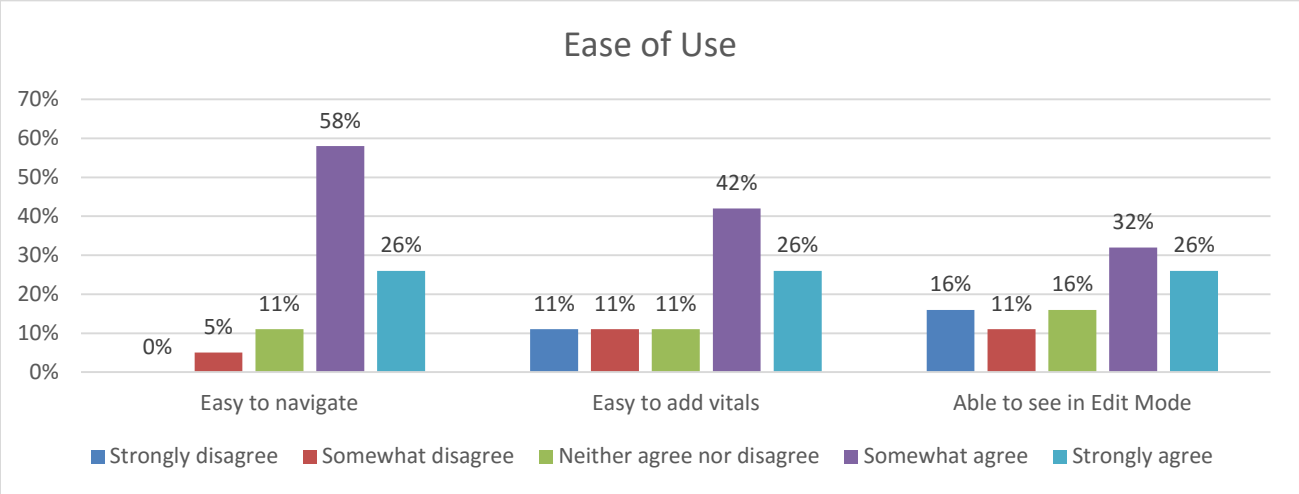


Figure 4-11 Ease of use

All participants reported that the app responded quickly so feedback was good (See Figure 4-12).

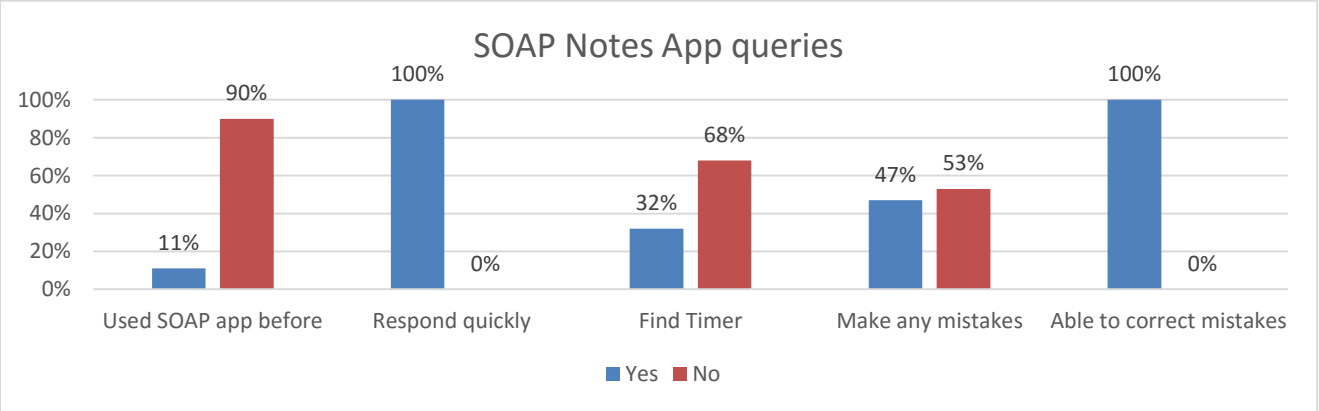


Figure 4-12 NOLS SOAP Note app answers

All the participants except one were able to send an email after creating a note using the application. The app afforded this functionality but it required the user to have email set up on their phone, and for the user to have the knowledge of how to send an email from an app.

There are many symbols used in the app. None of these were fully understood by all participants so the icons chosen could be improved upon (See Figure 4-13).

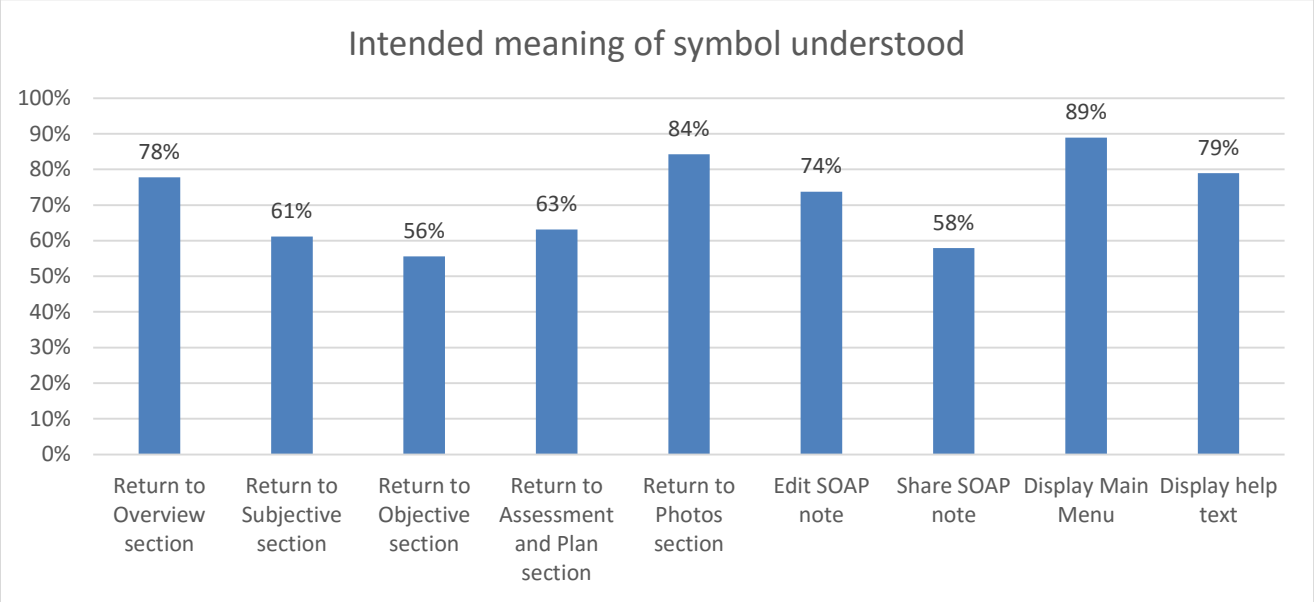


Figure 4-13 Intended meaning of symbols

A reason that may deter a person from using a product is if they make mistakes using the product. 47% of participants reported making a mistake such as typos, entering in Fahrenheit instead of Celsius and when entering the vitals, but all participants were able to go back and correct the mistakes.

Participants were asked about apps that they found to be well-designed and why they like these apps. The reported features from the well-designed apps were that they were user friendly, had clearly laid out screens, had easy logical and intuitive steps, had plenty of user options, and were easy and intuitive to use.

The participants were also asked about poorly designed apps, and why they did not like these apps. The reported problems were difficulty in searching for you want, trying to find correct menu options, and trying to touch small option buttons.

4.3.6 App Functionality

Participants reported that the majority of the functionality in the NOLS SOAP Note app is required, with only the Plan section and the Photos deemed slightly less necessary (See Figure 4-14). All the features are well designed according to the participants in the study, scoring on average about 80%.

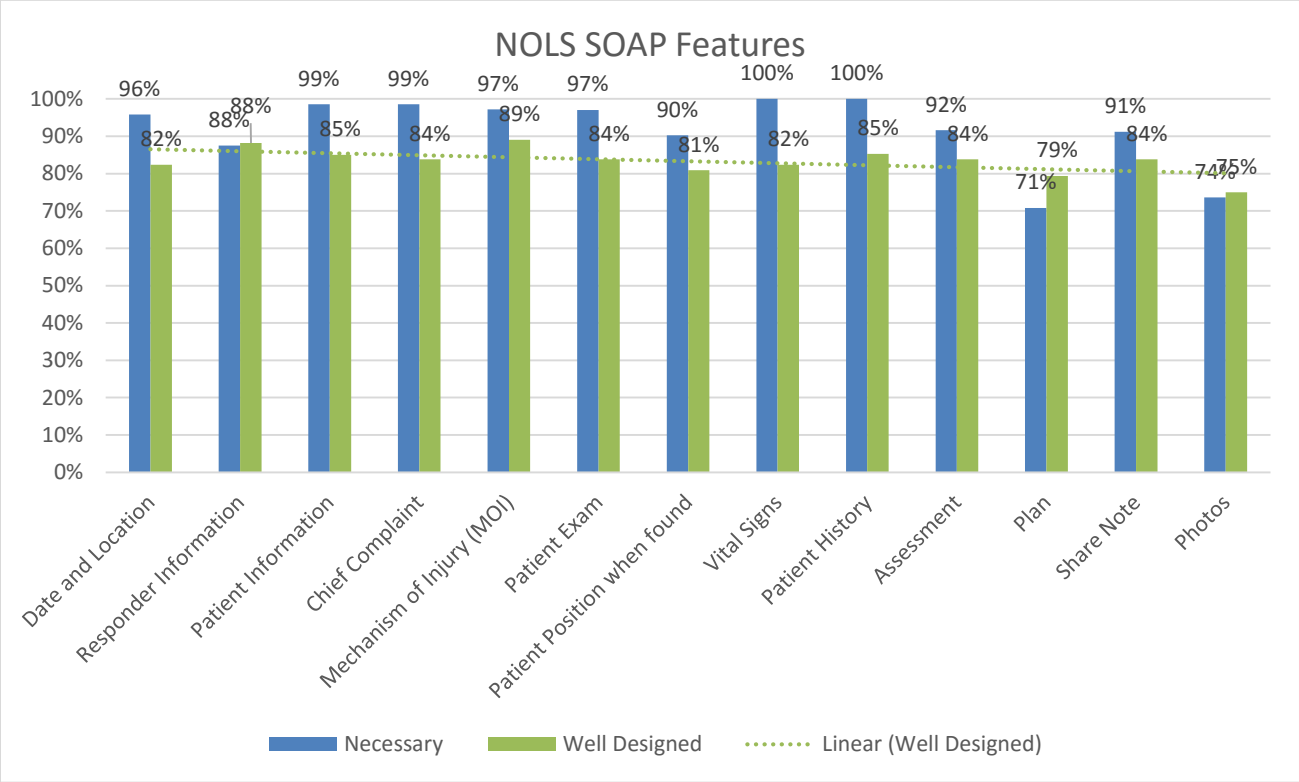


Figure 4-14 Are features necessary and well designed?

The participants were asked to provide feedback on the NOLS SOAP Note app functionality.

Date and Location

One participant reported that the co-ordinates are not relevant to the treatment plan, however it is necessary for the Mountain Rescue base and the paramedics to know the location of the patient. Other participants suggested recording the time of arrival on scene, recording the date in dd/mm/yyyy format, to be able to enter in co-ordinates manually and for cross compatibility with the app ViewRanger to pick up the location co-ordinates.

Responder Information

The PHECC pin number could be recorded in the app.

Patient Information

A reported problem was that there was nowhere to record patient information such as next of kin contact details. It would be beneficial to be able to add in a grid reference, or a photo of a map or a screenshot of a map of the current location.

Chief Complaint

One participant reported that it was not possible to record secondary complaints, and there is no separate textbox for provokes and palliates so the answer might be confusing. It was suggested to provide a drop down list of common chief complaints.

Mechanism of Injury (MOI)

A drop down list of common causes of Mechanism of Injury could be added e.g. fall, assault.

Patient Exam

A suggestion is to add an image with a check box for each major body part to show clearly that the head to toe examination has been completed. Another image that could be used is to show which body part is injured. One participant also suggests that more prompts should be added to this section.

Patient Position when Found

One participant reported that this information is not relevant but that 'where they are and how long they were there' is more relevant.

Vital Signs

It was recommended to set the blood pressure at a default value instead of having to scroll from 0 by two participants. It was reported that it was possible to record a heart rate of 5666. The option of adding in GCS (Glasgow Coma Scale) and blood sugar details should also be facilitated according to another participant.

Patient History

The only response to this section is that is necessary.

Assessment

Again it was suggested that an image of a body with comment boxes for detailing injuries would be useful.

Plan

An interesting comment was that it is the not the responsibility of the medic to plan the evacuation. The participant also responded that this information is not pertinent for doing a handover, and maybe more relevant for the incident commander rather than the medic.

Share Note

One participant asked if the note could be saved as a pdf for later filing, and another asked with whom the information should be shared with and if this is a data privacy issue.

Photos

As per one participant's response, there could be legal issues storing the image of a patient, and another reported that taking photos could also result in distress to the patient or the viewer of the image.

Other features

Many participants have suggested using drop down lists which would make it easier and potentially quicker to fill in the app. It would be advisable to add in validation to ensure that details recorded are relevant.

4.3.7 Patient Assessment App

Following evaluation of the NOLS SOAP Note app participants were asked to select which functionality they would deem to be important in a patient assessment app. The top 3 suggested features were the ability to record medication administered, a sound alert to let the medic know when to check the Vital signs again, and an image of a body to mark where there are any injuries or medical conditions. See Figure 4-15 for suggested new functionality.

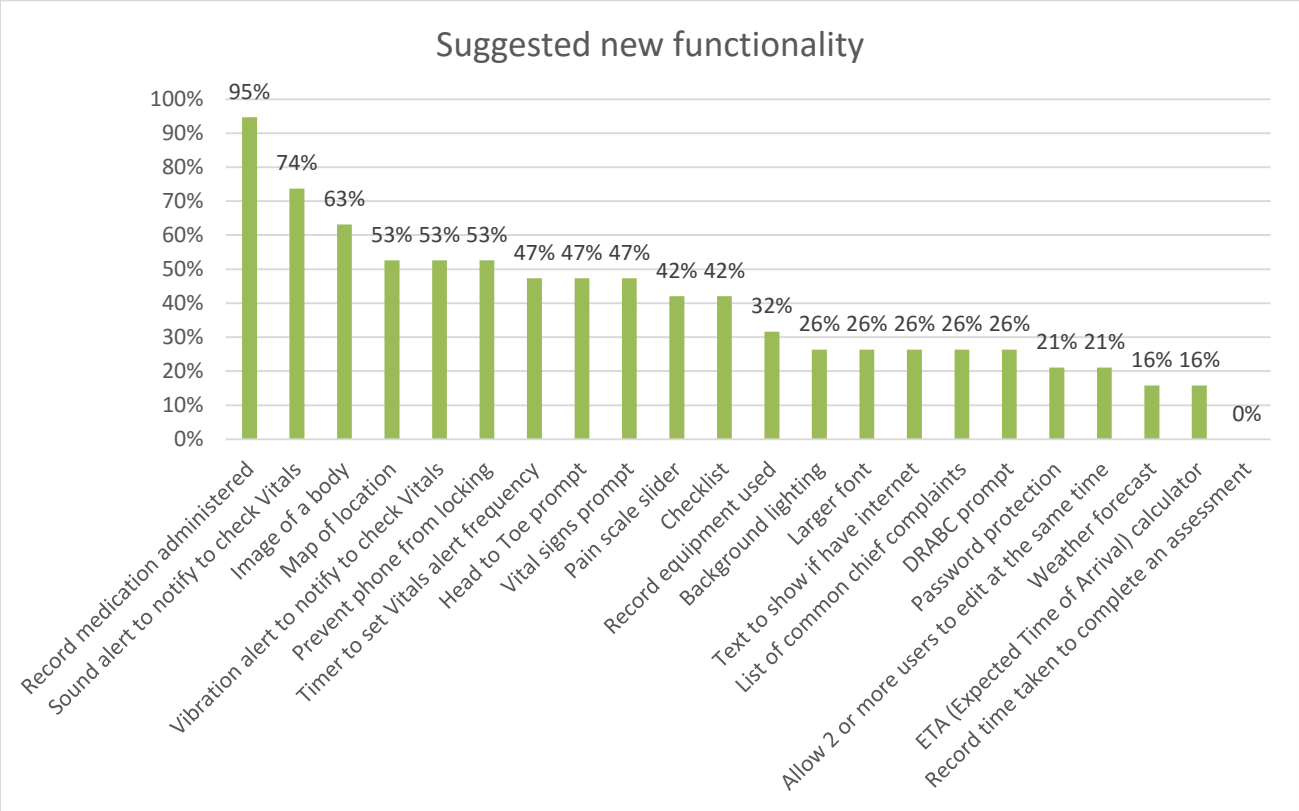


Figure 4-15 Suggested app functionality

Participants were then asked to propose other useful functionality.

The suggested functionality included:

- Grid reference instead of Latitude/Longitude co-ordinates
- Transport declined by patient checkbox
- Medication declined by patient checkbox
- Signature field
- Assistance received from bystanders' textbox

- Clinical impression textbox
- Casualty status textbox (Life threatening, non-serious, non-life threatening)
- Handover details to continuity of care
- Allow WhatsApp to Share options (currently just email)
- Simplified mode for short assessments
- More detailed mode for where more in-depth assessment is required
- Align to PHECC CPGs
- Ability to share with HSE ambulance, coastguard
- Ability to get medical oversight e.g. from Medico in Cork
- Use ViewRanger to show position and record screenshot from ViewRanger to show location on map (and possibly track details of where walked to get to location)

The last question asked was 'What factors/ concerns would prevent you from using a patient assessment app during a Mountain Rescue callout? The raised concerns included:

- Bad weather, environmental conditions
- Waterproofing of Smartphone
- Speed of data input
- Life of phone battery – Loose information until recharge
- Quicker and easier to write by hand. Provide an instant hard copy
- Ability to hand over written document to ambulance or coastguard
- Ease of use in the dark – ability to read screen if reading glasses required
- Apps could drain battery on the phone
- Lack of familiarity with app
- Data protection implications
- Need to store patient report forms
- Patient privacy
- Fear of losing phone
- Breaks rapport with patient

All these concerns need to be taken into account when designing a patient assessment app even though some of the issues cannot be resolved by a developer.

4.4 Interview Results

4.4.1 Method

Five interviews in total were conducted. The interviewees were sent emails in advance of the interview requesting for their participation in the study. Two interviews were conducted face to face and three interviews were conducted over the phone. The answers to the questions were written down by hand and later typed up into Excel. The data was then copied into a new Microsoft Word document for each participant, and the corresponding Word document was sent back to the relevant participant to confirm that the participant agreed with the recorded answers. For future studies the author may consider using an online questionnaire to record the interview answers, as this may reduce the time spent formatting the data for later analysis. See Appendix E Research Results for the full list of recorded answers.

4.4.2 Background

The interviewees included new team members and one founding team member. One interviewee has been on the team for 3 years but has worked with the team on callouts for over 12 years as part of the Incident Response team, and another interviewee has over 20 years' experience in cave rescue. All interviewees have worked for at least 3 years professionally in healthcare and they included, one doctor, two paramedics and two advanced paramedics. They were all deemed to have significant Mountain Rescue and professional healthcare experience to participate in the interviews.

4.4.3 Smartphone use in Mountain Rescue

The interviewees all reported using ViewRanger, a navigation app, and some have also used Google Maps. Only one person reported using first aid apps in Mountain Rescue which were the PHECC apps. All interviewees carry a Smartphone during callouts.

4.4.4 Smartphone use in Healthcare

The paramedics interviewed all reported that they use PHECC apps such as the CPG and Field guide. Other apps or websites that they have used include Tallaght Pharmacology, Medical Dictionary, ACLS Advisor, Socrates, Medscape, Figure 1, READ, RCH guidelines, EMWRAP and a specific Crumlin hospital laboratory tests app. All interviewees also carry a personal Smartphone at work.

4.4.5 Mountain Rescue Callout

To ascertain what data should be recorded in a patient assessment app, interviewees were asked what data should be recorded by a Mountain Rescue team at a callout. Figure 4-16 below shows the amalgamated results. Some of the recommended data falls outside the scope of a pure patient assessment as it also includes next of kin details, medic details and time of arrival on scene.

Patient details	Assesment	Vitals	Interventions	Times
•Name •Date of birth •Next of Kin •Next of Kin contact details	•AMPLE history •Chief complaint •Nature of injuries •Medical condition •OPQRST - Pain exam •Head to Toe •Line drawing •CSM •Nuero exam •Fluids in/out •What happened •MOI	•Pulse rate •Pulse quality (regular or irregular) •Respiratory rate •Respiratory quality •SPO2 •Blood Pressure •Pupils •Cap Refill •GCS •Blood Glucose	•Medications administered •Treatments •Who was in charge •PIN number •Medic details	•Arrival on scene •Vitals recorded •Interventions •Change in condition

Figure 4-16 Data that should be recorded by Mountain Rescue

All interviewees replied the condition of the patient determines how often the patient needs to be reassessed during an evacuation. An assessment could be done every 3 minutes for a serious head injury or it may just happen before and after treatment for a minor injury. A patient assessment app should allow for multiple assessments to be recorded.

Everyone agreed that the information that should be given to an awaiting paramedic during a handover of a patient should be in the IMIST/ AMBO format (See Figure 4-17). This is a recognised international standard that is now being used in hospitals around Ireland. It would be beneficial to have a screen in a patient assessment app that shows a summary view of the patients details in the IMIST/ AMBO format that could be used during the handover of a patient. See Chapter 2 – Handover Protocols.

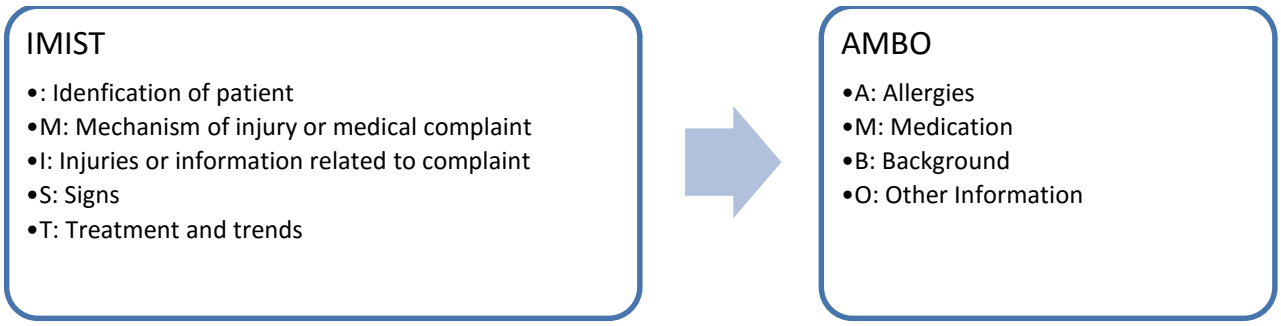


Figure 4-17 Communication Protocols (Pre-Hospital Emergency Care Council 2014)

According to one interviewee the Patient Care Report form (PCR) should be filled out for all callouts even if there is no injury. A copy of the PCR should be kept by the Mountain Rescue team for legal reasons and for statistical analysis. A record needs to kept of any medications administered and the evacuation method should be recorded on the PCR. Many of the team members are PHECC registered and therefore they must keep a record of patient contacts, as PHECC may conduct an audit later on.

When designing an app for patient assessment in Mountain Rescue it should be considered that the app could be used to record that there is actually nothing wrong with the person being assessed. This data (both the existence and non-existence of injuries and/ or medical conditions) could prove to be important for a possible court case in the future.

Additional things to consider when conducting the primary survey is to check for C-Spine injuries, catastrophic bleeding and to conduct an initial set of vitals. CSMs (Colour, Sensation, Movement) should also be assessed during the focused exam. For the treatment of patient in a Mountain Rescue scenario the plan should be split into two, an evacuation plan to be decided by the party leader and a treatment plan to be decided by the medic.

Figure 4-18 shows the author's understanding of what should be considered and what should be done when assessing and treating a patient. Figure 4-19 is an updated version of figure 4-18 using feedback from the interviewees.

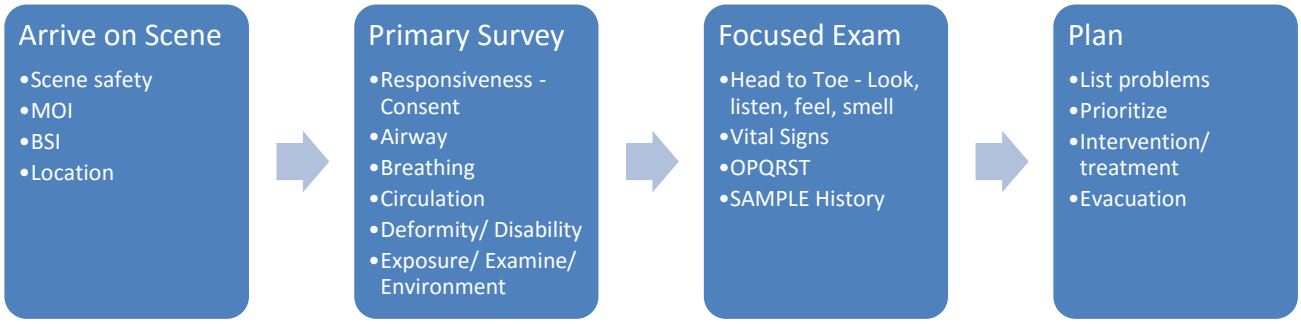


Figure 4-18 Suggested Assessment and Treatment Plan

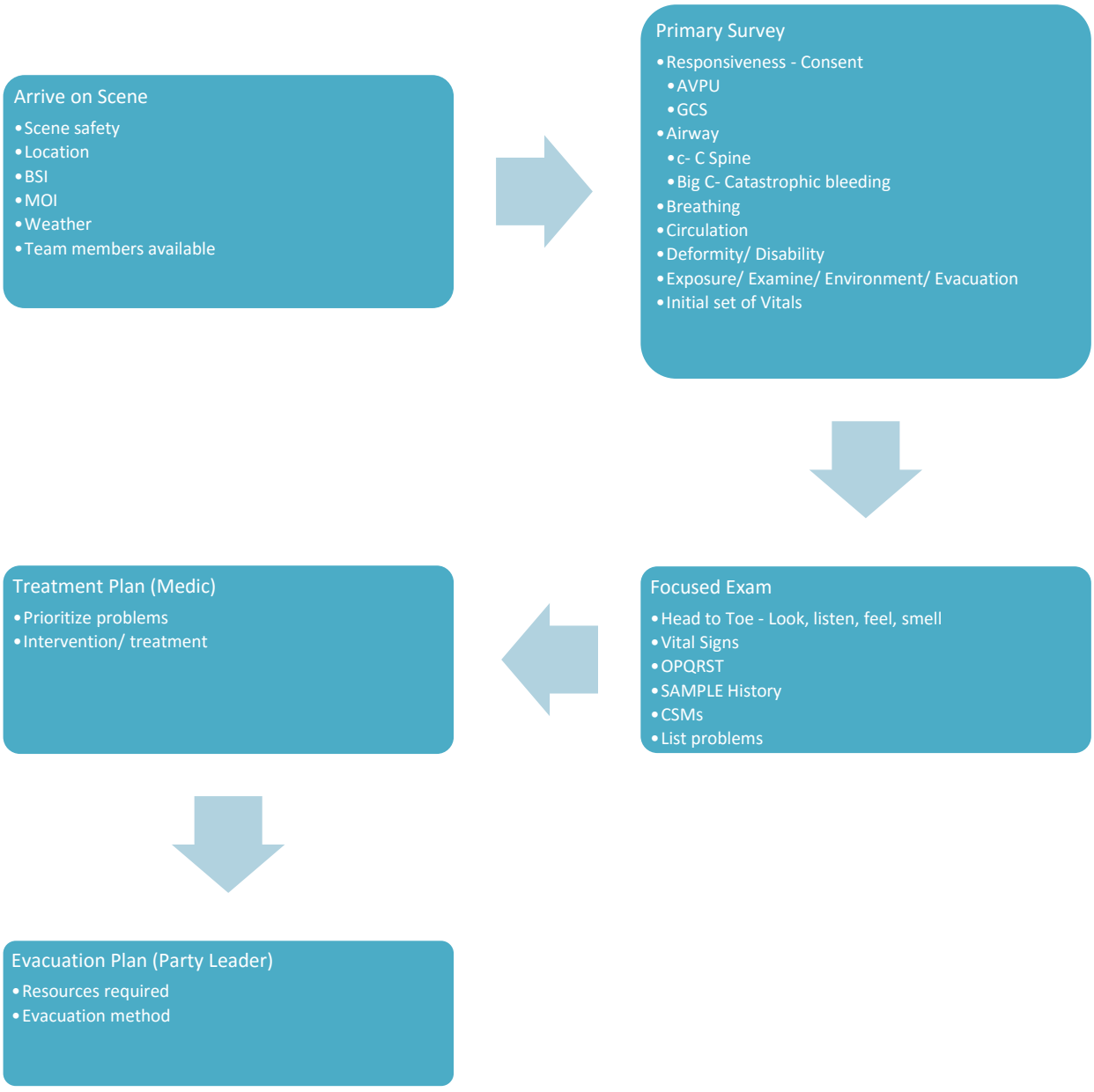


Figure 4-19 Assessment and Treatment Plan updated using interviewee feedback

4.4.6 Patient Care Report form

The PCR (Patient Care Report) form is beneficial to use in a handover but it has its limitations as it is not waterproof, it is difficult to write on in the rain, and it can fall apart. The interviewees like it because it acts as an aid memoire, it folds up small, vitals are in one section and if you know the format it is easy to use. However, the interviewees reported that they did not like that it is not waterproof enough, that it can take a long time to fill out for simple injuries, there is not enough space to write all the information, and it doesn't guide the user easily through it. It was also reported that there can be a lot of variance in filling out the document.

The interviewees could understand the possibility of using a PCR in an electronic format but they defined the current limitations as other systems would have to be interoperable, hospitals and paramedics should be able to receive the information, and results may still need to be transcribed to paper. A solution was proposed by one interviewee that the data from an electronic PCR or patient assessment app could be sent to a printer (in the Mountain Rescue base) that could print the details onto a paper PCR form. A trial ePCR (electronic PCR) has been used by the North East Ambulance service but this has not been rolled out to other areas in Ireland.

All interviewees agreed that the PCR form contains the required information for a patient handover, however some reported that the IMIST/ AMBO prompts are missing from the current form and these could be beneficial.

The majority of the interviewees agreed that Mountain Rescue personnel can make diagnosis, depending on their level of training and experience. However, one interviewee said that only a provisional diagnosis can be made as the patient is treated outside a medical center.

When designing an app for Mountain Rescue callouts, it must be considered if the app can or should replace the current use of PCRs. Mountain Rescue Ireland are also now developing their own PCR form to be used specifically in Mountain Rescue callouts which should also be considered in designing a patient assessment app – See Appendix C Patient Care Report forms.

4.4.7 Patient Handover in Mountain Rescue

As this section refers to patient handover to paramedics, only the 4 paramedics were asked questions 23 to 34.

The paramedics receive information about a Mountain Rescue callout from the National Ambulance Control Centre (NACC) in Tallaght, Dublin. They receive information about the gender, location, age, injury or medical condition of the patient from NACC as per the ASHICE (Age, Sex, History, Injuries or Illnesses, Condition, ETA) format. They also receive a despatch code (predefined code that represents the patient's condition), and they may be given more specific information such as the number of casualties, location description, the medical level of who is currently treating the patient and when the ambulance is expected to arrive. With a lengthy stretcher carry-out the awaiting ambulance may not be required for a few hours.

Communication with the Mountain Rescue base generally does not occur until the paramedics arrive at base, but can happen in advance by dialling a direct line using Tetra radios. It may be beneficial if paramedics could receive live information from a patient assessment app whilst on the journey to the scene or when they arrive at the Mountain Rescue base to prepare them for treating the patient.

Acting in their role as a paramedic, the interviewees all responded that they would like to receive information using the IMIST/ AMBO protocol during a handover at a Mountain Rescue callout. The interviewees expect a handover to take about 30 seconds, only up to 2 minutes if is complicated. It is expected that a PCR form is given to the awaiting paramedic.

4.4.8 Summary of Data Requirements

From the conducted interviews the following data categories should be recorded

- Patient Details (including next of kin)
- Assessment details (Primary and Focused Exam)
- Vitals
- Interventions
- Times

The output of the recorded data should be as per the IMIST/ AMBO protocol. An assessment should be recorded for each casualty even if they are not necessarily a patient. As a PCR form is required for a handover, the details from an app will have to be either transcribed to a paper form or sent to a printer to be printed onto a paper form. In the future it may be possible to send the details from a patient assessment app to an ePCR system if such a system was operational.

4.5 Review of Feedback

Based on the feedback received from the questionnaire and interview studies, the following additional features were added into the design of the prototype app.

- Patient Date of Birth, Patient full name
- Next of kin details
- Chief complaint
- Add CSM to Vitals (remove graph as not required)
- SpO_2
- Blood Glucose
- Casualty Status
- Record medication administered
- Medic PHECC pin number
- IMIST/ AMBO handover

If the prototype app was found to be beneficial the following features could be developed and added into the app at a later stage.

- Neuro exam
- GCS – Glasgow Coma Scale
- Change in condition
- Add Photos
- Sharing
- Co-ordinates, map of location, integration with ViewRanger
- Phone locking
- Vibration alert for taking vitals

4.5.1 Summary of Functionality

Table 4-1 is a list of current and proposed patient assessment app functionality.

Table 4-1 Summary of reviewed functionality

	Interview Feedback	In NOLS SOAP Note app	In current App Design	Questionnaire Comments	Added to Prototype	Later Development
Patient Details						
Name	Yes	No- Patient Initials	No - First Name only		Yes	
Date of Birth	Yes	Yes	No		Yes	
Next of Kin	Yes		No	Requested	Yes	
Next of Kin contact details	Yes		No	Requested	Yes	
Sex	No	Yes	Yes - Called Gender		Yes	
Age	No	Yes	Yes		Yes	
Other information	No	No	Yes		No	
Assessment						
AMPLE history	Yes	Yes	Yes	How long ago did incident occur	Yes	
Chief complaint	Yes	Yes	No		Yes	
Nature of Injuries	Yes	No	Yes		Yes	
Medical condition	Yes	No	Yes		Yes	
OPQRST – Pain exam	Yes	Yes	Yes		Yes	
Head to Toe	Yes	Yes - Free text only	No		No	Yes
Line drawing – image of body	Yes	No	Yes	Requested - Add in image of body	Yes	
CSM	Yes	Yes - Free text only	No		Yes	
Neuro exam	Yes	No	No		No	Yes
Fluids in/out	Yes	Yes (part of Patient History)	Yes (part of SAMPLE History)		Yes	
What happened	Yes	Yes (part of Patient History)	Yes (part of SAMPLE History)		Yes	
MOI	Yes	Yes	Yes	Requested - Add in drop down list of common MOI	Yes	
Vital Signs						
Pulse rate	Yes	Yes	Yes		Yes	
Pulse quality (regular or irregular)	Yes	Yes	Yes		Yes	
Pulse rhythm	No	Yes	No		No	
Respiratory rate	Yes		Yes		Yes	
Respiratory quality	Yes	Yes	Yes		Yes	
Respiratory rhythm	No	Yes	No		No	
SPO2	Yes	No	No		Yes	
Blood Pressure	Yes	Yes - Systolic and Diastolic	Yes - But Systolic only		Yes	
Pupils	Yes	Yes	No		Yes	
Cap Refill	Yes	No	No		Yes	
GCS	Yes	No	No	Requested	No	Yes
Blood Glucose	Yes	No	No	Requested	Yes	
Interventions						

	Interview Feedback	In NOLS SOAP Note app	In current App Design	Questionnaire Comments	Added to Prototype	Later Development
Medications administered	Yes	Yes - Free text only in Plan	Yes - Intervention		Yes	
Treatments	Yes	Yes - Free text only in Plan	Yes - Intervention		Yes	
Who was in charge	Yes	Yes	Yes		No	Yes
Pin number	Yes	No	No	Requested	No	Yes
Medic details	Yes	Yes - Current Certification	Yes		Yes	
Times						
Arrival on scene	Yes	Yes - Date only	No - But have callout start time	Requested - But in dd/mm/yyyy format	Yes	
Vitals recorded	Yes	Yes	Yes		Yes	
Interventions	Yes	No	Yes - But when injury/ condition recorded		Yes	
Change in condition	Yes	No	No		No	Yes
Callout						
Location		Yes	Yes		Yes	
Coordinates		Yes	No		No	Yes
Grid Reference		No	Yes		Yes	
Start date and time		No	Yes		Yes	
End date and time		No	Yes		Yes	
Status		No	Yes		Yes	
Other Functionality						
Patient position when found		Yes	No	Not relevant	No	
Assessment - list of possible problems		Yes	Yes - list of injuries/ medical conditions		Yes	
Plans - for problems and further care		Yes	No	Not relevant	No	
Anticipated Problems		Yes	No		No	
Add Photos		Yes	No		No	Yes
Share		Yes - By email	Yes	Save as pdf, Data issue	No	Yes
Useful Functionality						
Record medication administered		No	No		Yes	
Sound alert to notify Vitals check		No	Yes		Yes	
Map of location		No	No	Requested	No	Yes
Vibration alert to notify Vitals check		No	Yes		No	Yes
Prevent phone locking		No	No		No	Yes
Suggested Functionality						
Treatment declined (medication, transport)		No	No		No	Yes
Signature		No	No		No	Yes
Clinical impression/ Casualty status		No	No		Yes	
Handover details	IMIST/ AMBO	No	No		Yes	
Use with ViewRanger		No	No	Use to pick up location and map details	No	Maybe
Share with HSE, ICG	Able to use PCR	No	No		No	Maybe
Get Medical oversight from Medico		No	No		No	Maybe

4.6 Prototype Evaluation

4.6.1 Method

When the development of the prototype app was completed, members of the DWMRT were asked to try out the prototype app and fill in a final questionnaire. The questionnaire contained ten questions as per the System Usability Scale. This study was restricted as only team members that owned an Android phone could install the app on their phone for evaluation.

4.6.2 Evaluation Results

The average result returned was 82.6, which is a good score as previously stated that anything above 68 is considered above average (US Department of Health and Human Services 2016).

4.6.3 Comparison of Results

DWMRT members were asked to test the NOLS SOAP Note app and the prototype app using the same SUS scale so the two apps can be compared. The average result for the prototype app was only slightly below the result for the NOLS SOAP Note app as can be seen in Table 4-2.

Table 4-2 SUS comparison of apps

App	Average SUS Result
NOLS SOAP Note app	83.8
Prototype app	82.6

4.7 Conclusion

The members of the DWMRT showed a high level of IT proficiency as they were able to download an app, send information from the app to an email address and to fill in an online questionnaire without any assistance from the author. Also, all DWMRT members own a Smartphone, so the rescue team members proved to be an excellent user test group.

From reviewing ownership of Smartphones, and concluding that outputs from Smartphones vary depending on operating system, development and testing of apps should be done for both Android and iPhone Smartphones.

Overall the feedback from the evaluation of the NOLS SOAP Note app was positive, but members were still more likely to use the app during training than during a callout. The limitations as to the reluctance to use the app during a callout should be clearly identified and reviewed to see if they can be overcome.

The interviewees provided very similar answers, which proved that standard assessment and handover processes are already in place. These standard processes should be reflected in a patient assessment app.

The feedback from both the questionnaires and the interviews was very informative, and gave a very clear picture of what data and functionality is required or requested to be in a patient assessment app.

The prototype app appeared to be well received by the team members, as it scored comparable to the NOLS SOAP Note app using the same SUS questionnaire.

Chapter 5 App Design

5.1 Introduction

Following the literature review an initial app design was completed, which included screen mock-ups, a class diagram and a list of planned features. After receiving feedback from the interviews and the questionnaires a second design phase was completed, and an updated Software Requirements Specification (SRS) document was written (See Figure 5-1). An app was then developed by the author based on the SRS document (See Appendix A Software Requirements Specification).

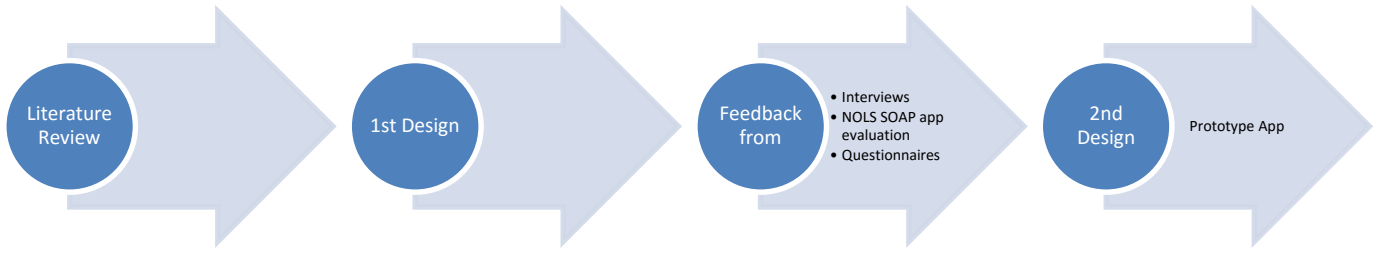


Figure 5-1 App design process

This chapter focuses on the design of the prototype app before and after the analysis of the research results. Details are then provided on how the prototype app was actually developed and deployed.

5.2 Design

5.2.1 Storyboarding

A review of storyboarding software tools was conducted. The author had previously used Pencil to create screen mockups, but this software was found to be quite basic. The author had also used Storyboarding in Microsoft PowerPoint, which was found to be very effective in informing software developers of the expected layout of a website, however this software does not allow for mockups of Android and IOS applications.

After reviewing several other products, the author decided to use Ninja Mock, a cloud based web application, as it allows a user to create up to 3 projects for free with no restrictions on functionality provided. Ninja Mock allows a user to easily create a wireframe diagram for websites, Android and IOS Smartphone applications. It also provides a range of icons, many of which are standard Android

and IOS images. Another interesting feature is that a hyperlink can be added to a control on the wireframe diagram, and when clicked it will bring the user to another predefined wireframe diagram. This allows for testing of the flow of the screens, to ensure that a user moves smoothly back and forth through the app.

Table 5-1 shows the various software tools that were evaluated.

Table 5-1 Storyboarding design tools

Mockflow	
Benefits	• Free for 1 designer • Various layout controls available http://www.mocklow.com
Limitations	Only one project can be created.
PowerMockUp	
Benefits	• Various design options such as WireframePro, DesignCollab, WebsitePro, and BannerPro http://www.powermockup.com
Limitations	$60 fee for one license.
Storyboarding	
Benefits	This is available in Microsoft PowerPoint for developers who have Visual Studio Professional installed. However, it is now available as standard in PowerPoint 2016.
Limitations	The design features are limited to Windows Mobile phones and Windows webpages.
Invision	
Benefits	The website is useful for sharing screen layouts with others to get feedback on layout and design. http://www.invisonapp.com
Limitations	There is no functionality to create screen layouts.
Pencil	
Benefits	• Free to use • Open source • Android and iOS design controls available http://pencil.evolus.vn/
Ninja Mock	
Benefits	• Free up to 3 projects • Android and iOS design controls available • Able to add hyperlinks to screen layouts -when a link is clicked the corresponding screen is shown. This is useful to test the flow of the screens. http://ninjamock.com

See Appendix B Mock-Up Software Tools for more information on the various storyboarding tools that can be used for designing apps.

5.2.2 Planned Features

Following the literature review a list of main functions for a patient assessment app were created as per Table 5-2. However, following the review of the feedback from the research this list was updated as per Table 5-3.

Table 5-2 Proposed main functions following Literature Review

Main Functions	Description
Record Patient Information	Users will be able to record • General patient information • Vital Signs • Medical and Trauma injuries • SAMPLE History
Sound Alert	Users will be prompted to complete another set of Vitals • 5 to 30 minutes after the last set of Vitals were recorded for a patient • There will be an option to set the frequency of the alert
Display Vitals clearly	Users will be able to view the previously recorded Vital signs in table and graph formats
Share information	Users will be able to send the full Callout information or a selected patient information to their own contacts using built in functionality on their Smartphone.
Display Summary information	Users will be able to view Callout summary information and Patient summary information.
Automatically set Callout details	The Smartphone application will automatically record the following information once a new callout is started on the application • Callout start date and time • Callout location • Medic details When all the patients have been transferred the callout is automatically ended.

Table 5-3 Main Functions proposed following Research Analysis

Main Functions	Description
Record Patient Information	Users will be able to record • General patient information • Vital Signs • Medical and Trauma injuries • SAMPLE History • Next of Kin contact details
Display Vitals clearly	Users will be able to view the previously recorded Vital signs in table format only
Display Handover information	Users will be able to view the Patient Summary information in the IMIST/ AMBO format
Medic Details	Users will be able to record Medic details • Name • PHECC pin number • First Aid Level

5.2.3 Application Screen Flow

Below are two diagrams showing how each screen in the prototype app will link to the next screen. The first diagram 5-2 shows the expected screen flow based on the design following the literature review, and the second diagram 5-3 shows the planned screen flow updated following the review of the results in Chapter 4 Analysis of Results.

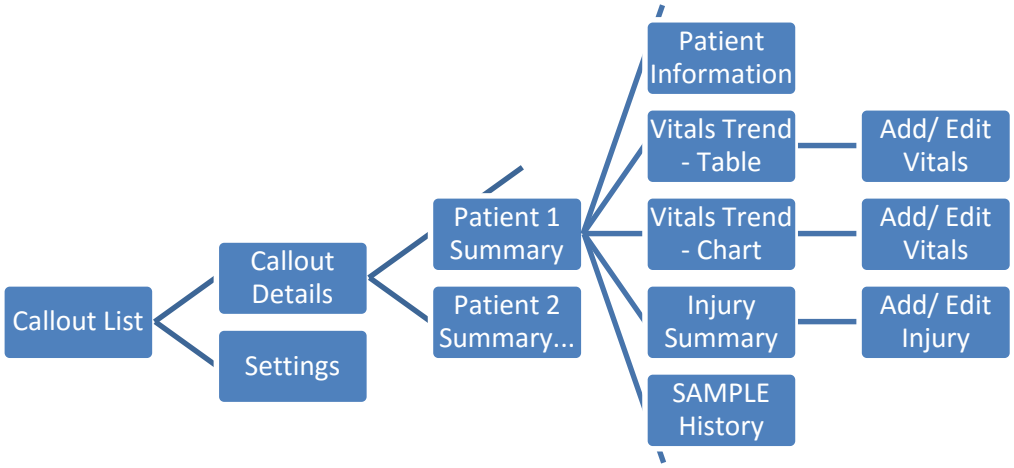


Figure 5-2 Application Screen Flow design following Literature Review

It was decided to simplify the design of the app by removing the complexity of adding one or more patients to a callout, and to just list patients instead. From the patient list screen, the user is brought to a Patient Summary screen, and then the user has a choice to move to one of six screens.

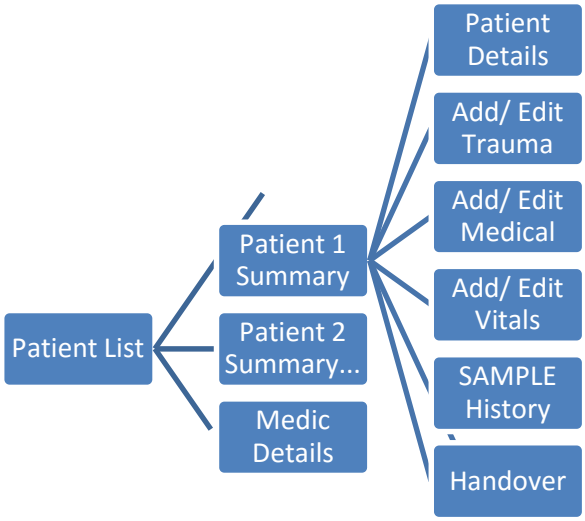


Figure 5-3 Application Screen flow following Research Analysis

5.2.4 User Interfaces

The below tables 5-4 and 5-5 give further information as to what was planned to be recorded and displayed on each of the app screens following the literature review and analysis of the research results. Tables 5-6, and 5-7 show the mockups of the designed screens. Table 5-8 shows the final screens actually developed for the prototype app. Due to time restrictions, the Medic Details screen was not added into the final prototype app.

Table 5-4 Proposed user interface screens following Literature Review

Screen	Features and Functions
Callout List	A list of current and previously created callouts will be displayed. From this screen the user can start a new callout.
Settings	The medic (user of the app) can store their name, and first aid level. This information will be sent with the callout report and is displayed on the Callout Details screen.
Callout Details	The Callout Details screen shows the medic name, grid reference and a list of patients. From this the screen the user can add a new patient or edit details for a previously created patient set of details.
Patient Summary	The Patient Summary screen shows the summary information for the patient. From this screen the user can add more patient assessment details or edit details for a previously created set of patient assessment details.
Patient Information	The Patient Information screen is used to for recording the patient's name, age, gender and other relevant patient information.
Vitals Trend • **Table** • **Chart**	The Vitals Trend screen contains two tabs – one contains a table of Vital results, and the second tab shows a chart using the same Vital results.
Trauma Summary	The Trauma Summary screen shows a summarized list of all traumas recorded.
Medical Summary	The Medical Summary screen shows a summarized list of all medical issues recorded.
SAMPLE History	The SAMPLE screen is used to record the patients SAMPLE History and the Mechanism of Injury.
Add Vitals	The user is able to add Vital signs using this screen.
Add Injury	The user is able to add Trauma or Medical details using this screen.

Table 5-5 Proposed user interface screens following Research Analysis

Screen	Features and Functions
Patient List	A list of current and previously documented patients will be displayed. From this screen the user can add or edit a patient.
Settings	The medic (user of the app) can store their name, PHECC pin number and first aid level.
Patient Summary	The Patient Summary screen shows the summary information for the patient. From this screen the user can add more patient assessment details or edit details for a previously created set of patient assessment details.
Patient Details	The Patient Information screen is used to for recording the patient's name, age, gender, contact details, location of incident and other relevant patient information.
Add Trauma	The user is able to add Trauma details using this screen.
Add Medical	The user is able to add Medical details using this screen.
Add Vitals	The user is able to add Vital signs using this screen.
SAMPLE History	The SAMPLE screen is used to record the patients SAMPLE History and the Mechanism of Injury.
Medic Details	The Medic details screen is used to record the name and the first aid qualifications of the Medic.

Table 5-6 Proposed screen mock-ups following Literature Review

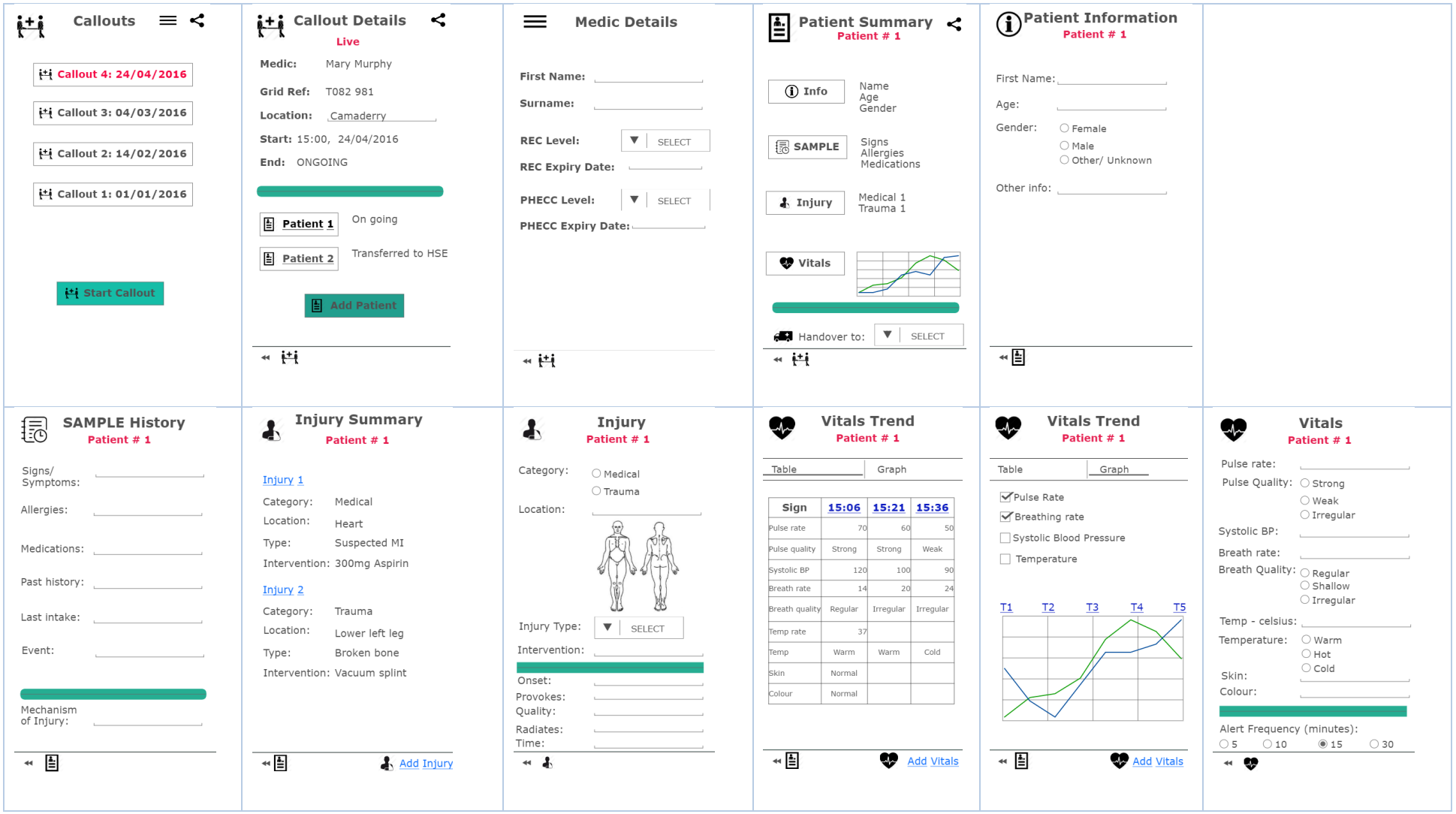


Table 5-7 Proposed screen mock-ups following Research Analysis

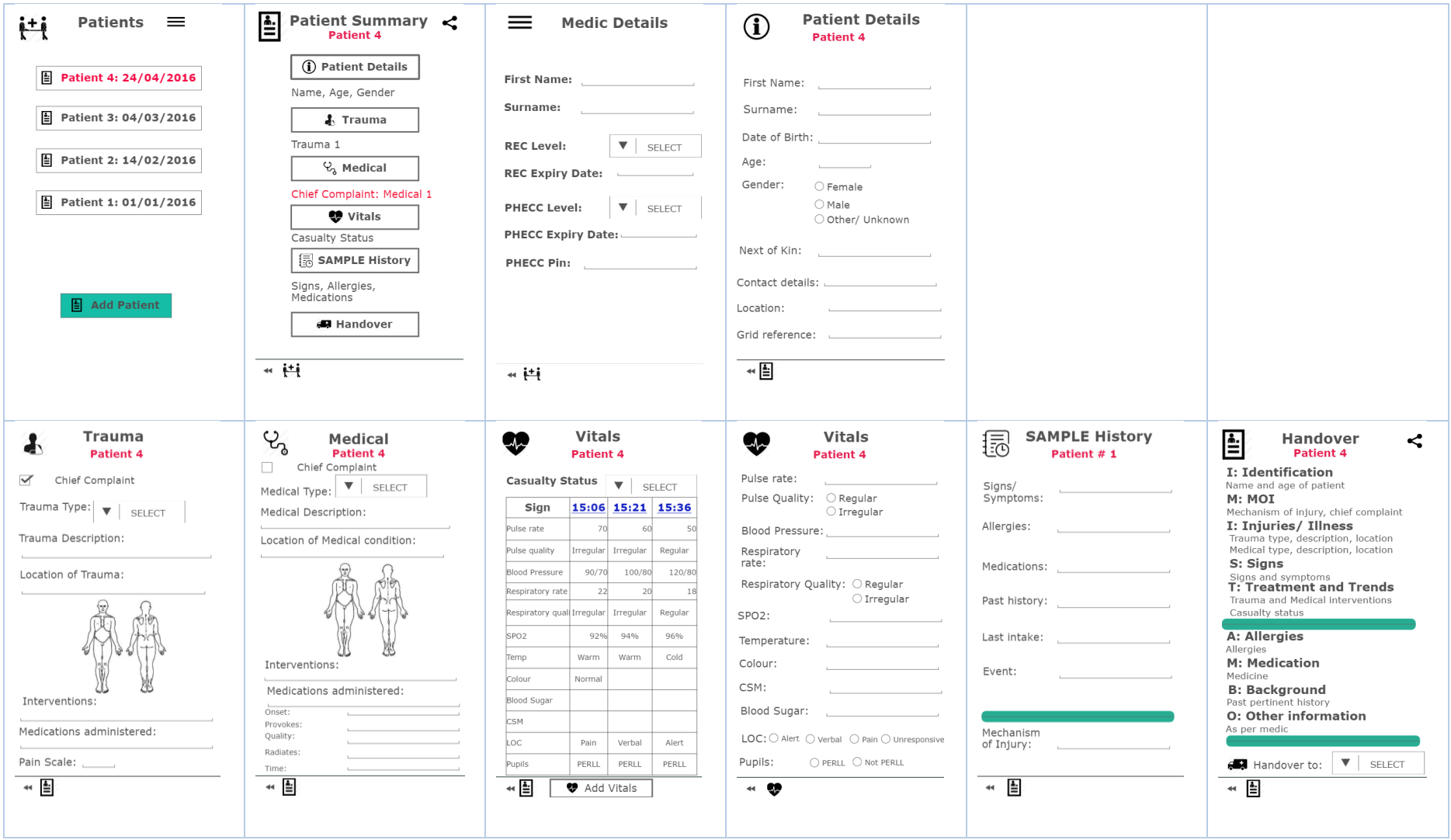
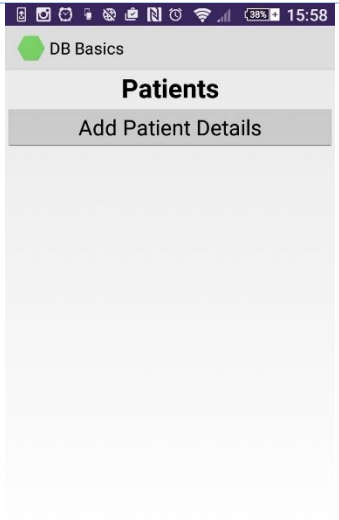
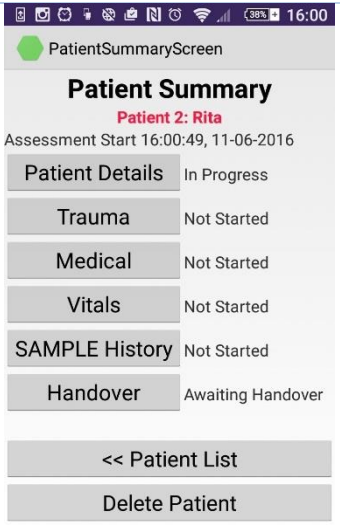
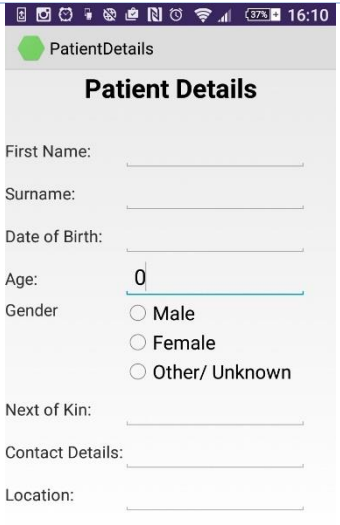
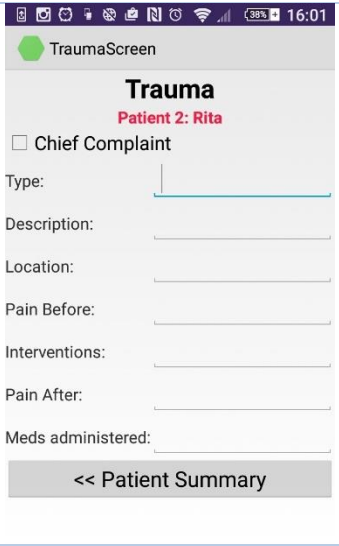


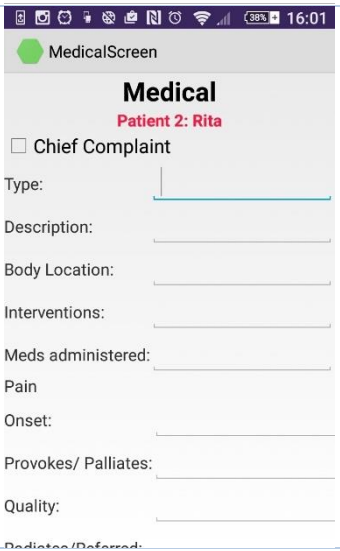
Table 5-8 Prototype App Screens

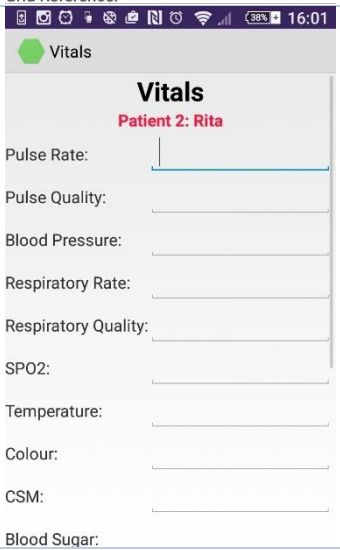


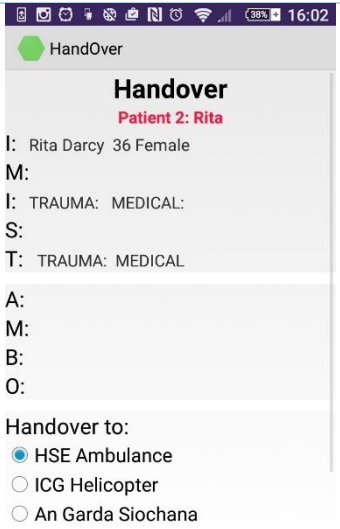












5.3 Development

A prototype app was developed by the author to record patient assessment details. The author referred to the Software Requirements Specification document when developing the application.

5.3.1 Integrated Development Environment

The prototype application is developed using Xamarin, which is an Integrated Development Environment (IDE) provided as part of Microsoft Visual Studio or as an individual download. The Xamarin IDE is designed specifically for developing mobile applications. The author has previously developed websites using Visual Studio and is familiar with this environment. Xamarin allows the user to add native user controls to an application, so that an Android application will have Android specific controls and an iOS app will have iOS specific controls so that an application will look and feel like it's platform type (Xamarin Inc. 2016c) (See Figure 5-4). Xamarin can be used to develop code that accesses built in functionality in a phone such as the accelerometer and the camera. The code is compiled in advance so it does not slow down performance at run-time (Xamarin Inc. 2016c).

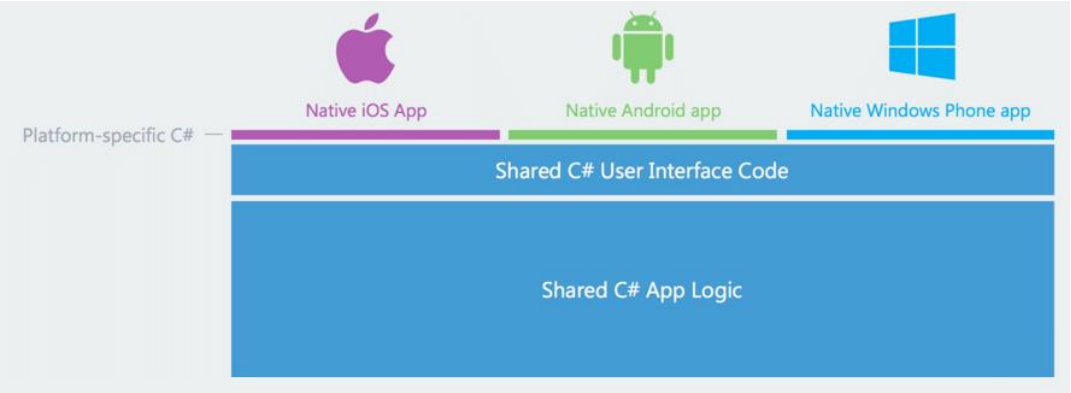


Figure 5-4 Xamarin Platforms (Xamarin Ltd. 2016)

The author investigated using the NetBeans IDE which is free and open source, but the development code is programmed using Java, JavaScript, PHP and C++ languages which the author is less familiar with. Also the NetBeans IDE does not easily integrate with a SQL (Structured Query Language) database, which is required for storing data for the prototype application.

5.3.2 Language

The prototype application is written in C#, as the author has previously developed web applications using this language. Xamarin allows for applications to be written in C#.

5.3.3 Android/ iOS/ Windows

A decision was made to develop for Android only as the author owns an Android Smartphone and is therefore able to test Android specific code.

In the future it is planned to add Speech to Text functionality using the free Google Voice API (Application Program Interface) to the prototype app (Xamarin Inc. 2016a). Although Xamarin allows for development of cross platform applications, to add in voice recognition functionality the application has to be built in 'native' code specifically for Android, iOS or Windows. There is a further limitation with the Google Web Speech API, as it only works when the user's device is connected to the internet.

5.3.4 Database

A SQLite database is used behind the prototype application to store the data recorded from the patient assessments locally on the user's device. Both Android and iOS devices are able to use SQLite databases as they have an in-built SQLite database engine (SQLite 2016).

One of the challenges of using a SQLite database is that is difficult to see if a database has successfully deployed to a Smartphone as there is no database GUI (Graphical User Interface) to visually see the database on the phone. When developing a website, a developer will use tools such as Microsoft SQL Server to see what tables and data exist in a database. Initially it was a challenge without using a GUI, so additional test code was written to test if a database had been downloaded, to create a table and to check if the table existed, to add items and to count the items to confirm that they had been added to the table on a Smartphone.

SQLite Browser was downloaded to test the scripts to create the required database tables (See Figure 5-5). This tool provides a simple GUI but it only showed the database tables on the author's laptop as opposed to the database tables on the author's Smartphone.

Figure 5-5 SQLite Browser

5.3.5 Architecture

Xamarin recommends that the code behind a Smartphone application should be divided into various application layers (See Figure 5-6). The Data Layer refers to the database files which in the case of the prototype is a SQLite database. The Data Access Layer is where the CRUD (Create, Update and Delete) SQL (Structured Query Language) and other database statements are stored (Xamarin Inc. 2016b). The business layer refers to the classes within the code, which should be reflected by the set-up of the database tables. The application and UI (User Interface) files are the code behind pages for the screens and the user controls and are generally platform specific (Xamarin Inc. 2016b).

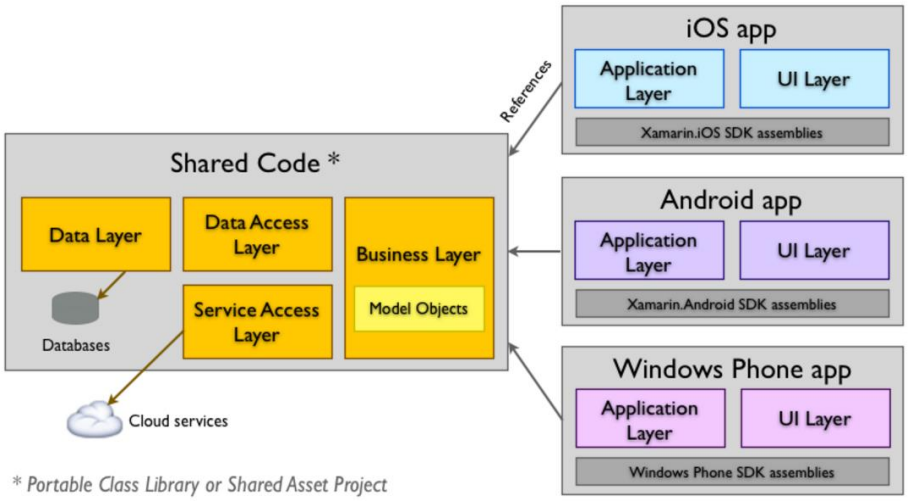


Figure 5-6 Xamarin Cross Platform Architecture (Xamarin Inc. 2016b)

A folder called Code was created to store the various development files (See Figure 5-7). A class was created for each database table and this class file was stored in the Business Layer folder. The code behind each of the user interface screens was stored in Activity files in the User Interface Layer folder. The code to create and interact with the SQLite database was stored in the Data Access Layer folder. A separate folder called ListAdapters was created to store the code for populating the Patient List on the main user interface screen. The screen designs or XAML (Extensible Application Markup Language) files were stored in a separate system created folder callout layout.

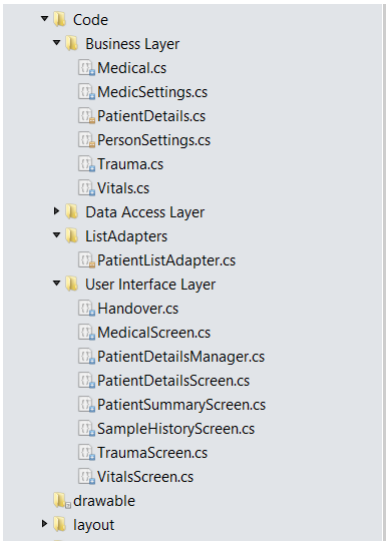


Figure 5-7 Prototype files

5.3.6 Debugging Method

Two main methods of debugging were used to develop the prototype, the first was to use an Emulator that ran on the development PC and the second was to use the author's personal Smartphone.

Xamarin works with an Emulator called 'Xamarin Android Player', which runs on a PC but looks and acts like a Smartphone (See Figure 5-8). When the emulator is selected during debugging, an Android phone displays on the screen of the PC, and the developer can flick through the emulator screens like on a normal Smartphone to test the application.

Figure 5-8 Xamarin Android Player Emulator

Another option is to deploy the application straight to the developer's personal Smartphone via either Bluetooth or via an USB cable connected to the developer's PC. When debugging is stopped the application still remains on the developer's Smartphone. Connecting to the PC via a USB cable was found to be the quickest method of debugging.

5.3.7 Version Control

The application code was backed up and stored on GitHub, a website that allows developers to store their code. The steps involved to manage storage of code on GitHub are to create a repository to store the project, create a master branch to store the master version of the code, create another branch to store code that is being developed, commit the changes in the new branch and then finally create a pull request to merge the new changes to the master branch (GitHub 2016) (See Figure 5-9). If there are problems with the code in the new branch the developer can go back and use the previously saved code stored in the master branch.

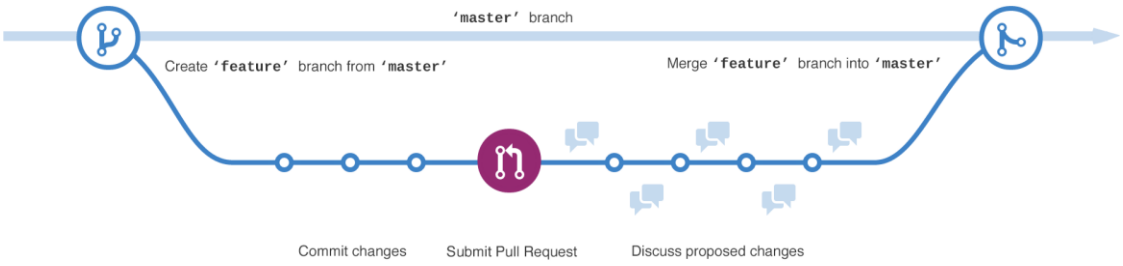


Figure 5-9 GitHub Version Control process (GitHub 2016)

5.4 Deployment

The prototype application was deployed to other Smartphones for testing by saving the application as an APK (Android Application Package) file to Dropbox and sharing the link to DWMRT members. When the team members clicked on the link, it allowed them to download and install the app directly onto their Smartphone. See Appendix F Deployment Instructions on how to install the app.

When the prototype is fully functional the author plans to deploy the app to Google Play to allow Android Smartphone users to download the app from there.

5.5 Conclusion

Creating the Software Requirements Specification documentation (See Appendix A) in advance of developing the app, proved to be a very structured method of clearly defining an app and helped to speed up the development process. The class diagram was particularly useful as it was used to define the database tables, the classes and to define the controls on the screen layouts.

The design process was iterative, with a first design made after the literature review, a second design made after the analysing the results, and a third stage of design where some screen layouts were changed during the actual development process. As the app is only a prototype it is envisaged that if the app is further developed, there will be further iterations of design including a focus on formatting.

The author got the opportunity to work with previously unused software tools such as Ninja Mock, Xamarin, GitHub and SQLite Browser. Ninja Mock was found to be an excellent tool for quickly creating screen mock-ups. Xamarin proved to be an easy tool to work with, and there are plenty of online support documents and videos to help develop apps using C# code.

The patient assessment prototype is the first Smartphone app that the author has developed so a considerable amount of time was spent learning how to develop an app initially. Some planned functionality was therefore removed due to time limitations, but a functioning patient assessment app was developed in the process.

Chapter 6 Conclusions

6.1 Introduction

In this final chapter, the strengths and limitations of the study are reviewed, and information is provided on how the final results of the study will be disseminated. One of the major implications of the study is not actually related to the app development but to the possible introduction of the IMIST – AMBO protocol during handovers from Mountain Rescue personnel to paramedics. Other recommendations are detailed and the author provides her reflections on the study and a status review of the original aims of the study.

6.2 Strengths and Limitations of the Study

6.2.1 Strengths

All four elements of the initial research plan; literature review, questionnaire, interviews and prototype evaluation were completed. A fully functional prototype app was developed by the end of the project, which was based on feedback from the research studies.

There was a very high level of participation of the selected study group of DWMRT members, who provided a huge amount of knowledge and feedback. It was beneficial that this focus group not alone had a very thorough understanding of the research problems but also had a high level of IT proficiency and were able to suggest and discuss solutions.

Design principles were reviewed to understand what makes a user more likely to use a product, and these principles were used in creating some of the research questions. It was important to learn that design is not purely about how a product looks, but it is more about the user experience.

6.2.2 Limitations

Initially it was difficult to find research papers relating to Mountain Rescue, patient assessment in first aid, and even in Smartphone technology. This highlighted that there is a lot of opportunity for further research in these areas.

The author does not have professional experience as a clinician, so was reliant on the input from professional healthcare workers.

It was time consuming to learn how to develop an app, and not all of the desired functionality was added to the prototype app due to time constraints. The final prototype app was restricted to Android use only which eliminated a considerable number of potential end users.

Another limitation was that the author only got to test the app on her own Smartphone. It would be very beneficial to test and view the app on a large selection of phones, and to observe how users interact with the app in training and callout situations. It would also be beneficial to ask other Mountain Rescue teams in Ireland to test out the app.

6.3 Dissemination

The final thesis document will be stored on Dropbox, and the link to the file will be sent to all DWMRT members for them to download and read if they wish to. The link to the thesis document will be sent onto people if requested.

The author will review the findings of the thesis initially with the DWMRT medical officer, and then with the DWMRT committee. The author will also review the findings and recommendations with the MRI committee.

6.4 Implications

Although the overall focus of the thesis was to design an app for patient assessment in Mountain Rescue, one of the major learnings from the study is that the handover process from Mountain Rescue personnel to paramedics could be improved upon by introducing the use of the IMIST - AMBO protocol. The author plans to suggest the use of the IMIST-AMBO protocol to the MRI committee. The introduction of the IMIST – AMBO protocol to Mountain Rescue teams could be enhanced by using the prototype app as part of the training and roll-out process.

6.5 Recommendations for Future Research

The prototype app developed as part of the project, contains eight screens and one database table behind it. It is envisaged that the app will continue to be developed in iterations or stages with additional functionality added as detailed in Table 6-1.

Table 6-1 Stages of prototype app design

Stage	Functionality
1	• Record patient assessment details in a single database table • Display summary patient assessment details on a Handover screen
2	• Record Medic details • Add in lists and database tables to allow for multiple traumas, medical conditions and vitals to be recorded • Update formatting of app • Record date and times for each list recorded
3	• Add in Head to Toe image to record location of trauma/ medical condition • Add in sound and vibration alerts to remind user to repeat vital checks • Add in functionality to send on recorded information
4	• Add in advanced exams – Neuro, GCS • Record photos • Display map
5	• Add in Voice Recognition – Record speech and convert to text • Prompt user using pre-recorded speech
6	• Develop app for iOS

It is recommended to conduct further and ongoing market research, to find out what related apps or software systems are available, if there is a gap in the market and if there is potential to fill such a gap. Further research should also be conducted to see if a patient assessment app can be used by other types of rescue or pre-hospital care organisations.

For a patient assessment app to be successfully used, it may need to integrate with other systems, such as printers, ambulance software, ePCR and EHR (Electronic Healthcare Record) systems. It is recommended to review other types of software used by paramedics in particular, in Ireland and abroad. It is also recommended to review OpenEHR as a template for integration.

Further research is recommended into the use of voice recognition, and whether it is possible to use in remote emergency situations. Other areas to research further in are data protection, data security and perhaps the use of encryption when sharing information from an app.

6.6 Reflections on the study

One of the major successes of the project was that a working prototype was developed that could be downloaded to other people's phones for use.

The final design of the prototype app was based on the collaboration of DMWRT members providing their input, and it was a very positive experience to get assistance from so many people.

In Chapter 1, several study aims were listed. Some of these aims were achieved, but as can be seen form Table 6-2 further work or testing is required to achieve all of the original study aims.

Table 6-2 Original study aims and status following project completion

	Study Aim	**Status**
1	Investigate what patient assessment Smartphone applications already exist that could be of benefit to Mountain Rescue teams.	Achieved
2	Evaluate similar patient assessment Smartphone applications.	Achieved
3	Determine which patient assessment details are already recorded by Mountain Rescue teams.	Further work required
4	Determine what is the pertinent information required for patient handovers to paramedics.	Achieved
5	Determine what is the pertinent information required for MRI for legal and statistical purposes.	Further work required
6	Determine what is the pertinent information required to be stored in a patient assessment tool for decision making and record keeping.	Achieved
7	Evaluate if implementing a patient assessment Smartphone application can assist in treating patients.	Testing required
8	Evaluate if implementing a patient assessment Smartphone application can assist in data transfer, collection and storage.	Testing required
9	Investigate what functionality would support the user of the Smartphone application.	Achieved
10	Investigate if voice recognition could be successfully used as part of the application functionality in particular.	Further work required
11	Investigate how to optimally design the Smartphone application to be used in conditions that Mountain Rescuers work in.	Further work required

Initially the author was disappointed to find the NOLS SOAP Note app as it originally appeared that there were no relevant patient assessment apps available and that there was a gap in the market. However, asking people to test this app and provide feedback on it turned out to be a great foundation for designing a similar app from.

As part of the research the author learnt new software skills, found new software products, learnt about the legal definition of software as a medical device, but more importantly about the value of involving others in the design of a product. If the prototype is further developed more stakeholders such as PHECC or HSE may need to be consulted to optimally design the app.

The ethical approval process took much longer than expected, which pushed out the original timelines for conducting the research studies. If designing the interview questions again, the author would add in more open ended questions to obtain more rich information. It was very fortunate that so many participants took part in the studies, and that they provided so much useful feedback.

As it took a considerable amount of time to develop the prototype, it could have been more efficient to ask users to review the screen layouts created using Ninja Mock and to ask for feedback on the content, navigation across screens, formatting and control layout based on these diagrams. The initial designs did change following analysis of the research results, further iterating the point for the need for collaboration and the involvement of stakeholders in design, and that designing a product is an iterative process.

It was challenging to learn how to develop an app, but as well as online documentation there are some particularly useful tutorials on YouTube which visually show how to develop particular functionality.

6.7 Conclusion

This thesis provided a great opportunity for the author to test out and research an idea that the author had held for a long time, and to provide motivation to actually learn and develop an app. The process of writing a thesis also provided a structured way to involve other people in the app design process.

After reviewing the use of the IMIST-AMBO protocol by paramedics at Emergency Departments, it makes sense that Mountain Rescue teams also adopt the usage of this protocol when handing over patients to paramedics. If this protocol is adopted, this could be a simple but a significant change in the care of a patient by Mountain Rescue personnel.

In conclusion, although considerable amount of work has been conducted in designing and developing a patient assessment app as part of this thesis, further work is required to develop the app to make it an optimal product to use in patient assessment in Mountain Rescue.

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Appendices

Appendix A Software Requirements Specification

A.1 Introduction

The name of the Smartphone Application is 'MR Patient Assessment'.

A.1.1 Purpose

The purpose of this Software Requirements Specification (SRS) is to explain the requirements to design a Smartphone application to assist patient assessment in Mountain Rescue, to software developers and to potential investors in the app.

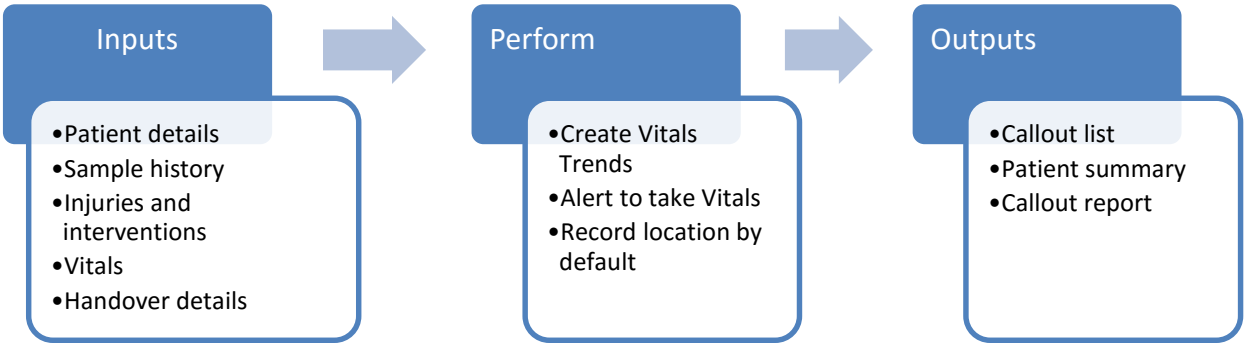


Figure A- 1 Patient assessment inputs, process and outputs flow

A.1.2 In Scope

- Data will be stored internally on a user's phone. This will allow for off-line capabilities.
- The application will be used by Mountain Rescue team members in First Aid training and in treating and assessing patients during Mountain Rescue callouts.
- The major functionality of the app is to
    - record information about a patient
        - Patient details
        - SAMPLE history
        - Medical and/ or trauma injuries
        - Vital signs
        - Handover details
    - prompt users to repeat Vitals checks
    - record additional information about a callout
        - Name of location
        - Start and end date/ time of a callout
    - Display Vitals in table and graph format
    - Share callout details including patient details to other relevant personnel
- There will be no restriction on which features a user can see.

- All text on the screens will be in English only.
- Data can only be shared when the user has Internet access.

A.1.3 Out of Scope

- The application will not be designed for general First Aid purposes.
- The application will not contain any clinical decision support functionality.
- The application will not integrate with medical devices.
- The application data will only be accessible on one Smartphone device i.e. if a new callout is recorded on the application, other users will not be able to see or edit the callout details recorded on their version of the application on their Smartphone. However, the user can share the information by sending an HTML link or by sending an email.
- There will be no restrictions on who the data can be sent to.
- There will be no charge to use the application.
- No translations into other languages will be provided.
- The application will be developed for Android Smartphones. The full functionality of the application might not be available to iOS and Windows Smartphone users.
- There will be no role based user security.
- The data will not be stored on an external database.
- An audit log will not be stored.

A.1.4 Goals

- Improve the process of recording details during a patient assessment.
- Improve communication of patient assessment details to the transferring agency and to the Mountain Rescue base.

A.1.5 Objectives

- Increase the quality and quantity of data recorded during a patient assessment.
- Provide users with a clear and easy method to record patient assessment details.
- Provide users with alerts so that Vitals are recorded regularly.
- Provide agencies such as the HSE or ICG with patient assessment information before and when they arrive on scene.
- Provide patient assessment details to the Mountain Rescue base during a callout to assist in their decision making.

A.1.6 End product

The application will be available to download to Android Smartphones.

A.1.7 Overview

The functions are clearly listed and a process flow diagram is used to explain the new functionality clearer. The specific details are given in both user interface and class details. High level use cases and definitions are also given.

A.2 Overall description

A.2.1 System interfaces

The application will not interface with other systems.

A.2.2 User interfaces

- The user interface will be in the form of mobile pages.
- A sound and a vibration pattern will be made, when Vital checks are due to be repeated. The app will default to the Vitals mobile page.
- The mobile pages will only be accessible from starting the application.
- Users can use the touch screen on their Smartphone device to enter in details and to move between mobile pages.
- The controls must be tabbed in order from top left down to bottom right.

A.2.3 Hardware interfaces

- The Smartphone application can be used on Smartphones but also on Tablets.
- For Voice Recognition to work, the hardware used must have a microphone, or the ability to use a peripheral microphone.

A.2.4 Software interfaces

- The application will not interface directly with other software systems.
- However, it will use the Smartphone's functionality to share information via email, WhatsApp etc.

A.2.5 Infrastructure

The code pages will be developed using the C# language, the layout pages will be developed using XAML and the overall application will integrate with a SQLite database.

A.3 Product functions

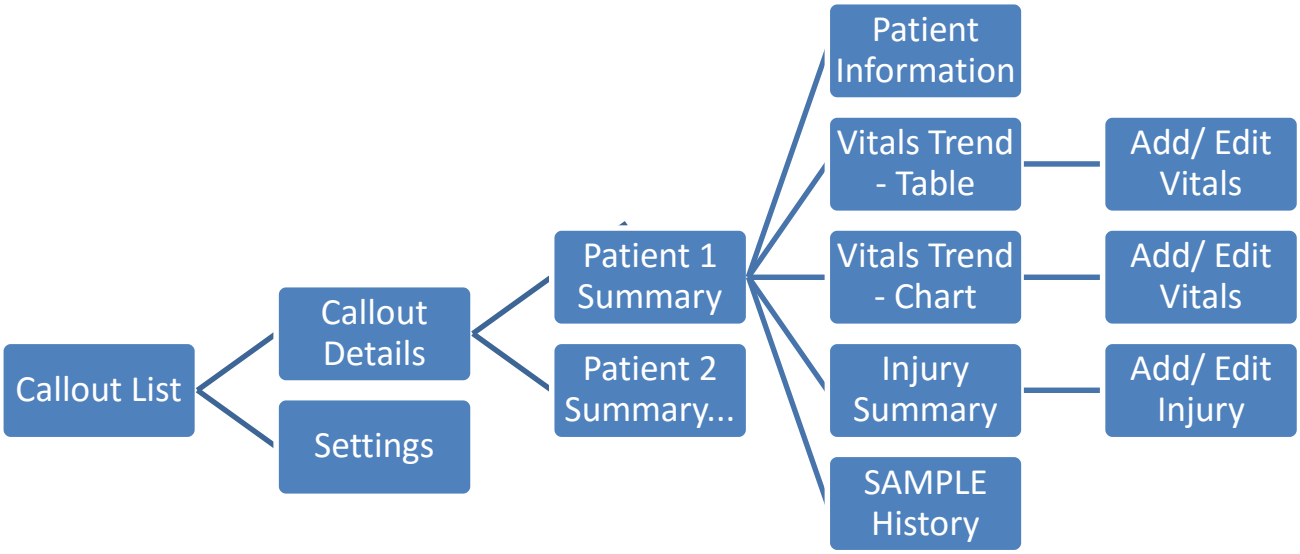


Figure A- 2 Prototype app functions

Table A- 1 Prototype app Main functions and description

Main Functions	Description
Record Patient Information	Users will be able to record • General patient information • Vital Signs • Medical and Trauma injuries • SAMPLE History
Sound Alert	Users will be prompted to complete another set of Vitals • 5 to 30 minutes after the last set of Vitals were recorded for a patient • There will be an option to set the frequency of the alert
Display Vitals clearly	Users will be able to view the previously recorded Vital signs in table and graph formats
Share information	Users will be able to send the full Callout information or a selected patient information to their own contacts using built in functionality on their Smartphone.
Display Summary information	Users will be able to view Callout summary information and Patient summary information.
Automatically set Callout details	The Smartphone application will automatically record the following information once a new callout is started on the application • Callout start date and time • Callout location • Medic details When all the patients have been transferred the callout is automatically ended.

A.3.1 Current process

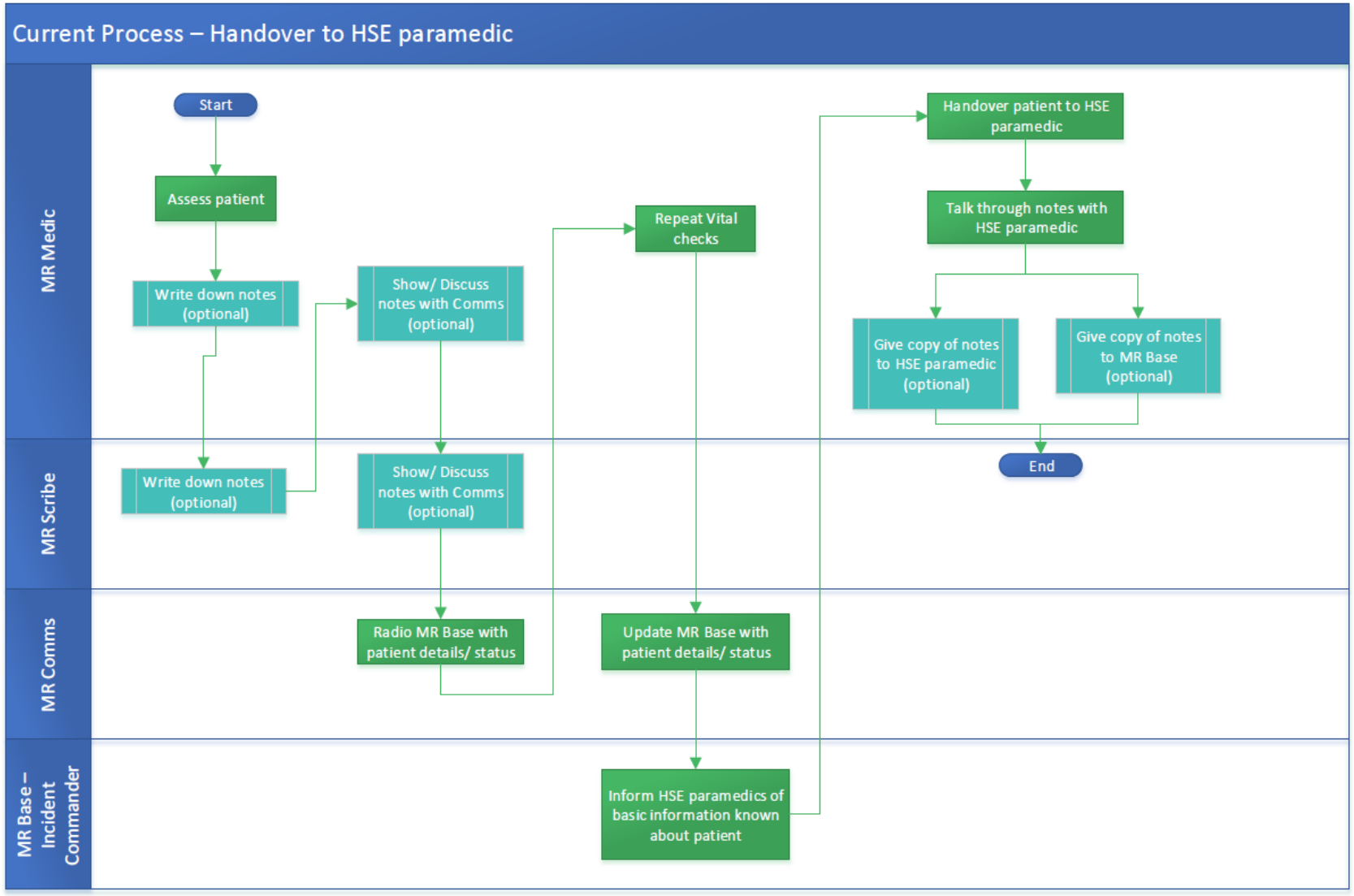


Figure A- 3 Current handover process to HSE paramedic

A.3.2 Proposed New Process Flow

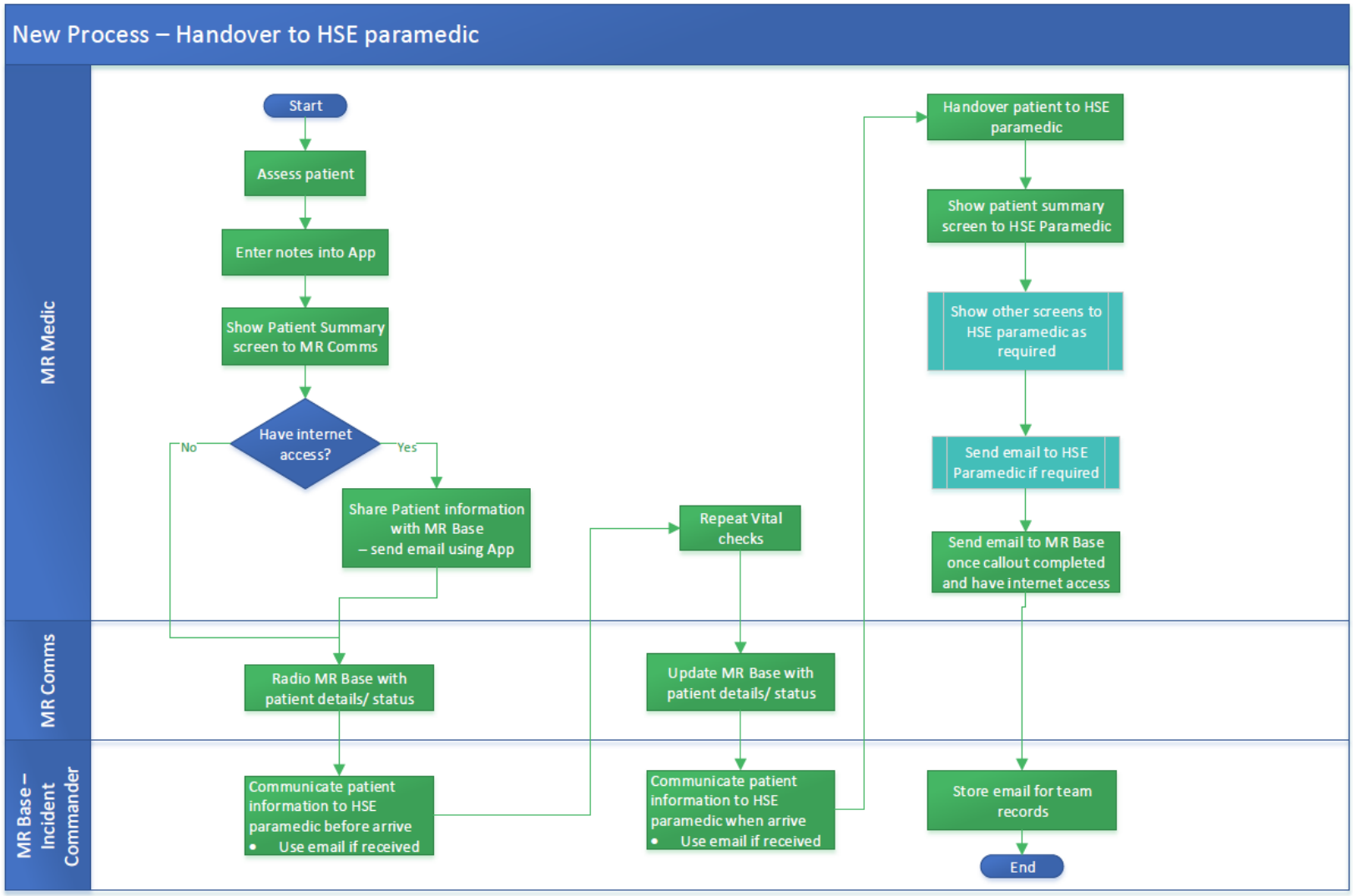


Figure A- 4 Propose new handover process

A.3.3 User characteristics

The users will be Mountain Rescue team members that are trained to a minimum of REC 3 First Aid Level. The users will already own a Smartphone and be familiar with using Smartphone applications. Demonstrations and training of the Smartphone application will be provided to the end users if required.

A.3.4 Constraints

- It will only be possible to share information if the user has internet access.
- It will only be possible to share information if the user has email functionality set up on their Smartphone.
- It will only be possible to automatically record the grid reference of the initial site of the callout if the user has GPS functionality on their Smartphone and it is turned on.
- The accuracy of the grid reference will be dependent on the GPS of the Smartphone, not on the application.

A.3.5 Assumptions and dependencies

- It is assumed that users know how to use the Share functionality on their Smartphone.
- It is assumed that the user may not have internet access at all times, and so the application will be designed to work in off-line mode as well as in on-line mode.

A.4 Specific requirements

A.4.1 User Interfaces

- **Website features**

Number	Summary	Details
3.2.1.1	Menu	Add in VTE Risk Assessment to the top menu in CMS
3.2.1.1	Title	Add the title 'VTE Risk Assessment' to the top of all the new VTE Risk Assessment webpages.

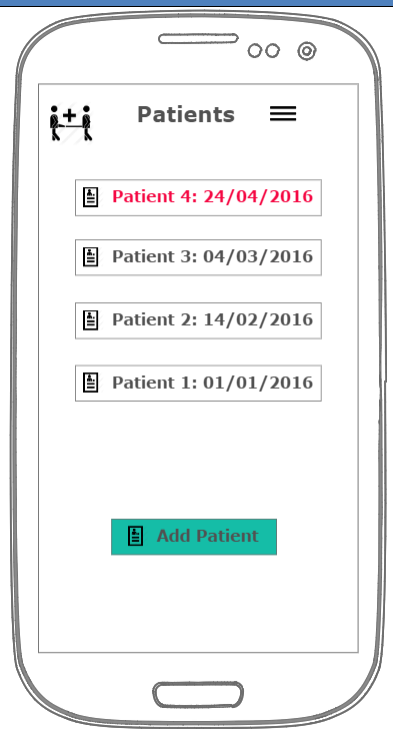
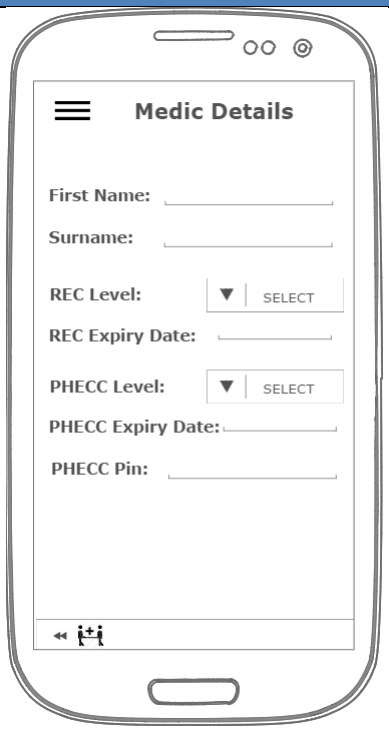
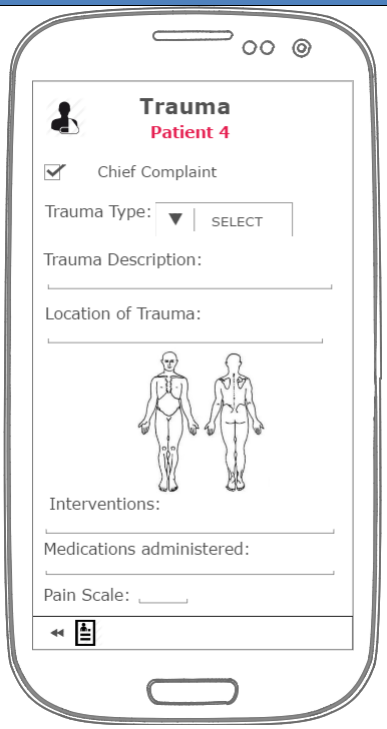
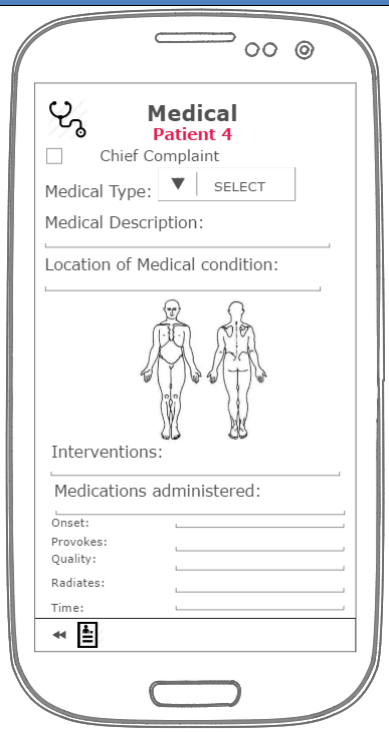
- **Alert**

Number	Summary	Details
3.2.2.1	Title	Add in subtitle 'Alert'
3.2.2.2	Message box	Display message box with the text 'VTE Assessment is required' and with the text 'Start VTE Assessment below?'
3.2.2.3	Text	Add in text dependant on the cause of the alert • 'Patient has just been admitted' • '24 hours since last assessment completed' • 'Patient is waiting to be discharged' • 'Abnormal laboratory result' • 'Proactive staff request'

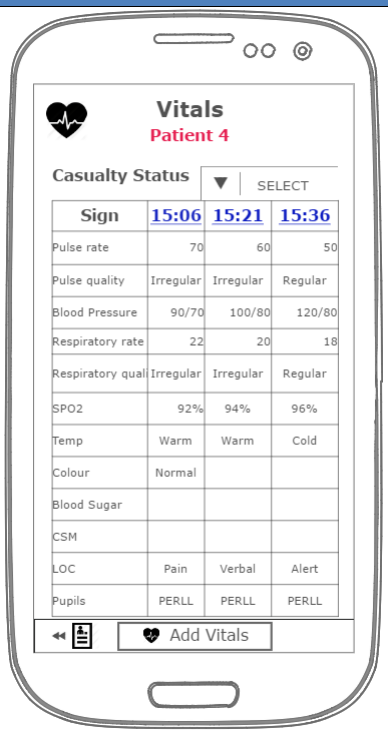
A.5 User Interface

A.5.1 Screen mock-ups

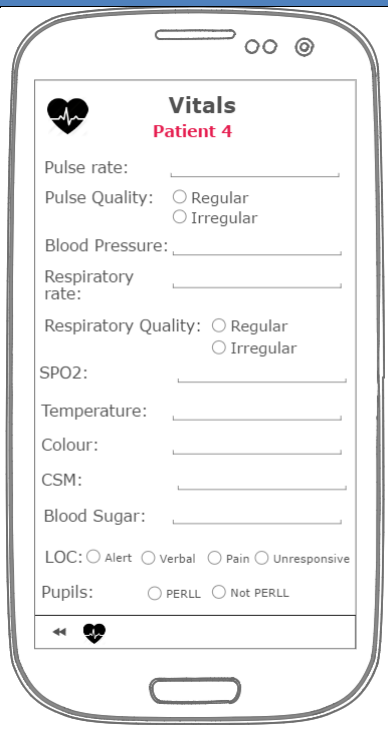
Table A-2 Screen mock-ups

Patient List	Patient Summary	Medic Details
		
Patient Details	**Trauma**	**Medical**
		

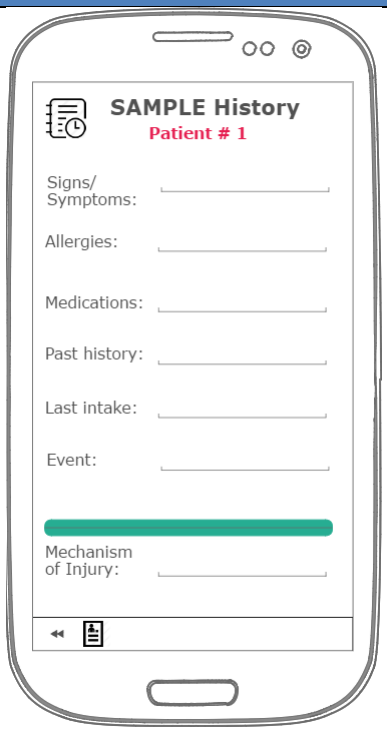
Vitals Summary



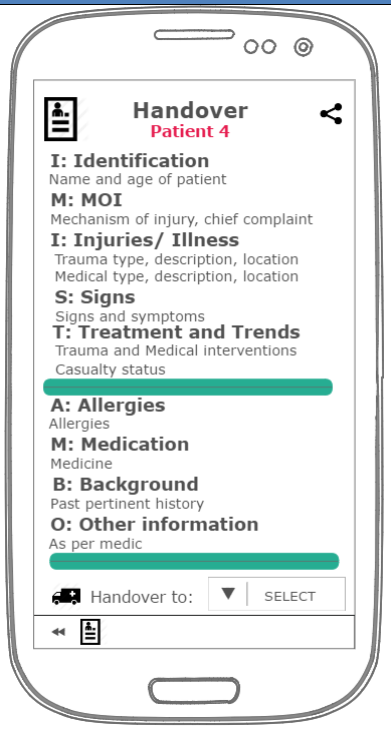
Vitals



SAMPLE History



Handover



A.6 Use Cases

A.6.1 Use Case Diagram

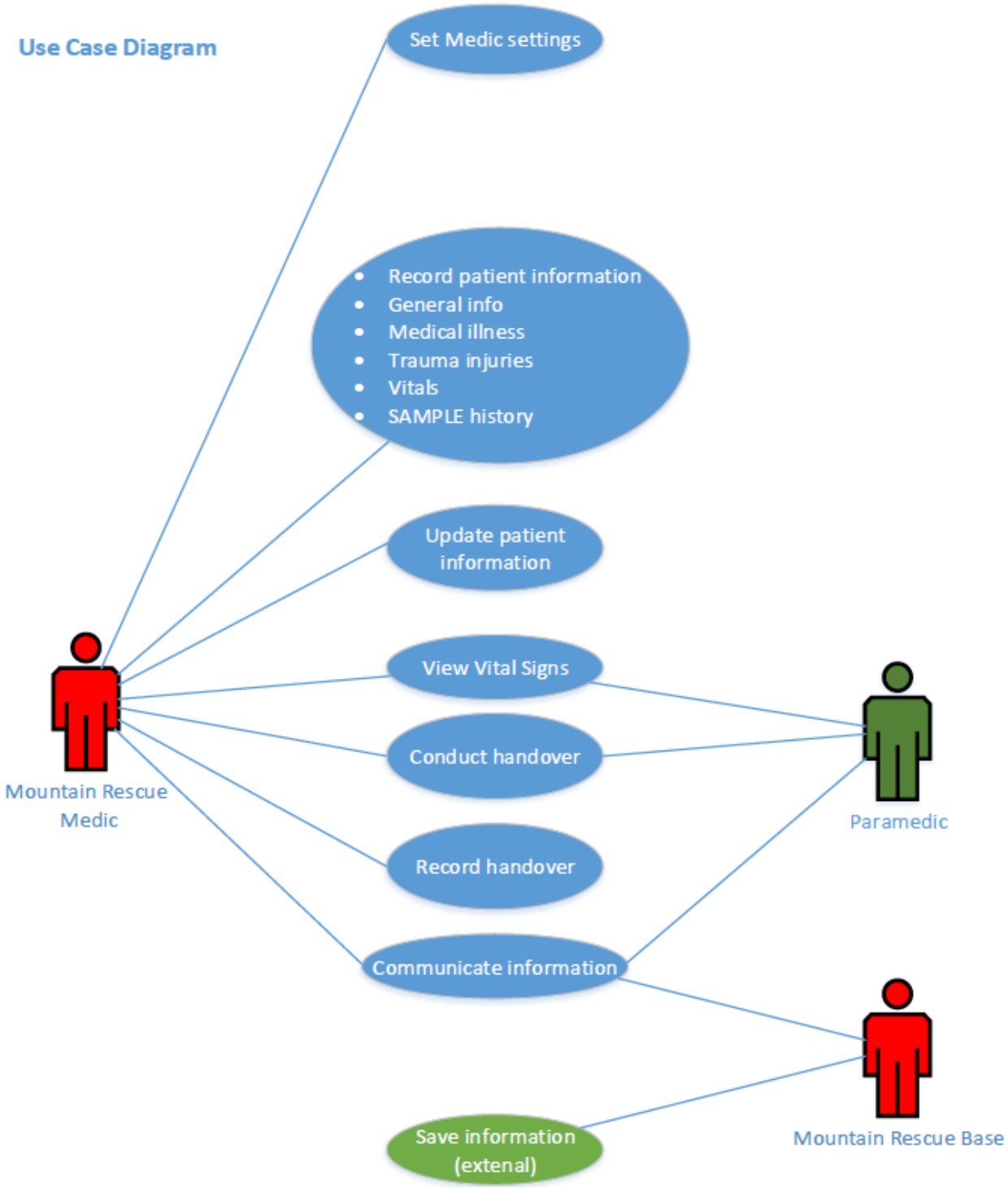


Figure A- 5 Use Case diagram

A.6.2 Use Case Summary

A use case diagram is a model of how the application will work from the point of view of the user.

Use Case Name	Use Case Description	Participating Actors
Set Medic Settings	Record details of the user of the application	• Mountain Rescue Medic
Start Patient	Create a new set of patient details	• Mountain Rescue Medic
Record Patient Information	Record patient information	• Mountain Rescue Medic
Alert Vital Signs	Alert the user to repeat the recording of vital signs	• Mountain Rescue Medic • Paramedic
Conduct Handover	Display summary information and detailed information to support handover	• Mountain Rescue Medic • Paramedic
Record Handover	Record handover details	• Mountain Rescue Medic
Share Information	Share information by email	• Mountain Rescue Medic • Mountain Rescue Base • Paramedic

A.6.3 Set Medic Settings

User Case Name	Use Case ID	Priority	Primary Business Actor	Other Actors	Other Stakeholders
Set Medic Settings	UC 1.0	Low	MR Medic		
Description					
The user of the application can record their name, first aid training levels, and first aid qualification expiry dates. The user's name will appear in the email sent out to share information about a callout.					

A.6.4 Start Patient

User Case Name	Use Case ID	Priority	Primary Business Actor	Other Actors	Other Stakeholders
Start Callout	UC 2.0	Medium	MR Medic		
Description					
When the user creates a new patient, the callout start time and date will be automatically recorded. Also the grid reference (if GPS signal is available) will be automatically recorded. The user will be brought to the Patient Details screen and the automatically recorded details will be displayed.					

A.6.5 Record Patient Information

User Case Name	Use Case ID	Priority	Primary Business Actor	Other Actors	Other Stakeholders
Record Patient Information	UC 3.0	Medium	MR Medic		
Description					
The user can record and update patient information for one or more patients. The user can record general information, SAMPLE history, injuries and vital signs.					

A.6.6 Alert Vital Signs

User Case Name	Use Case ID	Priority	Primary Business Actor	Other Actors	Other Stakeholders
Alert Vital Signs	UC 4.0	Medium	MR Medic		
Description					
The user can set a frequency as to when to reassess the vital signs of the patient. An alert will appear on the screen of the phone, and a sound and vibration will also be made.					

A.6.7 Conduct Handover

User Case Name	Use Case ID	Priority	Primary Business Actor	Other Actors	Other Stakeholders
Conduct Handover	UC 5.0	Medium	MR Medic		• MR Comms • MR Party Leader

					• Paramedic
Description					
The user can show the patient handover screen to other individuals to quickly communicate the condition of the patient. If more detail is required, then the user can go to the required screens.					

A.6.8 Record Handover

User Case Name	Use Case ID	Priority	Primary Business Actor	Other Actors	Other Stakeholders
Record Handover	UC 6.0	Medium	MR Medic		• Paramedic
Description					
When a patient has been transferred to a paramedic the agency of the paramedic is recorded. The date and time of the handover is automatically recorded.					

A.6.9 Share Information

User Case Name	Use Case ID	Priority	Primary Business Actor	Other Actors	Other Stakeholders
Share Information	UC 7.0	Medium	MR Medic		• MR Base • Paramedic
Description					
The use of the application can send on the full details of the callout including all the patient information recorded.					

A.7 Class Diagram

A.7.1 Original Class Design

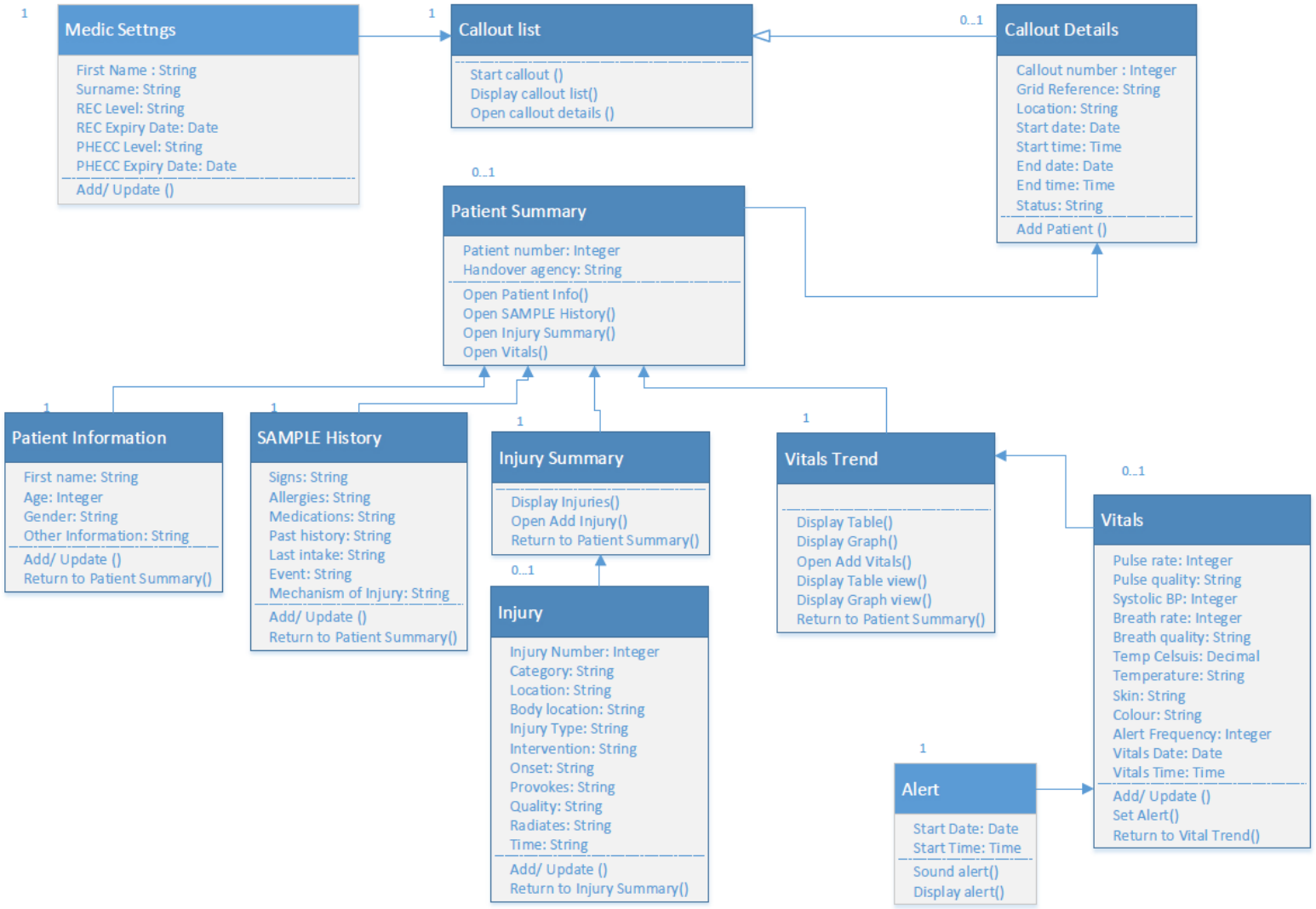


Figure A- 6 Class diagram – Original design

A.7.2 Updated Class Design

Figure A- 7 Updated class design

A.8 Sequence Diagram

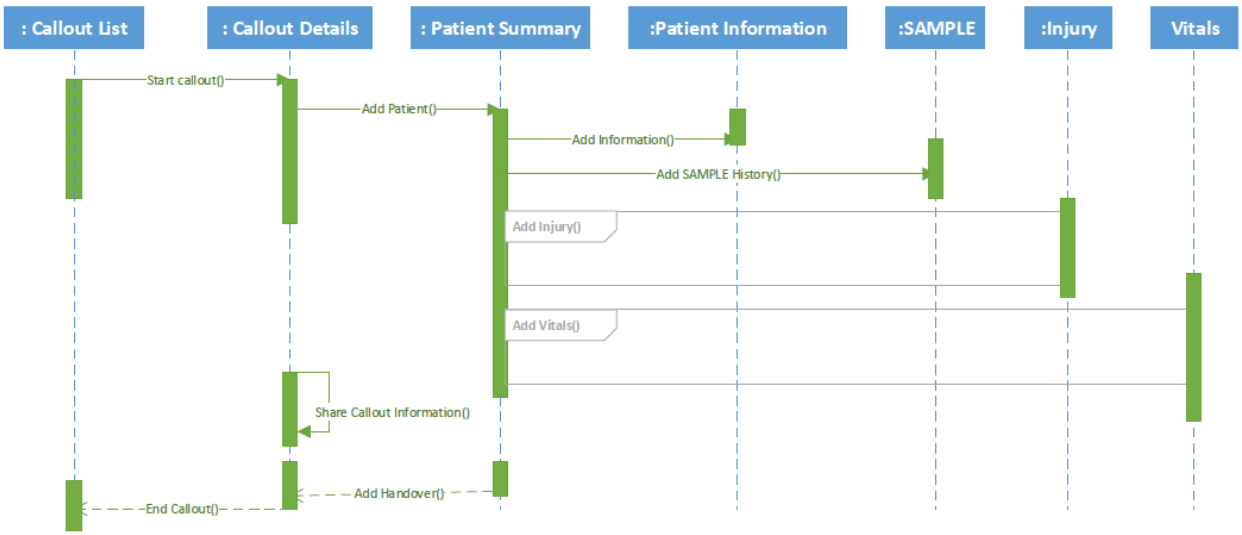


Figure A- 8 Sequence Diagram

A.9 Performance requirements

- The application should be available for use 24/7.
- The application should take less than 2 seconds to refresh or load.
- The application should be able to store up to 5 sets of patient details at one time for a live callout.

A.10 Design constraints

- The style of the pages must be the same throughout the application.
- Acronyms are to be avoided if possible.
- The prototype will be designed for Android only.

A.11 Application attributes

A.11.1 Reliability

- The alerts must appear/ sound at the correct times.

A.11.2 Availability

The website module should be available 24/7 365 days a year.

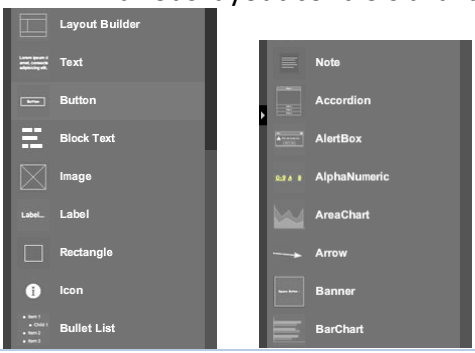
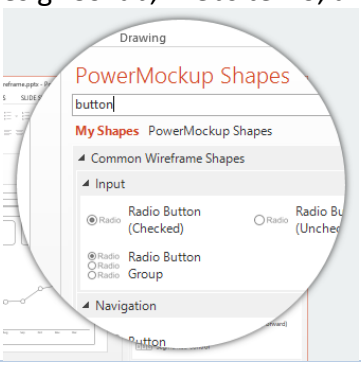
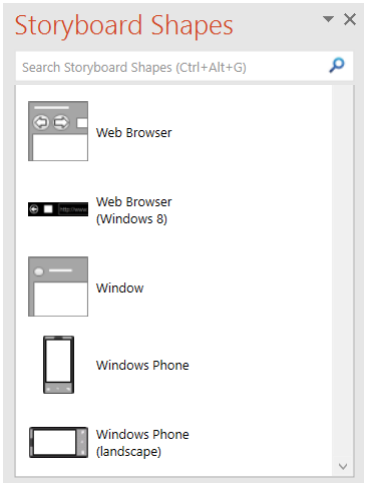
A.11.3 Security

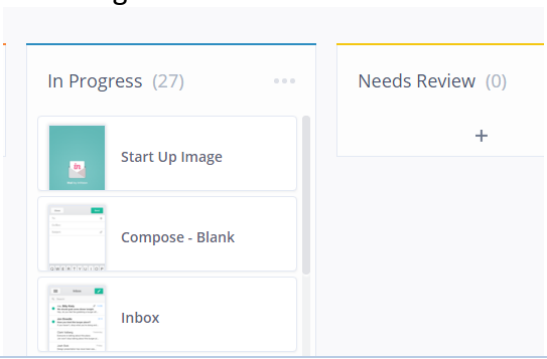
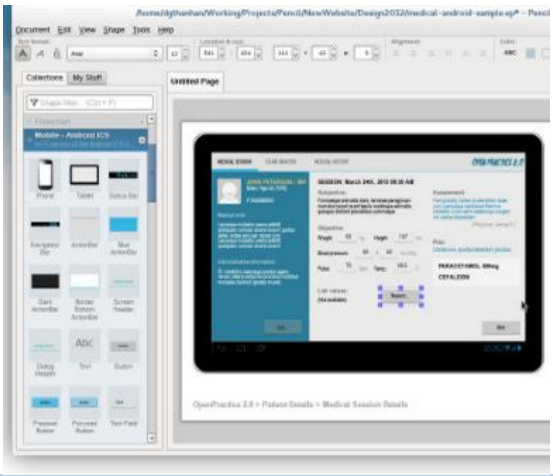
- There will be no security in the application. It will be up to the user to manage the use of the application and the data stored in the application.

Appendix B Mock-Up Software Tools

B.1 Evaluation of Mock-Up Tools

Table B-1 Mock-up Tools

Product	Benefits	Limitations
Mockflow	• Free for 1 designer • Various layout controls available 	Only one project can be created.
PowerMockUp	Various design options such as WireframePro, DesignCollab, WebsitePro, and BannerPro 	$60 fee for one license.
Storyboarding	This is available in Microsoft PowerPoint for developers who have Visual Studio Professional installed. However, it is now available as standard in PowerPoint 2016. 	The design features are limited to Windows Mobile phones and Windows webpages.

Invision	The website is useful for sharing screen layouts with others to get feedback on layout and design. 	There is no functionality to create screen layouts.
Pencil	• Free to use • Open source • Android and iOS design controls available • http://pencil.evolus.vn/ 	
Ninja Mockup	• Free up to 3 projects • Android and iOS design controls available • Able to add hyperlinks to screen layouts -when a link is clicked the corresponding screen is shown. This is useful to test the flow of the screens.	

Appendix C Patient Care Report Forms

C.1 PHECC Patient Care Report

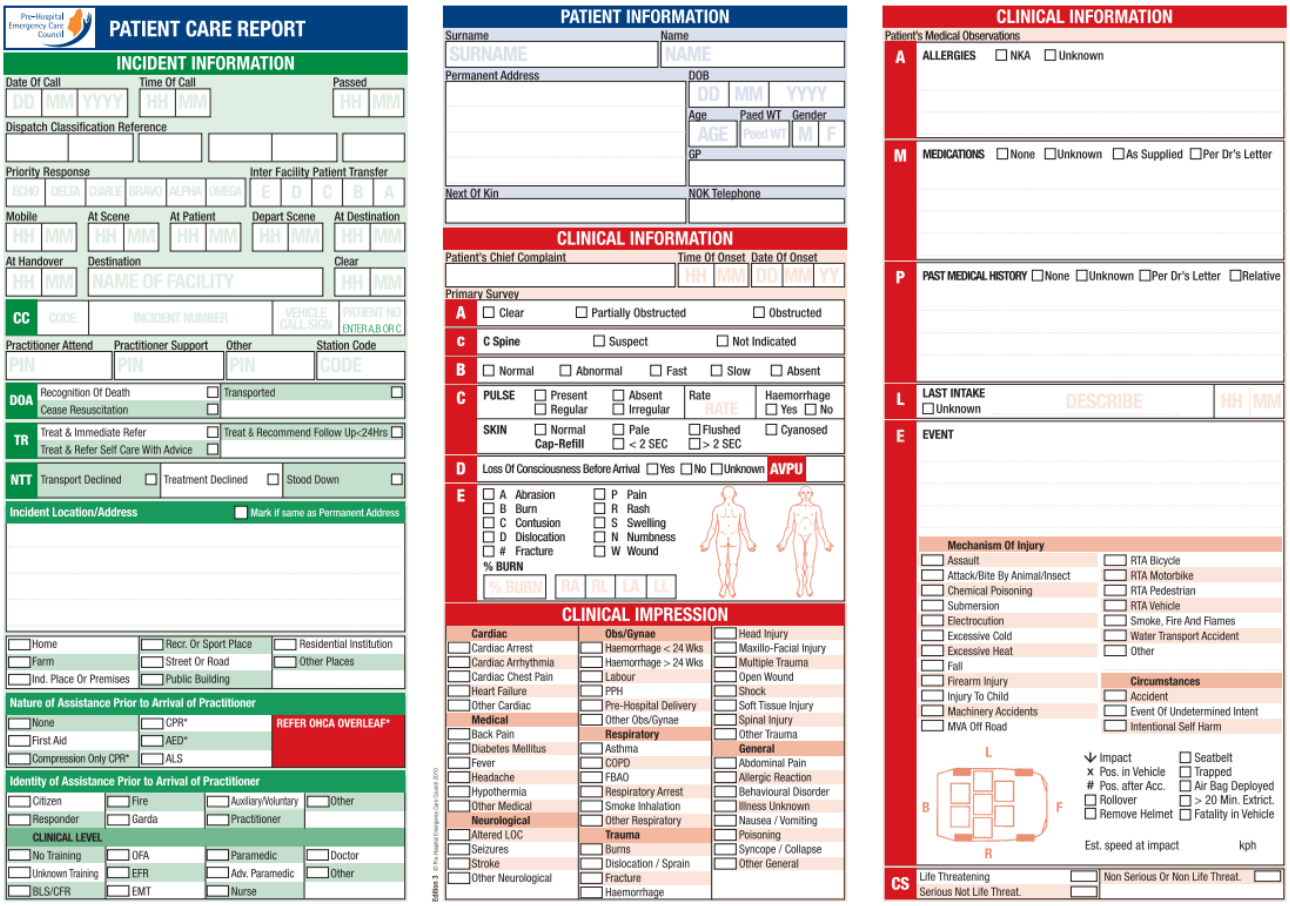


Figure C-1 PHECC Patient Care Report

C.2 Mountain Rescue Ireland PCR

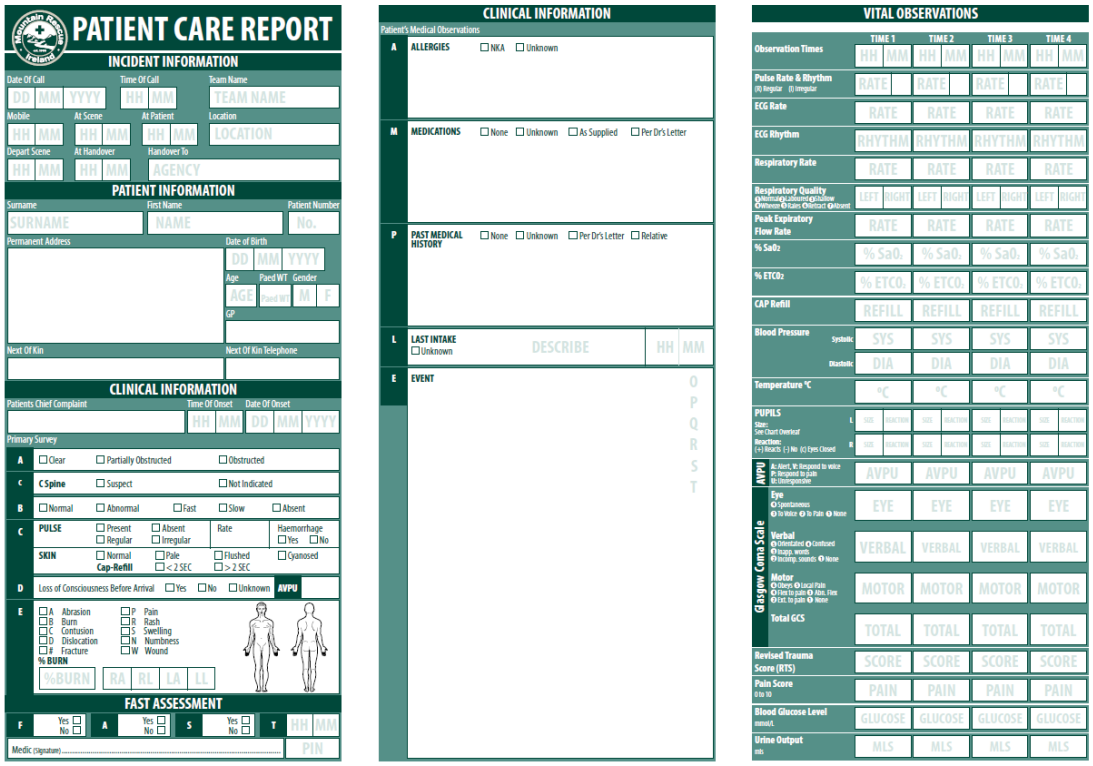


Figure C-2 Mountain Rescue Ireland PCR - page 1

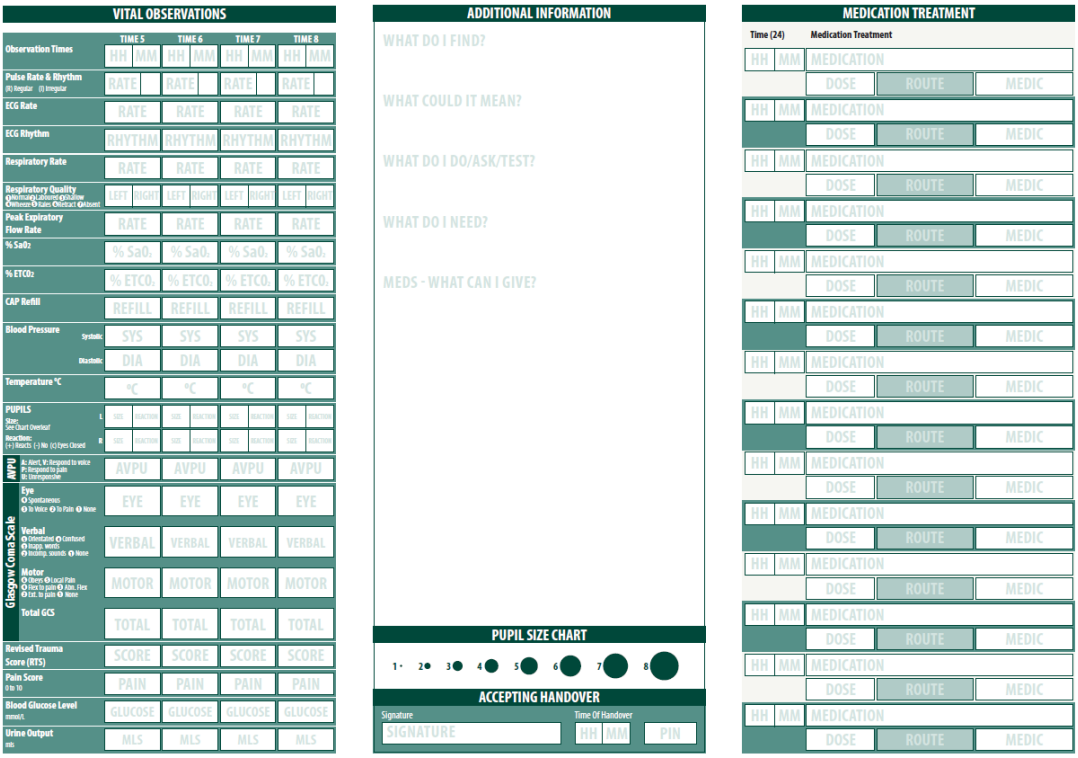


Figure C-3 Mountain Rescue Ireland PCR - page 2

Appendix D Ethical Approval

D.1 Research Project Proposal

PROJECT TITLE
What is the optimal design of a Smartphone Application to be used in Patient Assessment in Mountain Rescue?

PROJECT PURPOSE
Currently I am a full team member of the Dublin & Wicklow Mountain Rescue Team, and I have a personal interest in First Aid. My motivation to conduct this research is from my five years' experience on the team where I have identified problems in recording data during patient assessments, transferring patient data to paramedics and recording patient data for later analysis. I also wish to expand on research conducted as part of a previous Human Computer Interaction group project which resulted in a paper called 'The potential of using voice recognition in patient assessment documentation in Mountain Rescue'.

The problems that I have observed and experienced in conducting patient assessments in Mountain Rescue include that it is difficult to write and treat at the same time, the weather conditions can be formidable, the assessments may occur in the dark, and although a person may be designated as a 'scribe' to assist you they may disappear to get equipment or help with another part of the operation.

The purpose of this project is to conduct research to identify the optimal design for a Smartphone Application that will resolve or reduce the problems faced in patient assessment in Mountain Rescue.

This research will be used in the researcher's dissertation that will be submitted to Trinity College Dublin, in partial fulfilment of the requirements for the degree of Master of Science in Health Informatics.

RESEARCH METHODS

- Questionnaire
    - A link to an on-line questionnaire will be sent out to all current team members of the Dublin & Wicklow Mountain Rescue by the secretary of the team. The URL to the questionnaire will also be posted on the team's forum website. The team members will be asked to use the NOLS (National Outdoor Leadership School) SOAP Note Smartphone application and to provide feedback on this application using the questionnaire. The purpose of this task is to find out what functions the team members find to be beneficial in patient assessment, and to identify poorly designed and well-designed features of the app.
    - https://scsstcd.qualtrics.com/SE/?SID=SV_8HdMgtOGcIQVeSx
- Interviews
    - Interviews will be conducted with specifically chosen Dublin & Wicklow Mountain Rescue team members. The chosen team members will be those people who work professionally in healthcare in roles such as paramedics, doctors or first aid instructors. The purpose of the interviews is to clearly identify what is the pertinent information to store in a patient assessment app, and what data is required for patient handover.
- App Evaluation
    - It is proposed to create a prototype app using feedback from both the questionnaires and the interviews. A selected group of Mountain Rescue team members will be asked to use the prototype. The researcher will ask the team members for feedback following using the prototype. The selected group will also be asked to fill in a concise questionnaire to rate the prototype.
    - https://scsstcd.qualtrics.com/SE/?SID=SV_7OOqJc444gsXHAp

PARTICIPANT SELECTION
All participants selected will be Mountain Rescue team members. All participants will be at least 18 years of age as Mountain Rescue team members must be at least 21 years of age to join the team. There will be no exclusions.

- Questionnaire
    - A link to an on-line questionnaire will be sent out to all current team members of the Dublin & Wicklow Mountain Rescue by the secretary of the team. The URL to the questionnaire will also be posted on the team's forum website. It is expected that up to 10 members will fill in

the questionnaire.

- Interviews
    - I will ask a select group of 3 -5 Dublin & Wicklow Mountain Rescue team members that also work professionally in healthcare to participate in interviews. The team members selected for interview work professionally in roles such as paramedics, doctors or first aid instructors.
- App Evaluation
    - I will ask members of the Dublin & Wicklow Mountain Rescue Team to test out a prototype application and to provide their feedback directly to me. I will ask for the secretary of the team to send out an invitation to the team members to volunteer in the app evaluation study.

DEBRIEFING ARRANGEMENTS

I will inform all participants of the purpose of the research. If participants request to the see the results of any of the studies I will send on the final results in pdf format to their email address. If participants request to view the final thesis I will send on a pdf copy when the dissertation has been completed.

ETHICAL CONSIDERATIONS

There is a potential conflict of interest as I am a team member of the Dublin & Wicklow Mountain Rescue Team and I am friends with the team members.

There is potential for team members to fill in details from a real callout. However, I have requested in the questionnaire not to use data from a real callout. If I deem any of the data recorded in the questionnaire to be matching a real callout I will delete that questionnaire.

DATA CONFIDENTIALITY

As per the Data Protection Acts 1988 and 2003 the data will be anonymized and no disclosures of personal information will be provided, and no consent is required from the data controller.

All research and analysis documents used for this dissertation are/will be stored on the author's personal laptop. Only the author has access to this laptop, and the laptop is encrypted. All research and analysis documents relating to the dissertation will also be individually password protected.

The research and analysis documents include

- dissertation (Microsoft Word)
- results from the NOLS SOAP Note Evaluation Questionnaire (Microsoft Excel)
- data collected from the NOLS SOAP Note Evaluation Email (Microsoft Word)
- answers collected from the Interviews (Microsoft Word)
- results from the Prototype App Evaluation Questionnaire (Microsoft Excel)

Once the dissertation has been submitted, all relating research and analysis documents and surveys will be deleted.

- NOLS SOAP Note Evaluation Questionnaire
    - The questionnaire is hosted by Qualtrics. The option to *'Anonymize Response. Do NOT record any personal information and remove panel association'* has been selected and set to true, so that no personal information is automatically recorded.
    - When the questionnaires have been completed, the data will be exported out to the software product Microsoft Excel for analysis. There should be no identifiable information in the results. If a name has been added in by a participant, this will be removed from the data in the Excel sheet by the author.
- NOLS SOAP Note Evaluation Email
    - Participants will be asked to fill in patient assessment details into the NOLS SOAP Note app and then send an email from the app to the author's email account.
    - Participants will be asked not to use details from a real callout when filling in the patient assessment details. If details are found to be from a real callout the data will be eliminated from the study.
    - When an email is received from the NOLS SOAP Note app the author will copy the contents of the email into a Microsoft Word document. The contents of all subsequent emails will go into the same Microsoft Word document. Once the contents of the email have been copied successfully into the Word document, the original email will be deleted.
    - The NOLS SOAP Note app requires users to enter in their First Name, Last Name and

Training Level. Participants will be asked to set the First Name to 'Mickey', the Last Name to 'Mouse' and Training Level to 'Other'. When the contents of the emails are copied to the Word document, the First Name, Last Name and Training Level details will be deleted so if the participant has mistakenly put in their own name or training level this will not be stored.

- Interview Questions
    - The names of the interviewees will not be recorded.
- Prototype App Evaluation Questionnaire
    - The questionnaire is hosted by Qualtrics. The option to *'Anonymize Response. Do NOT record any personal information and remove panel association'* has been selected and set to true, so that no personal information is automatically recorded.
    - When the questionnaires have been completed, the data will be exported out to the software product Microsoft Excel for analysis. There will be no identifiable information in the results, as all the questions are closed and do not allow for text answers.

D.2 Questionnaire study

D.2.1 Information Sheet for Prospective Participants

Project Title: What is the optimal design of a Smartphone Application to be used in Patient Assessment in Mountain Rescue?
Name of Lead Researcher: Rita Darcy
Name of Supervisor: Mary Sharp
Lead Researcher's email: darcyri@tcd.ie
Lead Researcher's Contact Tel No.: 087-7546710
Course Name and Code: MSc Health Informatics
Estimated start date of survey/research: 14th March 2016

Background of Information:
The purpose of this project is to conduct research to identify the optimal design for a Smartphone Application that will resolve or reduce the problems faced in patient assessment in Mountain Rescue. This research will be used in the researcher's dissertation that will be submitted to Trinity College Dublin, in partial fulfilment of the requirements for the degree of Master of Science in Health Informatics. The research may also be published in scientific publications.

You have been selected to participate in this research as you are a member of the Dublin & Wicklow Mountain Rescue team and therefore have experience in participating in Mountain Rescue training, participating in Mountain Rescue callouts and are certified to a minimum standard of REC 3 (Remote Emergency Care) in First Aid.

Procedures of this study:
- You will be asked to download the Smartphone application NOLS SOAP Note.
    - The NOLS SOAP Note can be downloaded free of charge.
- You will be asked to create a 'Note' (patient assessment report) using the application.
- You will be asked to fill an on-line questionnaire following testing the SOAP Note Smartphone application.
- Your involvement in this study will take approximately 25 minutes.

Although you will be asked to send an email, all email addresses will be deleted and will not be included in the data for analysis. All data collected will be aggregated and anonymized.

Additional Information:
- Your participation in this study is voluntary.
- You may withdraw from the study at any point for any reason without any penalty.
- You do not have to answer each of the questions.
- The data will be anonymized. There will be preservation of your and third-party anonymity in analysis, publication and presentation of resulting data and findings. Please do not refer to any third parties directly.
- I do not anticipate any risks to you in this study. The benefits of participating in the study is that your feedback will allow me to design a Smartphone application that will be beneficial for patient assessment in Mountain Rescue.
- A copy of the research will be provided to you if requested.
- If you require any further information on the study, please feel free to ask me.
- I am a team member of the Dublin & Wicklow Mountain Rescue team. As a fellow rescue team member this is potentially a conflict of interest. Please provide honest feedback in the study.
- You may only participate in this study if you are 18 years of age or older and are competent to supply consent to participate in this study.
- In the very unlikely event that an illicit activity is reported to me during the study I will be obliged to report it to the appropriate authorities.
- In my dissertation I may use direct quotations when they are contextually appropriate, but you will still remain anonymous.
- I will act in accordance with the information provided (i.e. if I tell participants I will not do something, then I will not do it).

D.2.2 Informed consent form

BACKGROUND OF RESEARCH: *The process of recording and transferring notes from a patient assessment in Mountain Rescue can be quite challenging. The researcher found a smartphone application that may assist in patient assessment called SOAP Notes which was created by NOLS (National Outdoor Leadership School). The researcher is asking Mountain Rescue team members to test the SOAP Notes application and to provide feedback through this questionnaire. The results of the questionnaire will be used to optimally design a patient assessment application prototype.*

PROCEDURES OF THIS STUDY:
Participants are asked to do the following:

- *Download the NOLS SOAP Notes Smartphone application.*
- *Create a full 'Note'/ patient assessment report using the NOLS SOAP Notes Smartphone application.*
- *Send the report onto the researcher by email to darcyri@tcd.ie*
- *Answer the questions in the questionnaire.*

It will take approximately 5 - 10 minutes to create the 'Note'.
It will take approximately 15 minutes to answer the questionnaire.
There are no anticipated risks to the participants taking part in this questionnaire.

PUBLICATION: *This research will be used in the researcher's dissertation that will be submitted to Trinity College Dublin, in partial fulfilment of the requirements for the degree of Master of Science in Health Informatics. The research may also be published in scientific publications.*

Individual results may be aggregated anonymously and research reported on aggregate results.

DECLARATION:

- I am 18 years or older and am competent to provide consent.
- I have read, or had read to me, a document providing information about this research and this consent form. I have had the opportunity to ask questions and all my questions have been answered to my satisfaction and understand the description of the research that is being provided to me.
- I agree that my data is used for scientific purposes and I have no objection that my data is published in scientific publications in a way that does not reveal my identity.
- I understand that if I make illicit activities known, these will be reported to appropriate authorities.
- I freely and voluntarily agree to be part of this research study, though without prejudice to my legal and ethical rights.
- I agree not to mention any third parties directly.
- I understand that I may refuse to answer any question and that I may withdraw at any time without penalty.
- I understand that my participation is fully anonymous and that no personal details about me will be recorded.
- I have received a copy of this agreement.

Statement of investigator's responsibility: I have explained the nature and purpose of this research study, the procedures to be undertaken and any risks that may be involved. I have offered to answer any questions and fully answered such questions. I believe that the participant understands my explanation and has freely given informed consent.

RESEARCHERS CONTACT DETAILS: **darcyri@tcd.ie, 087-7546710**

URL: **https://scsstcd.eu.qualtrics.com/jfe/form/SV_8HdMgtOGcIQVeSx**

D.2.3 Questionnaire

I have read the information details form and the informed consent form and I consent to participate in this study by filling in this questionnaire.

- ❍ Yes
- ❍ No

- If you haven't done so already, please download the NOLS (National Outdoor Leadership School) 'SOAP Note' App.
- The App can be found by searching for 'SOAP Note' in Google Play Store on iTunes depending on your phone type.
- This App is provided free of charge.
- SOAP stands for Subjective, Objective, Assessment and Plan A SOAP note is similar to filling in a Patient Report form when treating a patient during a callout. It used for recording the Incident location, date and time Chief compliant Vital Signs Sample History Assessment and Plan A Smartphone application or program is also called an 'App'.

Instructions

- Open up the SOAP note on your Smartphone.
- Enter in the following details into the opening screen First Name - 'Mickey' Last Name - 'Mouse' Training Level – Leave as 'Other'
- Create a New SOAP note using dummy data. The data can reflect a typical scenario, however please do not use data from a real callout. Please fill in the details comprehensively.
- Send the completed SOAP note to darcyri@tcd.ie
    - Note: All email addresses will be removed from the data afterwards.
- Go back through the newly completed SOAP note and think about you liked or didn't like about the App, and think about what improvements could be made to the App.
- Fill in the questionnaire based on your thoughts on the App.

Questionnaire The questionnaire is divided into 6 Sections.

- Background: general questions about your experience in Mountain Rescue and First Aid
- Smartphones: general questions about your use of Smartphones
- System Usability Scale: rate the App using a standard scale
- App Evaluation: rate the App using questions based on design principles
- App Functionality: review the functionality in the App
- Patient Assessment App: review possible functionality for a new App

Have you created a note (Patient assessment report) using the NOLS SOAP Note App and sent the note by email to darcyri@tcd.ie ?

- ❍ Yes
- ❍ No

Background: general questions about your experience in Mountain Rescue and First Aid

How many years have you been involved in Mountain Rescue?

- ❍ Less than one year
- ❍ 1 - 5 years
- ❍ Greater than 5 years

How many years have you been involved in First Aid?

- ❍ Less than one year
- ❍ 1 - 5 years
- ❍ Greater than 5 years

Which First Aid certificates do you currently hold? Please select all that apply.

- ❑ REC 2
- ❑ REC 3
- ❑ REC 4
- ❑ REC 5
- ❑ PHECC CFR (Cardiac First Response)
- ❑ PHECC EFR (Emergency First Response)
- ❑ PHECC EMT (Emergency Medical Technician)
- ❑ PHECC Paramedic
- ❑ PHECC Advanced Paramedic
- ❑ WEMSI WFR (Wilderness First Responder)
- ❑ WEMSI WEMT (Wilderness Emergency Technician)
- ❑ WEMSI Wilderness Physician
- ❑ Other _____

What type of Mountain Rescue team member are you?

- ❍ Full team member
- ❍ Associate member
- ❍ Probationary member

Smartphones: general questions about your use of Smartphones

Do you own a Smartphone?

- ❍ Yes
- ❍ No

How many years have you used a Smartphone for?

- ❍ Less than 1 year
- ❍ 1 or more years

What type of Smartphone do you own?

- ❍ iPhone
- ❍ Android e.g. Samsung, Sony
- ❍ Windows e.g. Nokia
- ❍ Other _____

Please list any First Aid Smartphone Applications (Apps) that you have downloaded and used beforehand?

Do you carry a Smartphone during callouts?

- ❍ Yes
- ❍ No

Is your Smartphone designed to be waterproof?

- ❍ Yes
- ❍ No

Do you use a case to protect your Smartphone?

- ❍ Yes
- ❍ No

If No Is Selected, Then Skip To Have you used voice recognition before?

Does the case used to protect your Smartphone restrict usage of the screen?

- ❍ Yes
- ❍ No

Have you used voice recognition before?

- ❍ Yes
- ❍ No

Have you used Google Voice or Apple Siri before?

- ❍ Yes
- ❍ No

Does your Smartphone have a 'Glove mode' which allows you to use the Smartphone whilst wearing gloves?

- ❍ Yes
- ❍ No

If No Is Selected, Then Skip To End of Block

Do you find the 'Glove mode' to be effective?

- ❍ Yes
- ❍ No

Please provide an example of a Smartphone application (any type) that you found to be well designed (easy to learn, easy to use, enjoyable to use).

What did you like about the well designed Smartphone application?

Please provide an example of a Smartphone application (any type) that you found to be poorly designed (difficult to learn, difficult to use, difficult to use).

What did you not like about the poorly designed Smartphone application?

Do you need reading glasses to use a Smartphone?

❍ Yes

❍ No

System Usability Scale: rate the App using a standard scale Digital Equipment Corperation 1986 Brooke, J. (1996). System Usability Scale. Retrieved from http://www.usabilitynet.org/trump/documents/Suschapt.doc

Please provide your feedback of the NOLS SOAP Notes Smartphone application by answering the below questions. The questions listed below are from the System Usability Scale which is used globally for assessing systems usability.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I think that I would like to use this App frequently	❍	❍	❍	❍	❍
I found the App unnecessarily complex	❍	❍	❍	❍	❍
I thought the App was easy to use	❍	❍	❍	❍	❍
I think that I would need the support of a technical person to be able to use this App	❍	❍	❍	❍	❍
I found the various functions in this App were well integrated	❍	❍	❍	❍	❍
I thought there was too much inconsistency in this App	❍	❍	❍	❍	❍
I would imagine that most people would learn to use this App very quickly	❍	❍	❍	❍	❍
I found the App very cumbersome to use	❍	❍	❍	❍	❍
I felt very confident using the App	❍	❍	❍	❍	❍
I needed to learn a lot things before I could get going with this App	❍	❍	❍	❍	❍

App Evaluation: rate the App using questions based on design principles

Have you ever used the NOLS SOAP Note app beforehand? (Before being asked to complete this questionnaire)

- ❍ Yes
- ❍ No

How would you describe the overall experience of using the NOLS SOAP Notes app?

- ❍ Terrible
- ❍ Poor
- ❍ Average
- ❍ Good
- ❍ Delightful

Would you use the NOLS SOAP Notes app during a medical training session?

- ❍ Definitely not
- ❍ Probably not
- ❍ Might or might not
- ❍ Probably yes
- ❍ Definitely yes

Would you use the NOLS SOAP Notes app during a Mountain Rescue callout?

- ❍ Definitely not
- ❍ Probably not
- ❍ Might or might not
- ❍ Probably yes
- ❍ Definitely yes

Who would you recommend to use the NOLS SOAP Notes app when assessing a patient? Please select all that apply.

- ☐ Medic
- ☐ Scribe
- ☐ Both
- ☐ Other _____

When do you think the App should be used?

- ❍ During the assessment of the patient
- ❍ At intervals during the assessment of the patient
- ❍ After the assessment of the patient is complete

Did the NOLS SOAP Notes app respond quickly enough when you clicked on the buttons?

- ❍ Yes
- ❍ No

Is it easy to navigate from one screen to another?

- ❍ Strongly disagree
- ❍ Somewhat disagree
- ❍ Neither agree nor disagree
- ❍ Somewhat agree
- ❍ Strongly agree

Open up the NOLS SOAP Notes app again. Add in another set of vitals. Is it easy to navigate to the Vitals section of the app?

- ❍ Strongly disagree
- ❍ Somewhat disagree
- ❍ Neither agree nor disagree
- ❍ Somewhat agree
- ❍ Strongly agree

When adding in a new set of vitals was it clear to you that the app was in edit mode as opposed to read mode?

- ❍ Strongly disagree
- ❍ Somewhat disagree
- ❍ Neither agree nor disagree
- ❍ Somewhat agree
- ❍ Strongly agree

Did you see the Timer (Stopwatch) functionality that assists with taking vitals?

- ❍ Yes
- ❍ No

Do you understand the intended meaning of the below symbols? The symbol or icon is displayed on the left. The intended meaning is displayed on the right of the icon.

	Yes	No
Return to Overview section	❍	❍
Return to Subjective section	❍	❍
Return to Objective section	❍	❍
Return to Assessment and Plan section	❍	❍
Return to Photos section	❍	❍
Edit SOAP note	❍	❍
Share SOAP Note	❍	❍
Display Main Menu	❍	❍
Display help text	❍	❍

Did you make any errors or mistakes filling in the SOAP Note?

- ❍ Yes
- ❍ No

If No Is Selected, Then Skip To End of Block

Was it easy to correct the errors or mistakes?

❍ Yes

❍ No

Where did the error or mistake happen in the app?

App Functionality: review the functionality in the App

Below is a summary of the functionality in the NOLS SOAP Note app. Do you think the features are necessary for a patient assessment app?

	Definitely not	Probably not	Might or might not	Probably yes	Definitely yes
Date and Location	❍	❍	❍	❍	❍
Responder Information	❍	❍	❍	❍	❍
Patient Information	❍	❍	❍	❍	❍
Chief Complaint	❍	❍	❍	❍	❍
Mechanism of Injury (MOI)	❍	❍	❍	❍	❍
Patient Exam	❍	❍	❍	❍	❍
Patient Position when found	❍	❍	❍	❍	❍
Vital Signs	❍	❍	❍	❍	❍
Patient History	❍	❍	❍	❍	❍
Assessment	❍	❍	❍	❍	❍
Plan	❍	❍	❍	❍	❍
Share Note	❍	❍	❍	❍	❍
Photos	❍	❍	❍	❍	❍

Below is a summary of the functionality in the NOLS SOAP Note app. Do you think the features are well designed? (Easy to use, easy to learn, enjoyable to use)

	Definitely not	Probably not	Might or might not	Probably yes	Definitely yes
Date and Location	❍	❍	❍	❍	❍
Responder Information	❍	❍	❍	❍	❍
Patient Information	❍	❍	❍	❍	❍
Chief Complaint	❍	❍	❍	❍	❍
Mechanism of Injury (MOI)	❍	❍	❍	❍	❍
Patient Exam	❍	❍	❍	❍	❍
Patient Position when found	❍	❍	❍	❍	❍
Vital Signs	❍	❍	❍	❍	❍
Patient History	❍	❍	❍	❍	❍
Assessment	❍	❍	❍	❍	❍
Plan	❍	❍	❍	❍	❍
Share Note	❍	❍	❍	❍	❍
Photos	❍	❍	❍	❍	❍

Below is a summary of the functionality in the NOLS SOAP Note app. Please fill in any comments or suggestions you have for the below features.

- Date and Location
- Responder Information
- Patient Information
- Chief Complaint
- Mechanism of Injury (MOI)
- Patient Exam
- Patient Position when found
- Vital Signs
- Patient History
- Assessment
- Plan
- Share Note
- Photos

Patient Assessment App: review possible functionality for a new App

Would you recommend adding any of the below functionality to a patient assessment app? Please select all that apply.

- ❑ Graphic of a body (to show location of injury/ condition)
- ❑ Map of location
- ❑ Background lighting
- ❑ Larger font
- ❑ Vibration alert to notify to check Vitals periodically
- ❑ Sound alert to notify to check Vitals periodically
- ❑ Timer to set Vitals alert frequency
- ❑ Weather forecast
- ❑ Text/ image to show if have internet connection
- ❑ List of common chief complaints
- ❑ Password protection
- ❑ ETA (Expected Time of Arrival) calculator
- ❑ Record equipment used
- ❑ Record medication administered
- ❑ Pain scale slider - sad face to happy face
- ❑ Record time taken to complete an assessment
- ❑ Prevent phone from locking (and requiring user to enter in password to return to the app)
- ❑ DRABC prompt
- ❑ Head to Toe prompt
- ❑ Vital signs prompt
- ❑ Checklist
- ❑ Allow 2 or more users to edit the assessment at the same time

Can you suggest any other functionality that you would add to a patient assessment app?
What factors/ concerns would prevent you from using a patient assessment app during a Mountain Rescue callout?

D.3 Interview Study

D.3.1 Information Sheet for Prospective Participants

Project Title: What is the optimal design of a Smartphone Application to be used in Patient Assessment in Mountain Rescue?
Name of Lead Researcher: Rita Darcy
Name of Supervisor: Mary Sharp
Lead Researcher's email: darcyri@tcd.ie
Lead Researcher's Contact Tel No.: 087-7546710
Course Name and Code: MSc Health Informatics
Estimated start date of survey/research: 14th March 2016

Background of Research:
The purpose of this project is to conduct research to identify the optimal design for a Smartphone Application that will resolve or reduce the problems faced in patient assessment in Mountain Rescue. This research will be used in the researcher's dissertation that will be submitted to Trinity College Dublin, in partial fulfilment of the requirements for the degree of Master of Science in Health Informatics. The research may also be published in scientific publications.

You have been selected to participate in this research as you are a member of the Dublin & Wicklow Mountain Rescue team and therefore have experience in participating in Mountain Rescue training and in participating in Mountain Rescue callouts. You have also been specifically selected to participate in this research as you work professionally in healthcare as a paramedic, doctor or First Aid instructor.

Procedures of this study:
- A list of questions will be given to you in advance of the interview.
- You will be asked the questions during the interview.
- Your involvement in this study will take approximately 30 minutes.

All data collected will be aggregated and anonymized.

Additional Information:
- Your participation in this study is voluntary.
- You may withdraw from the study at any point for any reason without any penalty.
- You do not have to answer each of the questions.
- The data will be anonymized. There will be preservation of your and third-party anonymity in analysis, publication and presentation of resulting data and findings. Please do not refer to any third parties directly.
- I do not anticipate any risks to you in this study. The benefits of participating in the study is that your feedback will allow me to design a Smartphone application that will be beneficial for patient assessment in Mountain Rescue.
- A copy of the research will be provided to you if requested.
- If you require any further information on the study, please feel free to ask me.
- I am a team member of the Dublin & Wicklow Mountain Rescue team. As a fellow rescue team member this is potentially a conflict of interest. Please provide honest feedback in the study.
- You may only participate in this study if you are 18 years of age or older and are competent to supply consent to participate in this study.
- In the very unlikely event that an illicit activity is reported to me during the study I will be obliged to report it to the appropriate authorities.
- In my dissertation I may use direct quotations when they are contextually appropriate, but you will still remain anonymous.
- I will act in accordance with the information provided (i.e. if I tell participants I will not do something, then I will not do it).

Signed: ..... Date: .....
Lead Researcher

D.3.2 Informed consent form

LEAD RESEARCHER: Rita Darcy

COURSE: MSc Health Informatics

BACKGROUND OF RESEARCH: *The process of recording and transferring notes from a patient assessment in Mountain Rescue can be quite challenging. The researcher is asking specific Mountain Rescue team members who work in Healthcare to participate in an interview to ascertain the pertinent information required to be stored and transferred from a patient assessment in Mountain Rescue. The results of the interview will be used to optimally design a patient assessment application prototype.*

PROCEDURES OF THIS STUDY:
Participants are asked to do the following:

- *Read the interview questions in advance of the interview.*
- *Participate in the interview.*

The interview is expected to take approximately 30 minutes to complete.
There are no anticipated risks to the participants taking part in this interview.

PUBLICATION: *This research will be used in the researcher's dissertation that will be submitted to Trinity College Dublin, in partial fulfilment of the requirements for the degree of Master of Science in Health Informatics. The research may also be published in scientific publications.*

Individual results may be aggregated anonymously and research reported on aggregate results.

DECLARATION:

- I am 18 years or older and am competent to provide consent.
- I have read, or had read to me, a document providing information about this research and this consent form. I have had the opportunity to ask questions and all my questions have been answered to my satisfaction and understand the description of the research that is being provided to me.
- I agree that my data is used for scientific purposes and I have no objection that my data is published in scientific publications in a way that does not reveal my identity.
- I understand that if I make illicit activities known, these will be reported to appropriate authorities.
- I freely and voluntarily agree to be part of this research study, though without prejudice to my legal and ethical rights.
- I agree not to mention any third parties directly
- I understand that I may refuse to answer any question and that I may withdraw at any time without penalty.
- I understand that my participation is fully anonymous and that no personal details about me will be recorded.
- I have received a copy of this agreement.

PARTICIPANT'SNAME:

PARTICIPANT'S SIGNATURE:

Date:

Statement of investigator's responsibility: I have explained the nature and purpose of this research study, the procedures to be undertaken and any risks that may be involved. I have offered to answer any questions and fully answered such questions. I believe that the participant understands my explanation and has freely given informed consent.

RESEARCHERSCONTACTDETAILS: darcyri@tcd.ie, 087-7546710
INVESTIGATOR'S SIGNATURE:

D.3.3 Interview Questions

Background

1. Number of years involved in Mountain Rescue:
2. Number of years involved in Healthcare:
3. Healthcare role
   - ☐ First Aider
   - ☐ First aid instructor
   - ☐ Emergency Medical Technician
   - ☐ Paramedic
   - ☐ Advanced Paramedic
   - ☐ Doctor
4. Role in Mountain Rescue:

Smartphone Use in your role in Mountain Rescue

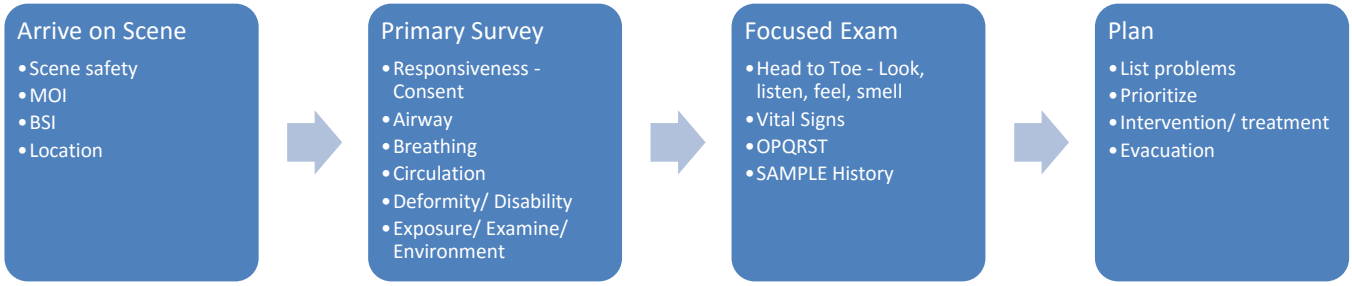
8. What Apps have you used beforehand in First Aid/ Healthcare for Mountain Rescue?
9. Do you carry a Smartphone during callouts?

Smartphone Use in your role in Healthcare

5. What Apps have you used beforehand in First Aid/ Healthcare for your job role?
6. Do you have use a Smartphone in work?
7. If so, is this provided by your employer or do you use your own personal phone?

Mountain Rescue Callout

10. What details would you expect/ recommend to be recorded at a callout by Mountain Rescue personnel if there was a patient?
11. How often would you expect the patient to be re-assessed during evacuation?
12. What information would you expect/ recommend to be given to the awaiting paramedic during the handover of the patient?
13. What details are stored after the callout and where are they stored?
14. Are there any legal requirements to store information?
15. Does the below graphic represent the steps taken in assessing and treating a patient?



Patient Care Report form

The Patient Care Report form can be used to transfer information during a handover of a casualty to a paramedic at a Mountain Rescue callout. This form is provided by PHECC (Pre Hospital Emergency Care Council).

16. Is the Patient Care Report form practical to use during patient handovers in Mountain Rescue?
17. What do you like about the Patient Care Report form?
18. What do you dislike about the Patient Care Report form?
19. What happens to the Patient Care Report after the patient handover in Mountain Rescue?
20. Would you find it useful to receive the full Patient Care Report in electronic format during a patient handover?
21. Do you think mountain rescue personnel are qualified to make diagnoses?
22. Do you think the Patient Care Report form contains the required details for a handover?

Paramedic Specific Questions

The below questions are only intended to be answered by team members who work professionally as paramedics or advanced paramedics outside of Mountain Rescue.

Patient Handover at a Mountain Rescue callout

23. What information would you request/ would like to receive from Mountain Rescue personnel at a handover?
24. Would it be useful to see graphs of vital signs?
25. What information is known in advance of arriving at the scene of a Mountain Rescue callout?
26. Who provides you with this information?
27. Would it be useful to receive the information as per the ASHIC Radio Message protocol? *See diagram below*
28. How do you communicate with the Mountain Rescue teams during a callout?
29. How long do you expect a handover to take?
30. Do you expect to receive a Patient Care Report from the Mountain Rescue Personnel?
31. Are other formats of a patient report form acceptable?
32. Would it be useful if mountain rescue personnel carried out handovers in the same manner as paramedics do when arriving at the Emergency Department of a hospital?
33. Do you use the IMIST - AMBO protocol during handovers to the Emergency Department?
34. Would the IMIST – AMBO protocol be a useful protocol to use during patient handovers in Mountain Rescue?

D.4 App Evaluation Study

D.4.1 Information Sheet for Prospective Participants

Project Title: What is the optimal design of a Smartphone Application to be used in Patient Assessment in Mountain Rescue?
Name of Lead Researcher: Rita Darcy
Name of Supervisor: Mary Sharp
Lead Researcher's email: darcyri@tcd.ie
Lead Researcher's Contact Tel No.: 087-7546710
Course Name and Code: MSc Health Informatics
Estimated start date of survey/research: 14th March 2016

Information:
The purpose of this project is to conduct research to identify the optimal design for a Smartphone Application that will resolve or reduce the problems faced in patient assessment in Mountain Rescue. This research will be used in the researcher's dissertation that will be submitted to Trinity College Dublin, in partial fulfilment of the requirements for the degree of Master of Science in Health Informatics. The research may also be published in scientific publications.

You have been selected to participate in this research as you are a member of the Dublin & Wicklow Mountain Rescue team and therefore have experience in participating in Mountain Rescue training, participating in Mountain Rescue callouts and are certified to a minimum standard of REC 3 (Remote Emergency Care) in First Aid.

Procedures of this study:
- You will be asked to try out a prototype Smartphone application.
- I will ask you for your feedback following trying out the prototype.
- You will be asked to fill in a short on-line questionnaire.
- Your involvement in this study will take approximately 15 minutes.
  All data collected will be aggregated and anonymized.

Additional Information:
- Your participation in this study is voluntary.
- You may withdraw from the study at any point for any reason without any penalty.
- You do not have to answer each of the questions.
- The data will be anonymized There will be preservation of your and third-party anonymity in analysis, publication and presentation of resulting data and findings. Please do not refer to any third parties directly.
- I do not anticipate any risks to you in this study. The benefits of participating in the study is that your feedback will allow me to design a Smartphone application that will be beneficial for patient assessment in Mountain Rescue.
- A copy of the research will be provided to you if requested.
- If you require any further information on the study please feel free to ask me.
- I am a team member of the Dublin & Wicklow Mountain Rescue team. As a fellow rescue team member this is potentially a conflict of interest. Please provide honest feedback in the study.
- You may only participate in this study if you are 18 years of age or older and are competent to supply consent to participate in this study.
- In the very unlikely event that an illicit activity is reported to me during the study I will be obliged to report it to the appropriate authorities.
- In my dissertation I may use direct quotations when they are contextually appropriate, but you will still remain anonymous.
- I will act in accordance with the information provided (i.e. if I tell participants I will not do something, then I will not do it).

Signed: .....
Date: .....
Lead Researcher

D.4.2 Informed consent form

LEAD RESEARCHER: Rita Darcy

COURSE: MSc Health Informatics

BACKGROUND OF RESEARCH: *The process of recording and transferring notes from a patient assessment in Mountain Rescue can be quite challenging. The researcher is asking specific Mountain Rescue team members who work in Healthcare to participate in an interview to ascertain the pertinent information required to be stored and transferred from a patient assessment in Mountain Rescue. The results of the interview will be used to optimally design a patient assessment application prototype.*

PROCEDURES OF THIS STUDY:
Participants are asked to do the following:

- *Try out a prototype Smartphone application as developed by the researcher*
- *Provide feedback to the researcher*
- *Fill in an on-line questionnaire*

The app evaluation is expected to take approximately 10 minutes to complete.
It is expected to take 5 minutes to complete the on-line questionnaire.
There are no anticipated risks to the participants taking part in this study.

PUBLICATION: *This research will be used in the researcher's dissertation that will be submitted to Trinity College Dublin, in partial fulfilment of the requirements for the degree of Master of Science in Health Informatics. The research may also be published in scientific publications.*
Individual results may be aggregated anonymously and research reported on aggregate results.

DECLARATION:

- I am 18 years or older and am competent to provide consent.
- I have read, or had read to me, a document providing information about this research and this consent form. I have had the opportunity to ask questions and all my questions have been answered to my satisfaction and understand the description of the research that is being provided to me.
- I agree that my data is used for scientific purposes and I have no objection that my data is published in scientific publications in a way that does not reveal my identity.
- I understand that if I make illicit activities known, these will be reported to appropriate authorities.
- I freely and voluntarily agree to be part of this research study, though without prejudice to my legal and ethical rights.
- I agree not to mention any third parties directly
- I understand that I may refuse to answer any question and that I may withdraw at any time without penalty.
- I understand that my participation is fully anonymous and that no personal details about me will be recorded.
- I have received a copy of this agreement.

PARTICIPANT'S NAME:
PARTICIPANT'S SIGNATURE:
Date:
Statement of investigator's responsibility: I have explained the nature and purpose of this research study, the procedures to be undertaken and any risks that may be involved. I have offered to answer any questions and fully answered such questions. I believe that the participant understands my explanation and has freely given informed consent.

RESEARCHERS CONTACT DETAILS: darcyri@tcd.ie, 087-7546710

INVESTIGATOR'S SIGNATURE:

Date:
URL: https://scsstcd.qualtrics.com/SE/?SID=SV_7OOqJc444gsXHAp

D.4.3 App Evaluation

I have read the information details form and the informed consent form and I consent to participate in this study by filling in this questionnaire.

❍ Yes

❍ No

System Usability Scale: rate the App using a standard scale Digital Equipment Corperation 1986 Brooke, J. (1996). System Usability Scale. Retrieved from http://www.usabilitynet.org/trump/documents/Suschapt.doc

Please provide your feedback of the NOLS SOAP Notes Smartphone application by answering the below questions. The questions listed below are from the System Usability Scale which is used globally for assessing systems usability.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I think that I would like to use this App frequently	❍	❍	❍	❍	❍
I found the App unnecessarily complex	❍	❍	❍	❍	❍
I thought the App was easy to use	❍	❍	❍	❍	❍
I think that I would need the support of a technical person to be able to use this App	❍	❍	❍	❍	❍
I found the various functions in this App were well integrated	❍	❍	❍	❍	❍
I thought there was too much inconsistency in this App	❍	❍	❍	❍	❍
I would imagine that most people would learn to use this App very quickly	❍	❍	❍	❍	❍
I found the App very cumbersome to use	❍	❍	❍	❍	❍
I felt very confident using the App	❍	❍	❍	❍	❍
I needed to learn a lot things before I could get going with this App	❍	❍	❍	❍	❍

Appendix E Research Results

E.1 Interview Results

Table E-1 Interview answers

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5
1. Number of years involved in Mountain Rescue:	3 years on the team, 12 years working with the team as part of the Incident Response Team	40	7 months	7 months	7 months, 21 years in Cave Rescue
2. Number of years involved in Healthcare:	21 Years	30 years in ambulance service, 10 years as Advanced Paramedic	3	5	5 years
3. Healthcare role	Advanced Paramedic	Advanced Paramedic	Doctor	Paramedic	Paramedic
4. Role in Mountain Rescue:	Full team member, Medical officer	Full team member	Team Member	Team member	Team member
5. What Apps have you used beforehand in First Aid/ Healthcare for your job role?	PHECC CPGs and PHECC Field Guide	PHECC Field Guide, Tallaght Pharmacology, Medical Dictionary, ACLS Advisor	Socrates, Medscape, Figure 1, READ (QXMED), RCH guidelines, EMWrap, Crumlin hospital laboratory tests app	PHECC CPG and Field guide	PHECC Practitioner app; Field Guide
6. Do you have use a Smartphone in work?	Yes	Yes	Yes	Yes	Yes
7. If so, is this provided by your employer or do you use your own	Use personal Smartphone	Use personal Smartphone	Use personal Smartphone	Use personal Smartphone	Use personal Smartphone
8. What Apps have you used beforehand in First Aid/ Healthcare for Mountain Rescue?	PHECC apps, ViewRanger	ViewRanger	ViewRanger, Google Maps	ViewRanger	Viewranger
9. Do you carry a Smartphone during callouts?	Yes	Yes	Yes	Yes	Yes

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5
10. What details would you expect/ recommend to be recorded at a callout by Mountain Rescue personnel if there was a patient?	Name, Date of Birth, Next of Kin, Contact details for Next of Kin, AMPLE history, Chief complaint, Nature of injuries, medical condition, Vital Signs, Medication administered	Time of accident, Time of arrival on scene, Time of all interventions, When vitals recorded, When change in patient's condition. SAMPLE History, OPQRST, Pain examination, Head to Toe - Line drawing - able to write on, CSM before and after, Neuro exam. Fluids in/out - Should check out the Mountain Rescue PCR - extended version of the PCR	Patient details, SAMPLE history, Injury, What happened, Vitals, any drugs given	Name, address, DOB, Next of Kin, Chief complaint, allergies, medications, last oral intake, Mechanism of Injury, Past Medical History, Full set of vitals: pulse rate, pulse quality (regular or irregular), respiratory rate, respiratory quality, SPO2, Blood pressure, Pupils, Cap Refill, GCS, Blood Glucose. Any medications, interventions done.	Name, age, date of birth, SAMPLE history, What happened, basic set of vitals, medications, who was in charge of log roll, splinting, pin number and medic details
11. How often would you expect the patient to be re-assessed during evacuation?	It depends on the condition - For simple injuries take vitals when treating patient, and 10 minutes afterwards. Continue to visually check patient during evacuation.	It depends	It depends - If lower leg not very often	It depends on the patient. Big sick every 10 minutes, small sick every 20-30 minutes - talk to patient to see how they are doing	All depends on the condition of the patient. If stable with lower leg injury, 1-2 set of vitals, check 20-30 minutes after administer pain relief. Ask the patient how do they feel. If head injury could be every 3 minutes.
12. What information would you expect/ recommend to be given to the awaiting paramedic during the handover of the patient?	ASHIC/ IMIST/ AMBO	IMIST	IMIST/ AMBO, ISBAR	IMIST/ AMBO. Anything out of the ordinary.	IMIST/ AMBO - it is an international standard
13. What details are stored after the callout and where are they stored?	The PCR should be filled out for all callouts even if there are no injuries. A copy of the PCR should be kept. The details from the PCR can be used for statistical analysis and for legal reasons in case information is required for a court case. The evacuation method should be documented in all cases.	A copy of the PCR should be kept for the team, and a copy should be sent onto the medical subcommitte of Mountain Rescue Ireland	Unsure of current practice	Unsure of current practice	Unsure of current process
14. Are there any legal requirements to store information?	For PHECC registered personal they must record all patient contacts, as PHECC may conduct an audit later on.	Contemporaneous notes should be kept in case of possible court action. A medical record is required for MRI insurance purposes, as the DWMRT is indeminified under MRI.	Assume store for 3 years	Need to record medications administered in case of future complaints, or the coroner's court.	As they are a medical document they should be stored for 7 years in a locked press, with access by one person only - the Medical officer. The document can be scanned but has to be stored on an encrypted drive. A record should then be kept of disposal.

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5
15. Does the below graphic represent the steps taken in assessing and treating a patient?	The diagram order should be changed to: Scene safety, Location, MOI, BSI. Then followed by AVPU, GCS. Then A-Airway, c-C Spine, B - Breathing, C - Circulation, D - Deformity, E - Environment. Head to Toe exam. It would be very beneficial to add in clinical decision support to an App to support differential diagnosis and deciding on medications to administer. The 'List Problems' should be moved into the Focused Exam section. The Plan section should be split in two a, Treatment Plan - Prioritize what needs to be treated first - Medic b, Evacuation plan - Party Leader	Arrive: Scene, location, BSI, MOI, Weather. Primary: Big C (for catastrophic bleeding) followed by A,B, C, D, E -and E for Evacuate. Focused exam missing CSMs. Plan - What do I see, What do I find, What can I do	Arrive on scene: Weather, team members available, access, egress and evacuation. Primary survey: move initial set of Vitals to here. Add in c for catastrophic bleedind and c-spine immobilization	Yes, but initial set of vitals are done during the primary survey; checking for pain scale, heart rate and pupil reaction.	Arrive on Scene: Be aware of what is happening.
16. Is the Patient Care Report form practical to use during patient handovers in Mountain Rescue?	Yes	Yes, but it would like to be able to photocopy the paper form before handing over original to paramedic.	The Wemsi notepad paper is more robust.	Handy to use in handover to paramedic. Difficult to write in the rain and on the side of a mountain.	It is not waterproof and can fall apart.
17. What do you like about the Patient Care Report form?	Folds up small	Aid memoire. It can be used at any skill level.	Aid memoire. Can be used to record Vitals, details and there is a carbon copy.	Know the format of it so easy to use. Vitals are in the one place.	Simplicity - work with it every day.
18. What do you dislike about the Patient Care Report form?	Needs to made more water resistant.	Can't keep a copy outdoors.	Can take a long time to fill out for simple injuries.	Not enough room to write all information. Have to open up to A2 size to write additional information. Medications box is very small.	For those not using it every day they can miss out on things to record, as it doesn't guide you through, and not always well explained on how to use. There can be a lot of variance in how they are filled in.
19. What happens to the Patient Care Report after the patient handover in Mountain Rescue?	The MR copy is stored in a secure location in case audits need to be carried out, and to identify learning points.	The MR copy is stored securely by the MR team, and a copy is sent onto the Medical Officer in MRI	Unsure of current practice	The PCR is brought to the triage nurse and gets scanned. One copy is stored in the patient's chart, and another copy is sent to the National Ambulance Control centre.	It usually ends up going into the ambulance.

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5
20. Would you find it useful to receive the full Patient Care Report in electronic format during a patient handover?	It is not necessary to have the PCR in electronic format but it would be useful send onto the hospital to assist in patient admission/ registration	Yes. It would need to be interopable with the new ePCR that is being introduced.	Yes. You would require a waterproof phone cover for inclement weather and hospital and paramedics should be able to receive it.	North East Ambulance service have trialled an ePCR. However there would be limitations in transcribing results across to paper.	No. Would need a system to receive the information. However if the details were sent to the base (MR van) and printed onto the PCR form this would be useful.
21. Do you think Mountain Rescue personnel are qualified to make diagnoses?	This would depend on their level of training and their experience.	Yes, but depending on the level of training of the rescue personnel.	They can make a provisional diagnosis.	Yes	Yes but up to your medical training/ qualified grade.
22. Do you think the Patient Care Report form contains the required details for a handover?	Yes	Yes, except for the IMIST reminder.	Yes. Except the ISBAR and IMIST/ AMBO prompts are missing.	Yes	PCR contains a lot of information. IMIST/ AMBO is missing from current PCR.
23. What information would you request/ would like to receive from Mountain Rescue personnel at a handover?	ASHIC/ IMIST/ AMBO	IMIST		See answer to question 10	IMIST/ AMBO - it is an international standard. A laminated card could be used for this purpose.
24. Would it be useful to see graphs of vital signs?	No. Just want to know if patient is stable or unstable.	No. A table of results is enough.		Depending on how the sick the patient is e.g. big sick and there is a huge change, otherwise not really	No.
25. What information is known in advance of arriving at the scene of a Mountain Rescue callout?	Despatch code (Previously defined codes that represent patients condition), description, gender, age, location to go to (address or grid reference if required), and other resources allocated to the patient e.g. Coastguard, Mountain Rescue	Patient status: Critical, Non-Critical, age, general information		Gender, location, injury, age	ASHICE. Patient details, number of casualties, injuries, medical level of who is treating them, and when are needed to arrive with ambulance
26. Who provides you with this information?	Information is generally received directly from the National Ambulance Control Centre (NACC) in Tallaght.	Initial information is from National Ambulance Control Centre, followed by Rescue Base and the Medic looking after the patient.		National Ambulance Control Centre	National Ambulance Control Centre
27. Would it be useful to receive the information as per the ASHIC Radio Message protocol? *See diagram below*	Yes	ASHICE: going to the scene. IMIST/ AMBO on handover and to the MR base.		Yes, but also need a clear address or location details.	Yes
28. How do you communicate with the Mountain Rescue teams during a callout?	Usually through the Control Centre on the way to the scene, and then when on scene via a HSE Tetra radio using the ISIS direct dial number	Face to face/ Moible		Communication is via the National Ambulance Control Centre	Meet at the MR base. Talk face to face. Sometimes able to talk via ISIS numbers.

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5
29. How long do you expect a handover to take?	30 seconds. No longer than 1 minute. The handover is verbal.	A couple of minutes		90-120 seconds	About 30 seconds unless complicated
30. Do you expect to receive a Patient Care Report from the Mountain Rescue Personnel?	Yes. The PRC should be handed over to the paramedic following the handover.	Yes		It would be great to get one	Yes. It is expected and if even more so if MR align with PHECC in the future.
31. Are other formats of a patient report form acceptable?	Yes, once the required information is given.	Yes		No. The PCR should be used.	Not currently
32. Would it be useful if Mountain Rescue personnel carried out handovers in the same manner as paramedics do when arriving at the Emergency Department of a hospital?	Yes	Yes		Yes	Yes
33. Do you use the IMIST - AMBO protocol during handovers to the Emergency Department? *See diagram below*	Yes. When arrange at hospital ask for the person in charge, conduct the handover, ask for any relevant questions.	Yes		Yes. The information may be passed via the NACC onto the hospital in advance of arriving with a very sick patient.	Yes
34. Would the IMIST – AMBO protocol be a useful protocol to use during patient handovers in Mountain Rescue?	Yes. It should be the only one used.	Yes		Yes	Yes

E.2 Email Results

Table E-2 Email results

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7	Participant 8	Participant 9	Participant 10
Location										
Date of Incident:	17/04/2016	18/04/2016	23/04/2016	2016-04-24	23/04/2016	23/04/2016	24/04/2016	2016-04-25	25/04/2016	
Location	Brockagh Mountain	Wicklow National Park	Sally Gap	Sugarloaf, Wicklow	O 132 457	Glencree	Dublin	Eagle crag, lough bray	Lugnaquillia	
Coordinates	53.2698041, -6.1158977		53.2472704, -6.2248126	53.1258349971577, -6.0773484251677		53.1993091, -6.2924516	53.2830417, -6.2441219		53.2039285, -6.6719084	
Subjective										
Initials	FJ	AL	FB	LP	DK	DH	WJM	SOB	ABC	JB.
DOB	24/08/1951	1976-01-26	01/09/1960	24/04/2016	11/01/1964	23/04/1981	24/04/1981	DOB: 1998-04-01	15/11/1972	31/03/1960
Age	64	40	55	0	52	35	35	18	43	56
Sex	Male	Male	Male	Male	Male	Male	Male	Male	Male	Female
Chief Complaint	Left side pain	Cardiac Chest Pain	Broken left leg	Chest pain	Lower right leg	Broken heart	# lwr left leg	Lower right leg injury	Fractured/ sprained right ankle	Chest pain
Onset	Gradual	Gradual	Sudden	Sudden	Sudden	Sudden	Sudden	Sudden	Sudden	Sudden
Onset Date			23/04/2016	24/04/2016	23/04/2016	21/04/2016	24/04/2016	25/04/2016	25/04/2016	25/04/2016
Onset Time		08:30				14:00	14:45		19:15	20:00
Provokes/ Palliates	Sitting palliates	Sitting semi fowlers arms across chest.	None	Exercise provokes	Weight applied	Mention of girlfriend	Nothing	Movement/splinting	Movement	Exercise
Quality	Crushing	Dull Pressure	Cramping	Crushing	Aching	Crushing	Sharp	Stabbing	Aching	Crushing
Radiation/ Region/ Referred	Left arm	Radiating ro neck	No		No	Dublin	Lwr left leg	Right ankle into right calf and foot	Up leg to lower back	Shoulders
Severity	7 out of 10	8 out of 10	7 out of 10	8 out of 10	7 out of 10	10 out of 10	7 out of 10	7 out of 10	8 out of 10	8 out of 10
MOI/ HPI	Pain started while walking around 12.30 pm	Hx of angina.... carries own GTN	Sudden fall - no history		Tripped	Gf said goodbye	Fall off bar stool	Walking, stepping into a hole in the bog	Tripped on s branch	Sudden onset central chest pain while walking
Spinal MOI		No	No	No	No	No	No	No	No	No
Objective										

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7	Participant 8	Participant 9	Participant 10
Patient Position When Found	Sitting on rock leaning forward		Seated	Supine	Sitting	Slumped on couch with tub of ice cream	Supine on floor, left leg contorted	Lying awkwardly with right foot twisted	Sitting on ground	Sitting
Patient Exam	Pale and distracted. In obvious pain.		Broken leg		Lower leg injury	No visible injury	Lwr left leg deformity above the ankle	Bruising and swelling over right ankle	DR ABCDE	A&O x 4. Pale diaphoretic Chest clear. Heart sounds normal. Abdo soft non tender. No ankle oedema. No other app defects.
Vital Signs										
Date	2016-04-17 |	2016-04-18 | 2016-04-18 |	2016-04-23 |	24/04/2016	23/04/2016	2016-04-23 |	2016-04-24 |		2016-04-25 |	25/04/2016
Time	14:30 |	12:30 | 12:40 |	11:30 |	11:39	16:58	16:18 |	15:04 |		20:35 |	22:24
LOR	AOx4 |	AOx4 | AOx4 |	AOx4 |	AOx4	AOx4	AOx4 |	AOx4 |	AOx4	AOx4 |	AOx4
HR	80 Irregular Weak |	90 Regular Bounding | 90 Regular Bounding |	100 Regular Strong |	90 Regular Weak	60 Regular Strong	64 Regular Strong |	96 Regular Strong |	85 Regular Strong	65 Regular Strong |	56 Regular Weak
RR	15 Regular Shallow |	16 Regular Easy | 16 |	20 Regular Labored |	15 Regular Easy	12 Regular Easy	12 Regular Easy |	20 Regular Shallow |	18 Regular Labored	12 Regular Easy |	22 Regular Easy
Skin	Pale Warm Moist |	Pale Warm Dry | Pale Warm Dry |	|	Pale Warm Moist	Pink Cool	Pink Warm Moist |	Red Warm Dry |	Pale Dry	Pink Cool Dry |	Pale Warm Moist
BP	100/70 |	140/98 | 138/92 |	83/127 |	120/66	/	122/78 |	138/94 |	/	125/84 |	102/78
Pupils	PERRL |	PERRL | PERRL |	PERRL |	PERRL	PERRL	PERRL |	PERRL |		PERRL |	PERRL

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7	Participant 8	Participant 9	Participant 10
Temp	35 °C |	35.9 °C | 36.2 °C |	35 °F |	38 °C	°F	37 °C |	36.5 °C |	°F	36 °F |	36.2 °C
Patient History										
Symptoms	In pain	Radiating pain, difficulty continuing with walk.	Pain from broken leg	Nausea, central chest pain rad to left arm and jaw		Nausea & crushing central chest pain	Pain in lwr left leg post fall	Pain in right lower leg, cold	Pain in lower right leg. Starting to complain of cold	Chest pain. Weak.
Allergies	No allergies	Not Known	None	NK alergies	Nuts	None	None	None	None	NKDA
Medications	Gtn	GTN	None	Warfarin		None	Ventolin	None	Insulin	None
Pertinent Medical History	Had treatment for angina. Has prescription GTN not with him.	Regular angina like symptoms. Diagnosed with angina 5 years ago. No other on own issues.	No previous history	Prev chest pain		None	Asthma - mild	None	Diabetes controlled with insulin	No sig
Last Intake/Output	Breakfast at 09.00	Breakfast..4-5 hours earlier. Scrambled eggs and toast with tea.. Snickers chocolate 1 hour earlier.	8.00am this morning	Breakfast 0800	Breakfast	1 litre ice cream - 10 minutes ago	Guinness pints X2, cavern dinner	Lunch @ 2pm	Lunch at 2pm, intermittent drinks in between	Dinner 18:00
Events Leading up to Injury/Illness	Walking from Laragh along Brockagh ridge exploring features on the mountain.	Events Leading up to Injury/Illness: Walking uphill.		Climbing sugarloaf		Didn't treat girlfriend as she expected	Post 13km hike, large dinner and drinks, legs cramped suddenly stood up quickly but caught leg in bar stool and fell over	Fall	On way to car park after 17km hike. Descending steel ground at the time	Chest pain while watching TV
Assessment										
Assessment	Heart attack	Primary and secondary surveys indicated angina event but unable to rule out possible MI.	Loss of blood	Chest pain		Extrication from couch will be tricky	Lwr leg fracture	Possible fracture/ ligament damage to right lower leg. Cold, needs shelter, cannot walk	Fractured ankle, Mild hypothermia, Hypoglycaemia	

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7	Participant 8	Participant 9	Participant 10
Plan	Make patient comfortable. Administer aspirin if ABBA permits. Insulate patient and provide added clothing to keep warm. Contact MR for assistance to move patient off mountain. Recommend helicopter evacuation with ambulance available at Brockagh church in case heli not available,,	ECG, SPO2 monitoring. Administered 300mg Aspirin.(No CIs),Administered GTN 2 x 0.4mg SL (No CIs)	Splint and evac	Stabilise and extract to HSE ambo		Tempt away from couch with promise of more ice cream	Pain relief and splinting	Right leg splinted; casualty insulated and made comfortable	Insulate patient. Sam splint ankle, Pain relief with entonox , Sugary food eg Mars bar and drinks	
Anticipated Problems	Possible cardiac arrest. Need to prepare for that but no defibrillators available initially., Keep patient calm and resting until help arrives.	Weather ruled out heli evac.,HSE ambulance en route but ETA 30 mins.,No local AED.	None			Supply of ice cream may be inadequate	Increase in pain	Difficult extraction, weather likely to disimprove	Hypos get worse	
Photos	Image 1: No Caption Provided	Image 1: No Caption Provided	Image 1: No Caption Provided			Image 1: Suggested medication...				
Sent from	Sent from my Samsung Galaxy Smartphone.	Sent from my Samsung Galaxy S6		Sent from my iPhone	Sent from my iPhone					

	Participant 11	Participant 12	Participant 13	Participant 14	Participant 15	Participant 16	Participant 17	Participant 18
Location								
Date of Incident:	26/04/2016	26/04/2016	2016-04-27	2016-04-24	2016-04-27	28/04/2016	28/04/2016	30/04/2016
Location		Tickknock forest	Djouce summit	Ballyhoura MTB trail centre	Walkinstown	Scalp, Co Wicklow	Liffey Valley Park, Lucan	
Coordinates	53.4294048, -6.4591081	53.4189577855929, -6.39514599767686			53.3190477, -6.335883		53.3532898459181, -6.41162562619163	
Subjective								
Initials	MW	DAN	POR	AM	MC	MM	CD	JOD
DOB	23/04/1975	08/12/1971	04/09/1970	27/04/1980	15/01/1982	28/04/1980	30/04/1987	30/04/2016
Age	41	44	45	36	34	36	29	52
Sex	Male	Female	Male	Male	Male	Transgender	Male	Male
Chief Complaint	Pain in lower right leg	Chest pain	Lower leg fracture	Head injury	Lower leg injury	Lower leg pain	Broken lower leg	Broken Heart
Onset	Sudden	Gradual	Sudden	Sudden	Sudden	Sudden	Sudden	Sudden
Onset Date		26/04/2016	27/04/2016	24/04/2016	27/04/2016	28/04/2016	28/04/2016	27/04/2016
Onset Time								
Provokes/ Palliates	Moving makes it worse	Heaving breathing	Any pressure makes it worse	No movement less pain	Any pressure or loading	Movement	Movement makes it worse. Splinting makes it better	Ice cream
Quality	Stabbing	Tight	Aching	Dull Pressure	Sharp	Stabbing	Aching	Stabbing
Radiation/ Region/ Referred		No		Localized to forehead	No	None	Feeling moves out from break on movement.	Heart region
Severity	8 out of 10	6 out of 10	6 out of 10	5 out of 10	6 out of 10	7 out of 10	9 out of 10	7 out of 10
MOI/ HPI		Walking uphill started to get weak and get chest pain	Slipped coming off the summit on wet rocks	Casualty struct a tree branch with head. No helmet.	Stepped backwards from a high step and went over on ankle. Casualty thought they heard/frlt a cracking.	Tripped over rock	Fall down stairs; leg broken	Got dumped
Spinal MOI	No	No	No	Yes	No	No	No	Yes
Objective								
Patient Position When Found	Lying on back	Sitting	Sitting up	Sitting against tree	Sitting down	Lying on back	At bottom of stairs. Sitting/lying	Prone

	Participant 11	Participant 12	Participant 13	Participant 14	Participant 15	Participant 16	Participant 17	Participant 18
Patient Exam	When pressure applied to lower right leg, the subject experiences shooting pain. Cap refill on right foot is present	First time to get pain like this no previous history	Slight abrasion on his face other than that swollen lower leg and feeling a little cold	Primary injury observer cut to forehead. Extensive bleeding. Patient alert. Treat for suspected spinal injury	Obvious swelling and tenderness on lower right leg. Suspected fracture.	Leg swollen, cms good	Full head to toe revealed nothing except lower leg injury. CSMs accessed and functioning.	Seems grand. Whinging a lot.
Vital Signs								
Date		26/04/2016		2016-04-24 |	2016-04-27 | 2016-04-27 |	2016-04-28 |	28/04/2016, 28/04/2016	| 2016-04-30 |
Time		20:25		11:30 |	15:28 | 16:05 |	15:47 |	11:48, 11:58, 120:08	| 12:39 |
LOR	AOx4 |	AOx4	AOx4	AOx4 |	AOx4 | AOx4 |	AOx3 |	AOx4 | / AOx4 | AOx4 | / AOx3 |	| AOxO |
HR	55 Regular Strong |	110 Irregular Strong	70 Regular Strong	60 Regular Strong |	65 Regular Strong | 65 Regular Strong |	80 Regular Strong |	60 Regular Strong | / 65 Regular Strong | 65 Regular Strong | / 80 Regular Strong |	| 52 Irregular Weak |
RR	15 Regular Easy |	24 Irregular Shallow	30 Regular Easy	12 Irregular Shallow |	20 Regular | 20 |	12 Regular Easy |	12 Irregular Shallow | / 20 Regular | 20 | / 12 Regular Easy |	| undefined Regular Shallow |
Skin	Pale Warm Dry |	Pale Cool Wet	Pale Warm Dry	Pale Cool Moist |	Pink Cool Dry | Pink Warm Dry |	Pale Cool Dry |	Pale Cool Moist | / Pink Cool Dry | Pink Warm Dry | / Pale Cool Dry |	| Pale Cool Dry |
BP	/P |	150/100	125/80	/P |	124/85 | 120/82 |	125/90 |	/P | / 124/85 | 120/82 | / 125/90 |	/ | 6/6 |
Pupils	PERRL |	PERRL	PERRL	Not PERRL |	PERRL | PERRL |	PERRL |	Not PERRL | / PERRL | PERRL | / PERRL |	| Not PERRL |
Temp	36 °C |	36.9 °C	35 °C	38 °C |	35 °C | 37 °C |	37 °F |	38 °C | / 35 °C | 37 °C | / 37 °F |	°F | °F |
Patient History								
Symptoms	Pain lower right leg when pressure applied, cannot support weight	Chest pain	Feeling a bit cold slightly dizzy	Headache and cold	Pain in lower leg	Cold, nausea	Pain from leg. No other symptoms	

	Participant 11	Participant 12	Participant 13	Participant 14	Participant 15	Participant 16	Participant 17	Participant 18
Allergies	NA	None	None	None	None	None	Penicillin.	
Medications		None	None	None	None	None	Inhaler	
Pertinent Medical History	Na	None	Felt a bit light headed coming down. Reckons he push too hard getting up to summit	Pertinent Medical History: None	None	None	Asthma	
Last Intake/Output	Has been kept hydrated by friend and had chocolate 45-60mins prior to arrival	Lunch 1400hrs, last toilet 1600hrs	Had water 30 mins ago	Irish breakfast @9am	2.30pm sandwiches and tea	Food 1pm, drink 2pm	Breakfast of porridge at 9.00	
Events Leading up to Injury/Illness		Strenuous walk	Walking down not concentrating.	Loss of bike control. No helmet	Stepped back from higher point and went over on ankle	Walking on rough ground	Tripped descending stairs	
Assessment								
Assessment	Suspected fracture of lower right leg	Cardiac issue, anxiety respiratory problem	Slightly hypothermic ,Minor abrasion ,Ankle possibly broken		Suspected break of lower right key and slightly cold	Very cold, hypothermia high risk	Internal bleeding; pressure of muscles on broken bone; shock	Will survive

	Participant 11	Participant 12	Participant 13	Participant 14	Participant 15	Participant 16	Participant 17	Participant 18
Plan	Secure injured leg to avoid further movement, Make subject comfortable, warm, food and water. Check vitals frequently	Aspirin, reassure patient call ambulance	Treated for hypothermia by insulating and given food and a hot drink and both of us in a group shelter. ,Abrasion was not serious and bandaged up ,Used a splint on the ankle and strapped up. , Mountain Rescue called and expected within the hour. Was informed that the coastguard also notified.		Splint leg and give paracetamol and nurofen for pain and swelling. Also insulate casualty and arrange for transport to hospital for definitive care.	Apply kissue	Ambulance/MRT called. Splint injury; keep Cas warm and insulated; package on stretcher and evac	
Anticipated Problems	Uneven terrain for extraction, best route will need to be sourced and be as even as possible. Slow carry due to nature and pain of injury, large numbers required for carryout	Patient collapse , ambulance can only get as far as gate so patient needs to be packaged and carried to gate			Have all required equipment and personnel for treatment and evacuation so no problems anticipated.	Very long carry out, limited rescue personnel	Moving from stairs to stretcher.	
Photos								Image 1: No Caption Provided
Sent from	Sent from my iPhone			Sent from Yahoo Mail on Android		Sent from my iPhone		

E.3Questionnaire Results

E.3.1 Questions

Table E-3 Questionnaire answer types

	Question	Type
1	How many years have you been involved in Mountain Rescue?	Single
2	How many years have you been involved in First Aid?	Single
3	Which First Aid certificates do you currently hold?	Multi
4	What type of Mountain Rescue team member are you?	Single
5	Do you own a Smartphone?	Single
6	How many years have you used a Smartphone for?	Single
7	What type of Smartphone do you own?	Single
8	Please list any First Aid Smartphone Applications (Apps) that you have downloaded and used beforehand?	Multi
9	Do you carry a Smartphone during callouts?	Single
10	Is your Smartphone designed to be waterproof?	Single
11	Do you use a case to protect your Smartphone?	Single
12	Does the case used to protect your Smartphone restrict usage of the screen?	Single
13	Have you used voice recognition before?	Single
14	Have you used Google Voice or Apple Siri before?	Single
15	Does your Smartphone have a 'Glove mode' which allows you to use the Smartphone whilst wearing gloves?	Single
16	Do you find the 'Glove mode' to be effective?	Single
17	Please provide an example of a Smartphone application (any type) that you found to be well designed (easy to learn, easy to use, enjoyable to use).	Multi
18	What did you like about the well-designed Smartphone application?	Multi
19	Please provide an example of a Smartphone application (any type) that you found to be poorly designed (difficult to learn, difficult to use, difficult to use).	Multi
20	What did you not like about the poorly designed Smartphone application?	Multi
21	Do you need reading glasses to use a Smartphone?	Single
22	Please provide your feedback of the NOLS SOAP Notes Smartphone application by answering the below questions. The questions listed below are from the System Usability Scale which is used globally for assessing systems usability.	Multi
23	Have you ever used the NOLS SOAP Note app beforehand? (Before being asked to complete this questionnaire)	Single
24	How would you describe the overall experience of using the NOLS SOAP Notes app?	Single
25	Would you use the NOLS SOAP Notes app during a medical training session?	Single
26	Would you use the NOLS SOAP Notes app during a Mountain Rescue callout?	Single
27	Who would you recommend to use the NOLS SOAP Notes app when assessing a patient? Please select all that apply.	Single
28	When do you think the App should be used?	Single
29	Did the NOLS SOAP Notes app respond quickly enough when you clicked on the buttons?	Single
30	Is it easy to navigate from one screen to another?	Single
31	Open up the NOLS SOAP Notes app again. Add in another set of vitals. Is it easy to navigate to the Vitals section of the app?	Single
32	When adding in a new set of vitals was it clear to you that the app was in edit mode as opposed to read mode?	Single
33	Did you see the Timer (Stopwatch) functionality that assists with taking vitals?	Single
34	Do you understand the intended meaning of the below symbols? The symbol or icon is displayed on the left. The intended meaning is displayed on the right of the icon.	Multi
35	Did you make any errors or mistakes filling in the SOAP Note?	Single
36	Was it easy to correct the errors or mistakes?	Single
37	Where did the error or mistake happen in the app?	Multi
38	Below is a summary of the functionality in the NOLS SOAP Note app. Do you think the features are necessary for a patient assessment app?	Multi
39	Below is a summary of the functionality in the NOLS SOAP Note app. Do you think the features are well designed? (Easy to use, easy to learn, enjoyable to use)	Multi
40	Below is a summary of the functionality in the NOLS SOAP Note app. Please fill in any comments or suggestions you have for the below features.	Multi
41	Would you recommend adding any of the below functionality to a patient assessment app? Please select all that apply.	Multi
42	Can you suggest any other functionality that you would add to a patient assessment app?	Multi
43	What factors/ concerns would prevent you from using a patient assessment app during a Mountain Rescue callout?	Multi

E.3.2 Single Answer Question Results

Table E-4 Single answer question results

	Question	Answer	Result
1	How many years have you been involved in Mountain Rescue?	Less than one year	10%
		1-5 years	47%
		Greater than 5 years	42%
2	How many years have you been involved in First Aid?	Less than one year	5%
		1-5 years	5%
		Greater than 5 years	90%
4	What type of Mountain Rescue team member are you?	Full team member	79%
		Associate member	11%
		Probationary member	11%
5	Do you own a Smartphone?	Yes	100%
		No	0%
6	How many years have you used a Smartphone for?	Less than 1 year	0%
		1 or more years	100%
7	What type of Smartphone do you own?	iPhone	42%
		Android	53%
		Windows	0%
		Other	5%
9	Do you carry a Smartphone during callouts?	Yes	100%
		No	0%
10	Is your Smartphone designed to be waterproof?	Yes	26%
		No	74%
11	Do you use a case to protect your Smartphone?	Yes	79%
		No	21%
12	Does the case used to protect your Smartphone restrict usage of the screen?	Yes	13%
		No	87%
13	Have you used voice recognition before?	Yes	42%
		No	58%
14	Have you used Google Voice or Apple Siri before?	Yes	42%
		No	58%
15	Does your Smartphone have a 'Glove mode' which allows you to use the Smartphone whilst wearing gloves?	Yes	32%
		No	69%
16	Do you find the 'Glove mode' to be effective?	Yes	17%
		No	83%
21	Do you need reading glasses to use a Smartphone?	Yes	33%
		No	67%
23	Have you ever used the NOLS SOAP Note app beforehand? (Before being asked to complete this questionnaire)	Yes	11%
		No	90%
24	How would you describe the overall experience of using the NOLS SOAP Notes app?	Terrible	0%
		Poor	0%
		Average	21%
		Good	68%
		Delightful	11%

	Question	Answer	Result
25	Would you use the NOLS SOAP Notes app during a medical training session?	Definitely not	0%
		Probably not	11%
		Might or might not	16%
		Probably yes	53%
		Definitely yes	21%
26	Would you use the NOLS SOAP Notes app during a Mountain Rescue callout?	Definitely not	16%
		Probably not	21%
		Might or might not	42%
		Probably yes	21%
		Definitely yes	0%
27	Who would you recommend to use the NOLS SOAP Notes app when assessing a patient?	Medic	0%
		Scribe	74%
		Both	26%
		Other	11%
28	When do you think the App should be used?	During the assessment	47%
		At intervals	42%
		After the assessment	11%
29	Did the NOLS SOAP Notes app respond quickly enough when you clicked on the buttons?	Yes	100%
		No	0%
30	Is it easy to navigate from one screen to another?	Strongly disagree	0%
		Somewhat disagree	5%
		Neither agree nor disagree	11%
		Somewhat agree	58%
		Strongly agree	26%
31	Open up the NOLS SOAP Notes app again. Add in another set of vitals. Is it easy to navigate to the Vitals section of the app?	Strongly disagree	11%
		Somewhat disagree	11%
		Neither agree nor disagree	11%
		Somewhat agree	42%
		Strongly agree	26%
32	When adding in a new set of vitals was it clear to you that the app was in edit mode as opposed to read mode?	Strongly disagree	16%
		Somewhat disagree	11%
		Neither agree nor disagree	16%
		Somewhat agree	32%
		Strongly agree	26%
33	Did you see the Timer (Stopwatch) functionality that assists with taking vitals?	Yes	32%
		No	68%
35	Did you make any errors or mistakes filling in the SOAP Note?	Yes	47%
		No	53%
36	Was it easy to correct the errors or mistakes?	Yes	100%
		No	0%

E.3.3 Multi Answer Question Results

Table E-5 Multi answer question results

Question

3 Which First Aid certificates do you currently hold?

		Total	Percentage
1	REC 2		
2	REC 3	11	58%
3	REC 4	1	5%
4	REC 5	0	0%
5	PHECC CFR (Cardiac First Response)	1	5%
6	PHECC EFR (Emergency First Response)	1	5%
7	PHECC EMT (Emergency Medical Technician)	3	16%
8	PHECC Paramedic	1	5%
9	PHECC Advanced Paramedic	1	5%
10	WEMSI WFR (Wilderness First Responder)	1	5%
11	WEMSI WEMT (Wilderness Emergency Technician)	3	16%
12	WEMSI Wilderness Physician	1	5%
13	Other	1	5%
	Casualty Care in MR level 2		

8 Please list any First Aid Smartphone Applications (Apps) that you have downloaded and used beforehand?

- PHECC Field Guide
- PHECC EFR CPG
- Irish Red Cross First Aid app
- Medicare
- RCSI MyHealth

17 Please provide an example of a Smartphone application (any type) that you found to be well designed (easy to learn, easy to use, enjoyable to use).

- ViewRanger
- Hailo
- PHECC
- Instagram
- KBC Online banking
- AIB Online banking

18 What did you like about the well-designed Smartphone application?

- User friendly
- Well laid interface, easy to use, easy step by step
- Clearly laid out screens, easy logical and intuitive steps
- Intuitive to use
- Easy to use, very accessible and plenty of user options
- Moves seamlessly from one map to another, able to zoom in, synchronises easily with online version

19 Please provide an example of a Smartphone application (any type) that you found to be poorly designed (difficult to learn, difficult to use, difficult to use).

- Irish Wildlife
- Booking.com

- Viewranger
- PHECC apps

20 What did you not like about the poorly designed Smartphone application?

- Lots of information but difficult to search for you what you want
- When outdoors, trying to touch small option buttons or trying to find correct menu option can prove difficult
- Difficult to access the relevant information quickly and easily
- Has potential to do more. Difficult to use with a patient as it seems inappropriate to use your phone and you have to explain what your doing

34 Do you understand the intended meaning of the below symbols? The symbol or icon is displayed on the left. The intended meaning is displayed on the right of the icon.

		Yes	No	Total	% Yes
1	Return to Overview section	14	4	18	78%
2	Return to Subjective section	11	7	18	61%
3	Return to Objective section	10	8	18	56%
4	Return to Assessment and Plan section	12	7	19	63%
5	Return to Photos section	16	3	19	84%
6	Edit SOAP note	14	5	19	74%
7	Share SOAP note	11	8	19	58%
8	Display Main Menu	16	2	18	89%
9	Display help text	15	4	19	79%

37 Where did the error or mistake happen in the app?

- Editing the vitals
- General typos
- Filling out textbox
- Entered degrees Fahrenheit not Celsius
- Couldn't input grid reference manually. (Would be useful to link to Viewranger/ Google maps)
- When returning to add or change information

38 Below is a summary of the functionality in the NOLS SOAP Note app. Do you think the features are necessary for a patient assessment app?

Feature	**Necessary**	**Well Designed**
Date and Location	96%	82%
Responder Information	88%	88%
Patient Information	99%	85%
Chief Complaint	99%	84%
Mechanism of Injury (MOI)	97%	89%
Patient Exam	97%	84%
Patient Position when found	90%	81%
Vital Signs	100%	82%
Patient History	100%	85%
Assessment	92%	84%
Plan	71%	79%
Share Note	91%	84%

Photos	74%	75%

39 Below is a summary of the functionality in the NOLS SOAP Note app. Do you think the features are well designed? (Easy to use, easy to learn, enjoyable to use)

See above table of results – question 38

40 Below is a summary of the functionality in the NOLS SOAP Note app. Please fill in any comments or suggestions you have for the below features.

Date and Location	Co-ordinates not relevant to treatment plan.
	time of arrival, injury should be an option.\\Cross compatibility with viewranger would be helpful
	Easy
	Date format is MM/DD/YYY\format option would be useful
	It would not let me manually enter coordinates in the event I had no gps signal. MInor detail but I think an important one
Responder Information	Request PHECC PIN where applicable.
	Is this particularly needed?
Patient Information	Easy to use
	No area to enter patient info or their location other than coordinates in a Lat Long only format. Being able to enter a grid reference or photo of a map screenshot or select an area on a map would be great.
	place to enter next of kin contact details would be beneficial
	Clearly needed
Chief Complaint	drop down of common chief complaints with text box appearing on selection of other might be helpful
	This could mask other injuries. Is it the thing about which the casualty is chiefly complaining, or is it what the Medic views as being the chief injury?
	No space for secondary complaints. Asks for spinal MOI but only allows yes or no response. Same box for provokes/palliates, might be hard to tell which is which.
Mechanism of Injury (MOI)	Expand on quick access options. Ie Fall. Assault. Etc
	dropdown as above
	Needed
Patient Exam	checkbox of body areas to tick checked for head to toe or field to enter body part that couldn't be checked or image of body with ability to select limb etc injured might be helpful
	Could include more prompts
Patient Position when found	Dropdown list would help here
	Not the most vital piece of info. Where they are and how long they were there is more relevant.
	dropdown
	Helpful
Vital Signs	For blood pressure shorten scale to range eg < or > beyond normal BP range to save scrolling from 0
	Expand to include. GCS. Blood sugar.
	Temp - If you have hot and warm you should also have cool and cold for accuracy.\If the BP and Pulse were tabulated like a calcuator keypad it might make selection faster and easier than scrolling to 140...
	didn't see timer, this would be very helpful so should be clearer
	Easy to use, and helpful

	Explanation not readily available. Allowed me to enter heartrate of 5666 and didn't immediately prompt an error until I went back into the record.
Patient History	Sample history - needed
Assessment	might be helpful: image of body - select body part on image - comment box appears to enter comment about injury in that area
	Could be ongoing, like several sets of vital signs. Pain level could fluctuate and be recorded several times
Plan	The plan is really the responsibility of someone else aside from the medic so this might be a bit too much info.
	not sure this is useful as likely not required by person taking handover
	Helpful, but prob more for incident commander
Share Note	Ok...can it be saved as PDF for filing?
	This worked but there seems to be overlap with some info such as main complaint and injuries found and treatment etc. Some info seemed to get 'lost' after keying it in and I had to repeat two or three steps.
	With whom? Needs to be careful, data integrity, etc
Photos	maybe a prompt asking you if you want to take a picture of the injury
	May present legal issues storing pt images
	I mistakenly selected a photo I did not want to use but when I selected the correct one it kept reverting to the wrong photo. The only way I found to correct this was to opt to take a photo as opposed to load one already in the gallery.
	Could cause distress to casualty. Would have to be explained to casualty. Could cause distress to unsuspecting viewer

41 Would you recommend adding any of the below functionality to a patient assessment app?

Record medication administered	95%
Sound alert to notify to check Vitals	74%
Image of a body	63%
Map of location	53%
Vibration alert to notify to check Vitals	53%
Prevent phone from locking	53%
Timer to set Vitals alert frequency	47%
Head to Toe prompt	47%
Vital signs prompt	47%
Pain scale slider	42%
Checklist	42%
Record equipment used	32%
Background lighting	26%
Larger font	26%
Text to show if have internet	26%
List of common chief complaints	26%
DRABC prompt	26%
Password protection	21%
Allow 2 or more users to edit at the same time	21%
Weather forecast	16%
ETA (Expected Time of Arrival) calculator	16%
Record time taken to complete an assessment	0%

	Question
42	Can you suggest any other functionality that you would add to a patient assessment app?
	Grid Reference vs LatLong
	1.Transport declined by patient tick box. 2.Medication declined by patient tick box. 3.Signature field.... 4.Free text box to describe assistance received from bystanders for example. 5.Clinical impression and Casualty Status boxes (Life threat, non serious, serious non life threat). 6.Handover details to continuity of care.
	Add WhatsApp to the share option
	I think that there could be possibly 2 modes one being a simplifed and shorter assessment when time is an issue or if you were alone or in a small hasty group and the second being a more detailed including all of the above for when you have time or a more in dept and regular assessment is needed.
	Being able to accept and enter grid references.
	Treatment suggestions. Align to PHECC CPGs. Slicker design, I found it clunky.
	able to share with HSE ambulance/coastguard\\perhaps able to get medical oversight? medico cork?
43	What factors/ concerns would prevent you from using a patient assessment app during a Mountain Rescue callout?
	Bad weather conditions
	Weather, light, waterproofing of Smartphone, temperature, speed of data input.
	Environmental conditions & Phone battery status
	Quicker and easier to fill out a slate by hand. Ability to handover a written document to ambulance or coastguard
	Privacy and confidentiality. Possibly slower than pen and paper. Battery life, smart phone unreliability.
	weather can be an issue. Paper and pen are still very reliable and provide instant hard copy
	bad weather, loss of battery (once the battery goes, all of your initial notes are lost until you recharge) , signal, possibility of dropping phone on steep ground
	Battery life of phone\Ease of use in dark, cold or very wet conditions\Ability to read screen if reading glasses required
	Electronic device failing in poor conditions
	Battery life on phone , combined with other apps , fear that it could drain the battery very quick
	Patient privacy
	Quite possibly because I am always concerned about battery life of the phone as I nearly always use view ranger and like most call out its always possible that a call might go on for a considerable length of time.
	Lack of familiarity and possible issues with the outdoors such as rain, gloves, darkness, cold etc. \Battery power as the phone is useful for mapping and communications also.\ We still need to keep patient report forms where possible so while this is an excellent potential for MR records how is the data handed over to an ambulance crew and what are the data protection implications.
	recipient of handover may not have access to note shared electronically in the time immediately following handover, fear of loss of info half way through assessment by accidentally discarding note (not sure if this possible)
	Battery life. Blood on the phone. Someone standing on the phone.
	Phone battery. Awkward GUI.
	time consuming compared to paper and pen.\\phone wet / broken.\\breaks rapport with patient

E.3.4 System Usability Scale – NOLS SOAP Note

Table E-6 SUS NOLS SOAP Note

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
I think that I would like to use this App frequently	4	4	4	4	4	2	3	5	4	4	2	5	4	4	4	4	4	4	2
I found the App unnecessarily complex	1	4	1	2	2	4	2	1	1	1	2	1	4	3	2	1	1	4	4
I thought the App was easy to use	5	5	5	5	4	3	4	5	5	5	5	5	5	4	4	5	5	2	3
I think that I would need the support of a technical person to be able to use this App	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
I found the various functions in this App were well integrated	5	5	5	5	4	3	5	5	4	4	5	5	5	4	4	2	4	3	3
I thought there was too much inconsistency in this App	1	2	1	1	2	2	1	1	2	1	1	1	1	2	5	1	2	1	3
I would imagine that most people would learn to use this App very quickly	5	5	5	5	4	4	4	4	5	5	5	5	5	4	4	5	4	4	4
I found the App very cumbersome to use	4	4	1	1	2	4	1	1	2	1	1	1	1	2	1	1	2	4	4
I felt very confident using the App	4	4	4	5	4	5	5	5	5	5	5	4	5	4	4	5	4	4	4
I needed to learn a lot of things before I could get going with this App	1	1	2	1	1	1	2	1	1	1	1	1	2	1	1	1	1	1	1

Adjusted Scores	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Total	35	31	37	38	32	25	34	39	36	38	36	39	35	31	30	36	34	26	23
Total Score (Total * 2.5)	87.5	77.5	92.5	95	80	62.5	85	97.5	90	95	90	97.5	87.5	77.5	75	90	85	65	57.5

Average Score = 83.6

E.4 Prototype Evaluation

E.4.1 System Usability Scale – Prototype App

Table E- 7 SUS Prototype app

	1	2	3	4	5	6	7	8	9	10
I think that I would like to use this App frequently	4	4	5	3	2	4	5	4	3	4
I found the App unnecessarily complex	2	1	1	1	2	2	2	1	2	2
I thought the App was easy to use	4	1	5	5	4	2	4	5	4	4
I think that I would need the support of a technical person to be able to use this App	1	1	1	2	1	1	4	1	1	1
I found the various functions in this App were well integrated	4	4	5	5	5	5	5	5	4	4
I thought there was too much inconsistency in this App	3	4	3	2	1	2	3	2	1	2
I would imagine that most people would learn to use this App very quickly	4	5	5	5	5	5	5	5	4	5
I found the App very cumbersome to use	2	1	1	1	1	4	1	1	2	1
I felt very confident using the App	4	5	4	5	5	4	3	4	3	5
I needed to learn a lot of things before I could get going with this App	1	1	1	1	1	4	1	1	1	1

Adjusted Scores	1	2	3	4	5	6	7	8	9	10
Total	31	31	37	36	35	27	31	37	31	35
Total Score (Total * 2.5)	77.5	77.5	92.5	90	88	67.5	78	92.5	78	88

Average Score = 82.8

Appendix F Deployment Instructions

F.1Steps to Download Prototype App

- Open the following link on your own Smartphone
  - https://www.dropbox.com/s/wf8svhgsd8deuqk/com.mr.PatientAssessment.apk?dl=0
  - You can select Dropbox or Chrome to open the link
  - Dropbox will open
- Don't press 'Open in App'
  - Instead press the down load arrow as highlighted by the red arrow

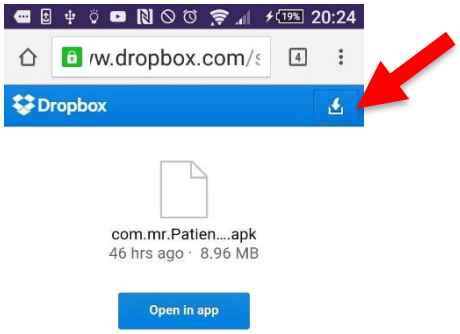


Figure F-1 Open download from Dropbox

- Choose Direct Download

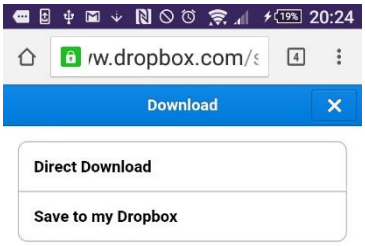


Figure F-2 Direct Download in Dropbox

- Press OK if get warning that the file might be harmful

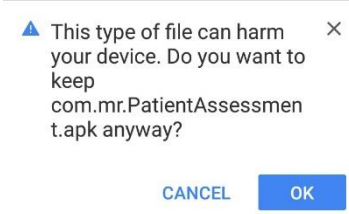


Figure F-3 File warning

- Open the download (PatientAssessment.apk)
- You might get a warning message 'Install Blocked'

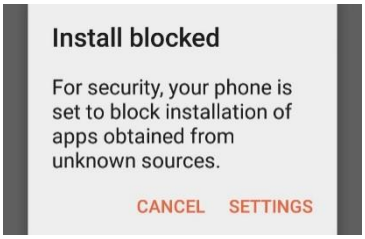


Figure F-4 Install blocked

- Click on Settings
- Set 'Unknown Sources' to Yes

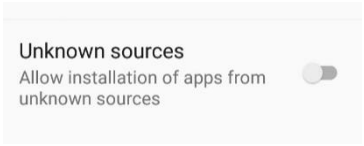


Figure F-5 Set unknown sources to yes

- Return to the download

- Press Install when asked to Install

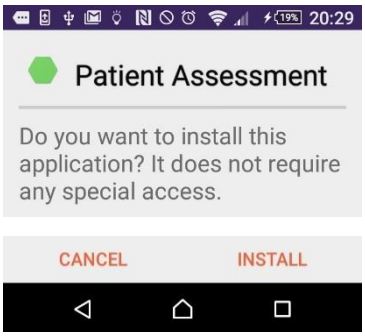


Figure F-6 Install Patient Assessment app

- Press Open when installed