UNDERSTANDING USER PERSPECTIVES OF PERSONAL SAFETY APPLICATIONS ON MOBILE DEVICES

By

Hasmeet Singh Chandok

Submitted in partial fulfillment of the requirements
for the degree of Master of Computer Science

at

Dalhousie University
Halifax, Nova Scotia
August 2018

DEDICATION PAGE

I would like to dedicate this thesis to my family for providing me the opportunity to study and grow in my life.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Personal safety applications on mobile devices have gained attention recently, and solutions have been developed with features such as fake calls, panic buttons, etc. However, little research has been done to understand *how* these applications can be used in an unsafe situation. In our research, we conducted semi-structured interviews with 30 participants, and recorded their perceptions of using personal safety applications in three unsafe Scenarios. The unsafe Scenarios were varied in the level of the individual's isolation and we asked participants about their perceptions of their personal safety and the actions that they would take both before and after installing a personal safety application on their phone. Most participants indicated that they would include a personal safety application as part of their collective response to unsafe situations. However, there was also resistance to solely relying upon an application, as participants did not trust that it would be effective and that they would be able to successfully use it in an unsafe situation. Furthermore, many participants were also concerned about privacy issues; whether the application was collecting and sharing their information. Based upon the findings, we have provided design recommendations for such applications.

LIST OF ABBREVIATION USED

Apps	Applications
preApp	Interview conducted before participants installed personal safety applications
postApp	Interview conducted after participants installed personal safety applications
PRISM	Privacy, Security and Personal Safety with Mobile Technologies
WLAN	Wireless Local Area Network
SHIELD	Social sensing and Help In Emergency using mobiLe Devices
ICT	Information and Communication Technology
HRM	Halifax Regional Municipality
LGBTQQIP2SAA	Lesbian, Gay, Bisexual, Transgender, Questioning, Intersex, Pansexual, Two-spirit (2S), Androgynous and Asexual
CCTV	Closed Circuit TeleVision
GSM	Global System for Mobile

ACKNOWLEDGEMENT

With a deep sense of gratitude, I wish to express my sincere, heartfelt thanks to my supervisors, Dr. Kirstie Hawkey and Dr. Raghav Sampangi whose encouragement, guidance, and support from the initial to the final level enabled me to develop an understanding of the problem. Their profound insight into HCI, excellent research experience, positive attitudes and a big smile always motivated me to overcome each and every hurdle. In addition, they were always accessible and willing to assist their graduate students in their research. As a result, research became smooth and rewarding for me.

I would like to thank Dr. Mike Just from Heriot-Watt University, UK and Dr. Alette J. Willis from University of Edinburg, UK for their expertise and guidance for this project. I would like to thank my teammates Dilpreet Singh Gill and Jeya Balaji for their support.

Chapter 1- INTRODUCTION

1.1 PROBLEM DEFINITION

Personal safety is one of the principal concerns of any responsible society in the world. It is evident that the problem of personal safety is faced more by women and LGBTQ+[1] (Lesbian, Gay, Bisexual, Transgender, Queer) people than men in general [77]. The case of an attack and then rape of women on a bus in India in 2012 and the rape case of a 6-year-old girl in Pakistan in 2017 are few high-profile examples [2][3] of the problem of personal safety. Missing people from the streets who are later found murdered or being trafficked, also calls for better personal safety measures as this problem is prevalent in even the most developed countries of the world [79,80]. It is essential for our society to work on limiting and preventing these types of incidents from happening.

Perception towards personal safety can be subjective as it can depend on many factors: women and elderly populations have been found to be more concerned than men about personal safety [9]. Plenty of research has been done on the tourists visiting foreign countries and how their perceptions of safety are formed within those countries [10,12,30]. The degree to which a person can feel unsafe from their surroundings can either be dependent on the individual or external factors. Nationality, purpose of the visit [11], and past experiences with crime are individual factors, whereas road traffic is listed as an external factor

[1] This definition is different from what has been used in other chapters of this thesis because the paper by SOW [77] uses this definition.

[9, 10]. For example, individuals visiting Cape Town for holidays found it safer in comparison to people visiting the same location to see friends/family or for business purposes [11]. Moreover, an individual's perception about personal safety in a certain surrounding might also be affected by personal biases, such as recommendations from different online/offline sources and time spent in that neighborhood. Indeed, the complexity of this issue has led to various types of solutions: from changing the environment around us so to better facilitate the individuals' desires for personal safety to personal means of empowering individuals to seek help when they are in need [4,6].

In the past, many different measures have been proposed as prevention mechanisms for these types of incidents, out of which making changes to environments, such as better lighting [4] and increased police/security patrols [5] are a few examples. Recent surveys, such as the one conducted by Peña-García et al. with 275 people in the city of Granada (Spain), indicated that the people feel much safer in well-illuminated (that is, uniformly lit) streets [6]. Researchers have even gone a step further to understand how techniques such as dynamic street lighting have a correlation to the perception of safety in unsafe situations [7]. Increased visibility by others, either in the form of having people around or having areas patrolled more by security/police, have also proven to be helpful in studies conducted in the past by Cozens et al. [8]. However, whether security in a certain area can be equated to the presence of uniformed personnel, has also been debated [12]. Using the transit survey data describing St. Louis Metro Link riders in the United States, Kim et al. found that females used Light Rail (local railway transit in St. Louis) more often if the areas are well patrolled [5].

The use of independent resources such as pepper spray to ensure safety has been gaining more attention in recent research regarding personal safety. As part of this attention, the role of mobile phones has been considered due to their ubiquitous presence and frequent use, and the various ways they can help their users to obtain assistance (e.g., calling for help) [13]. Past studies [14, 16, 17, 19] have shown that women feel more secure when they have their mobile phones, and that seeking help in response to trouble (security) is one of the primary reasons to use a mobile phone. These findings, as well as the higher availability and frequent use of mobile phones, contribute to why mobile phones are being investigated for numerous social causes, including personal safety [15]. Governments around the world have also shown interest in motivating their citizens to develop solutions through personal safety applications [18], and some, like India in particular, have mandated a "panic button" feature for all phones by 2017 [23,78].

Although much work has been done in terms of developing mobile solutions such as developing personal safety applications with a range of features like location sharing, panic alarms and messaging [20,22,27,32,36], researchers/developers are still mainly focused on designing solutions without a proper understanding of the issue from a user's perspective. However, recent research has started to focus on understanding how these solutions are applicable and usable in specific situations. For example, Karusala and Kumar [21] investigated the experiences of women in public spaces in India and their opinions on the compulsory panic button using semi-structured interviews and surveys. Through their findings they emphasized that the mandate to have a panic button on every phone would prove likely to be ineffective in public places. Reasons for it to be ineffective were twofold: the panic

button's limited ability to interact in any manner, and misunderstanding the effect of important factors such as perceptions of safety in public spaces and law enforcement on women's safety in public spaces [21]. However, the trial of having panic buttons on all the mobile phones has just started earlier this year (May, 2018) and no data has been released on the effectiveness of the buttons, making it hard to comment on any claims [78].

Our research wished to go beyond designing new solutions; we wondered about the efficacy of the already available personal safety applications, and how the general population would use the personal safety applications in Scenarios they perceived to be unsafe. In this way, we define the effectiveness of personal safety apps as a measure of whether the apps might actually be used by people to protect their safety in a perceived unsafe situation. We aimed to evaluate effectiveness by using Scenarios as stimuli for conducting semi-structured interviews with the participants and also sought recommendations from users on what features they would wish to have included for future personal safety applications.

In our research, we define personal safety as: *a person's ability to protect themselves in situations perceived to be unsafe, involving a potential threat to their well-being (hereafter, referred to as an "unsafe situation").*

1.2 THESIS CONTRIBUTION

We explored the effectiveness of three personal safety apps by conducting semi-structured interviews with 30 participants. The effectiveness of the apps was tested by the use of three different Scenarios with varying degrees of risk and reach for help.

In order to choose the applications for our study, we tested/analyzed commercial applications for personal safety available in play store (Android) or app store (Apple). We evaluated ten applications in total and categorized them into three categories, namely: Purpose Based Tracking, Minimalistic Design and Fully Featured personal safety applications. Fully Featured applications include many features other than just informing the appropriate authority/person in the application itself. A careful decision needs to be made on what features to use in a specific situation such as Bsafe. On the other hand, Minimalistic Design applications have very simple user interfaces and include basic features such as seeking help using text/call, which may lead to very fast reactions in unsafe situations such as Circleof6. Purpose Based Tracking applications are not actually designed for personal safety as their basic purpose, but include features like family location tracking and can act as a personal safety application in many different situations such as Life360. We have chosen one application from each category which have suitable functionality and robustness to be evaluated by our users. All three applications are available for Apple and Android devices.

We recruited participants who had reported at least one experience of an unsafe situation. This initial screening was required to gain more accurate results as we relied on participants to imagine their past situations when they read three unsafe Scenarios provided by researchers during the study. The Scenarios were created in a manner to give minimal information to convey a risky situation, allowing participants to create the details specific to their own subjective and contextual concerns.

With all the participants, we tried to understand their reactions to these Scenarios both before and after introducing the personal safety applications to them. While they used the personal safety applications, we observed participants' behavior on how they made their choices for giving permissions to the apps and how thoroughly they went through the terms and conditions (T&C). The observations were made by the second researcher present in the room. Observations included understanding whether the participant agreed to give a specific permission to the applications and if they made any effort to read reviews or T&C of the applications. All the Scenarios were carefully designed to apply to all gender identities and age groups, and were also very general (i.e. not presenting any particular situation). We explored the correlation of any behavioral changes in terms of giving permissions, storage and data collection while installing and using personal safety applications in comparison to the other applications. Furthermore, we investigated the reasons behind the choices made by the participants regarding using a specific personal safety application and any recommendations for future personal safety applications.

This thesis contributes to the fields of personal safety through mobile applications, safety perceptions and initial directions towards framework design for safety applications. The contributions are as follows:

- Classification of perceived unsafe situations by various demographics.
- Exploration of how personal safety applications are used when users encountered unsafe situations (in lab conditions).

- Examination of behavioral differences of users in the presence and absence of personal safety applications when faced with unsafe situations (in lab conditions).
- Providing a variety of reasons for the choices made by the users when it comes to personal safety applications.
- Providing initial directions to developing a framework for designing personal safety applications for different Scenarios.
- Suggesting an additional category namely “combined” to categorize responses from the participants.

1.3 THESIS OVERVIEW

Chapter 2 describes the background works related to our topic. We begin with surveying the use of personal safety mobile applications and focusing on specialized personal safety applications available in the marketplace. We then discuss previous work on use and effectiveness of these applications in unsafe situations and ways of evaluating these approaches.

In Chapter 3, we discuss our motivation for our study design. We designed a study, which we then evaluated by conducting pilot studies with lab members. Using the feedback collected from the pilot study and recommendations given by the Dalhousie Research Ethics Board (hereafter “REB”), we present our final study design.

In Chapter 4, we present results obtained by conducting the study with 30 participants, exploring their reactions to the Scenarios in the presence and absence of personal safety

apps. We then explore any trends in the results obtained by our participants from different demographics.

Chapter 5 analyzes this thesis' work and discusses the initial directions our results provide for designing a framework on developing personal safety applications in different Scenarios, which justifies our approach towards the problem, presents the opportunities to explore the problem for better understandings, and discusses limitations of our research study.

Finally, Chapter 6 provides the conclusions drawn from our work with consideration of the fact that it has not been performed in actual settings. It then discusses the theoretical implications which can be derived from our research. We conclude by listing the future directions of personal safety applications which should be further investigated.

1.4 COLLABORATION

The research presented in this thesis is a part of a project called PRISM (Privacy, Security and Personal Safety with Mobile Technologies) undertaken by an interdisciplinary team of researchers from Dalhousie University, Heriot Watt University and University of Edinburgh. A research paper from the same body of work as presented in this thesis, titled “On the Effectiveness of Personal Safety Apps in Public Spaces” [76], is being prepared for publication at a suitable venue. Another graduate student (Dilpreet Singh) in the same project (PRISM) has explored the literature and some of the applications/frameworks proposed

for personal safety applications. Their work gave us a good deal of understanding and future direction for our study and aspects of personal safety which we explored further in our research.

Chapter 2- REVIEW OF LITERATURE

In this chapter, we review the literature related to the topic of public safety and some of the methods used at present (mobile applications available in the Android and Apple app marketplaces in our case) to ensure public safety using technology. We first examine the past work done in understanding how people perceive public safety at any given location at certain times of the day. We then review the existing literature on the use of mobile applications for public safety and its relation to changes in this perception. Finally, we discuss work related to some of the mobile applications for personal safety that are available in the market. We conclude this chapter by explaining why we have chosen to research the use of personal safety applications as part of an overall response in an unsafe situation.

2.1 PERCEPTION FORMATION ABOUT PUBLIC SAFETY

Perceptions about feeling safe (or not) at any specific place are always subjective. Many studies have been conducted in the past to understand different factors, including lighting, presence of uniformed personnel, and past experience with crime [4, 6, 7, 12]. We define *perceived personal safety* as a person's immediate sense of security and an absence of anxiety of becoming victimized when traveling through a particular environment at any given location.

2.1.1 External factors

Research has been undertaken to understand external factors that play significant roles in perception formation for individuals about their safety at any given location. Street lighting

is critical not only for avoiding obstacles and crime prevention, but also for providing a general sense of security to road users. Peña-García et al. [6] conducted a survey with 275 randomly-chosen pedestrians (anonymous, no personal information was asked except for education and gender) who were walking along five different streets of the city of Granada, Spain with similar lighting conditions (illumination uniformity and light intensity) and number of pedestrians on the street at given times. The survey asked 11 questions, mostly relating to how participants felt about the presence of lighting on the street, intensity, uniformity and how some of these factors influenced their minds about perceived safety. They found that well-illuminated streets with uniformed lighting help people feel safe. This safety perception is even stronger when illumination levels are higher, as they help individuals achieve a feeling of alertness (e.g. recognizing faces of surrounding people). In terms of studying the difference in perception with the colour of the lighting, whether it is yellow or white, the study found that people felt safer in white light when compared to yellow light, even if white light results in more light pollution [6].

Considering light pollution and energy waste aspects related to having continuous, highly-intense street lighting has called for a better understanding of concepts such as dynamic lighting and smart light distribution. Smart light distribution is a lighting technology using automated high efficiency controls to adjust lighting based on conditions such as daylight availability. These solutions may sound promising as they illustrate an effort to improve situational awareness by providing better lighting while keeping lighting distributions efficient; however, the question of how people actually perceive safety with these new implementations is an important concern and will need to be addressed to understand how

safer and efficient lighting solutions can be created in future. Haans et al. [7] explored how pedestrians gain an advantage from the presence of lighting and how it can be intelligently distributed over lamp posts in dynamic road lighting conditions. They focussed on understanding whether people feel safer having more lighting around them or on the parts of the road that lie ahead [7]. To what extent an individual's sense of safety is influenced by features of the physical environment has been described in the research of Haans et al. by three proximate (immediate) cues: *prospect* (having an overview), *refuge* (perceived escape possibilities) and *escape* (perceived hiding places for offenders), as defined by Fisher et al. [35], which are loosely related to the prospect-refuge theory proposed by Bloabaum et al. [24].

A multiple phase study consisting of two experiments was conducted by Haans et al. [7] at a test site as shown in Fig 2-1. These experimented aimed to understand whether people feel safe with more light in their primary surroundings or on the parts of the road that they are approaching. Haans et al. also confirmed that the perceived personal safety of their participants at night can be better described by changes in the participants' perception of prospect, refuge and escape [7]. We explored this study by Haans et al. [7] in depth to understand the perception of safety created by people under different lighting conditions as it is an important factor to consider when imagining an unsafe situation. As mentioned in Chapter one, the Scenarios presented to the participants were very general in nature, and we expected our participants to think about the specifics of a past unsafe situation during the different semi-structured interviews conducted in our research study. Surprisingly, when voluntarily expressing their imagined unsafe situations, most of our participants

noted that they took place at night. This data makes it essential to understand how the absence/presence of light affects perceived safety in a given situation and the work by Haans et al. [7] provides a clear understanding of this issue.

In the first experiment performed by Haans et al. [7], 29 women ranging in age between 19-30 (Mean= 22.9) were taken to a comparatively unfamiliar test site as presented in Fig 2.1. The majority of these women believed the site to be at least fairly safe. The women participated in a two (road segment: east and west) by three (conventional, ascending and descending light distributions, as shown in Fig. 2-2) within subject experimental design study. For phase one, participants were made to stand in the middle of the road. They were then subjected to nine different lighting distributions with one on the east and other on the west, while Haans et al. counterbalanced the order across participants. After reaching the end of the road, participants were asked which light distribution they preferred with respect to perceived personal safety. In comparison, in phase two, again starting from the middle of the road, all of the participants were presented six road lighting conditions; however, one at a time, while counterbalancing the order across the participants. The participants were then asked to complete a questionnaire in which every particular street segment was evaluated for perceived personal safety, and through immediate cues, prospect, concealment and escape. At the end of experiment 1, the participants completed another questionnaire about femininity and masculinity characteristics as well as other demographics [7].

In Fig. 2.1 black squares represent the LED luminaries used in experiment 1 and 2. In experiment 2, the LED luminaire indicated with the black triangle was used in addition to

the ones described for experiment 1. The black star indicates the positioning of participants [7].

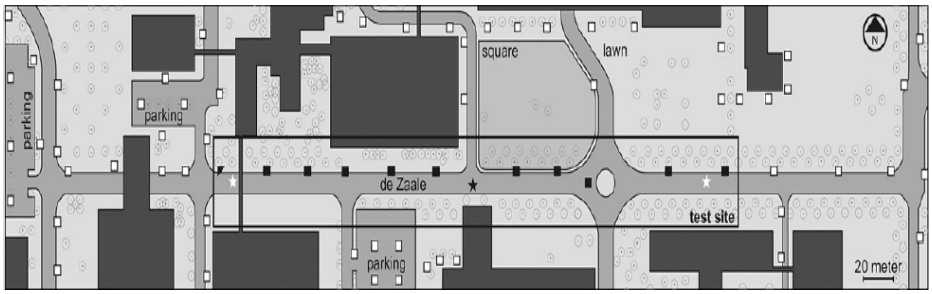

Figure 2-1 Test site of the study by Haans et al. [7]

From experiment 1, Haans et al. [7] claim to have found that pedestrians would rather have light in their immediate surroundings with respect to their perceived personal safety even if it meant having lower illumination on the parts of the road lying ahead. In terms of gender, men/women evaluated with higher feminine characteristics (biological or psychological) perceived a higher threat of crime outdoors at night in comparison with men/ women evaluated with less feminine traits [7], confirming the results of past research [31].

In experiment 2 by Haans et al. [7], fifty participants (28 men and 22 women) ranging in age between 18-27 years (Mean = 21.8). These participants were mainly undergraduate students from a few different technology institutions. Similar to experiment 1, most of the participants stated that they believed the test site (which was the same as experiment 1) to be fairly safe. Participants were subjected to three conditions (control, dark spot and spotlight) of light distribution as shown in Fig 2.3 within-subject experimental design study.

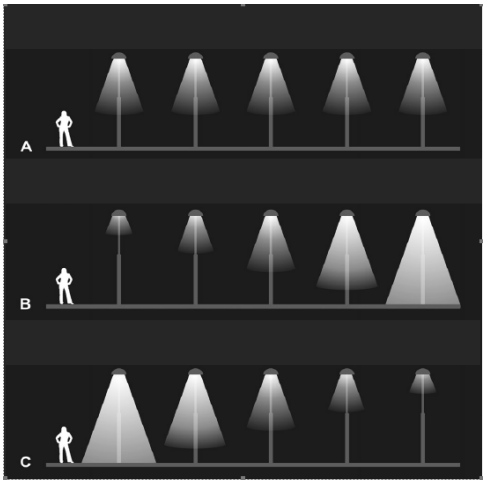

Figure 2-2 The conventional (A), ascending (B), and descending light distribution (C) in experiment1[7].

A "so called" Wizard-of-Oz set-up of dynamic lighting system was used. The set-up is considered to be a "so-called" implementation of the Wizard-of-Oz technique as the current position of the participant during the experiment was not being monitored live as its usually done in Wizard-of-Oz set-ups. Participants were required to press a button on a radio link to let their position on the street be known to researchers while they walked down the street from east to west under three different conditions, counterbalanced across the participants. An experimenter from the control room was able to initiate a computer program which changed the intensity of lamp posts every 3.75s (derived from the pilot study) for a duration of 15s (the average time taken by a pedestrian to move from one lamppost to another; monitored from the pilot study) until the end of test site. After every route, the participants were asked to assess the safety on the street by doing a questionnaire before beginning to move in the opposite direction under the next lighting condition. At the end of the experiment, the participants were asked to complete a questionnaire asking for several demographic details. Haans et al. [7] claim to find similar results from experiment 2 as experiment 1; participants still seemed to prefer more lighting in their immediate surroundings

with female participants having lower perceived personal safety in comparison to male participants. Both experiment 1 and 2 took thirty minutes to execute and a compensation of €10.00 was offered to the participants from each experiment.

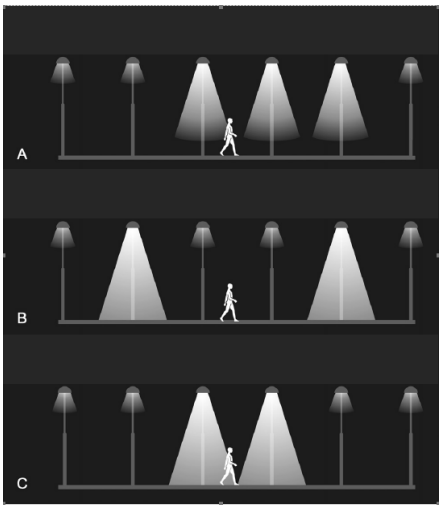

Figure 2-3 The control (A), dark spot (B), and spotlight conditions (C) in experiment 2 [7].

Based on their results, Haans et al. [7] claim to associate a higher sense of safety with higher prospect and refuge, but lower concealment. Alhough this study had many limitations, such as conducting the experiment in a relatively safe setting and asking participants to indicate their position through an action (experiment 2), which may have affected the results; the study gives a better insight into perceived personal safety in the context of the distribution of lighting.

Similar to the presence/absence of lighting, a few other external factors seem to affect perceived safety in an unsafe situation. It has been noted by a a number of researchers that fear in any particular situation does not only develop because of risk and past experience of crime, but also due to exposure to crime through mass media, traffic and individuals'

respective perceptions of police effectiveness at any specific destination [29,10]. Cultural differences of how police presence can minimize crime can be derived from the deterrence theory [81]: an increased police presence will increase the likelihood of catching individuals disobeying the law while they are committing crimes. The findings from a comprehensive literature review conducted by Zhao et al. [34] for 26 different projects (conducted between 1977-1999) echo the findings surrounding the question of how an increased police presence affects perceived personal safety.

Another instance of deterrence theory in action can be observed from a study conducted to monitor the effects of police presence on urban driving speeds. This study claimed that the presence of police vehicles can both reduce the number of vehicles exceeding the speed limit by two-thirds and also create a memory effect of police presence which lasts at least two days [30]. This memory effect may lead to temporarily creating a better sense of perceived safety for the people who witness police presence in certain settings. However, the claim that a higher sense of perceived personal safety is directly proportional to the presence of uniformed personnel or police is strongly debated by different researchers in the last decade [12,10].

Amir et al. [10] conducted a study in Kuala Lumpur to understand the factors influencing perception of safety where 156 participants (mostly international female travellers) of a diverse age range and educational backgrounds answered a self-administered questionnaire. The questionnaire focussed on understanding the participants' perception of safety in the presence of police professionals, among other factors presented in Table 2-1. When

asked about the effects of the presence of police/uniformed personnel on their perceptions of public safety, two perspectives were among the participants (based on the division of public and tourists). The presence of a greater number of police/securitiy in any area may lead participants to either feel safer and more secure or created doubts about their safety in that particular area, as shown in Table 2-1 [10].

Table 2-1 Perceptions of safety and evaluation of measures/instruments [10]

Safety and Security Instruments/ Mean Measures	Very Good	Good	Average	Poor	Very Poor
Pedestrian Design	**17**	**73**	**54**	**12**	**0**	**2.38**
Provision of closed circuit television (CCTV)	**10**	**46**	**71**	**21**	**8**	**2.81**
Signboard or direction board	**21**	**61**	**48**	**4**	**2**	**2.54**
Amount of lighting	**18**	**88**	**43**	**6**	**1**	**2.24**
Safety information	**14**	**47**	**72**	**18**	**5**	**2.68**
Number of police and security	**30**	**50**	**51**	**24**	**1**	**2.25**

Similarly, another study conducted by Kwaku Adutwun [12] also challenges the claim that the presence of uniformed personnel leads to an increased perception of safety in a tourist population. Kwaku Adutwun [12] suggested that tourists feel unsafe if repeatedly reminded to be vigilant.

When it comes to surveillance, it is hard to deny that the physical presence of authorities has been heavily replaced by virtual surveillance methods like CCTV cameras or similar devices. Multiple studies have been conducted in the past to understand the change in the perception of perceived safety by the use of CCTV in an area. The results seem to suggest that CCTVs can be effective in improving perceived safety to different degrees in some cases, but not always. Bennett et al. [25] conducted a study with 716 participants with an almost equal number of male and female (91.1 % Caucasian and 8.9% non-white) participants: 62% of the participants represented the 16-39 age group and 38% of them representing the 40+ age group. Participants were selected using quota sampling to resemble the resident population of the city centre (Cambridge, England) in 1991. A total of 713 interviews were conducted, where each interview took 10 minutes to complete. They found that one third of their sample believed that CCTVs were effective in crime detection and deterrence, in turn improving perceived safety, where female participants supported this claim 8% more than male. Female and elder participants were more in the favour of installing CCTV-cameras. Moreover, a larger percentage of “non-white” participants compared to “Caucasian” participants reported that CCTV would be effective in improving the perceived safety in the area [25].

An extensive survey of literature conducted in the UK on the research studies on CCTVs during 1990-1999 also claims that CCTVs have been effective in reducing the fear of crime in public places [28]. However, the effect differs in different situations: in some situations, the percentage of people feeling safer after installation of CCTVs only increased by 10%, whereas in others it increased by more than 30% depending on factors such as place of implementation [28]. On the contrary, another study [33] claims that CCTV is unlikely to make women feel safer in town centres that are dominated by men at night. Another study [41] conducted on public CCTV network in Philadelphia, USA also found the use of cameras resulted in a 13% reduction in crime, with many sites in the city showing similar results.

Some of the other external factors which have been discussed by other researchers include, but are not limited to, road traffic, presence of potentially risky people and past experiences with crime. These factors seemingly show a direct proportionality between these factors; that is to say, more road traffic/presence of potentially risky people/greater risky experience and risk/perceived fear towards personal safety.

Aforementioned factors in this Section, seem to have a direct relationship to how someone would perceive safety in any particular area. Although we are not researching these factors directly in our study, the independence given to the participants in our research study by keeping the Scenarios (Appendix E) general and lacking details about the specifics of an unsafe situation makes these factors important to our research study. The nature of the descriptions given for Scenarios in our study gives the participants liberty to imagine any

situation with varying degrees of the presence/absence of these factors for e.g. participants talk about running towards a street with better lighting and more police presence such as downtown when encountered with an unsafe situation. Knowing how these factors influence the perception of safety for any given place helps us to develop a better study design and evaluation.

2.1.2 Individual factors

Perception of fear and perceived personal safety are not merely dependent on external factors, but also notably on individual factors including, but not limited to, age, gender and educational background as explained later in this Section. In the past, many researchers have discussed their results describing how these factors, when considered individually, show differences in conclusions drawn about potential effects of perceived personal safety from these studies.

Researchers have studied the effects of factors such as gender on perceived personal safety [12,25,38], which is elaborated here by explaining work discussing specific genders and their perceived safety in comparison to others. It has been evident from everyday incidents around the world and research that people with more feminine characteristics (biological/ psychological) and those who identify as LGBTQQIP2SAA (lesbian, gay, bisexual, transgender, questioning, intersex, pansexual, two-spirit (2S), androgynous and asexual) seem to have a higher sense of feeling unsafe [8, 9, 31, 10, 38]. Throughout this and upcoming chapters, the term LGBTQQIP2SSA will refer to lesbian, gay, bisexual, transgender, questioning, intersex, pansexual, two-spirit (2S), androgynous and asexual.

Evidently, a greater number of the studies conducted towards perceived personal safety are directed towards groups at risk, like females and LGBTQQIP2SSA people [7, 10, 12].

A study was conducted by George [9] with 438 participants (53% male and 47% female) to understand the perception of safety of the people visiting the city of Cape Town particularly in some of the most famous spots of the city. Visitors were asked to fill out an exploratory survey regarding perceived safety in the city. They found that female participants seem to evaluate the situations less safe than men when questioned about the exact same situations in daytime. In comparison, perception of safety after dark did not show any considerable difference between the responses of the male and female participants [9].

Numerous studies have attempted to explain why, given similar test conditions, female participants report a decreased perceived personal safety in comparison to male participants, for example female participants support the policy of having CCTV cameras in public places [25,44,28]. Bennett et al. [25] and Philips [28] argue that female participants seem to agree more (71.8%) with the claim that having CCTV can help to improve perceived safety than male participants (60.4%). This view is supported by the study completed by Haans et al. [7] where male and female participants were tested by researchers for their perceived safety by having them walk in three different lighting arrangements as shown in Figs. 2.2 and 2.3. Researchers found that female participants felt lower personal safety in comparison to male participants when subjected to similar experimental conditions. Similarly, Hunecke et al. [24] propose that femininity, but not masculinity, affects perceived safety.

Similarly, Amir et al. [10] surveyed 156 international female travellers in the city of Kuala Lumpur about their perceived safety, and found that 87.3% of the respondents traveled with at least one partner. They argue that this fact highlights that female travellers felt unsafe and insecure when travelling alone. Their findings are similar to the findings of Barker and Page [39], and Donaldson and Ferrerira [40] which show that women prefer to travel with a companion. The papers listed above [7,9,10,12,24] explain how females and persons who exhibit feminine traits have a lower perceived personal safety in comparison to men in similar situations, which in turn expresses how gender is one of the factors affecting perception of safety for any given place.

However, there is a consensus among some researchers that gender is not proven to be an important factor affecting the traveller's perception of public safety, specifically in the case of safety from crime at any travel destination [37, 45, 46]. Numerous studies have attempted to explain the correlation of age to perceived safety at a particular place [9,11,12,25]. It has been suggested that support for implementing measures to improve personal safety such as CCTV are supported more (78.8%) by people 40 years or older than people in the age group of 16-39 [25].

Another study by George [11] concludes that older respondents (up to 55 years of age and older) were more likely to feel worried about their personal safety with their increasing age when compared to younger respondents. A similar view is supported by Yannakis et al. [52]. It might be possible that older people may not have adequate enough physical abilities, such as vision or body strength) to conduct everyday tasks or to defend themselves in potential unsafe situations, in comparison to younger age groups. Boakye et al. [12] argue

that in the study conducted on 420 participants with more than 50% of them being young (age<30), 58% of young people were most likely to believe themselves to be more vulnerable to crime with only 25% older participants (age >50) thinking the same.

Commenting on correlation between age group and perceived safety if an individual has already encountered danger in the city, George [9] argues that younger visitors had more probability to feel insecure than older visitors during the time they spent in the city. The sense of insecurity can be credited to their higher likelihood of going out in the evenings or at night when compared to older, mature visitors who were more experienced travellers. Along the same lines, younger visitors may choose more "backpacker-type" accommodations such as Airbnb or student hostels instead of main spots for mass tourists such as hotels [9]. Together these studies outline that age is a pivotal factor to determine the perceived safety in any given surroundings.

Several researchers [9,11,49] have reported analyses of changes in perceived safety in correlation to the nationality of the individuals in question. George [11], while conducting a study perceiving safety of participants visiting TMN Park (mountain hike) in Cape Town, found that tourists from North America, South Africa and the UK were more likely to fear for their personal safety than tourists from Germany and Holland. It is possible because of several reasons such as past experiences with crime, recommendations from friends or purpose of visit. George [9] suggested that visitors coming to see family and friends perceived higher threats to their safety than others visiting for business or holidays, which could be

possible because of familiarity with the area of crime. These results support the study conducted by Mavondo et al. [49].

A broader perspective has been adopted in a study by Bebbett et al. [25] where participants were investigated on their perceived personal safety on the basis of their ethnic origin and related conditions. Although they did not find any significant differences (33.3% Caucasian vs. 31.0% others) explaining why certain individuals feel unsafe in similar situations, the percentage of non-white individuals worried about being mugged, assaulted or insulted is notably higher than that of white individuals.

Another study was conducted by Bridgman [82] where 159 participants, both male and female from different ethnic origins living in a West Auckland community in New Zealand, answered questions about their perceived personal safety in their neighbourhood. Bridgman [82] reported that European participants were more concerned about personal safety and crime in comparison to people from other cultures. The European groups were also more likely to request more frequent police patrols and were less interested in participating in community-based approaches. Bridgman [82] also found that perception of safety is influenced by the culture and ethnic origin, and specifically, found that frequently one or a group of cultures are seen as the problem by the dominant culture.

In view of all that has been mentioned so far [11,25,82], one may assume that the nationality/ethnicity of an individual affects how safe they feel in any given environment. Although there has not been any direct relationship found between the educational levels of

the visitors to their perceived safety, it is still believed to affect how safe an individual feels in any given surroundings, as explained in study conducted by Demos [57]. Demos [57] claims that visitors with higher educational levels might be more aware of the places they are visiting as they may do more research and be more aware of the safety standards of their destination, which in turn may reflect their actions and a better perception of security for any place. Overall, there seems to be much evidence of how perceived safety for a certain environment around individuals can be dependent on many external and internal factors making safety a very personal, subjective and complex issue.

2.2 MOBILE PHONE, PERCEPTION AND PERSONAL SAFETY

Taking note of the complexity of the issue of perceived personal safety, humans have been seeking solutions for quite a while and mobile phones have emerged as one of the promising solutions for improving personal safety. Mobile phones, which initially provided the comfort of contacting others in your network in seconds around the globe, are now being explored for multiple purposes. Considering the high availability and use of mobile phones around the world, researchers have been investigating if any solutions to our safety issues can be developed using mobile phones.

Given the rapid growth and intrusion of mobile devices in our everyday life, it is not an overstatement to say that mobile devices are looked upon as the first solution to all our daily life tasks, starting from waking up with morning alarms to falling asleep while checking emails at night. It has been reported that 63% of the world population owns a mobile device, which constitutes to 4.7 billion mobile phones [43]. Beyond making changes to the

built environment such as street lighting [5] and increasing visibility to others [7], personal means of protecting safety have become the focus of recent research. The role of mobile phones has been considered due to their ubiquitous presence, frequent use [13], and the various mechanisms they offer for obtaining assistance (e.g., calling for help). The universal presence, higher availability, and possibility of becoming a significant part of our overall response to unsafe situation motivates us to explore mobile phones as a solution to personal safety issues.

2.2.1 Improved perception of security with mobile phones

An increased sense of security has been reported by individuals in the presence of mobile phones. [27, 19]. Mobile phones offer enhanced features enabling calls for help to include location information. Major mobile phones manufacturers, like Apple Inc. and Google LLC. [83], have started to come up with more solutions related to personal safety issues, for instance enabling live location sharing with other users using the "Find my friends" and "Trusted contacts" applications respectively. These trends of increased inclination of mobile phone manufacturers and higher availability [43] have motivated researchers to explore mobile phones as a potential way to mitigate personal safety issues.

Chumiskey et al. [55] investigated whether women prefer mobile devices as a tool for self-defence by surveying 197 female participants from a first-year introductory psychology class within the 18-58 age range in the United States. They used questionnaires with fourteen scaled and three open-ended questions, and concluded that women not only consider

their mobile devices as important tools for self-defence, but also for psychological relief. The study concluded a favourable evaluation of mobile phones in comparison to other tools of self-defence proves that when encountering an unsafe situation, women might prefer to defend themselves psychologically than physically.

Several studies have reported that people with mobile devices feel safer and more willing to take part in activities including higher risk situations or going to unfamiliar places [14, 17, 16]. Feeling safer in the presence of mobile phones clearly indicates that it may lead to better perceptions of personal safety for participants in some situation. These findings motivate us to explore more literature on how mobile phones help women feel safer in an environment.

In their analysis of how the presence of mobile devices affects our travel behaviour, Fiore et al. [14] claim that the presence of mobile phones motivates people to travel by making them more informed. This results in making them more effective in planning their resources and travel itineraries, for example making the access to larger physical spaces easier or helping them plan their travel time and resources in efficient manners. However, this may not always be the case, as mobile phones can sometimes make travel less enjoyable (e.g. by decreasing situational awareness or by increasing mental burden) [14]. Similarly, Savage et al. [16], investigated the social impact related to the usage of mobile devices, listing the tendency to keep in touch at all times, an increase in risk taking, and perceiving more control over situations. These findings echo the conclusion that mobile phones are motivators in improving perceived personal safety for people.

In another study by Nasar et al. [17], two surveys were conducted with 600 and 499 undergraduate students (both male and female) with complete results from 317 and 305, respectively, at Ohio State University to understand the correlation between mobile phones and safety among students. Their study suggested that 77.3% of students who carried mobile phones felt safe at night because of it, and 40% of these students reported that they would walk somewhere after dark where they would usually not go without a companion because of the improved perception of safety in the presence of mobile phones. On the contrary, they also discuss user behaviour such as the decreasing awareness of the immediate environment and late reactions in unforeseen situations, leaving the question of comparative advantages over disadvantages of having mobile phone for safety purposes open for further research.

As reported through many studies that women tend to feel more unsafe than men in similar situations [28, 9, 56], past literature has shown a notable difference in the impact of mobile phones on increasing the perceived safety for men and women [51]. For example, Roman and Chalfin [50] found that female respondents were 52% more likely to report a higher level of fear than men when walking in their own neighbourhoods; however, in neighbourhoods with higher rates of violence, men and women were equally fearful.

Tennakoon et al. [19] conducted a study in two countries, Canada and Sri Lanka, to understand mobile phone use and sense of security. They surveyed a total of 425 and 109 participants online in Canada and Sri Lanka, respectively, while conducting semi-structured interviews with 16 Canadians and 20 Sri Lankans to investigate usage trends and attitudes

towards technology to learn the behaviours of users in terms of using mobile phones to increase their sense of safety. They found that 75% of the respondents who answered the survey by saying that they "*never or rarely*" used a mobile phone as a source of increased sense of safety, were male, whereas 65% of the respondents who claimed to use mobile phones for increased personal safety purposes were female. Country, as a factor, was not found to be significant in the results of using mobile phones for increased sense of security. Overall, they concluded that women use mobile phones to increase their sense of personal and individual security, imagining it would help protect them in risky situations involving themselves, while men imagined more benign situations, such as an automobile breakdown or being available to assist someone else. Satchell and Foth [53] found similar gender-based associations between mobile phone use and personal sense of security.

Similarly, Line et al. [60] attempted to understand the role of ICT in everyday lives using a qualitative diary and interview study with students aged 18-28 and part-time working mothers. The researchers discussed a participant talking to her friend while walking to work when her friend is walking to work in another city, believing the mobile phone to be acting as tool of risk mitigation in different ways for both of them, as a way to stop personal attacks in public spaces. Another study by Aoki et al. [48] conducted a focus group followed by a questionnaire to understand the use of mobile phones for safety and found similar results confirming the research by Line et al. [60]. They found that a significant group of participants believe that mobile devices are part of their everyday life and they actively use them for managing their time/resources efficiently and contacting people as required.

Reducing avoidance behaviour amongst vulnerable groups, mainly women in the research surveyed, has the social justice benefit of levelling participation in public spaces and therefore in civic society. However, mobile phones used in this way may actually introduce risk. Nasar et al. [17] found that 42% of women indicated that when they had a mobile phone with them, they would walk places they would not usually walk, compared to only 28% of men who would change their behaviour. Nasar et al. [58] argue that depending on how phones are being interacted with, this could actually put vulnerable groups in more danger. For example, speaking on a mobile phone reduces a person's situational awareness, which can put them at increased risk, e.g. pedestrian safety. This leads to a potential risk homeostasis: a process where the reduction in situational awareness could balance out any increase in safety actually provided by the mobile phone. Thus, while mobile phones appear to increase an individual's perception of safety and impact on their behavioural reactions, they may introduce additional risks: it is not entirely clear that mobile phone use for this purpose provides a real improvement in safety.

2.3 PERSONAL SAFETY APPLICATIONS

In the recent past, research has been conducted with the aim to design specialized tools to facilitate personal safety in unsafe situations. Several personal safety mobile applications (or, apps) have been developed (e.g., Bsafe, CircleOf6, Life360), as well as apps that connect with wearable devices, such as a wearable button [65], a whistle [70] and a watch [75]. Bsafe [67] is a fully functional personal safety application available for both Android and Iphone which helps the user to seek assistance from immediate surroundings using features like loud sirens, alarms and fake calls from others by sharing the live location or through

texting/calling for help. Life360 [42] is a purpose-based location tracking application used to track the locations of friends and family and also allows check-ins to keep track of their whereabouts while texting privately or in groups. Life360 is also available on both Google Play and the Appstore. Circleof6 [72] is a Minimalistic Design-Based personal safety application which lets you seek help from the circle (contacts added by user) by either seeking interruptions or sending panic messages along with your location.

A large and growing body of literature has investigated different approaches being followed to develop personal safety applications. In this Section, we present an in-depth review of the past literature on the solutions designed with a focus on how they intend to achieve actionable results, such as calling for help or sending a text to seek assistance. Yet, most of the existing research seems to focus on building solutions without a clear understanding of the problem from the user's perspective.

Some of the common apps attempt to serve as solutions in which the request to obtain help from trusted parties is quickly triggered by the user when they are in an unsafe situation. Initially, we discuss some solutions created by exploiting the high-tech location capabilities of mobile devices that have been mainly used for navigation, business fleet or related services in the past.

In terms of responding to an unsafe situation, one can use different types of solutions, either technical, such as using basic mobile features or using a personal safety application, or non-technical solutions, such as running away from the situation or confronting it. A combination of any two same (technical) or different (technical and non-technical) solutions

can also be used to respond to an unsafe situation. A study conducted by Gates et al. [63] categorized the behavioural reactions to a fear of crime as avoid, collect, and protect. A response would be categorized as AVOID if it includes the participant seeking to get out of the situation using an action such as running away from situation or ignoring the conversation, whereas Gates et al. would characterize a response as PROTECT if it includes responses to confront the other party directly such as confronting the other person in your conversation about feeling unsafe from their actions. On the other hand, a response would be fall in the COLLECT category if it includes an effort to communicate with someone to seek assistance such as by calling/texting for help either using a mobile phone or a safety application.

However, as we will discuss in chapters 4 and 5, in our study, we found that our participants' responses sometimes seemed to overlap some of these three categories of responses. Therefore, to better categorize the responses we received, we considered combined responses, i.e. a combination of pairs among avoidance, collective and protective responses. A response would be characterized as COMBINED if the response falls into more than one category, for instance texting for help using a personal safety application and ignoring the conversation. We found this characterization of behavioural reactions helpful and used them to categorize the solutions in the next Section.

2.3.1 Solutions involving collective response at the time of panic

Ovelgonne et al. [27] proposed a social Emergency Alert Service (EAS), which is a social-network-based solution to seek assistance when in trouble, citing the reason that it is

difficult to seek help from strangers in today's fast-paced world is because of the so-called by-stander effect as explained by Latane et al. [56]. Ovelgonne et al. proposed a one-click system that would share an individual's phone location with a number of social network contacts at the time when assistance is requested. It would give priority to contacts with whom there has been more recent communication, and are more physically proximate at the time of the alert. If a user is found in a proximity of 1km, it generates a possible route using the map service available on the device. However, it does not consider the possibility of that the contacted user (the individual coming to help) can themselves be a threat to the user seeking help. They discussed the challenges of starting communication with helper clients (who receive the text from the user who needs help) as using this proposed system would always need the helper client to keep an open-connection. A connection can be opened by the helper client either after being informed directly by the help-seeking client or through the GSM (Global Systems for Mobile) provider of the help-seeker through a call/SMS.

Thakur et al. [32] proposed a fully distributed infrastructure-less platform based on proximity-enabled trust and co-operation to be used in emergency rescue and alert Scenarios. A system called SHIELD (Social sensing and Help In Emergency using mobiLe Devices) was developed which utilizes Bluetooth and/or WLAN traces to achieve minimal response time and maximum availability resulting in minimum reliance on traditional centralized emergency systems/infrastructure. The SHIELD system uses a database of trusted encounters (e.g. based on past proximate Bluetooth connections) to seek help, eventually avoiding raising an alarm to a central system (such as the central university campus system, in this

case). They maintain that these types of infrastructure-less systems, in terms of their design, are not just capable of providing maximum availability and minimum response time, but can also be more scalable and cross-platform (device manufacturers) compatible.

Similarly, Ananda et al. [20] proposed a system ("CHEEKA") in which when users are in a unsafe situations, the location of the users is shared periodically with either the user-defined contacts or user's Facebook friends who have accepted to continuously share their location with the system. It also uses augmented reality to add an extra layer on a Google Map to show the location of your friends from Facebook so users can make better decisions in unsafe situations. The CHEEKA system also lets users switch to a stealth mode where your location is not tracked by the application. Ananda et al. [20] performed a small evaluation (5 participants) of their app, though the evaluation focused only on the accuracy of the location details.

2.3.2 Solutions involving specific triggers devices

Researchers and developers have also focussed on proposing or designing solutions that involved specific trigger devices and resulting communications. KishorBabu et al. [22] proposed an alert and tracking system that, in addition to communicating the location, also sends a voice recording of 30 or 60 seconds depending on the option selected by the user. Different options in the application are provided in the order of the severity of the situation and ability to reach help. However, it is worth noting that they have not conducted any formal evaluation of their application or of other (similar) applications.

Similarly, Toney et al. [36] proposed a safety armband for women and children that is enabled by a switch or a fall detector, which is interfaced with a wireless camera using a GSM/GPS kit interfaced in the arm band. After the system is triggered by the user, it starts sending panic messages to pre-assigned contacts and records video of the incident using the wireless camera attached somewhere on the user's body. It sends text messages every 30 seconds and continues to live stream the video to the central police control room until the system is manually stopped. It also sends and lets the authorities track the user's location using the GPS form of the arm band. Researchers claim that these types of solutions help police obtain video evidence for such incidents. Both Chang et al. [61] and Chand et al. [37], moreover, provide sensor-based solutions that involve shaking the phone, in addition to an app-based panic button.

Personal safety apps and systems have also been designed for specific populations. Satchell and Foth [53] designed a separate device for the purpose of protecting the personal safety of remote-working engineers. Kim et al. [68] developed a system for automatically tracking elderly patients, whereby location patterns can trigger an alarm when they differ from recorded norms. Ramalingam et al. [59] developed an app for detecting an extreme heart rate (anything but normal heart rate) while an individual is driving, and, under pre-defined conditions, it sends the individual's location information via SMS and Facebook. Saranya and Selvakumar [47] proposed an Android-based system for parents to track their children.

Chand et al. [73] developed a women's safety application namely WoSApp, which allows the victim to inform the local police station by either pressing the panic button or by shaking the phone 40 times consecutively in 8 seconds. Users' locations and emergency contact information, as given by users at the time of application installation, is sent to the local police station. The prototype of the application was tested, but no actual results were collected or further evaluated.

Mokryn et al. [69], came up with a self-learning opportunistic system called Helpme for skilled personnel and public, which enables a mobile phone ad-hoc network over WI-FI to find help from your peers for the time between a disaster and when help arrives. Helpme supports the idea of getting help from users' peers, assuming some of them are trained medical or relief professionals. They tested their system on iPhones and iPads by doing four experiments. In each experiment, individuals emulated being professionals who could help, and others emulated being the ones seeking help. The experiments were carried out with variations in terms of how one agrees to help and how someone could ask for help. They found that personalizing the routing of requests by learning the environment in a content-based opportunistic network could be effective to gaining help from peers before actual help arrives. The matching process of finding the helper for someone seeking help was done using a pre-defined matching algorithm which continues to update the information about different users whenever it finds them online. However, emulating the situation and not conducting an actual study with human subjects, as well as only testing it on Apple devices, makes it less externally valid and leaves the question of testing the application for usability quite open for future work. Also, the assumption of always having a

trained professional in the network may not always hold true and relying on algorithms to match with person who may help seems to present a flawed study design.

Dimond et al. [66] and Ahmed et al. [71] led studies to understand the problem of public sexual harassment and how sharing stories can help. Ahmed et al. [71] designed an application that allowed women to share their experiences with one another that also included a panic button. However, in their application evaluation, no feedback on the button feature was provided by the study participants (who were asked to provide feedback on a variety of application options).

Together these studies outline the fact that there has been extensive work on proposing/developing different device-based solutions, but a very limited amount of scientific literature is available on how these solutions might actually be used to react in unsafe situations, nor much in the way of evaluation. Table 2-2 provides a summary of applications we reviewed and includes the best information available by reading through the corresponding research papers.

Table 2-2 Summary of reviewed safety applications

Features	Bsafe	Life360	Circle of 6	Social EAS	CHEEKA	SHEILD	Tony et al. [36]
Follow Me (Continuous location update)	x	x	x			x	
Share GPS Location	x	x	x		x	x	x
Type of Request to connect with friends	SMS	Unique code to be shared with the family member	SMS		SMS		SMS
Check - IN	x						
Status of Friend/ Family member's phone		x					
Recording (AV)						x	x
Available platforms	iOS and Android	iOS and Android	iOS and Android	None (proposed)	NA	NA	NA
Number of Clicks to enter Panic mode	2	3	2	1			
Call emergency Services (911 or other local numbers)	x		x				
Mark safe places		x					
Other features		Crash Detection					x

2.4 SUMMARY

The studies highlighted in this chapter and provided thus far give evidence that the focus of developing solutions specific to a population or a certain type of unsafe situations is increasing. The willingness to have and use these personal safety applications in combination with other traditional measures are still an open question for the researchers to study. Researchers like McCarthy et al. [1] used a survey (n=469) to investigate the willingness of Irish transport users to download and use a personal safety app, finding that there was some willingness to download and use such apps. However, there was no consideration of specific safety Scenarios, nor as to how personal safety apps might be used with other safety measures.

Similarly, Karusala and Kumar [15] used semi-structured interviews (n=17) and a survey (n=30) to investigate the experiences of women in public spaces in India, and their feelings on the panic button mandate. Their approach rightly focused on the problem, with the panic button being one of several possible solutions, although they did not focus on any particular safety Scenarios, or other potential safety app features.

A considerable amount of literature has been published [36, 81, 53] in recent years which propose certain frameworks for public safety applications and, thus, calls for evaluation of the available applications in terms of their usage in different types of unsafe situations. Drawing from an extensive range of sources on the development of personal safety solutions, we set out to run an in-depth study to understand how people might use mobile phones and personal safety apps, and how they are combined with other measures of an

overall response to an unsafe situation. Also, we question whether current personal safety apps present themselves as viable tools that people will use to respond to unsafe situations? Moreover, our study aims to understand the new features people really expect in a personal safety application, which can help to enhance the user-experience in currently proposed frameworks and available applications in an unsafe situation. In the next chapter, we discuss the design of our study and the ways we explored our participants' reactions.

Chapter 3- METHODOLOGY

In the preliminary literature explored, we learned how to any human being safety is a very subjective and personal affair, affected by external and individual factors. Moreover, our perception of safety in any environment is dependent on factors such as our gender, age, and experience with crime. The presence of mobile applications that claim to enhance our perception of safety give rise to many open questions [22], for example:

- How are mobile applications effective in an unsafe situation?
- Are these applications something we can completely rely on?
- Do we have to somehow use them in combination with traditional measures such as 911 (emergency helpline)?

Furthermore, a recent increase in the development of more and more mobile solutions and limited research on how they might actually be used (and can be usable) in unsafe situations makes these questions significant for further understanding in terms of making these applications more useful. In light of the literature reviewed in Chapter 2, we developed specific research questions to understand the use of these apps in unsafe situations and how use/dependency on these application changes with different genders among other factors.

In this chapter, we will discuss our research questions (in Section 3.1); participants (in Section 3.2); study design (in Section 3.3), which will include our study setting; and task design. In the end, we aim to discuss our data processing (in Section 3.4), which is comprised of data collection followed by discussing the data coding.

3.1 RESEARCH QUESTIONS

As described in Chapter 2, different solutions, such as those developed by mobile phone manufacturing companies including basic mobile features, e.g. Find My Friends in Apple Inc. iPhones or the standalone mobile safety applications for different platforms (Google Play store, App store etc.), provide multiple options for users to respond to unsafe situations. A response to an unsafe situation can include single or combinations of solutions which might include personal safety applications. People have been using non-technical responses, such as seeking help from those around us or even confronting the situation, and basic mobile phone features for seeking assistance for quite some time; however, how individuals may end up using one of these personal safety applications still remains an unexplored question to a greater level. This question motivated us to design three high-level research questions for our research study.

The high-level research questions are as follows:

1) **RQ1** : *How might people use mobile phones and personal safety apps to respond to perceived unsafe situations ?*
   Through this question, we tried to investigate whether people use mobile phones or personal safety apps when facing a perceived unsafe situation.

2) **RQ2** : *How might mobile phones and apps be used as part of an overall response to unsafe situations?*
   In RQ2, we tried to investigate how individuals may use personal safety applications and mobile phones when faced with a perceived unsafe situation in combination with traditional measures such as running away from the situation or shouting for help.

3) **RQ3** : *Do current personal safety apps provide themselves as useful tools that individuals will use to respond to perceived unsafe situations ?*
   In RQ3, we tried to answer the usefulness of these safety applications in the perceived unsafe situations.

RQ1 and RQ2 may seem very similar at first. However, in RQ1 we were looking to understand the use of mobile phones and personal safety apps in perceived unsafe situations, whereas in RQ2 we were looking to understand the use of mobile phones and personal safety apps in combination with traditional measures taken in unsafe situations such as shouting for help.

3.2 PARTICIPANTS

Drawing from the past literature on mobile devices presented in Chapter 2, it is evident that the use of mobile applications for seeking assistance is not limited to any particular age group, which motivated us to keep the recruitment process open to the public along with university students/faculty/staff. We recruited participants of 18 years-of-age or more from Dalhousie University students, faculty, and staff, as well as the general population from the Halifax Regional Municipality (hereafter HRM). We recruited 30 participants for our study. The study included two groups of 15 participants each, with a balanced number of male and female participants. We considered that this number of participants would be adequate to satisfactorily collect all the necessary qualitative and quantitative data. Our target population was anyone from HRM, with at least one experience of having felt unsafe in the past. Using the initial screening questionnaire (Appendix A), only participants who had at least one past experience of feeling unsafe were invited to take part in the study. It was necessary to filter participants with at least one unsafe experience as in our study we

provide the participants with three general Scenarios (Appendix E) lacking any specific details about the risks involved in the situation.

3.2.1 Recruitment

We recruited participants with a broad spectrum of demographic characteristics (See Appendices C and D) and diversity. We recruited our participants by broadcasting the recruitment notice (Appendix B) through email groups (such as Notice Digest Today@Dal), the Computer Science Faculty mailing list (csall@cs.dal.ca, etc.), online classified ads (e.g. Kijiji), and social media (e.g. Facebook). We also recruited participants by sending out announcements through email to all Dalhousie University students, faculty, and staff. We also posted printed recruitment notices on the Dalhousie Library bulletin board, at the gym, at the helpdesk in the Killam library, and in public grocery stores. We first asked for the permission of any administrator/moderator/supervisor before posting online or physically.

In the email, participants were asked to reply to the listed researcher if they were interested in participating in the study. A screening questionnaire was sent to potential participants who were 18 years-of-age or more and had one or more past experience of having faced an unsafe situation (details of the situation were neither asked nor gathered). All of the qualified participants were contacted to decide a mutually convenient time to conduct the study at the Graphics and Experimental Media (GEM) Lab, on the fourth floor of the Mona Campbell Building, Dalhousie University.

As previously discussed, in our initial recruitment phase, we filtered participants for having experienced one or more unsafe situations in the past. It was important to recruit people

with past experiences because in our study we asked participants to imagine the specifics of the risks involved in three unsafe Scenarios with varying degrees of isolation provided by the researcher to the participants to respond to. Furthermore, an individual with past experiences (details of the past unsafe situation were neither asked nor gathered), of feeling unsafe would be better able to provide accurate results in the study by in terms of making more realistic choices in the given Scenarios. Experienced participants may even respond well to the questions related to the additions that could be made to the mobile applications to make them more usable in unsafe situations.

3.2.2 Recruitment Challenges

Initially, we planned to recruit 45 participants including 15 participants who self-identified as male, female, and LGBTQQIP2SAA. We faced a major challenge in recruiting participants identifying their gender as LGBTQQIP2SAA (lesbian, gay, bisexual, transgender, questioning, queer, intersex, pansexual, two-spirit (2S), androgynous, and asexual) [84]. We advertised in our recruitment notice that someone who is not comfortable revealing their gender/identity through email could contact us anonymously. We took extra steps to recruit more LGBTQQIP2SAA individuals by reaching out to the local organizations which helped us circulate the recruitment email. We contacted the Equity and Accessibility office and with their help circulated the notice to different organizations on campus, such as South House, DalOut, and Phoenix House.

We were only able to recruit one participant from the last category, which resulted in dropping that category for our data analysis stage. We cannot confidently state the reason why we receive such a small number of responses from the LGBTQQIP2SAA community. An

inability to recruit participants from the LGBTQQIP2SAA community resulted in making our study results less externally valid. It is important to consider the perspective of LGBTQQIP2SAA individuals as it is evident from the literature that they feel more unsafe in perceived situations than other gender identities [8, 9, 31, 10, and 38]. Therefore, it is recommended for future studies to make further efforts to recruit LGBTQQIP2SAA participants as this demographic will contribute much-needed information in the field of personal safety.

3.3 STUDY DESIGN

We chose to design our study as a controlled lab-study for two reasons: first, simulating an unsafe environment for the participants was difficult as we were advised by Dalhousie REB to choose the study area with the consideration that it should not remind the participants of any past experiences which may lead to mental distress. We paid special attention to keeping participants safe as at all times. We provided a list (Appendix J) of resources/places to seek help if the participant felt stressed or any other related mental condition in or following the duration of study. Participants were also told while giving consent that they could choose to leave the study at any point if they felt uncomfortable. Participants' decisions to leave the study did not affect their financial compensation, which was paid at the time of starting the study. Furthermore, if they chose to leave the study, their data was deleted.

Secondly, we wanted to keep the conditions similar for each participant as we needed to study the behavioural differences in our data analysis. We implemented a within-subjects study design in a controlled lab environment where all of the participants were subjected to same conditions in a similar order as expressed in Section 3.3.1. The within-subjects

study design helped to better understand emerging trends in terms of behavioural differences in responses to unsafe situations, specifically with regards to the gender identities of the participants. All of the participants (m or f) were assigned to the study in a random order to reduce any affects/bias.

The study was divided into three Stages with Stage 1 being used to screen, recruit and obtain consent participants for the study and to gather demographic data. Stage 2 included defining and characterizing unsafe situations with an introduction to our three Scenarios, along with our semi-structured preApp questionnaire. In Stage 3, participants were introduced and trained on personal safety applications and then their preferences in terms of application installation were recorded, followed by our semi-structured postApp questionnaire. At the end of Stage 3, we asked participants for their recommendations on making the tested apps more usable. The term "preApp" refers to the interview conducted before participants installed the personal safety applications, whereas "postApp" refers to the interview conducted after participants installed the personal safety applications.

Our study used semi-structured interviews in which participants were asked to read three Scenarios. We used semi-structured interviews because they helped us better explore the theme of our study (i.e. the use of mobile safety applications in unsafe Scenarios) by letting the participants consider new ideas (i.e. how these applications can be made more usable). The Scenarios were intended to evoke reactions from the participants based on their descriptions of an unsafe situation. In particular, participants were asked to put themselves in the place of the main actor in each Scenario (Appendix E). We provided fake information

(email addresses and phone numbers) for the participants who were not comfortable including their personal information.

For each interview, two researchers were present, one who would interact with the participant as required (e.g., to ask questions and answer any questions the participant may have at any time), while the other researcher took comprehensive notes. It was important for the first researcher to concentrate fully on the participants as they may, at some point, need help asking questions or getting trained to use the applications as our results solely relied on the answers by our participants. The second researcher made sure not to miss any important information/questions/expressions/gestures from participants while the first researcher arranged the next phase of the study. The interviews were recorded (audio), and this information was used to confirm the accuracy of the note taking. We ran a small number (with three lab members {2m, 1f}) of pilot studies to confirm the suitability of our data collection approach. Taking note of the complex and subjective nature of personal safety, we felt it was better to do more than one pilot study including both male and female lab members.

3.3.1 Study Methodology

The study was conducted at the Graphics and Experimental Media (GEM) Lab, on the fourth floor of the Mona Campbell Building, Dalhousie University. The total study took between 2-2.5 hours depending on participant interaction.

As described previously, a screening questionnaire was sent to those who showed interest in participating in the study. After verifying their past experience of having faced at least

one unsafe situation (details of the situation were neither asked nor gathered), and age to be more than 18, they were recruited similar to the research analyzed in the literature review regarding investigating personal safety [55]. Participants were told to bring their own mobile devices or agreed to use a lab phones to install the applications while doing the experiment. We also filtered participants depending on their identified gender as we aimed to only have 15 participants from each of the two categories (i.e. male and female). After a participant was chosen, they were compensated ($30) for their participation irrespective of whether or not they completed the full study. Because personal safety is a sensitive subject, researchers did not intend to have any participant to continue the study if they felt uncomfortable at any stage of the study, without making any mentions about the reasons. As recommended by our ethics committee (Dalhousie's REB), all of the participants were also told that they could stop anytime during the study if they felt uncomfortable. It was advised by Dalhousie's REB that while conducting the study, if the participant is reminded of any past unsafe/stressful experience through any Scenario/interview question, then they should be allowed to leave the study at any point to prevent any mental harm to the participants. Furthermore, any participant not feeling mentally well may also not give accurate responses, which could affect the accuracy of our results. At all Stages of the study, we made sure to keep our participants comfortable and answered any questions they had.

At the beginning of the study, the lead researcher explained the study (3 Stages as explained in Table 3-1) to each participant. Then participants were given the informed consent form (Appendix C) to read and sign. Participants were given no time limit to read the form and

ask questions about any concerns that may have risen from the consent form. Once participants signed the form, they were assigned an ID (random order) which was linked to their personal information in a Microsoft Excel workbook.

Table 3-1 Stages of study

Stage	Name	Activities
1	Initial Set-up	I. Screening, Recruitment and Consent II. Demographic Questionnaire
2	Comprehending Unsafe Situation	I. Interview 1: Defining and Characterizing Unsafe situations II. Introducing scenarios III. preApp scenario responses
3	Understanding the use of Personal safety application	I. Introducing apps, training and recording preference selection II. postApp scenario responses III. Future application use and suggestions

All the participants were informed that they could choose to revoke their data (exactly one week after participation in the study). All of the data forms were linked using this participant ID.

In the next part of the study, participants were asked to complete a demographic questionnaire (Appendix D), which included questions about their age, length of time for which

they have been staying in Canada, gender, level of education, mobile phone usage, frequency, and type of applications used etc. The demographic information was recorded to determine trends, if any, in behavioural reactions towards personal safety perceptions as observed in past literature [9, 11, 28, 52].

In Stage 2, participants had a brief interview with the lead researcher (Appendix G) in which the lead researcher tried to understand how the participants define unsafe situations and what elements they think characterize unsafe situations. This data was recorded to analyze if there were any differences in terms of how a group of people identifying with certain gender or age group perceived safety differently from what has been reported in the past literature [11, 25].

Afterwards, the researcher described three unsafe Scenarios (Appendix E) to the participants, to understand their perspectives on how they would react in these situations. These Scenarios were designed to increase the perceived risk to the reader (from Scenario 1 to 3) based on progressively greater levels of isolation and a reduced availability of assistance, drawing on previous research that used "being alone" as an important factor for understanding safety perception [17]. In particular, note that the level of social isolation respectively increases from having friends nearby, to an arranged meeting with a stranger, to being alone.

Since previous research identified that men and women perceive different risks associated with situations [53, 19], we decided to avoid providing a more detailed Scenario (e.g., that

might describe a specific threatening action within the Scenario) and opted to allow participants to imagine potential outcomes within their own personal tolerances. This decision was confirmed via our ethics approval process, as we were asked to generalize our Scenarios and to avoid specifying particular threats that might trigger uncomfortable memories for a participant before we obtained approval from Dalhousie's REB. For each Scenario, participants were asked to provide their reaction to the Scenario in the form of an action that they might take in response (hereafter preApp responses).

In Stage 3, participants were introduced to three personal safety apps (Bsafe [67], CircleOf6 [72], Life360 [42]). Sample home screens for these three apps are shown in Figure 3.1. We chose apps that offer a representative set of personal safety features (e.g., a panic button for sending locations via SMS text, a fake call, a "follow me" feature to allow trusted friends to track your location). We also chose apps that are available for download for both Android and iPhone. Our aim was not to evaluate these apps, but rather to understand how individuals might choose and potentially use an app to respond to unsafe situations. After choosing an application in the first part of Stage 3, participants did not have a chance to change their choice of the application during the study, but were asked at the end of the study if they would have liked to use features from the other two applications in the future.

In addition to viewing a short text and video summary, which we produced, of the apps and their features, participants were asked to explore the apps through their own phones' app stores. This process could include reading app reviews and terms-and-conditions. Participants were again offered time to understand applications using videos available on a

laptop and manual of the applications (Appendix F), and to ask any questions they may have.

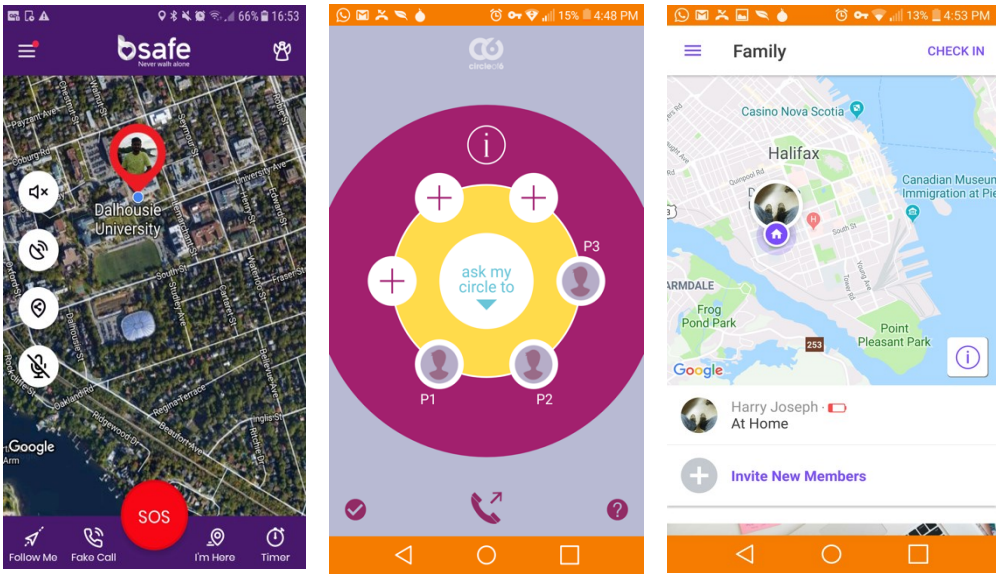

Figure 3-1 Home screen of all three applications on an Android device in the order of Bsafe (left), Circleof6 (center), Life360 (right)

Participants were then asked to choose an application and install the application (either on their own phone or the one they got from lab- an LG-D722 running Android OS v5.0.2, and an iPhone 6 running iOS v10.0.3). At the time of installation, another researcher observed to understand what choices they made regarding app installation and permissions. At this point we also asked participants to identify any concerns they might have regarding app permissions and potential data collection. Participants were then trained on their choice of application using paper tutorials for 15 minutes and then were given another 15 minutes to interact with their chosen applications to increase their understanding before starting the interviews. A researcher was always available to answer any questions participants had while they were training/interacting with the applications.

Table 3-2 List of three unsafe Scenarios

#	**Scenarios**
1	You have arrived at a community gathering with friends, but there are also many people there whom you do not know. While talking with a stranger, something this person says makes you uncomfortable. You look around but cannot see any of your friends, making you feel unsafe.
2	You have arranged to meet with a stranger in a parking lot in a distant neighbourhood during daylight hours to finalize a purchase from a classified website. While talking with this person, something that they do makes you feel very uncomfortable and unsafe.
3	You are walking home alone late at night and you notice that someone is walking behind you. You attempt to ignore them but something in their actions makes you believe that they might harm you.

The Scenarios used for our research were developed in collaboration with a team member, Dr. Alette Willis, who is a professional psychologist and social scientist (currently the Chancellor's Fellow in Counselling and Psychotherapy at The University of Edinburgh), with research/consulting experience in personal safety-related matters. We also worked extensively with Dalhousie's REB to make our Scenarios more applicable and general in nature. At the recommendation of Dalhousie's REB, special consideration was given to ensure that these Scenarios not include specific details about the surrounding environments, or of the incidents themselves. This measure was taken to prevent situations in which participants could feel uneasy or might be reminded of their past experiences in unsafe situations, wherein they might feel the need to seek out medical or mental health support.

Afterwards, the researchers conducted a semi-structured interview; responses to this interview are henceforth referred to as postApp responses. In this interview, participants were prompted to understand the choices made for the specific applications and asked about their reactions for the three unsafe situations using the applications (Appendix H). In this case, participants were required to consider using the apps for their reactions. The interview also included questions about how participants could use the application in the future, if they would like to have any desired functionalities added which would make it more usable in unsafe situations. Participants were asked about any issues they might have with the data collection and storage by the application. After collecting the participants' postApp reactions, we asked some forward-looking questions, such as whether participants felt that they would actually use personal safety apps in the future, and whether they had any suggestions for new app features. Knowing how many participants may or may not use personal safety applications and the reasons pertaining to their choices helped us better understand their perceptions towards safety apps.

3.3.2 Study Instruments

The complete study took around 2-2.5 hours, depending on participant interaction, and the audio for the whole interview was recorded. Participants gave their permission for recording in the consent form.

In Stage 1, after a participant was qualified to be a part of the study after screening and signing of consent form, they were moved to the next step of Stage 1 where they answered the demographic questionnaire (Appendix D). In this questionnaire, other than asking the usual attributes like gender, age group, employment status and education, some additional

information was asked. Additional information being asked included, ethnicity, duration of stay in HRM and Canada, if participants considered themselves disabled or racially visible minorities. Some additional questions included daily usage of mobile phones, frequency of downloading new applications, and the types of applications participants have downloaded in the past. This additional information was asked to determine any similarities in how participants may perceive safety belonging to any sub-group of users who might have similar behaviours.

Qualifying to Stage 2, in the first interview participants (Appendix G) answered questions about the types of situations they would perceive as unsafe and what characteristics would qualify situations as unsafe without discussing any of their past experiences about feeling unsafe. These questions were aimed to make the participants think about the factors/characteristics/whose presence that make them feel unsafe in any given situation.
Considering the sensitivity of the situation, a list of resources available for helping was made available to our participants during the study. This list (Appendix J) included the resources present on- and off-campus for both immediate and long-term help.

In the next step, after being given a written description of the three Scenarios, as shown in Table 3-2 (one at a time to avoid any bias in the answers), and enough time to go through them, participants' reactions to those Scenarios, listed in Table 3-2 (preApp responses), were noted by both researchers. This part of the study was important to understand how participants would usually encounter three different unsafe Scenarios with varying levels of difficulty in attaining help.

In Stage 3, after being introduced to the three safety applications, participants were made comfortable with them through the use manual (Appendix F) and instructional videos. Then participants were asked to install their chosen applications. Their choices about the permissions and any other activities were observed while they were asked to choose one app from the three and install it on either their own phone or the lab phone. Participants were given the choice of either an iPhone or Android phone. In this Stage, we were trying to understand if the participants had any special preferences towards giving a safety app more/less permission than any regular app in terms of data privacy and security.

Finally, in the last interview (Appendix H) our focus was on understanding why and how participants made choices from the three available applications, and the impact of their chosen applications on their responses in the same three Scenarios (Appendix E). After collecting the participants' postApp reactions, we asked some forward-looking questions, such as whether participants felt that they would actually use a personal safety app in the future, and whether they had any suggestions for new app features.

3.4 DATA PROCESSING

3.4.1 Data Coding

Previous research on personal safety in general suggests categories of reactions to the fear of crime [63, 74]. We found the categories suggested by Gates et al. [63] to be useful in both evaluating recent research literature on mobile phones and personal safety, and in analyzing our own data. Their three categories of behavioural responses to the fear of crime [63] are: avoidance (e.g., not walking in certain areas), collective reactions (e.g., walking with an escort), and protective reactions (e.g., carrying pepper spray).

For preApp and postApp Scenario reactions, we classified participant responses based on the behavioural reactions to the fear of crime from Gates et al. [63]. For avoidance, we included responses that involved attempting to end the interaction with the person in the Scenario, such as:

- Attempting to ignore the conversation, or leaving the interaction.
- Using an app, a feature such as a fake call could assist with avoidance.

For collective responses, we included responses that attempted to communicate with a known individual to make them aware of the individual's situation, or to ask for their assistance such as:

- Shouting for help
- Using a phone/app to call or text a known individual for assistance

For protective responses we included responses that involved confronting the other party in the interaction, such as:

- Telling them to stop their current behaviour.

We classified responses as a combined response if they fit more than one category, e.g., an avoidance and collective response in which participants tried both to ignore the conversation, while texting friends their location. In our results, when presenting participant quota-

tions that described their imagined behavioural reactions, we provided the participant number, where "M" is used to prefix male participants, and "F" female, e.g., "F11" is the identifier of our 11th (of 15) female participants.

3.4.2 Data Collection

We collected data in all the three Stages of our study as outlined in Table 3.2.

Table 3-3 Data collection instruments used in different Stages

Phase	Instruments	Description
Pre-study	Questionnaire	Screening, Demographic, phone usage habits, Knowledge of surroundings, daily habits around using mobile applications and Consent
During-study	Open-ended Questionnaire	Understanding unsafe situations and characteristics related to them
	Print manual	Introducing three unsafe scenarios
	Open-ended Questionnaire and Audio-recorder	Recording the reactions to unsafe scenarios: preference on using mobile phone or non-technical responses, relying on friends/family/strangers or emergency services
	Instructional videos, Mobile phones and print materials	Training on how to use applications and observing the preferences made in terms of choosing mobile phones and permissions given during application installations
	Audio recorder and Questionnaire (open-ended)	Recording reactions on unsafe scenarios: preference given to using basic phone features or personal safety apps, relying on friends/family/strangers or emergency services. Analyzing any specific changes in behaviors towards unsafe situations.
Post-study	Questionnaire	Understanding reasons for choices made, privacy issues, data storage concerns and suggestions for future applications

As highlighted by Waycott et al. [62], and due to the potential sensitivity of the subject matter for our study, we took additional precautions to ensure the wellbeing of our researchers and participants. As noted earlier, consistent with the decisions of our ethics

board, we did not ask participants to share specific information about their past personal safety experiences, nor did we present them with a detailed example of an unsafe Scenario. In addition, prior to starting the study we made our researchers aware of our institution's counselling and support services, and we provided access to this same information for our participants on our participant information sheet (Appendix J).

Chapter 4- RESULTS

In this chapter, we present the results of the study described in Chapter 3, which was conducted with 30 participants. We organized our results by the three Stages that we used in the experiment. In Stage 1, we discuss the characteristics of our study sample, such as the different age groups, educational levels, employment statuses, ethnicity and other details. Results from Stage 2 will be summarized in this Section after we discuss participants' perspectives on safety for the given situations; this Section will also cover introducing the different unsafe Scenarios (Appendix E) and the preApp responses for these Scenarios. Under the heading of Stage 3 results, we report the participants' reactions (postApp) to the Scenarios after they have been introduced to the safety application (Appendix F), as well as any future directions/suggestions the participants had towards creating a safety application with new features that they believe may be more useful in unsafe situations. We also discuss participant concerns about app permissions, privacy and data-storage for the given safety applications.

In our research, we consider the effectiveness of an application as a measure of whether an application will actually be used by individuals to protect themselves (personal safety).

4.1 SAMPLE CHARACTERISTICS

After initially screening the candidates for the qualifications of age (18 years or older) and past experiences of feeling unsafe, we recruited 30 participants. We were aiming to recruit a diverse population of participants with different age groups, gender identities, ethnicities

(native and non-native) including racially visible minorities, and educational levels. Having a diverse sample (Appendix D) helped us study the different trends suggested by past literature about perceived safety in given situations, for example, the trend that states that women feel more unsafe than men [8, 31]).

Table 4-1 Data from demographic questionnaire

Age Group	**Male**	**Female**
18-24	**8** (M1,M3,M4,M6,M7,M8,M14,M15)	**9** (F1,F2,F3,F5,F6,F7,F8,F9,F10)
24-34	**7** (M2,M5,M9,M10,M11,M12,M13)	**6** (F4,F11,F12,F13,F14,F15)
Highest level of education completed		
Some college credit	**1** (M14)	**0**
High school or equivalent	**4** (M1,M4,M6,M8)	**5** (F1,F3,F5,F6,F10)
Bachelor's degree	**8** (M2,M3,M7,M9,M10,M11,M13,M15)	**10** (F2,F4,F7,F8,F9,F11,F12,F13, F14,F15)
Graduate School	**2** (M5,M12)	**0**
Employment Status		
Student	**11** (M1,M2,M3,M4,M6,M7,M8,M9,M11, M12,M14)	**13** (F1,F2,F3,F4,F5,F6,F7.F9,F10,F11,F12,F13,F15)
Employed for wages	**4** (M5,M10,M13,M15)	**2** (F8,F14)
Ethnicity		
Asain	**10** (M1,M2,M3,M4,M5,M7,M8,M11,M13,M15)	**7** (F2,F4,F6,F9,F12,F13,F14)

Arab	**4** (M6,M9,M12,M14)	**2** (F1,F10)
African	**0**	**1** (F7)
Latino	**0**	**2** (F11,F15)
Caucasian	**1** (M10)	**3** (F5,F8,F3)
Racially Visible		
Yes	**11** (M1,M2,M3,M5,M6,M7,M8,M11,M13,M14,M15)	**11** (F1,F2,F3,F4,F6,F7,F9,F10,F12,F13,F14)
No	**4** (M4,M9,M10,M12)	**4** (F5,F8,F11,F15)
Time spent on mobile phone in a day (hours)		
1-4	**8** (M1,M14,M4,M6,M7,M110,M12)	**5** (F4, F7,F8,F12,F114)
4-8	**6** (M2,M5,M8,M11,M13,M15)	**6** (F2, F3,F9,F10,F11,F15)
8-12	**1** (M3)	**2** (F3,F13)
>12	**0**	**2** (F1, F6)
How many applications you install in a month?		
<2	**9** (M1,M4,M6,M9,M10,M11,M12,M13,M14)	**9** (F1,F3,F5,F6,F7,F8,F9,F10,f15)
>2	**6** (M2,M3,M5,M7,M8,M15)	**6** (F2,F4,F11,F12,F13,F14)

In our results, when presenting the number of males and females falling in the same category or responding a certain way to a question, we provide the count in the form of (x “m”, y “f”), which indicates x number of males and y number of females.

We recruited an equal number of male and female participants for our study, ranging between the ages of 18-34. In this sample, 17 participants were in the 18-24 age group (8m,9f)

and 13 participants were in the 25-34 age group (7m,6f). In our sample, 24 (11m, 13f) participants were university students, whereas 6 were employed outside of the university (4m, 2f). In terms of education levels, 10 participants (5m,5f) had high school diplomas (or equivalent) or some college credits and the other 20 had higher education, like a bachelor's or master's degree. Interestingly, 22 (11m, 11f) of our participants reported themselves to be racially visible minorities. In reference to ethical representation in our recruitment, we had a total of 17 participants who were of Asian[2] origin (10m, 7f), 6 were of Middle Eastern origin (4m, 2f), 4 were of European origin (1m, 3f), and 3 were of Latino or African origin (3f). A total of 28 (93.3%) of our participants claimed to spend at least two hours (13m,15f) on their mobile phones every day, with 20 (12m,8f) reporting that they download at least one application a month. All of the participants recruited for the study have been residing in the HRM for quite some time: they understand the area very well, with 15 (6m,9f) participants residing in the HRM for less than two years and 15 (9m,6f) for two or more years. A detailed record of the results from our demographic questionnaire is available in Table 4.1.

4.2 UNDERSTANDING SAFETY AND PREAPP RESPONSE IN UNSAFE SCENARIOS- RESULTS FROM STAGE 2

Stage 2 of the study began with us inquiring the participants about how they understand unsafe situations. In our first interview, we asked our participants about the types of situations they would categorize as unsafe. Along the same lines, we also queried them about elements that they felt would characterize a situation as unsafe.

[2] *= Indian origin (9), Chinese origin (3), Pakistani origin (5)

The questions we asked our participants were:

1. What types of situations would you define as an unsafe?
2. What are the elements that characterize an unsafe situation?

For both our questions, the participants provided more than one response, which lead to a greater number of total responses in comparison to the total number of participants. Participants were asked to respond to the questions verbally and their responses were audio-recorded and written down by the second researcher. Considering the sensitivity of the matter being investigated, both questions were made optional and participants were informed about their option to not answer the questions both written on the consent form and verbally before starting the questionnaire. All 30 participants opted to respond to both questions.

In response to the first question, all of the participants responded by listing a type of threat to define an unsafe situation. Two broad themes of threats emerged from the analysis of the participants' responses: *physical threats* and *verbal threats*. The single most recognizable threat, mentioned by half of the participants (6m, 9f), was the threat of physical harm. For example, one interviewee (M15) said: “When I know something scary is going to happen to me physically”. It was followed by a threat of verbal harm in different forms, such as racist or gender specific comments, which were reported by 11 (4m,7f) participants. One of the female participants (F6) said: “When someone comments about my race”. The other types of threats discussed were a fear of monetary loss mentioned by 3 participants (2m,

1f), and 4 participants (1m, 3f) discussed immediate threats such as cyclones and tsunamis. Table 4-2 summarizes the results from question 1.

Table 4-2 Summary from question 1- Interview 1

Type of threat perceived	**Male**	**Female**
Physical	**6** (M1,M2,M5,M8,M12,M15)	**9** (F1,F3,F5,F7,F8,F9,F11,F12,F14)
Mental	**3** (M9, M2, M15)	**5** (F3, F7, F9, F13,F14)
Emotional	**1** (M7)	**2** (F7, F15)
Verbal	**1** (M2)	**1** (F11)
Racial	**1** (M7)	**1** (F7)
Gender Specific		**1** (F14)
Emergencies	**5** (M4,M2,M6,M10,M14)	5 (F5, F7,F9,F11,F15)
Being unaware of the intentions of people around me	**3** (M1,M11,M10)	**0**
Monetary harm	**2** (M3,M12)	**1** (F12)
Unfamiliar locations	**1** (M13)	**2** (F6,F3)

In response to the second question ("What are the elements that characterize an unsafe situation?"), participants listed a number of characteristics that would lead them to perceive a situation as unsafe. The absence of known people (friends or family members) or the presence of suspicious people in any given situation were listed as factors categorizing situations as unsafe. Over half of our participants (8m, 10f) reported being alone, and 24 (12m, 12f) indicated the presence of strangers or people under the influence of drugs or

alcohol as elements of unsafe situations. Being present at places with higher crime rates, lower illumination levels and even fewer familiar places were reported by 20 (11m, 9f) participants. Table 4-3 summarizes the results from question 2.

Table 4-3 Summary from question 2- Interview 1

Elements	**Male**	**Female**
Being Alone (even in presence of people)	**8** (M1,M3,M5,M6, M7,M8,M13,M15)	**10** (F2,F3,F4,F5, F6,F7,F8,F9,F10,F12)
Emergency	**4** (M2,M9,M11,M14)	**4** (F4,F6,F7,f11)
Uncontrolled Situations	**3** (M1,M4,M15)	**1** (F14)
Presence of suspi-cious/untrusted people	**6** (M2,M12,M10, M15,M11,M9)	**7** (F2,F4,F7,F9,F10,F14,f15)
Places with less or no il-lumination	5(M1,M5,M6,M9,M10,M11)	**8** (F1,F5,F6,F7, F9,F13,F15,F3)
Presence of less familiar people	**1** (M7)	**2** (F10,F14)
Places we know very less about/ with high crime rates	**5** (M3,M7,M11,M13,M14)	**5** (F3,F6,F9,F14,F15)
Self-doubt/ Random thoughts/ Childhood memories	**1** (M10)	**2** (F7,F8)
Bad dreams	**1** (M15)	**1** (F15)
Presence of people under drug/alcohol influence	**5** (M3,M7,M11,M14,M13)	**7** (F15,F13,F9,F8,F5,f4)
Presence of strangers	**3** (M1,M7,M10)	**2** (F5,F6)
Yelling/ Weird noise/Bad temperament/verbal abuse	**1** (M15)	**5** (F10,F7,F13,F9,F2)
Sensitivity to different ideologies(religious/non-religious)	**1** (M10)	**1** (F8)
Racial discrimination	**2** (M5,M15)	**3** (F10,F4)
Being followed by a stranger.	**1** (M8)	**5** (F4,F9,F10,F11,F14)

Presence of weapons		4(F2,F4,F10,F15)
Cyber Threat		**1**(F4)
Rumors		**1**(F4)
Presence of authorities around you		**1** (F4)
Misunderstandings		**1** (F8)
Violation of personal space		**1** (F11)
Being minority		**2** (F14, F9)
Learning new skills (Driving)		**1** (F14)
Not having/ Losing means of communication.		**1** (F12)
Places with conflicts		**1** (F15)

Some of the factors which were only mentioned by female participants included the presence of weapons, cyber threats, rumors and learning new skills. Other commonly identified characteristics (by 19 participants (8m, 11f)) were emergency or verbal abuse (e.g. yelling, weird loud noises).

In Stage 2, we presented our participants with three different Scenarios and asked them how they might react in each of these Scenarios. The purpose of this Stage was to understand how people would react to the given Scenarios *before* they are introduced to personal safety applications. As described in Chapter 3, the participants' reactions to these Scenarios are defined as one of the three behavioural reaction categories: collective(C), avoidance(A), and protective(P), which are based on the work of Gates et al. [63]. For each participant, only one response was considered for any given Scenario [76]. If a participant's

response fell into two categories at the same time, for example stating "I will get away from the situation and call for help," it would be categorized as a combination of two categories with a "+" sign (i.e. Avoidance + Collective, indicated by A+C).

4.2.1 Scenario 1

Of all the given Scenarios, Scenario 1 was the least unsafe. This was because it introduced participants to a Scenario in which they imagine a situation where they have their friends physically around (least isolated), but not in sight, which makes it the easiest Scenario to seek help, of the three Scenarios. As noted in Chapter 3, only one Scenario was shown to the participants at a time. Scenario 1 stated: "**You have arrived at a community gathering with friends, but there are also many people there whom you do not know. While talking with a stranger, something this individual says makes you uncomfortable. You look around but cannot see any of your friends, making you feel unsafe.**"

In response to Scenario 1, 9 (6m,3f) participants opted to respond using avoidance by either not showing interest, leaving by pretending to be busy, or simply walking away from the situation. When discussing this Scenario, a female participant (F6) said, "If possible, I will just excuse myself", whereas a male (M6) participant said, "Look away for something and get away from the conversation". One participant (F4) argued for a lenient approach, saying, "I will try to change the topic and if I still feel uncomfortable, then would politely leave". Another common view among the participants was to use a protective response (5m, 2f) to finish the conversation. In this case, participants mentioned that they would confront the person to stop interrupting them; for instance, participant M5 indicated that

he would “engage in a conversation with that person and try to understand why would that person say something to make me uncomfortable. If it still bothers me, I will confront them”.

3(1m, 2f) participants resorted to using collective responses in which they would seek help from strangers or friends in their surroundings or may contact a friend using their mobile phone. Another set of participants (3m, 8f) indicated that they would respond by using a combination of the avoidance and the collective responses by first trying to get away from the situation and then seeking help from an external source such as friends or calling for a cab. Participant M8 said: “I will walk away first and when I feel safe, I will call or text my friends and go to them”. Only a small number of participants (4m,5f) suggested that they would use their mobile phones either in a collective or a combination of collective and avoidance responses to either call or text their friends for purposes like seeking help or requesting interruptions.

4.2.2 Scenario 2

In Scenario 2, participants were asked to respond to a Scenario that was riskier than Scenario 1. We designed this Scenario to be more isolated and difficult to get help. Scenario 2 was stated as: **“You have arranged to meet with a stranger in a parking lot in a distant neighbourhood during daylight hours to finalize a purchase from a classified website. While talking with this person, something that they do makes you feel very uncomfortable and unsafe.”**

In this case, 6 participants (3m, 3f) suggested that they would consider a collective response by informing close ones (family/friends) about their location details or by trying to call them using their mobile phones. For instance, (M7) one participant suggested, “Will let someone close know about the place/direction I am headed to as soon as possible. I will also continue to monitor the situation for any threat and call 911 if required”. However, given the same situation, another participant (M13) preferred to just have someone know their location while they make the deal, whereas one participant (F14) took an aggressive approach as she mentioned that she would “Call a friend at the same time if situation goes out of hands, while doing the deal”.

Another set of participants (2m, 1f) emphasized that when confronting the person, they would take a protective approach. Participant F8 responded that “I will finish the sale and run if it gets worst, while keep myself ready to text/call someone as the other person can’t see my screen while dealing. But would confront the person, if required.” In contrast, male participants took similar approaches but preferred being more upfront by recommending not discussing the topic that makes them feel uncomfortable and emphasizing completing the purchase.

6 (2m,4f) participants chose avoidance to handle the situation. They tried to end the uncomfortable encounter by moving to a more accessible place (public places) or by finishing the conversation in different ways. Two participants (M2, F15) said: “ As soon as I will have the first uncomfortable encounter, I will leave the place,” whereas another participant (F1) mentioned that “ I will find an excuse to get out of the situation politely as being rude

can put you in dangerous situations". Another participant (F11) considered a different approach to avoid the situation by "Giving vague responses to finish the deal as soon as possible because of fear".

The remaining 15 participants (7m,8f) considered using collective and avoidance approaches at the same time, which meant ending the conversation and contacting someone for assistance, choosing between the closed ones (family/friends) or emergency services (911 or other available services).

Around 74% of the participants (22 out of 30), consisting of an equal number of male and female participants, turned toward their mobile phones to communicate with their friends/family or emergency services, which in turn shows how heavily we rely on mobile phones when it comes to communication for our personal safety. However, mobile phones have only been used by the participants choosing to use the collective approach or the combination of avoidance and collective approaches for their responses to the unsafe situation. Table 4.2 shows responses from all 30 participants in the form of the categories of the responses they choose to adopt in the preApp Scenarios, where parenthetical values are the number of responses that included the use of a mobile phone [76].

Table 4-4 preApp Scenario responses.
Figures in parenthesis represent the number of times mobile phones was used.

Behavior Reaction Groups

#	Avoidance	Collective	Protective	Avoidance + Collective	Phone used
1	9	3(3)	7	11(6)	9
2	6	6(6)	2	16(16)	22
3	6	7(6)	3	14(14)	20

4.2.3 Scenario 3

In Scenario 3 participants were queried to respond on the Scenario that had the most risk of the three given Scenarios. It was considered the riskiest because it introduced participants to a Scenario in which they had to imagine being the most isolated and having the most difficulty in seeking help. Scenario 2 was stated as: **"You are walking home alone late at night and you notice that someone is walking behind you. You attempt to ignore them but something in their actions makes you believe that they might harm you."**

Using a collective approach for responding to the given Scenario, 7 participants (4m, 3f) considered seeking help by either using their phone to call their family/friends or emergency services or by simply looking for the closest known/unknown individual around

them for seeking assistance. A female participant (F2) said: “I would call my mom and stay on the phone with her, until I reach my destination,” whereas male participants (M1,M4,M2) considered getting away from the situation towards a more crowded place as M4 mentioned: “Try moving towards the street with more people and then calling friend for help”. Another group of participants (2m, 1f) seemed to choose a more protective approach by opting to confront the person and then decide on their next actions. On this response, participant M10 said: “I will change lanes and if I still feel like being followed. I will just confront the person,” and F8 said that she would “move to a street with more light and if still being followed, I will stop and analyze what they do. I think it makes them scared”.

However, a total of 6 participants (1m, 5f) opted to choose an avoidance-based approach by choosing to be on the phone to pretend that they know someone around. An example of this was participants pretending that their destination was not so far or that someone was waiting to pick them up at a location a very short distance away, whereas other participants opted to run/walk away from the situation to seek a safer place.

14 participants in Scenario 3 seemingly used a combined avoidance and collective approach in their responses, where they preferred to get away from the situation first while seeking assistance from friends/families, emergency services, strangers or moving to a crowded/well-lit place. As mentioned by participant M7: “I will walk faster, change my route and call 911. But won’t stop until I feel safe”. For Scenario 3, 67% of the participants, which accounted for 20 (11m, 9f), said they would use their phone for communication in

order to seek help when employing a collective response or when using a combined response of both avoidance and collective.

Phones have been used in all three Scenarios by the participants to seek assistance as shown in Table 4-2, although an increase in use can be seen to correlate with an increase in isolation and difficulty in seeking help as it is clearly evident that the use of phones is much higher in Scenarios 2 and 3 in comparison to Scenario 1. In Scenario 1 mobile phones were used by the participants who opted for a collective approach or a combination of avoidance and collective approach, mostly to texting friends. In Scenarios 2 and 3 mobile phones were used by the participants who chose a collective approach as a part of the solution, but were used for extensively calling friends/family or emergency services.

4.3 POSTAPP RESPONSE FOR UNSAFE SCENARIOS AND FUTURE FUNCTION SUGGESTIONS- RESULT FROM STAGE 3

Stage 3 of the study was initiated by each participant installing one of the three personal safety applications on their mobile phones. Out of the 30 participants, 18 (10m, 8f) used lab phones, providing reasons like privacy and security or being low on storage space or battery power. Out of the 10 male participants, at least 8 of them cited privacy and security concerns as one of their reasons for not using their own phones, whereas the other two participants gave reasons such as not having enough storage space on their phones, low battery power, and being "bored" with their own phones. 5 female participants cited the reason for using the lab phones as being low on storage space and other two participants cited security concerns, followed by boredom by 1 female participant.

The remaining 12 (5m, 7f) participants opted to use their own phones on the grounds that they may use the application in future, the mere convenience (familiarity with the device), and/or curiosity of how the application would look on their phones. Participants mostly cited the reason to not use lab phones as the convenience/familiarity of device (2m, 4f) followed by being able to keep it afterwards which was cited by 2 participants (2f). 3 of the female participants (F6,F8,F10) explicitly mentioned that they did not care about their personal data as they believe that it is already "out there" because of they had used other applications which requested intensive amounts of data on their phones, whereas only one male participant (M3) cited this reason. Ironically, another male participant's (M3) reason for not using a lab phone was not to leave any trace of his personal information on the lab phone, even though he knew that for our experiment fake information could be used, this explanation was provided by the researcher present in the room.

12 (8m, 4f) participants used fake data (such as a fake name, phone number, and contacts) provided by the researchers, but we are not sure if the remaining 28 (7m,11f) participants used their personal information because while going through the consent forms, all of the participants were told that they could use fake data if they did not want to use their own information. Based on the postApp responses, we found that some of the participants did include fake data in their apps; however, they did not use the fake data provided by the researchers as is was or in its entirety. We do not report any numerical results or statistical results on this behaviour by our participants because this behaviour was observed during data analysis, after the conclusion of the study. Evidently, the choice of using the personal

or lab device and using fake data or not, in terms of conducting privacy research, seems very complicated and may need further investigation.

With regard to choosing the mobile safety application, 6 participants selected Life360, whereas 11 (7m,4f) partipants chose Circleof6, and the other 13 participants (5m,8f) chose Bsafe, making Bsafe the most selected application. The participants' reasons for making their selection out of the three apps seemed to involve design, the number of features, and specific features. In the case of Bsafe, the most cited reason for its choice was simplicity in design and features, such as fake call, alarm and embedded Google Maps. For Circleof6, the most cited reason was design followed by the fact that it only uses SMS to communicate and doesn't need an active internet connection. For Life 360, design remained the most significant reason followed by features, such as pre-written messages and the ability to send messages to seek assistance from a greater number of people at the same time (6 in both Life360 and Circlof6, 3 in Bsafe). Tables 4-5 and 4-6 summarize the reasons for choosing specific applications by male and female participants, respectively.

While the participants installed their chosen applications on the phones (lab or own phone), the permissions given by the participants were recorded by the researcher. When participants were asked if they bothered to look into what permissions the application requested, 10 (7m,3f) participants reported that they looked into them carefully, whereas 4 participants (2m,2f) suggested that they did not care to look into them.

Table 4-5 Reasons for choosing applications- Male

Application	**Reason**	**Number of participants**
Bsafe	Fake call	**1** (M12)
	Exact location feature	**1** (M9)
	Alarm	**1** (M9)
	Check-in	**1** (M15)
	Faster (better for emergencies)	**1** (M13)
	Has sufficient features	**1** (M2**)**
	Better interface	**1** (M15)
	Individualistic (relies more on yourself)	**3** (M9,M13,M2)
	Broadcast to limited number of people	**1** (M2)
	Simple to use	**1** (M13)
Circleof6	Indicative- interface	**4** (M6,M11,M5,M4)
	Simple to use	**3** (M6,M7,M8)
	Better Design	**1** (M6**)**
	Just relies on SMS	**6** (M11,M8,M6,M5,M4,M3)
	Has sufficient features	**3** (M11,M7,M5)
	Good on battery (doesn't have google maps)	**1** (M7,)
	Pre-written messages	**1** (M5)
	Customization (option to add emergency numbers)	**2** (M5,M8)
L360	Suits my life style	**1** (M10)
	Has sufficient features	**1** (M1)
	Interactive design	**1** (M14)
	Looks trustworthy	**1** (M14)
	Easy to use	**1** (M14)

The other 16 participants (6m, 10f) claimed that they usually notice the permissions for any app they install on the phone, but because it is a personal safety application they intentionally gave it access to all of the data the applications asked for. This behaviour may suggest that these participants were naïve (or that they behaved in a naïve manner during the study) in terms of not looking at the permissions simply because the applications they were using were personal safety applications.

After installing the applications, 26 (13m, 13f) participants gave access to all the permissions, even though 10 participants showed their concerns about application permissions. Participants were most concerned about the permissions to access contacts and send notifications. A total of 9 (5m, 4f) participants looked into reviews and the terms and conditions of the applications before installing. Additionally, a total of 8 (3m, 5f) participants listed that they had concerns regarding the applications collecting and sharing their data with others without permission.

After the introduction to the applications the participant were told that they could use the applications for as long as 30 minutes, a time frame which none of the participants fully utilized. A researcher was always available to answer any questions in this 30-minute period of exploration. Participants were then asked to react to the same Scenarios. Now that they had access to the mobile applications, the answers to the Scenarios gave insight into how their attitudes shifted towards tackling unsafe situations.

Table 4-6 easons for choosing applications- Female

Application	**Reason**	**Iteration**
Bsafe	Fake call	**3** (F8,F12,F7)
	Exact location feature	**1** (F15)
	Alarm	**2** (F8,F12)
	Check-in	**1** (F7)
	Has sufficient features	**6** (F4,F5,F2,F1,F12,F7)
	Design (1-click options)	**3** (F5,F1,F15)
	Better Interface	**2** (F5,F7)
	Individualistic (relies more on yourself)	**1** (F4)
	Simple to use	**2** (F1,F12)
	Google Maps	**2** (F8,F2)
	I can relate to be helpful through my past experi-ences	**2** (F2,F5)
C6	Simple to use	**4** (F14,F10,F6,F3)
	Indicative- Interface	**1** (F6)
	Limited features (Less memory)	**1** (F6)
	Location feature	**1** (F14)
	Reaches 6 people at same time	**2** (F10,F3)
	Gives out limited infor-mation	**1** (F3)
Life360	More features	**2** (F9,F13)
	Design	**2** (F9,F13)
	Ease of use	**1** (F9)
	Serves multiple purposes	**2** (F9,F11)
	Check-in	**1** (F11)

4.3.1 Scenario 1

For Scenario 1, a total of 14 (7m, 7f) participants indicated that they would use a collective reaction such as using the text feature: “I need to talk” (M6) in Circleof6 or using Bsafe sending a custom text to their contacts (M3). 7 (5m, 2f) participants suggested that they would use avoidance, for example, participant M4 mentioned that he would “End the conversation politely and leave the spot”. However, only 4 (2m, 2f) participants would use a protection reaction which mainly consisted of reactions like the one by participant F8: “Confront directly as it doesn’t make me afraid”.

In terms of changes in the behavioural responses to unsafe situations, a shift in the approach, such as moving from protective responses to collective responses, could be seen for thirteen participants. For these 13 participants, their category of preApp response is different from their postApp response, with the biggest growth in the collective responses, while the other three (avoidance, protective and combinational (A+C)) categories saw a decline. A total of 11 responses which either fell into avoidance, protective or combined avoidance and collective in the preApp responses changed to the collective only category in the postApp responses. Table 4.3, shows responses from all 30 participants in the form of the categories of the responses they choose to adopt in the postApp Scenarios, where parenthetical values are the number of responses that included the use of a mobile phone [76].

Table 4-7 postApp Scenario response.
Figures in parenthesis represent the number of times mobile phones was used.

Behavior Reaction Groups

#	Avoidance	Collective	Protective	Avoidance + Collective	Application used
1	7(1)	14(10)	4	5(1)	12
2	2(2)	21(14)	1	6(4)	20
3	2(1)	20(13)	0	8(7)	21

Moreover, in the preApp response, only 9 participants claimed that they would use their phone, whereas in the postApp response 12 participants advised that they would use the features of the mobile safety applications. Furthermore, it is apparent that just like preApp response, the app in postApp response was mainly used for a collective reaction (individually or in combination with avoidance). However, the postApp responses did include some instances of the avoid response, such as using the fake call feature of Bsafe.

4.3.2 Scenario 2

For Scenario 2, 21 participants (12m, 9f) suggested that they would use a collective response including asking their contacts for assistance. For instance, a male participant indicated that he would use the "follow me" feature to share his location: participant M2 said he would “Use follow me and then call someone directly” and participant F5 suggested

that she would be “Sharing the location and yelling”. In another instance, participant F9 showed her concern for security and privacy while using a collective response: “I would share my continuous location, but I need a feature to somehow remind me to turn it off when I am not unsafe anymore”. Another set of 6 participants (1m, 5f) indicated that they would use a combination of avoidance and a collective response where one participant suggested, “I will broadcast my location and then get a fake call” and one male participant chose a protective approach by opting for confrontation. Another group of participants (1m, 1f) opted to use avoidance tactics such as “using fake call”. In Scenario 2, again a similar trend for the postApp reactions from Scenario 1 can be noticed as 18 of the participants have agreed to use the application by either using the collective approach in itself or collectively with avoidance, and only two responses included avoidance.

4.3.3 Scenario 3

For Scenario 3, 20 participants (10m, 10f), consisting of an equal number of male and female participants, opted for a collective response and none of the participants opted for a protective response. For example, participant M4 listed that “he would use follow me, alarm and then call 911”, whereas participant F5 said she would “Us[e] location sharing and then looking for help around me”. 2 participants (2f) indicated that they would use avoidance as F4 suggested using “fake call, if the person comes really close to me”. The other 8 participants (5m,3f) decided to use a combination of avoidance and a collective approach for their responses: “Try to go out of the situation, if I can and call 911 and stay on the phone while looking for help around me,” as indicated by F1. Ironically, one partic-

ipant (M5) said, “I will seek help directly, by getting into a store and pretending that someone I know is around me”. The trend towards changing behaviour reaction categories from preApp response to postApp response is similar to Scenario 1 as well as 2, with the biggest increase in the collective response and all other categories facing a decrease.

Moreover, 20 participants suggested that they would use features of the applications in the postApp response when using the collective approach either individually by contacting their friends/family or in combination with avoidance, whereas only one participant claimed to have used avoidance by using features like fake call.

At the end of Stage 3, we questioned our participants about the features they felt would be helpful in a personal safety application. Their suggestions included having a way to connect directly to authorities like police or harassment helplines, and having quicker and easier access to the applications when in unsafe situations. For instance, a suggestion to have a small pattern of clicks on the screen or continuous pressure applied on the phone using pressure sensors to send a request to seek assistance emerged from a few participants. Developing safety features to help people in unsafe Scenarios where there is no cellular or internet connection seemed to be most requested feature. Also, being able to record audio and video evidence at the time of incident and being able to easily forward it to authorities was the other most suggested feature. Participants also suggested some features which were available in some applications such as “check-in”, continuous location tracking in Life360, and precise location in Bsafe, will be very helpful. In the next chapter, we discuss the

implications of our results, how they help us answer our research questions, and if they are congruent with the previous research reported on the same subject.

Let us revisit our motivating questions from Chapter 3:

1. How are the applications effective in unsafe situations?
2. Are these applications something we can completely rely on?
3. Do we have to somehow use them in combination with traditional measures such as 911 (emergency helpline)?

It is evident from our results that 14 out of 30 participants agreed to use the personal safety applications as part of their responses to our given Scenarios. This response rate may imply that the current available solutions are efficient only when being used in combination with other traditional measures (such as running away, calling 911) and are yet to be found sufficiently trustworthy by users to use them as their standalone measure when facing perceived unsafe situations.

Chapter 5- DISCUSSION

In this chapter, we discuss the results of our study and how they help us answer our research questions. Initially, we discussed how individuals use their mobile devices and personal safety applications when they find themselves in unsafe situations. We do so by analyzing the results of our participants' reactions to unsafe Scenarios and their reliance on mobile phones in the Scenarios. We also look into changes in participant behaviour after being introduced to the mobile applications, while also considering application features being used by the participants in unsafe situations. Then, we discuss our results to gain a better understanding of how mobile phones and personal safety applications can be used as part of a bigger response to unsafe situations. We consider participant responses such as non-technical reactions as well, where participants react to a situation without using any applications or mobile phones. We focus on understanding participants' behavioural responses in the different Scenarios.

Finally, we try to assess our results in terms of participants' reactions to investigate if the current personal safety applications produce themselves as feasible tools to be used by individuals in unsafe situations. We describe participant reactions to Scenarios (both pre-App and postApp) with regard to using personal safety applications, mobile phones, or both. We discuss design recommendations for anyone trying to develop a product for similar purposes. We also discuss distinctive trends found in participant reactions. Lastly, we discuss the limitations of our study and the impacts of these limitations on the different Stages of the study, and, consequently, on the results we obtained.

5.1 USE OF MOBILE PHONES AND APPLICATIONS IN UNSAFE SCENARIOS

In this Section, we discuss our first research question: "**How might people use mobile phones and personal safety apps to respond to unsafe situations?**"

5.1.1 Use of mobile phones

Our results from the preApp Scenarios can be clearly aligned with the previous research [14, 16, 27, 19]. They confirm that individuals feel safer when they carry mobile phones. In our preApp responses, a majority of the participants agreed to use their mobile phones in Scenarios 2 and 3.

We tried to further investigate how individuals may use their mobile phones in unsafe Scenarios by providing them with three Scenarios with increasing degrees of threat, isolation and difficulty in seeking help. In previous literature [28, 9, 19], it has been claimed that the women tend to feel more unsafe than men in unsafe situations, whereas our results do seem to show any considerable difference. The exact behavioural reactions of men and women in the preApp and postApp Scenarios are listed in Tables 5-1 and 5-2 and do not seem to show any considerable observational differences. However, the reactions by men and women to similar Scenarios seem to differ in their approach, even though similar behavioural reactions are consistent in all three Scenarios. For instance, avoidance used by female participants in Scenario 1 is polite and mild in comparison to men: participant F1 said, "Will try to end the conversation by changing the topic", whereas participant M13 said he would "just walk away from there".

Table 5-1 Behavioural reaction of male and female participants in preApp Scenarios

preApp responses				
Scenario #1	Avoid	Collect	Protect	Avoid + Collect
M	6	1	5	3
F	3	2	2	8
Scenario #2				
M	2	3	2	8
F	3	7	1	4
Scenario #3				
M	1	4	2	8
F	4	7	1	4

This difference in the trends can be attributed to the methodology as most of the studies done in the past [17,50] directly or indirectly involved asking questions about how participants would react in unsafe situations, whereas we proceeded to provide an organized group of scenarios to conduct the study which is unlike the methodology used in previous research.

Table 5-2 Behavioural reaction of male and female participants in postApp Scenarios

postApp responses				
Scenario #1	Avoid	Collect	Protect	Avoid + Collect
M	5	7	2	1
F	2	7	2	4
Scenario #2				
M	1	12	1	1
F	0	9	0	5
Scenario #3				
M	0	10	0	5
F	2	10	0	3

In terms of the use of mobile phones in our three given unsafe Scenarios, we obtained dissimilar reactions. For Scenario 1, fewer (9) participants relied on the use of a mobile phone, with the majority of them choosing non-technical (without using mobile phones) methods to seek assistance, which resulted in employing avoidance and protective type responses. Participant M1 said he would "End the conversation politely by changing the topic and leave the spot", whereas participant F8 said she would "Confront directly and ask for help, if needed". But, if the participants relied on mobile phones, the majority of the time they were used as a part of the collective response to contact their close ones (friends/family). In the cases of the other two Scenarios, more participants, in comparison

to Scenario 1, relied on their mobile phones as a part of their collective response. For Scenario 2, 22 participants used their mobile phones, whereas in Scenario 3, 20 participants used their mobile phones to seek assistance. In summary, we observed that in the preApp conditions, our participants consistently chose to use mobile phones as part of their collective responses to all three of the given unsafe Scenarios.

5.1.2 Use of personal safety applications

In this Section, we focus on understanding the shift in the behavioural reactions of the participants after being introduced to personal safety applications. We discuss how some of the participants found personal safety applications more useful in unsafe situations, leading to changes in their behaviour: from not using mobile phones in the preApp Scenarios to using the safety applications on their mobile phones in the postApp Scenarios.

It is rather interesting that the number of participants (51) who indicated that they would use their mobile phones to respond in any of the preApp Scenarios were consistent with the number of participants (53) who agreed to use an app in the postApp Scenarios for the same Scenarios. On the other hand, the participants who claimed to use their mobile phones in preApp responses may not always be the ones who agreed to have used an application in their postApp responses.

In Scenario 1, from the 21 participants who claimed not to use mobile phones in the preApp Scenarios, 6 of them agreed to use an application in the postApp Scenarios. Likewise, out

of the total 8 participants who agreed not to use mobile phones in preApp sceanrios, 5 would use an application in postApp Scenarios. Out of 10 non-phone users (preApp) in Scenario 3, 7 users (postApp) would employ an application in percieved unsafe situations.

These reactions show how some of the participants who were not using mobile phone as a part of their response in the preApp Scenarios agreed to use personal safety apps for their postApp responses, suggesting that personal safety applications seem to provide something more than the basic features of mobile phones. Furthermore, additional features provided by these applications seem to fill the gaps left by the insufficiency of the basic features of the mobile phone, such as calling and texting to seek assistance.

5.1.3 Frequently used application features

In postApp responses, in terms of responses to unsafe situations, the features available in personal safety applications were frequently chosen over or collectively used with the basic features present on the mobile devices. Some of the most used features included: sending pre-defined texts for requesting interruption, sharing live or one-time location co-ordinates, and calling family/emergency services (limited to Scenarios 2 and 3). Sending pre-defined texts in applications, such as Bsafe and Circleof6*,* saves the hassle of typing the message and could help by sending texts to multiple people (already part of the user's circle) at once. Location sharing was used by the majority of our participants (11m,10f) because they were assured of sharing their current/live location with their loved ones (friends/family) when in unsafe situations. Needless to say, the use of sharing live locations comes with privacy concern; one of the participants, F9, said: “I would like to get informed to stop sharing my

location after a while". The ability to call or text either your friends, family or emergency services was mentioned often (7f, 3m) in both preApp (using only features already included on mobile phones) and postApp (having an option to use applications) responses.

A few features being used for avoidance responses included pretending to be on a call with someone was mainly included in the participants' preApp responses, or using features like "fake call" from Bsafe to receive a fake call from a number/ contact which users can name anything (Cab, Police etc.), as discussed in participants' postApp reactions.

The trend of using mobile phones either without applications (preApp) or with applications (postApp) as a part of a collective response may indicate that participants still prefer to rely somewhat on their surroundings. These collective responses ranged from seeking helping from strangers to simply trying to get away from the situation by looking for a well-lit street/establishment to provide a safer feeling.

5.2 USE OF MOBILE PHONES AND SAFETY APPLICATIONS AS A PART OF OVERALL RESPONSE

In this Section, we discuss our findings with respect to our second research question: "**How mobile phones and apps might be used as part of an overall response to unsafe situations?**"

We examined responses by the participants to our unsafe Scenarios. These responses included non-technical responses (not including mobile phones), such as seeking human help

from their surroundings by yelling, in addition to the use of mobile phones or personal safety applications to seek assistance. We aimed to understand the changes in the participants' overall behavioural reactions both before and after being introduced to personal safety applications.

Before being introduced to personal safety applications (preApp), the overall reactions from the participants were very different for all three Scenarios. In Scenario 1, where the participants' friends were nearby but may or may not be immediately visible at the given time, participants relied mainly on avoidance and protective responses without the use of mobile phones. Avoidance reactions included “ending the conversation” or “leaving the situation,” whereas protective reactions included direct confrontation with the person participants were feeling unsafe from.

Relying less on phones included fewer collective responses either on their own or even combined with avoidance reactions. In combined avoidance and collective reactions, participants' reactions mainly relied upon seeking help from people around them by moving away from the situation and then using mobile phones to seek help through text/call, if required. Th behaviour of the participants remained very similar in preApp and postApp reactions in Scenario1.

In Scenarios 2 and 3, there was a decline in the protective reactions between preApp and postApp responses as represented in tables 4-2 and 4-3. The number of protect responses in the preApp responses was 12 (out of 90, 30 responses from each Scenario), whereas it

decreased down to 5 in the postApp responses. On the other hand, where avoidance-only reactions also decreased from 21 to 11, the number of combinational reactions with avoidance and collective responses increased from 57 to 73. In contrast to the Scenario 1, all the combinational reactions in Scenarios 2 and 3 included the use of mobile phones. In addition to mobile responses, participant F2 also indicated a physical response (avoidance), “Try to get of the situation” in response to Scenario 2, and participant F7 stated, “Running away for help” in response to Scenario 3 [76].

Interestingly, in the postApp Scenarios, the majority of the participants, when relying on using on the personal safety applications, had more collective responses than in combination with avoidance, which was mostly the case in the preApp responses. But in both preApp & postApp cases, participants had mixed preferences in terms of using the personal safety applications, the basic features of the phone, or physical actions (<15%) when responding to unsafe situations. It is apparent that the use of mobile phones and personal safety applications increase in participants' responses to Scenario 2 and 3 for the preApp and postApp responses, respectively.

Similar to previous findings in Section 5.5.1, with respect to observational differences, there were not any considerable differences between the responses of male and female participants in our study, even after the introduction of safety applications. However, our qualitative analysis demonstrated that our research aligns with the past literature [14, 17] : women seem to feel afraid in comparison to men, given the same Scenario. In the postApp

responses, a female participant (F2) in Scenario 1 preferred to text her friend first and pretend to be busy on her phone until her friend came to the rescue, whereas a male participant (M2) who also choose an avoidance response decided to smile and walk away from the conversation.

5.3 VIABILITY OF CURRENT PERSONAL SAFETY APPLICATIONS

In this Section, we discuss our findings with reference to our third research question: "**Do current personal safety applications provide viable tools that individuals will use to respond to unsafe situations?**"

We assessed the viability of the tools (safety applications) by assessing if the participants agreed to use mobile phones (preApp) or the personal safety applications (postApp) in the given unsafe Scenarios. 29 (15m, 14f) participants agreed to use their mobile phones in at least one of the Scenarios in the preApp response, whereas a total of 28 (14m, 14f) participants agreed to use the personal safety applications in again at least one of the three given unsafe Scenarios. This statistic shows how mobile phones and personal safety applications can be used either individually or as a part of the solution to unsafe situations. On the other hand, when asked if the participants would use the applications in the future, 14 (8m, 6f) said yes, whereas 9 (4m, 5f) participants said they will not and the remaining 7 (3m, 4f) said they may use a personal safety application. Of the 7 participants who opted as being undecided (maybe), participant F5 said, "I grew up here, so I don't need it. I may use it if I move," whereas participant M10 mentioned, "Maybe once I get married". Participant M10 further elaborated that he may find the application of his choice to be more useful

when he had a family of his own to have someone close to him added as a personal contact on the app, who could track and offer support when needed.

When it came to making a choice between the applications, there were a few factors responsible. Some of the most cited reasons included better design and interface (8m, 7f), ability to customize (6m,3f), and the nature of features as per an individual's requirements (4m,3f).

Another concern that was common for choosing the applications was related to privacy. Interestingly, more than half (6m, 10f) of our participants mentioned that they are usually concerned about the permissions requested by an application, but in this case, they would not care as it is a personal safety application. On the other hand, 4 (2m, 2f) participants responded that they do not care about permissions when installing applications, whereas the remaining 10 (7m, 3f) said they read through all the permissions being asked by the application and agreed to them. Out of 16 (6m,10f) participants who said that they did not care about the permissions, while installing the personal safety applications, only 6 (6f) participants used their own phones. In future studies that build on this work, it will be interesting to explore the reasons expressed by the participants who chose not to use their own phones.

With regard to the collection of data (e.g. location) and being able to overlook some permissions, our findings are consistent with the research conducted by McCarthy et al. [1].

Some of the other concerns included giving access to phone contacts, as one of the participants, M3, mentioned that "it [application] should just let me enter the contacts". Some participants (2m, 3f) also indicated that they may consider using the applications if they give them direct and easy access to authorities.

Another set of 7 participants (3m, 4f) still believed that they do not require a personal safety application as they need more concrete measures when they aren't feeling safe, with a few participants saying they can't trust the application and another group (5f) saying, "Brain doesn't work when it's not safe". A few other participants (2m) mentioned that they may reconsider using the applications when they have families. A few of them suggested they are happy with the current features available on their phone which included the standard features of calling/texting, or sharing locations through third party applications which are not being used for personal safety primarily.

It is clear from our discussions that personal safety applications prove to be effective and viable for some of the participants in unsafe situations; specifically, in case of collective responses – individually or in combination with avoidance. 14 out of 30 (46.67%) of the participants indicated that they would use personal safety applications in the future as a part of their responses.

Participants reported to have many privacy issues with the personal safety applications as indicated by our statistic that 18 out 30 people preferred to use lab phones. Our participants indicated that they were not comfortable installing/using the apps on their own phones

because the apps needed to access the information about their contacts and required access to storage and other phone data. For future studies on understanding the use of personal safety applications in perceived unsafe Scenarios, it will be interesting to create an application specifically for the purposes of the study, which does not collect any of the participants' data and instead focuses on observing behaviours of the participants using that personal safety application.

Participants found the applications presented to them useful for responding to the given unsafe Scenarios. While we do not claim to have found all the answers when it comes to understanding perceptions towards mobile safety application, we believe that our research does provide some much-needed insight into how these apps can be used in unsafe situations.

5.4 DESIGN RECOMMENDATIONS

After gaining a thorough understanding of the results and the feedback provided by the participants, a few design recommendations can be drawn for anyone attempting to make personal safety applications in the future:

- ***Triggering of an operation*** (e.g. sharing location) can be a very challenging task when someone is an unsafe situation. Some apps require several clicks to be done in a given order to access the features. It has also been debated that the need of being so mentally involved in the phone/application, even for a few seconds, can

lead to negatively affecting the user's situational attention [54]. An easier triggering mechanism for seeking assistance of any sort would surely let some users reconsider using personal safety applications. Using different sensors in the phones to trigger an activity can be a potential option. An example of this could be to use motion sensor in the phone to display the panic button on the home screen of the phone after the phone has been shaken for more than *n* times (the choice of *n* can be determined specifically by the application developer).

- ***Seeking limited permissions*** in terms of user contacts, photos, among other factors, would also help making users feel comfortable installing the applications. It is understandable that a trade-off of more features involved in an application seeking more permissions is inevitable. For example, to use video monitoring features on an app, it may need access to contacts, camera and even social media profiles, depending on the application features in order to send/share the video recording of the live incident as evidence with the people on your social media or contact list. Making the application modular (i.e. seeking respective permissionswhen that specific feature is used) may also help, as the user can have clear discretion of not being able to use a certain feature when not giving specific permissions. A similar practice of making applications modular is also being practiced and recommended by major official mobile application guideline platform providers such as Android [85] and Apple [86]. No matter how modular the app is, it still follows a *one size fits all* approach, which calls for extensive research to understand how can one develop a solution that can serve the masses by adapting to users' specific needs.

- Including features which can potentially ***increase the possibility of obtaining help more quickly*** in any given circumstance is also beneficial. Being able to directly call/ share the user's location with loved ones, emergency services, such as 911 or any equivalent (a grouped network of volunteers helping each other), came up as another important recommendation by our participants. For example, having a specifically *red* coloured button to contact authorities in any safety application can help achieve the goal of obtaining help more quickly. Furthermore, it is important because some of our participants still believed in seeking help from authorities rather than relying on apps, especially in Scenario 2 and Scenario 3. However, it is important to prevent/limit any false positives in this case to keep the valuable resources from being wasted. A mechanism of having the user re-confirm after an alert has been raised before alerting emergency services can be implemented to limit false positives. Yet, the trade-off in this case is that if the user is truly in danger or feeling unsafe, they may not be in a position to re-confirm. A balanced approach could be to alert emergency contacts after a certain duration of time to address the possibility that the user may be away from their phone or not in a situation to re-confirm.
- ***Limited or lessen dependency on data*** or even cellular networks in terms of obtaining help as some of these unsafe incidents may happen in places with limited or no network. Developing solutions that rely more on cellular services than data, such as Circleof6, in which most of actions seeking assistance include sending a text or location through cellular networks would also open the use of the application to people who might not have access to data.

- Having ***applications/features specific to different age groups***, such as having a permanently live location sharing mechanism or having a feature of permanently sharing the health data (such as heart rate) with one click for long intervals with one to two specific users may also make applications more useful for elderly people. Integration with other applications with huge user bases like WhatsApp or Facebook can also be deemed as a possibility to reach far more people for seeking assistance, but again having no cellular network or data can lead to limiting the possibilities.
- ***Developing wearable devices***, where operations can be triggered through the phone by receiving commands from a wearable device, for example by sensing change in pressure or a motion pattern using Bluetooth technology or a network connection.

Other recommendations from our participants included prompt video and audio recording of the situation and being able to store it in cloud or even on phones, can be great assistance when looking into these incidents at a later Stage. It is always challenging to have a great user-interface while adding a plethora of features in any application, which we believe may call for having different applications for different situations/age groups.

We believe that, in the ever-changing domain of mobile technology, there are endless possibilities for creating better solutions for personal safety. An effort to implement these design recommendations, using available and future technologies, can surely help convince more individuals to use personal safety applications which can lead to keeping individuals safer. Furthermore, an emerging market of personal safety has gained the attention of big

technology giants like Google which came up with its own personal safety application called “Trusted Contacts” in 2016 [83], which is used to share the users' locations with their trusted contacts to seek assistance. We believe that the world’s interest and market share of personal safety solutions through mobile applications will increase in coming years.

5.5 LIMITATIONS

No study is perfect and our study is no exception. Our research study included a group of participants who were either students or recent graduates from Dalhousie University living in the HRM (Halifax Regional Municipality) from an age group of 18 to 34. As mentioned in our ethics proposal, we tried to recruit an equal number (15) of male, female and LGBTQQIP2SAA participants. However, we had a great difficulty in recruiting LGBTQQIP2SAA participants, which lead to only considering male and female participants in our study. It is quite clear that the results obtained from our research cannot be potentially valid for the entire target population. Moreover, some of the questions asked in interview 1 about understanding safety for individual participants were open-ended questions asked in front of researchers and being audio recorded, which may had led to some bias by the participants. Participants may not have shared what they actually felt because of a fear of being judged, as their responses were being said in front of two people.

Our study was conducted in a closed room with two researchers and with responses being recorded using an audio recorder. This study environment might have led to some personal

bias or apprehensions in our participants, which may have had some impact on our observations as well. For example, participant F14 mentioned after one hour of the study, "I feel much more comfortable now than I was when we started." Future research based on this study would need to be mindful of this aspect and consider some form of corrective measures in the study design.

Our study mainly depended on using semi-structured interviews to ask participants about what they thought in three given Scenarios and where they may feel potentially unsafe. It is evident that the results obtained may not always match the reactions obtained in an actual Scenario (if we neglect the ethical issues of conducting a more realistic experiment). We still believe we have contributed some much-needed knowledge in the domain of personal safety.

Chapter 6- CONCLUSION AND FUTURE WORK

6.1 CONCLUSIONS

This research study was conducted to understand how personal safety applications can potentially be a part of an overall solution in unsafe situations, with different levels of risk. We conducted semi-structured interviews with 30 participants (15m, 15f) to gain a better understanding of how participants may react to a potential unsafe situation.

Our research concludes that personal safety applications seems to provide a reliable and effective solution for the majority of our participants, especially when opting for collective behavioural reactions. Our participants found the applications to be a good addition to their responses to the three given unsafe Scenarios. Some participants still believed that it is hard to rely on mobile applications when encountering unsafe situations and will rely on contacting emergency services or using the basic features of mobile phones, such as texting/calling seeking help. A total of 14 participants out of the 30 agreed to use a personal safety application in future as a part of their collective responses.

In terms of choosing a personal safety application, the most significant factors involved were usability and privacy concerns. Participants were a great deal concerned about what data was being collected by the applications and how it was being used, as some users were specifically concerned with whether the applications were using/selling their data to third party applications. Other concerns about using applications were related to seeking excessive permissions (e.g. contacts) as participants felt that considering the features available in the applications, permissions were not justified.

The issue of personal safety is subjective to individuals and having a clear overall understanding of the audience for which a personal safety solution is being created is essential. The needs and effectiveness of the solutions may not simply rely on individuals but on their surroundings and the sort of help available around them. For instance, an elderly person with limited mobility may not have the physical or mental ability to always remember/care to turn off location sharing with their loved ones, whereas it can be of a great deal of importance for a physically and mentally capable adult.

With regard to the available personal safety applications, our study recorded the perceptions of 30 participants before and after using the solutions in unsafe Scenarios to conclude how personal safety applications can be used as part of their collective responses. The privacy issues and data security concerns related to these applications call for more work in this domain in future. Effectively developed personal safety applications will help solve many problems for many different sections of our society.

6.2 FUTURE WORK

To the best of our knowledge, this study is the first of its kind to evaluate the viability of using personal safety applications by participants for given unsafe situations. We would like to propose some suggestions that could be considered as future work in this domain.

6.2.1 More realistic evaluation

We have reported the results of how personal safety applications can be a viable addition to the overall responses of individuals in unsafe Scenarios when adopting collective behavioural responses with regard to unsafe situations. Perhaps, being able to conduct a more realistic study, while respecting the ethics and safety of the participants will lead to more accurate findings and provide new insights, for example creating simulated/VR/AR environments to make the Scenarios feel more realistic. It can be challenging yet rewarding to use VR/AR as it proves to be more realistic, resulting in obtaining more accurate results to better understand perceptions about personal safety applications. Challenges may include developing an effective study design adaptable for the general population and all age groups. Training the participants with the hardware can be another challenge for researchers as well.

Moreover, future work may also consider conducting a controlled group study to understand the users' perspectives of personal safety applications. The study could be conducted with a control group consisting of people who feel that they have not experienced an unsafe situation. Such a study design will provide a better/balanced understanding of how a better-representative sample of people around the world feel about personal safety and help determine any new features that may be required in improved personal safety applications for the future.

6.2.2 Improved applications

It is quite evident from our study that the issues like privacy and concerns around data collection and protection are very prevalent when it comes to making a choice regarding using personal safety applications. Another greater concern around the use of personal safety applications is having better ways to trigger the operations to seek assistance, for example, sending texts or making phone calls for help. Having better and less time/attention consuming trigger mechanisms, such as wearable devices which can trigger signals using sensors (pressure and motion sensors), would surely eliminate or minimize the impact on situational attention, which might help make to applications more convenient to use in unsafe situations.

In summary, our semi-structured within-subjects study conducted with 30 participants (15m, 15f) to understand the perceptions towards personal safety applications concludes that most participants (14 out of 30) would include personal safety applications as part of their collective responses to unsafe situations. Based on our study design, we have provided design recommendations for such applications.

REFERENCES

[1] McCarthy, O.T., Caulfield, B. and O'Mahony, M., 2016. How transport users perceive personal safety apps. *Transportation research part F: traffic psychology and behaviour*, 43, pp.166-182.

[2] Sky News, Zainab Ansari: 'Prime suspect' arrested after girl raped and murdered Retrieved 27 July 2018 from https://news.sky.com/story/zainab-ansari-prime-suspect-arrested-after-girl-raped-and-murdered-11211283

[3] Phillips, M., Mostofian, F., Jetly, R., Puthukudy, N., Madden, K. and Bhandari, M., 2015. Media coverage of violence against women in India: a systematic study of a high profile rape case. *BMC women's health*, 15(1), pp.(1-10).

[4] Painter, K., Lighting and Crime Prevention: The Edmonton Project 1988 Retrieved 13 June 2018 from https://www.ncjrs.gov/App/abstractdb/AbstractDBDetails.aspx?id=115335

[5] Kim, S., Ulfarsson, G.F. and Hennessy, J.T., 2007. Analysis of light rail rider travel behavior: Impacts of individual, built environment, and crime characteristics on transit access. *Transportation Research Part A: Policy and Practice,* 41(6), pp.511-522.

[6] Pena-Garcia, A., Hurtado, A., Aguilar-Luzon, M.C., 2015. Impact of public lighting on pedestrians' perception of safety and well-being. *Safety Science, Vol. 72* pp.142-148.

[7] Haans, A., A.W. de Kort, Y., 2012, Light distribution in dynamic street lighting: Two experimental studies on its effects on perceived safety, prospect, concealment, and escape, *Journal of Environmental Psychology, 32(12), pp. (342-352).*

[8] Cozens, P., Neale, R., Whitaker, J., Hillier, D., 2003, Managing crime and the fear of crime at railway stations- a case study in South Wales (UK), *International Journal of Transport Management, 1(3), pp. 121-132.*

[9] George, R., 2002, Tourist's perceptions of safety and security while visiting Cape Town, *Tourism Management, 24(5), pp. (575-585).*

[10] *Amir, A.F., Ismail, M.H.I., See, T.P., 2014,* Sustainable Tourist Environment: Perception of international women travelers on safety and security in Kuala Lumpur, *Asia Pacific International Conference on Environment-Behaviour Studies*, Berlin, Vol. 168, pp. (123-133).

[11] George, R.,2010, Visitor perceptions of crime-safety and attitudes towards risk: The case of Table Mountain National Park, Cape Town, *Tourism Management,31(6), pp.(806-815).*

[12] *Boakye, K.A., 2012,* Tourists' views on safety and vulnerability. A study of some selected towns in Ghana, *Tourism Management,33(2), pp.(327-333).*

[13] Forgays, D.K., Hyman, I., Schreiber, J., 2014, texting everywhere for everything: Gender and age differences in cell phone etiquette and use, *Computers in Human Behaviour, Vol. 31, pp(314-321).*

[14] Dal Fiore, F., Mokhtarian, P.L., Salomon, I. and Singer, M.E., 2014. "Nomads at last"? A set of perspectives on how mobile technology may affect travel. *Journal of Transport Geography*, 41, pp.97-106.

[15] Kugler, L., 2016. Smartphone apps for social good. *Communications of the ACM*, 59(8), pp.18-20.

[16] Davis, D.M., 1993. Social impact of cellular telephone usage in Hawaii. In Vol. II, Honolulu, *HI: Pacific Telecommunication Conference* (pp. 641-648).

[17] Nasar, J., Hecht, P. and Wener, R., 2007. 'Call if you have trouble': Mobile phones and safety among college students. *International Journal of Urban and Regional Research*, 31(4), pp.863-873.

[18] Whitehouse, "Apps Against Abuse", 2011. Archived at https://obamawhitehouse.archives.gov/1is2many/apps-against-abuse

[19] Tennakoon, K.U.S. and Taras, D.G., 2012. The relationship between cell phone use and sense of security: A two-nation study. *Security Journal*, 25(4), pp.291-308.

[20] Ananda Kanagaraj, S., Arjun, G. and Shahina, A., 2013, October. Cheeka: A mobile application for personal safety. In *9th IEEE International Conference On Collaborative Computing: Networking, Applications and Worksharing*

[21] Karusala, N. and Kumar, N., 2017. Women's Safety in Public Spaces: Examining the Efficacy of Panic Buttons in New Delhi. *CHI 2017.*

[22] KishorBabu, S., Sagar, V.V., Nikhitha, B. and Priyanka, P., 2015, March. Exigency alert and tracking system. In *Computer Engineering and Applications (ICACEA), 2015 International Conference on Advances in* (pp. 700-705). IEEE.

[23] Huizhong, Wu. 2016. India says every phone must have a panic button by 2017. Available at http://money.cnn.com/2016/04/27/technology/india-smartphone-panic-button-rape/index.html (last accessed 10 Aug 2017).

[24] *Bloabaum, A., Hunecke, M., 2005* PERCEIVED DANGER IN URBAN PUBLIC SPACE The Impacts of Physical Features and Personal Factors, *Environmental and Behaviour, 37(4) pp.(465-486).*

[25] Bennett, T., Gelsthrorpe, L.,1996, Public attitudes towards CCTV in public places, *Studies on Crime and Crime Prevention*,5(1), pp(72-90).

[26] Appleton, J. (1975). The experience of LANDSCAPE. London: Wiley Retrieved July 2018 from https://www.bookdepository.com/Experience-Landscape-Jay-Appleton/9780471962359

[27] Ovelgönne, M., Sonnenbichler, A.C. and Geyer-Schulz, A., 2010, July. Social emergency alert service-a location-based privacy-aware personal safety service. In *Next Generation Mobile Applications, Services and Technologies (NGMAST),* 2010 Fourth International Conference on (pp. 84-89). IEEE

[28] Phillips, C., 1999, A review of CCTV evaluations: Crime reduction effects and attitudes towards its use, *Crime Prevention Studies,Vol. 1, pp.(123-155).*

[29] *Garofalo, J., 1979,* Victimization and the Fear of Crime*, Journal of research in Crime and Delinquency,16(1), pp.(80-97).*

[30] *Armour, M., 1986,* The Effect of Police Presence on Urban Driving Speeds*, ITE Journal, 56(2), pp(40-45)*

[31] Human Rights Campaign, Sexual Assault and the LGBTQ Community, Retrieved 27 July 2018 from https://www.hrc.org/resources/sexual-assault-and-the-lgbt-community

[32] Schafer, J.A., Huebner, B.M. and Bynum, T.S., 2006. Fear of crime and criminal victimization: Gender-based contrasts. *Journal of Criminal Justice*, 34(3), pp.285-301.

[33] Brown, S. (1998). "What's the Problem, Girls? CCTV and the Gendering of Public Safety." In: C. Norris, J. Moran and G. Armstrong (eds.), Surveillance, Closed Circuit Television and Social Control. Aldershot, UK: *Ashgate,* 17 (4), page(s): 304-324

[34] Jihong “Soloman” Zhao , Matthew Schneider & Quint Thurman (2002) The effect of police presence on public fear reduction and satisfaction: A review of the literature, The Justice Professional, 15:3, 273-299, DOI: 10.1080/0888431021000049471

[35] Fisher, B.S, Nasar, J.L., 1992, Fear of Crime in Relation to Three Exterior Features Prospect, *Refuge and Escape*, 24(1), pp.(35-65).

[36] Toney, G., Jabeen, F. and Puneeth, S., Design and implementation of safety armband for women and children using ARM7. In *2015 International Conference on Power and Advanced Control Engineering (ICPACE)*.

[37] Chand, D., Nayak, S., Bhat, K.S., Parikh, S., Singh, Y. and Kamath, A.A., 2015, November. A mobile application for Women's Safety: WoSApp. In *TENCON 2015-2015 IEEE Region 10 Conference* (pp. 1-5). IEEE.

[38] Pat Griffin & Mathew Ouellett (2003) From Silence to Safety and Beyond: Historical Trends in Addressing Lesbian, Gay, Bisexual, Transgender Issues in K-12 Schools, Equity &Excellence in Education, 36:2, 106-114, DOI: 10.1080/10665680303508

[39] Barker, M., Page, S.J., 2002 Visitor safety in urban tourism environments: the case of Auckland, New Zealand, *Cities*, 19 (4), pp. (273-282). https://doi.org/10.1016/S0264-2751(02)00024-0.

[40] Donaldson, R. and Ferreira, S. (2008). Perceptions of International Tourists to South Africa on Safety and Security – implications for the 2010 FIFA World Cup. *Journal of Sport and Tourism*,168(9), pp.(123-133).

[41] Jerry H. Ratcliffe , Travis Taniguchi & Ralph B. Taylor (2009) The Crime Reduction Effects of Public CCTV Cameras: A Multi-Method Spatial Approach, *Justice Quarterly*, 26(4), 746-770, DOI: 10.1080/07418820902873852

[42] Life360, "The New Family Circle" Communication App. Retrieved 13 Sept 2017 from https://www.life360.com/

[43] Statista, Number of mobile phone user's form 2015 to 2020, Retrieved in July 2018 from https://www.statista.com/statistics/274774/forecast-of-mobile-phone-users-world-wide/

[44] Gill, M., Bryan, J., Allen, J., 2007, Public Perceptions of CCTV in Residential Areas "It Is Not As Good As We Thought It Would Be." *International Criminal Justice Review, 17(4), pp. (304-324).*

[45] Sonmez, S.F., Graefe, A.R., 1998, Influence of Terrorism Risk on Foreign Tourist Decisions, *Annals of Tourism Research, 25(1), pp.(112-144).*

[46] . Lepp, A., Gibson, H., 2003 Tourist roles*, Perceived Risk and International Tourism, Annals of Tourism Research*, 30(3) pp.(606-624).

[47] J. Saranya and J. Selvakumar, "Implementation of children tracking system on android mobile terminals," *2013 International Conference on Communication and Signal Processing*, Melmaruvathur, 2013, pp. 961-965.doi: 10.1109/iccsp.2013.6577199

[48] Aoki, K., Downes, E.J., 2003, An analysis of young people's use of and attitudes toward cell phones, *Telematics and Informatics, 20(4), pp.(349-364).*

[49] Yvette Reisinger & Felix Mavondo (2006) Cultural Differences in Travel Risk Perception, *Journal of Travel & Tourism Marketing*, 20:1, 13-31, DOI: 10.1300/J073v20n01_02

[50] Roman, C.G. and Chalfin, A., 2008. Fear of walking outdoors: a multilevel ecologic analysis of crime and disorder. *American journal of preventive medicine*, 34(4), pp.306-312.

[51] Schafer, J.A., Huebner, B.M. and Bynum, T.S., 2006. Fear of crime and criminal victimization: Gender-based contrasts. *Journal of Criminal Justice*, 34(3), pp.285-301.

[52] Gibson, H., Yiannakis, A., *Tourist roles, Needs and the Lifecourse, Annals of Tourism Research*, 29(2) pp.(358-383).

[53] Satchell, C. and Foth, M., 2011, May. Welcome to the jungle: HCI after dark. In *CHI'11 Extended Abstracts on Human Factors in Computing Systems* (pp. 753-762). ACM.

[54] XPrize, "Anu & Naveen Jain Women's Safety XPRIZE", 2017. Available at http://safety.xprize.org/ (last accessed 8 Aug 2017)

[55] Cumiskey, K.M. and Brewster, K., 2012. Mobile phones or pepper spray? Imagined mobile intimacy as a weapon of self-defense for women. *Feminist Media Studies*, 12(4), pp.590-599.

[56] B. Latan´e and J. M. Darley, 1970, The Unresponsive Bystander: Why doesn'the help? *New York: Appleton-Century-Crofts*, Vol 1, pp. (127-133).

[57] Demos, E., 2008, Concern for Safety, *Journal of Travel & Tourism Marketing*, 1(1), pp. (81-88), DOI: 10.1300/J073v01n01_06

[58] Nasar, J., Hecht, P. and Wener, R., 2008. Mobile telephones, distracted attention, and pedestrian safety. *Accident analysis & prevention*, 40(1), pp.69-75.

[59] Ramalingam, A., Dorairaj, P. and Ramamoorthy, S., 2012. Personal Safety Triggering System On Android Mobile Platform. *International Journal of Network Security & Its Applications*, 4(4), p.179.

[60] Line, T., Jain, J. and Lyons, G., 2011. The role of ICTs in everyday mobile lives. *Journal of Transport Geography*, 19(6), pp.1490-1499.

[61] Chang, J.C., Wang, P.S., Fan, K.H., Yang, S.R., Su, D.Y., Lin, M.S., Sun, M.T. and Tseng, Y.C., 2011, September. iMace: protecting females from sexual and violent offenders in a community via smartphones. In *Parallel Processing Workshops (ICPPW), 2011 40th International Conference on* (pp. 71-74). IEEE.

[62] Waycott, J., Munteanu, C., Davis, H., Thieme, A., Branham, S., Moncur, W., McNaney, R. and Vines, J., 2017. Ethical Encounters in HCI: Implications for Research in Sensitive Settings. In *CHI EA 2017*.

[63] Gates, L.B. and Rohe, W.M., 1987. Fear and reactions to crime: A revised model. *Urban Affairs Quarterly*, 22(3), pp.425-453.

[64] Forgays, D.K., Hyman, I. and Schreiber, J., 2014. Texting everywhere for everything: Gender and age differences in cell phone etiquette and use. *Computers in Human Behavior*, 31, pp.314-321.

[65] React Mobile, Enterprise Safety Platform. Retrieved 23 September 2017 from https://reactmobile.com/

[66] Dimond, J.P., Dye, M., LaRose, D. and Bruckman, A.S., 2013, February. Hollaback!: The role of storytelling online in a social movement organization. In *Proceedings of the 2013 conference on Computer supported cooperative work* (pp. 477-490). ACM.

[67] BSafe, "Never Walk Alone" Personal Safety App. Retrieved 13 Sept 2017 from http://getbsafe.com/

[68] Kim, S.C., Jeong, Y.S. and Park, S.O., 2013. RFID-based indoor location tracking to ensure the safety of the elderly in smart home environments. *Personal and Ubiquitous computing*, 17(8), pp.1699-1707.

[69] O. Mokryn, D. Karmi, A. Elkayam and T. Teller, "Help Me: Opportunistic smart rescue application and system," *2012 The 11th Annual Mediterranean Ad Hoc Networking Workshop (Med-Hoc-Net)*, Ayia Napa, 2012, pp. 98-105. doi: 10.1109/MedHocNet.2012.6257129

[70] Wiso, World's easiest personal safety device. Retrieved 6 April 2017 from http://www.thewiso.com/support.html?setLng=en-US

[71] Ahmed, S.I., Jackson, S.J., Ahmed, N., Ferdous, H.S., Rifat, M.R., Rizvi, A.S.M., Ahmed, S. and Mansur, R.S., 2014, April. Protibadi: A platform for fighting sexual harassment in urban Bangladesh. In *CHI 2014* (pp. 2695-2704). ACM.

[72] CircleOf6, Personal Safety App. Retrieved 1 November 2017 from https://www.circleof6app.com/

[73] D. Chand, S. Nayak, K. S. Bhat, S. Parikh, Y. Singh and A. A. Kamath, "A mobile application for Women's Safety: WoSApp," *TENCON 2015 - 2015 IEEE Region 10 Conference*, Macao, 2015, pp. 1-5. doi: 10.1109/TENCON.2015.7373171

[74] Rader, N.E., Cossman, J.S. and Allison, M., 2009. Considering the gendered nature of constrained behavior practices among male and female college students. *Journal of Contemporary Criminal Justice*, 25(3), pp.282-299

[75] Titan Sonata, Analog Safety Watch. Retrieved 11 Sept 2017 from https://www.titan.co.in/product/sonata-white-dial-analog-safety-watch-for-women/90057SL01

[76] Just, Mike et al. (2017). On the Effectiveness of Personal Safety Apps. *Unpublished manuscript*

[77] Status of women Canada: *About Gender-based Violence*, Retrieved 5 August 2018 from https://www.swc-cfc.gc.ca/violence/strategy-strategie/gbv-vfs en.html?wbdisable=true

[78] Press trust of India: *Trails of "Panic-buttons" on Phones To Begin in UP on January 26, 2018*, Retrieved 5 August 2018 from https://www.ndtv.com/india-news/trial-of-panic-button-on-phones-to-begin-in-up-on-january-26-1795027

[79] National Observer, Emily Gilpin: *Hundreds march to honor and remember the lives of missing and murdered women*, Retrieved 5 August 2018 from https://www.nationalobserver.com/2018/02/14/news/hundreds-march-honour-and-remember-lives-missing-and-murdered-women

[80] The globe and mail, Tavia Grant: *THE TRAFFICKED*, Retrieved 5 August 2018 from https://www.theglobeandmail.com/news/national/the-trafficked-sexual-exploitation-is-costing-canadian-women-their-lives/article28700849/

[81] *Deterrence Theory of Punishment: Definition and Effect on Law Obedience*, Retrieved 5 August 2018 from https://study.com/academy/lesson/deterrence-theory-of-punishment-definition-effect-on-law-obedience.html

[82] Bridgman, G. (2017). Perceptions of Community Safety in West Auckland and White Fragility, Whanake: *the Pacific Journal of Community Development*, 3(2), 20–30.Auckland, New Zealand : Unitec Institute of Technology. Unitec ePress.

[83] The Verge, Nat Garun: *Google's new Trusted Contacts app lets you share your location during emergencies,* Retrieved 5 August 2018 from https://www.theverge.com/2016/12/5/13842058/google-trusted-contacts-personal-safety-android-app

[84] Citizens project, Kristy Milingan: *Language Matters* Retrieved 5 August 2018 from http://www.citizensproject.org/2014/02/20/language-matters/

[85] Free code camp, Nikita Koslov: *How modularization can speed up your android app's built time*, Retrieved 5 August 2018 from https://medium.freecodecamp.org/how-modularisation-affects-build-time-of-an-android-application-43a984ce9968

[86] Prototypr, Amit Aggarwal: *Modularizing powerful ios apps into powerful kits* Retrieved 5 August 2018 from https://blog.prototypr.io/architecting-ios-development-at-zomato-cf894a7fa5e3

APPENDIX A: SCREENING QUESTIONNARE

1. Are you age 18 or older?
   - Yes
   - No

2. How many experiences do you have in which you felt unsafe in a situation?
   - 0
   - 1 or more
3. Sex:
   - Male
   - Female
   - LGBTQQIP2SAA (lesbian, gay, bisexual, transgender, questioning, queer, intersex, pansexual, two-spirit (2S), androgynous, and asexual)

APPENDIX B: RECRUITMENT NOTICE

We are recruiting participants to take part in a study to assess personal safety mobile applications. We are looking for participants who are 18 years or older, who have at least one experience of feeling unsafe in any situation. We are interested to learn whether there are differences according to the sex, so we encourage males, females and LGBTQQIP2SAA community to take part.

A screening procedure will be conducted to finalize the participants for the study. Those interested in the study will be sent a screening questionnaire to assess suitability for the study.

The study will be conducted in the Graphics and Experiential Media (GEM) Lab, on the 4th floor of Mona Campbell building, Dalhousie University. You will be given a device (Android/iPhone) to use in the study, if you prefer not to use your own. First, you will meet the researcher, where the study will be explained in detail and you will be asked to provide informed consent. You will then complete a brief demographic questionnaire and be interviewed to learn your experiences with personal safety. We are not interested to know details of your past experiences as we are just looking for a general description of when you would characterize a situation to be unsafe. You will then be given a list of scenarios of potentially unsafe situations and will be asked to describe how you might respond. You will then be given a list of personal safety applications to choose from and will be asked to download the one on your phone or lab device. You will be trained on how to use it.
The researcher will observe you while you are installing the application. You will then be asked on how you would use the application in the same unsafe scenarios and how such applications might change your reactions in the future. The entire session is expected to take about 2.5- 3 hours to complete. Each participant will be compensated with $30 for participating in the study, which is paid at the time of initiating the study.

If you are interested in participating, please contact Hasmeet Singh Chandok by email at Singh@dal.ca.

If you do not wish to disclose your identity to the researchers, you can also use an anonymous email, which is not linked to your personal information.

APPENDIX C: CONSENT FORM

Principal Investigators: Hasmeet Singh Chandok, a graduate student at Faculty of Computer Science, singh@dal.ca
Contact Person: Hasmeet Singh Chandok, Faculty of Computer Science, singh@dal.ca
Supervisor: Dr. Kirstie Hawkey, Faculty of Computer Science, hawkey@cs.dal.ca
Co-Supervisor: Dr. Raghav Sampangi, Faculty of Computer Science, raghav@cs.dal.ca
Other Researchers: Dr. Mike Just, Associate professor, School of Mathematical & Computer Sciences; Computer Science, Heriot Watt University
Dr. Alette Willis, Chancellor's Fellow, School of Health in Social Science, University of Edinburgh
Dilpreet Gill, MACS student, FCS
JeyaBalaji Samuthiravelu, MACS student, FCS
Funding provided by: The study is funded by NSERC

Introduction:

We invite you to take part in a research study being conducted by Hasmeet Singh Chandok, a student at Dalhousie University as part of his computer science degree program. Your participation in this study is voluntary and you can withdraw from the study at any time. You can even choose to withdraw your data within 1 week after participation, if you don't feel comfortable about it for any reason. The study is described below in detail. It includes all the risks and benefits you might face during the study. Participation in the study may increase your knowledge about personal safety applications and we might learn things that will benefit others. You should discuss any questions you have about this study with Hasmeet Singh Chandok (singh@dal.ca).

Purpose:

The purpose of our research is to understand the user behavior while installing and using personal safety applications in an unsafe situation. The information below will tell you about what is involved in the research, what you will be asked to do and about any benefit, risk, inconvenience or discomfort that you might experience.

You should discuss any questions you have about this study with the researcher (Hasmeet Singh Chandok). Please ask as many questions as you like. If you have any questions later, please contact at singh@dal.ca.

Who Can Take Part in the Research Study?

You should be 18 years of age or older, with at least 1 experience of feeling unsafe in a situation.

What You Will Be Asked to Do:

In the beginning, researcher will explain the study in detail and will be given a consent form to read thoroughly and sign. You will be then asked to fill up a demographic questionnaire followed by a brief interview to understand more about your personal experiences with unsafe situation. The unsafe scenarios will be explained to you and you will be asked to discuss your reactions on those scenarios. You will then be asked to choose an application from a list of applications, which would fully explain about what that application does

and how. After this, you will be asked to install a personal safety application on your phone or lab phone, provided by the researcher and your installation preferences will be observed. You have the option of using your personal accounts, or if you are not comfortable using personal accounts, you will be provided with fake email addresses, names and contacts to register and use the app considering your privacy needs. When using your phone or the phone we provided, you will be required to give access to contacts stored on the device. In case you use your own phone, it would also mean that you might be required to give permission to the application to access your personal contacts photos, camera etc. as listed in Appendix F. Finally, you would be doing a semi-structured interview with the researcher to help them know more about why you chose that particular application from the list, how would you use these applications in future, what new features would you expect to have in these applications. The whole session will take approximately 2.5- 3 hours in total.

In the interview, another researcher would be taking notes of the conversation between you and the main researcher. These notes would be used for the analysis and once the analysis is complete, they would be destroyed. While the analysis is underway the notes would be saved in locked cabinet and are only accessible to the researchers.

Possible Benefits, Risks and Discomforts

Participation in the study may increase your knowledge about available personal safety applications and we might learn things that will benefit others. You will be compensated with $30 for participating for the whole study even if you are not able to finish.

All the personal details will be kept confidential. Your comments may be quoted in the report and any published materials. If we include any of your quotes in our publications, you will be referred by a participant ID and not by your name or any other personal information. All the research data will be kept safely in a locked cabinet and using pseudonyms or participant numbers which will preserve the anonymity of the textual data. The data will be kept for 3 years and will be destroyed after that.

If you decide to withdraw from the study at any point before completion no data will be retained. All data will be destroyed, except the consent form signed by you.

If you feel uncomfortable at any time of the study, you are free to stop participating. You can also choose to withdraw the data, even after completing the study. However, it must be done within 1 week after participation. Moreover, all the voice recordings will be password protected and will be accessible to researchers involved in this project. Once transcribed, the recordings will be destroyed.

Even when you are using your own phone, you will be provided with fake data to use in the application if you do not want to use your own information. It will include fake contacts, names and email.

As we will be using third party applications, you may sometimes feel frustrated by the applications being unresponsive. There may also be some risk of embarrassment for not being able to use the applications properly. It may also cause distress while doing the study, as we will be talking about unsafe situations. A list of resources available on/off-campus will be provided to you at the end of the study, if requested. (**Appendix J).**

If you have any ethical concerns about your participation in this research, you may also contact Research Ethics, Dalhousie University at (902) 494-1462, or email: ethics@dal.ca.

Signature Page
Project Title: Understanding the user perspective of personal safety applications on mobile devices.
Lead Researcher: Hasmeet Singh Chandok, a graduate student at Faculty of Computer Science, singh@dal.ca
"I have read the explanation about this study. I have been given the opportunity to discuss it and my questions have been answered to my satisfaction. I hereby consent to take part in the study. However, I understand that my participation is voluntary and that I am free to withdraw from the study at any time."
I understand that beyond 1 week after participation it will not be possible to remove my data, as informed in the consent form.

Participant	Researcher
Name: _____	Name: _____
Signature: _____	Signature: _____
Date: _____	Date: _____

"I would like to know about the results of this study, once completed"

- ☐ Yes Email address: _____
- ☐ No

"I agree that my participation in the experiments will be audio recorded and another researcher will take notes from my conversation for analysis. I understand that this is a condition of participation in the study and this audio recording and notes may be used in publication or presentation of results, after being anonymized."

- ☐ Yes

☐ No

Participant	Researcher
Name: _____	Name: _____
Signature: _____	Signature: _____
Date: _____	Date: _____

"I agree to let you directly quote any comments or statements made in any written reports or interview and I understand that the anonymity of textual data will be preserved by using pseudonyms/participation id."

☐ Yes
☐ No

Participant	Researcher
Name: _____	Name: _____
Signature: _____	Signature: _____
Date: _____	Date: _____

APPENDIX D: DEMOGRAPHIC QUESTIONNAIRE

Feel free to skip any questions that you would not like to answer.

1. How do you identify yourself?
   - Male
   - Female
   - LGBTQQIP2SAA (lesbian, gay, bisexual, transgender, questioning, queer, intersex, pansexual, two-spirit (2S), androgynous, and asexual)

2. What is your age?
   - 18-24 year's old
   - 25-34 year's old
   - 35-44 year's old
   - 45-54 year's old
   - 55-64 year's old
   - 65-74 year's old
   - 75 years or older

3. What is the highest degree or level of school you have completed? *If currently enrolled, highest degree received.*

   - No schooling completed
   - Nursery school to 8th grade
   - Some high school, no diploma
   - High school graduate, diploma or the equivalent (for example: GED)
   - Some college credit, no degree
   - Trade/technical/vocational training
   - Associate degree
   - Bachelor's degree
   - Master's degree
   - Professional degree
   - Doctorate degree

4. Employment Status: Are you currently…?
   - Employed for wages
   - Self-employed
   - Out of work and looking for work
   - Out of work but not currently looking for work
   - A homemaker
   - A student
   - Military
   - Retired
   - Unable to work

5. Ethnicity origin (or Race): Please specify your ethnicity
   - White
   - Hispanic or Latino
   - Black or African American
   - Native American or American Indian
   - Asian / Pacific Islander - For eg. Chinese, Japanese, Korean, Indian, Pakistani, Bangladeshi, Burmese, Cambodian, Filipino, Laotian, Thai, Vietnamese)
   - Other

6. For how long you have been in Canada:
   - > 2 year
   - <=2 year

7. How long have you lived in Halifax Regional Municipality?
   - > 2 year
   - <=2 year

8. Do you consider yourself to be a racially visible person?
   - Yes
   - No

   Examples of racially visible groups, include, but aren't limited to:
   • Black
   • Latin American
   • East Asian (e.g., Chinese, Japanese, Korean)
   • South Asian (e.g., Indian, Pakistani, Bangladeshi)
   • Southeast Asian (e.g., Burmese, Cambodian, Filipino, Laotian, Thai, Vietnamese)
   • West Asian and Arab (e.g., Iranian, Lebanese, Egyptian, Armenian, Palestinian, Syrian Moroccan)
   • People of mixed origin (e.g., with one parent in one of the racially visible groups listed above).

9. Do you consider yourself a person with a disability?
   - Yes
   - No

   Examples of groups of persons with a disability, include, but aren't limited to:
   • Coordination/dexterity (e.g. cerebral palsy)
   • Blind/visual impairment
   • Speech Impairment

- Non -visible physical impairment (e.g. hemophilia)
- Developmental/mental impairment (e.g. Down's syndrome)
- Mobility impairment (e.g. need to use a wheelchair)
- Learning disability (e.g. dyslexia)
- Deaf/hearing impairment
- Psychiatric impairment (e.g. severe depression)

10. How many hours on an average do you spend on your smartphone every day?
    _____

11. How often do you download new applications on your smartphone?
    _____

12. What type of applications do you usually download on your smartphone?
    _____
    _____
    _____
    _____

APPENDIX E: SCENARIO'S

Scenario 1: You have arrived at a community gathering with friends, but there are also many people there whom you do not know. While talking to a stranger, something this person says makes you uncomfortable. You look around but cannot see any of your friends, making you feel unsafe.

Scenario 2: You have arranged to meet with a stranger in a parking lot in a distant neighborhood during daylight hours to finalize a purchase from a classified website. While talking with this person, something that they do makes you feel very uncomfortable and unsafe.

Scenario 3: You are walking home alone late at night and you notice that someone is walking behind you. You attempt to ignore them but something in their actions makes you believe that they might harm you.

Justification (Not to be shown to the participants, at the time of study.)
The scenarios are intended to meet the following three principles:

- They should be applicable to all participant groups.
- They should use minimal information to convey a risky situation, allowing a participant to create the details specific to their own subjective and contextual concerns.
- The scenarios should gradually increase the perceived risk (from Scenario 1 to Scenario 3) based on increased levels of isolation and a reduced availability of assistance.

APPENDIX F: APPLICATION BROCHURE

Brochure of Personal Safety Apps

Contents

Organization of the report

This report analyses three different mobile applications in various aspects. Each mobile application is described using five different sections which are explained as follows.

Description

This section of the application provides a description of the application to the reader. This is a general overview of the mobile application explained in Layman's terms.

Why this application?

This section provides a more detailed description of the application in a view of the explaining "Novelty" of the application.

Why should someone use this application?

This section explains the key takeaways of the user from the application. This explains the major features, advantages of using this application, etc.

Technical Specification of the application

This section explores the application in a technical point of view. The permissions used by the application are discussed in this section.

SWOT for the application

SWOT is an acronym for Strengths, Weakness, Opportunities and Threats in the context of project management. SWOT analysis is performed on a business model or a project to analyse in a constructive and efficient manner. This section analyses the application in a SWOT perspective.

1.1 Description

Bsafe is a personal safety application loaded with all the necessary safety features that are required to keep some one feel safe. Bsafe basically creates your own personal safety network. This network can have as many as people you want, it can be either your family or friends or buddies on your community.

1.2 Why Bsafe?

Bsafe has varied features like creating individual personal safety networks for different groups of people. Some of the other features that Bsafe uses are

1. Share GPS location to friends or family (both continuous location updates and panic update)

2. Timer mode that automatically creates a panic alert and sends it to the personal safety network after a particular time.

3. Fake call helps to create a fake incoming call.

1.3 Why should someone use?

Bsafe compared to other similar personal safety applications in the market; it is one of the useful emergency applications. It has the features that are required for most of the users.

1.4 Technical specification for Bsafe

Bsafe requests access of:

1. User Account information

2. Contact information

3. GPS Location

4. SMS and Phone

5. Photos and Media access

6. Storage, Camera, Wifi, Microphone

1.5 SWOT for Bsafe

Bsafe has all the required features that need to be present in a personal safety application. Number of features is more and sometimes the application looks feature heavy. User Interface is easily understandable which overcomes the effect of feature heaviness. Application has no noticeable bugs or flaws.

2.1 Description

Life360 is a personal safety app that mainly focuses on family and close friend's safety. It has features to create circles to add family members. Those who are in the circle can access the other circle member's location, battery percentage, etc. Life360 also has other premium features like Driving analysis, crash detection, etc.

2.2 Why Life360? Why should someone use Life360?

Life360 not only acts as a personal safety app. It also helps in locating the status of family member/friends. Life360 has a list that continuously displays the vital stats for the close circles phone. Life360 can also be used to check where a person's location. (E.g. To check the location of the kid on a school bus, etc.)

2.3 Technical Specifications of Life360

Life360 is available for both Android and iOS platforms. Life360 uses the following permissions:

1. User Account information, Running Apps
2. Contact information, Calendar
3. GPS Location
4. SMS and Phone
5. Photos and Media access
6. Storage, Camera, Wi-Fi, Microphone

2.4 SWOT for Life360

Life360 is a full-fledged tracking application that focuses on personal safety too. Life360 does what it is supposed to do. Live tracking and Check-in updates are more useful tracking feature for general-purpose day-to-day use. Generally personal safety applications will not frequently used apps. It consumes space in the device memory, and can't be avoided. But Life360 tries to change this by adding some additional functionality to make its users use this for day-to-day general purpose activities like, tracking family member's location.

Circle of 6 is a simple personal safety application where one can add a group of 6 friends or close family member. When a panic situation is experienced, Current GPS location can be shared with the circle or the app can send a text to the circle requesting a call back.

3.2 Why circle of 6? Why should someone use it?

Circle of 6 follows a minimalistic UI theme and simple interface. This helps when someone to do the intended operation when experiencing a panic situation. Circle of 6 also uses SMS as the method of communication to communicate with the circle.

3.3 Technical specification of Circle of 6

Circle of 6 is available for both Android and iOS platforms. Circle of 6 uses the following permissions:

1. User Account information
2. Contact information
3. GPS Location
4. SMS and Phone
5. Photos and Media access
6. Storage, Network

4. SWOT for Circle of 6

Circle of 6 is a focused personal safety application with crisp and easy to use interface. Many Universities and other giant corporations use circle of 6 as their personal safety application. Circle of 6 has a very simple interface, which helps the user to select their intended action. Circle of 6 is also stable with no noticeable bugs.

APPENDIX G: INTERVIEW 1

1. **What type of situation would you define as an unsafe situation?**
   (You can choose not to answer this question, if it makes you uncomfortable)

   _____
   _____
   _____
   _____

2. **What are the elements that characterize an unsafe situation?**
   (You can choose not to answer this question, if it makes you uncomfortable)

   _____
   _____
   _____
   _____

APPENDIX H: SEMI- STRUCTURED INTERVIEW

1. Why did you choose to use your own phone or the lab phone? Please elaborate.
   _____
   _____
   _____
   _____
   _____
   _____

2. What factors did you consider while choosing the personal safety application from the list?
   a) _____
   b) _____
   c) _____
   d) _____
   e) _____
   f) _____
   g) _____
   h) _____
   i) _____
   j) _____

3. Did you care about what permissions personal safety applications ask for at the time of installation?
   a) Yes
   b) No
   c) I usually notice, but I didn't care in this case because it was about personal safety.

4. Did you care about the data being collected by the application and its storage and how it's being shared with others (security)?
   _____
   _____
   _____
   _____

5. How would you react to all three scenarios discussed before, if you had access to this application?
   Scenario 1:

Scenario 2:

Scenario 3:

6. How would you react on in the unsafe situation listed by you in your first interview (Appendix G)?

7. Do you think you will use any personal safety application in future?

8. Is there any more functionality you would like to have in the personal safety application you choose?
(It can also from two other applications we had in the list).

Thanks a lot for participating in the study.

We will be using these questions for starting the interview and may ask participant to elaborate on it.

APPENDIX I: EMAIL CORRESPONDENCE WITH EQUALITY AND ACCESSIBILITY OFFICE, DALHOUSIE STUDENT UNION

Monday, January 23, 2017 at 11:31:37 AM Atlantic Standard Time

Subject: Re: Regarding conducting a study on understanding the user's perspective of personal safety applications
Date: Friday, January 13, 2017 at 3:49:44 PM Atlantic Standard Time
From: DSU Equity Office
To: Hasmeet Singh Chandok

Good Afternoon Hasmeet,

Sounds great! Let me know if you need anything else.

In solidarity,

Masuma Khan
Campaigns and Outreach Coordinator
Equity and Accessibility Office

From: Hasmeet Singh Chandok
Sent: Friday, January 13, 2017 3:42:06 PM
To: DSU Equity Office
Subject: Re: Regarding conducting a study on understanding the user's perspective of personal safety applications

Hi Masuma,

Their has been a concern raised by the ethics board about the word "hire" used in the last email, i sent to you asking your help in-terms of recruiting participants. We would like to replace the word "hire" by "recruit". Please let us know if you would have any issues supporting us to disseminate the information, because of the change listed above.

Thanks
Hasmeet Singh Chandok
Student-MCS
Faculty of Computer Science
Dalhousie University

From: DSU Equity Office
Sent: Monday, November 21, 2016 10:19:32 AM
To: Hasmeet Singh Chandok
Subject: Re: Regarding conducting a study on understanding the user's perspective of personal safety applications

Good Morning Hasmeet,

This initiative sounds wonderful, I would be willing to circulate this email amongst the DSU members. Look forward to working with you,

Masuma Khan

Campaigns and Outreach Coordinator
E&A Office

From: Hasmeet Singh Chandok
Sent: Monday, November 21, 2016 10:14 AM
To: DSU Equity Office
Subject: Regarding conducting a study on understanding the user's perspective of personal safety applications

Hello Masuma,

My name is Hasmeet Singh Chandok, final years Masters of Computer Science student at Faculty of Computer Science, Dalhousie University.I am conducting a research study to understand the user's perspective on personal safety applications. We are looking to hire 15 participants each from males, females and LGBTQ+ from Dalhousie community (Students, General Public, Staff).I am attaching a recruitment notice in this email.Can you please help us circulating this email to the students through all the possible channels. Please let me know if you have any question.

Thanks
Hasmeet Singh
Student,MCS
Faculty of Computer Science

APPENDIX J: COUNSELLING AND PSYCHOLOGICAL SERVICES

Counselling Services

2nd floor, LeMarchant Place
1246 LeMarchant Street
Halifax, NS B3H 4R2

Phone: 902-494-2081
Fax: 902-494-3337

General enquiries: recepcps@dal.ca
Director: joanne.mills@dal.ca

Human Rights & Equity Services

Henry Hicks/Academic Administration Building
Dalhousie University
c/o The President's Office
6299 South St, room 2
P.O. Box 15000
Halifax, NS, B3H 4H6

Phone: (902) 494-6672
Fax: (902) 425-1207
Email: dalrespect@dal.ca

Student Health Services

Dalhousie University
1246 LeMarchant Street, 2nd floor
PO Box 15000
Halifax, NS, B3H 4R2

Phone: (902) 494.2171
(phone lines open 8 a.m.-close)
Fax: (902) 494.6872

APPENDIX K: EXAMPLE ELEMENTS OF AN UNSAFE SITUATION

Elements that can characterize unsafe situations:

1. **Being Alone**
2. **Places with low/no lighting (darkness).**
3. **In the presence of drunk people.**
4. **Natural Emergencies**

APPENDIX L: LETTER OF APPROVAL

Social Sciences & Humanities Research Ethics Board
Letter of Approval

March 14, 2017

Hasmeet Singh Chandok
Computer Science\Computer Science

Dear Hasmeet Singh,

REB #: 2016-4058
Project Title: Understanding the user perspective of personal safety applications on mobile devices

Effective Date: March 14, 2017
Expiry Date: March 14, 2018

The Social Sciences & Humanities Research Ethics Board has reviewed your application for research involving humans and found the proposed research to be in accordance with the Tri-Council Policy Statement on *Ethical Conduct for Research Involving Humans.* This approval will be in effect for 12 months as indicated above. This approval is subject to the conditions listed below which constitute your on-going responsibilities with respect to the ethical conduct of this research.

Sincerely,

Dr. Karen Beazley, Chair

APPENDIX M: APPROVAL FOR AMENDMENT

Social Sciences & Humanities Research Ethics Board
Amendment Approval

April 06, 2017

Hasmeet Singh Chandok
Computer Science\Computer Science

Dear Hasmeet Singh,

REB #: 2016-4058
Project Title: Understanding the user perspective of personal safety applications on mobile devices

The Social Sciences & Humanities Research Ethics Board has reviewed your amendment request and has approved this amendment request effective today, April 06, 2017.

Sincerely,

Dr. Karen Beazley, Chair