

# **MOBILE PERSUASIVE APPLICATION FOR RESPONSIBLE ALCOHOL USE: DRIVERS AND IMPACT OF SOCIAL INFLUENCE STRATEGIES**

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## **ABSTRACT**

Alcohol consumption has been accepted as a norm in our society, its excessive consumption comes with serious health and financial risk and if not treated early can sometimes lead to death. For young adults, binge drinking – taking huge quantity of alcohol in a short period of time – is becoming increasingly popular largely due to social influence from their peers and has been identified as a public health concern for middle school adolescents. Hence there is need for studies that identifies interventions and how such interventions can be best delivered.

This research investigated the use of persuasive technology as an intervention mechanism for reducing alcohol risk. Persuasive technology is the use of computer to motivate behaviour change without the use of force. This research examines the drivers influencing user acceptance of a mobile application to deliver persuasive intervention to discourage irresponsible alcohol use and also investigated the effect of two social influence strategies (comparison and competition) of persuasive technology in motivating a healthy and responsible alcohol use behaviour.

To achieve this, I developed two versions of a cross-platform mobile application (Control Version and Social Version) implementing a tool for measuring self-reported alcohol consumption, based on AUDIT (Alcohol Use Disorder Identification Test, a standard tool for screening for excessive drinking). The control version of the app deploys the following strategies: self-monitoring, goal setting, feedback, reward, reminder, and simulation. The intervention version contains all the strategies in the control version and in addition, two social influence strategies – comparison and competition. In a 30-days long study with volunteers using the app daily (n=42), we first used the Technology Acceptance Model (TAM) tool to find out the drivers for user intention to use the mobile persuasive application for responsible alcohol use. The results showed that aesthetically pleasing user interface and user experience and perceived usefulness are the main drivers of intention to use. We also measured the AUDIT Score of the participants before and after 30 days of using the application, comparing the AUDIT scores of the user groups assigned to the two versions of the application. The results show that in the control version group, there was no significant difference in the AUDIT scores before and after the intervention, while in the group using the social version there was a significant improvement (decrease in the AUDIT score) after using the application.

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## **DEDICATION**

This work is dedicated to God Almighty, Al-Hameed – the praiseworthy.

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## CHAPTER 1: INTRODUCTION

Different people consume alcohol for different reasons such as to taste and enjoy, relieve stress, elevate good mood, anxiety, peer-pressure, environmental influence or social norm. Alcohol consumption has become part of many people's social life. However, its excessive use comes with serious medical, social and economic consequences. Research has shown that the health care cost for families with an alcohol use disorder (AUD) member is twice that of the families without one; also half of the emergency room admissions in the United States [1] are alcohol-related. The Canadian Center on Substance Use and Drug Addiction (CCSUDA) estimated the total cost of alcohol-related harm to Canadians to be \$14.6 billion per year.

Alcohol consumption is linked to engaging in risky sexual behaviours that can lead to unplanned pregnancies and HIV/AIDS [2]. Alcohol use during pregnancy can have negative effects on the offspring [3], such as brain damage, growth impairment, neuro-cognitive delays and altered facial features- commonly referred to as fetal alcohol spectrum disorder (FASD) [4]. Among young-adults, the risks associated with the use of alcohol are associated with an exhibition of poorer performance on attention, visuospatial, memory and other executive function tasks[5].

AUD directly correlates to other behaviour problems, such as violence and gambling. These behaviour problems can negatively impact personal relationships, work performance, career opportunities and increase crime-rate in a society.

Government bodies and health organisations have defined strategies and action plans to reduce the harmful use of alcohol. These strategies revolve around enacting drink-driving laws that limit the acceptable blood alcohol concentration (BAC) for drivers, regulating alcohol price and distribution and providing psychosocial interventions for harmful alcohol users [6]. While the interventions have been proven to alleviate short-term alcohol-related problems, they are not sufficient to produce long-lasting behavioural changes [7].

The increase in technological adoption has created unique opportunities for researchers and health practitioners to offer preventive measures to AUD and other substance use disorders using technologies such as smartphones, websites, CD-ROM etc. Research has found technological or

computerized interventions known as persuasive technology (PT) to be effective in motivating behavioural change [8]–[10]. Persuasive technology refers to a hardware and software that uses the computer as a medium to reinforce or change attitudes or behaviors without using coercion or deception [4].

## **1.1 Motivation**

Over 200 health conditions are directly and indirectly linked to harmful alcohol use, including maternal and child health, infectious diseases such as HIV/AIDS, viral hepatitis, tuberculosis, non-communicable diseases, mental health injuries and poisoning [6]. In 2013, Canada reported that almost 80 percent of its population consumed alcohol the previous year, and 4.4 million Canadian consumed enough alcohol to be at risk of chronic health diseases in that period [11]. Furthermore, in the same period, it was reported that 3.1 million Canadians consumed enough alcohol to put society at risk. However, aside from the personal health risks alcohol poses to individuals, it is also one of the leading risk factors of population health worldwide, and in many cases, alcohol is often consumed alongside other psychoactive substance use such as marijuana, tobacco and opioids [11].

The prevalence of alcohol abuse cuts across all age groups and genders. Research has shown that an average of six (6) teenagers between the age of 10 – 19 are hospitalized daily in Canada for conditions entirely caused by alcohol [12] and over 60% of Canadians between the ages of 15 – 19 have at least one drink in a year [11]. Binge drinking, which is the consumption of an excessive amount of alcohol in a short period, has been found to be a public health issue for middle school adolescents [13] and the risks associated with underage alcohol consumption are alcohol poisoning, motor vehicle accidents which can lead to severe injuries or death, unwanted pregnancy, liver damage, mental health problems and infectious and non-communicable diseases. Hence there is a need for researchers to introduce techniques to motivate and educate people, especially young adults, to adhere to healthy drinking behaviour.

## **1.2 Problem Statement**

The challenges related to educating young people about responsible alcohol consumption are significant. Research shows social learning (observing the behaviour of others to motivate one's behaviour) is one of the leading factors of binge drinking among young adults [14]. Social learning is a persuasive strategy that can be used to change behaviour. In this thesis, I investigate the receptiveness of young adults to the use of a mobile application as a means to deliver intervention

that can help to reduce alcohol risk and encourages good alcohol consumption behaviour. Additionally, I also examine the effectiveness of using social learning as the theoretical model for developing this intervention. I am particularly interested in evaluating social comparison and competition, which are two major components of social learning and to find effective ways of using persuasive technologies to motivate healthy drinking behaviour among teenagers and young adults. Hence, this thesis aims to address the following questions:

1. *What drives the user acceptance of a mobile app to deliver interventions that encourages responsible alcohol usage??*
2. *How effective is a persuasive mobile app in changing user behaviour towards more responsible drinking habits?*
3. *Would adding social learning strategies – competition and competition – make the persuasive app more effective?*

### **1.3 Overview of Thesis**

This thesis is organized in seven chapters as described below:

*Chapter 1: Introduction*

*Chapter 2: Research Background and Methodology:* This chapter presents the related work and literature review for this thesis. It includes the necessary backgrounds on PT, behavioural change theories such as Social Learning Theory (SLT) and Social Cognitive Theory (SCT), Persuasive System Design Framework (PSDF), Technology Acceptance Model (TAM), Game as a Persuasive Technology. The chapter also contains related backgrounds on AUD, Alcohol Use Disorder Identification Test (AUDIT) and related works on the existing interventions and measures for AUD. Finally, the Design Science Research (DSR) method adopted for this thesis is introduced in this chapter. The DSR stages starting from Problem identification to Objective of Solution, Design and Development, Demonstration, Evaluation and Communication are discussed.

*Chapter 3: Persuasive Technology as an Intervention for Alcohol Use:* This chapter presents the persuasive intervention that was evaluated in this thesis. It describes the following persuasive strategies in the context of AUD: *self-monitoring, self-efficacy, simulation, personalized feedback, social learning, social comparison and competition.*

*Chapter 4: Development and Implementation:* This chapter presents the implementation of the persuasive system. The components of the mobile application, the design choices for the framework used for the development, the libraries, the mobile and cloud platform adopted for the development of the application are discussed in this chapter.

*Chapter 5: Experiment Design Tools and Procedures:* This chapter presents the details of the study conducted and its execution. The number of participants, the location the experiment was conducted, the duration of the experiment, the grouping of participants into the control group and intervention group are also discussed in this chapter. This chapter also contains the AUDIT tool used for the experiment and the details of the ethical approval and authorization required for the experiment to be conducted.

*Chapter 6: Results, Analysis and Summary of Finding:* This chapter describes the results of the data analysis.

*Chapter 7: Conclusions and Future Work:* This chapter summarizes the intervention presented in this thesis and outlines the future directions for this research.

## CHAPTER 2: RELATED WORK

### 2.1 Overview of Literature review

Given the negative effect of AUD on both an individual and societal level, it is important to look at the available and emerging theories to try and explain the reason for a rise in alcohol usage, especially in the young population and the difficulties these demographics face in an attempt to effect change whilst also being open to new solutions that may be driven by technology. In this section, PT and the various behavioural models and frameworks will be defined and discussed in depth. Furthermore, the available tools used in assessing alcohol use disorder and the common interventions employed in previous studies in an attempt to stem the negative impact of AUD will be explored.

### 2.2 Persuasive Technology and Captology

The term “Persuasive technology” was coined by BJ Fogg during his graduate studies at Stanford University in the 1990s. He defined persuasive technology as “*an interactive technology that attempts to change attitude or behaviour in some way*” [15] without the use of coercion or deception. For a technology to be categorized as a PT, the behavioural or attitudinal change must be planned and not side-effects of using the technology. It has been argued that computers do not have intentions of their own [16], the effects on behaviour or attitude of a PT is a reflection of the intention of those who create, distribute or adopt the technology. This intention is categorized into three based on the source of intent as described by Fogg [15].

- Endogenous: Those who create or produce the PT.
- Exogenous: Those who distribute or give access to the PT.
- Autogenous: The users of the PT.

Captology is the study of the “*theory, design and analysis of computers as persuasive technologies*” [17]. The term “Captology” was based on the acronym derived from “Computers as Persuasive Technologies”. The figure 2.1 below shows Captology as the intersection of the study of persuasion and technology.



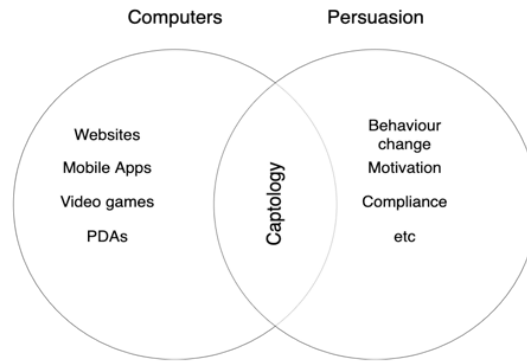


Figure 2.1: Captology, the intersection of computers and persuasion, adapted from BJ Fogg [15]

Fogg also introduced the concept of “functional triad”. This is a conceptual framework that illustrates the three roles technology play in persuasion. These roles include *technology as a tool*, *technology as a medium* and *technology as a social actor*.

- a. *Technology as a tool*: Technology has made it possible for human to do things that were impossible to do before.
- b. *Technology as a medium*: Technology is being used as a means of delivering contents in different formats e.g. text, images videos etc.
- c. *Technology as a social actor*: Technology influences human behaviour by providing supports or leveraging social rules and dynamics [17]

Figure 2.2 below represents the visual representation of the functional triad with examples of different technologies.

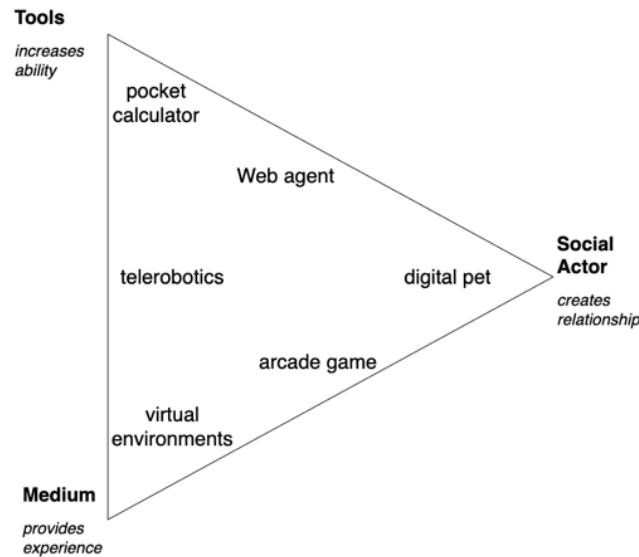


Figure 2.2 Functional Triad, adapted from BJ Fogg [15]

## 2.3 Behaviour Change Theories

Behaviour change theories are theories that try to explain why behaviours change. They have interrelated constructs and concepts that explain the underlying factors such as personal, social, environmental and individual characteristics responsible for behaviour change [18]. Glanz and Bishop [18] define the purpose of behaviour change theories (in health domain) as follows:

- a. Understand why people do or do not practice health-promoting behaviours;
- b. Help identify what information is needed to design an effective intervention strategy; and
- c. Provide insight into how to design a program so it is successful.

Behavioural change and theoretical models have evolved over the years and dozens of new models have been developed but no single model dominates the research practices in the promotion of healthy behaviour [18]. Examples of common behaviour change theories used in health intervention are described as follows:

### 2.3.1 Health Belief Model (HBM)

This was developed in the 1950s in an attempt to understand why people refuse to adopt disease prevention strategies. This model suggests that the belief in the threat of disease and the belief in

the effectiveness of an intervention can predict the possible adoption of the intervention or behaviour [19].

The constructs for HBM is shown in Figure 2.3 below. HBM has been applied in interventions aiming at behaviour change in situations like early cancer detection, and hypertension screening and to reduce risk factors for cardiovascular disease [18].

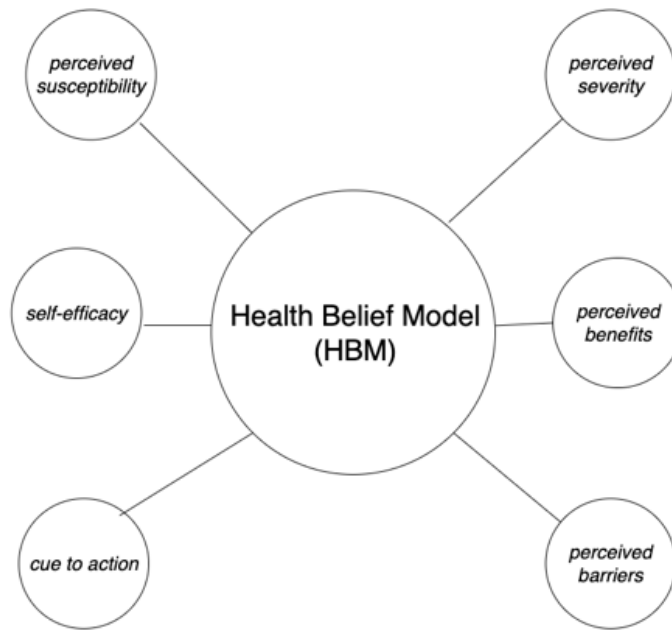


Figure 2.3 Health Belief Model adapted from [18]

### 2.3.2 Theory of Reasoned Action (TRA)/Theory of Planned Behaviour (TPB)

Theory of Reasoned Action aims to predict the intention to engage in a behaviour. The TPB is an extension of TRA which includes the measure of perceived behavioural control (PCB) [20]. Figure 2.4 represents the TPB constructs and the relationships between them. TPB has been used successfully as the underlying theory in interventions improving healthy dietary behaviours among adolescents [21], to predict dental attendance among younger adults [22], smoking and substance abuse [19].

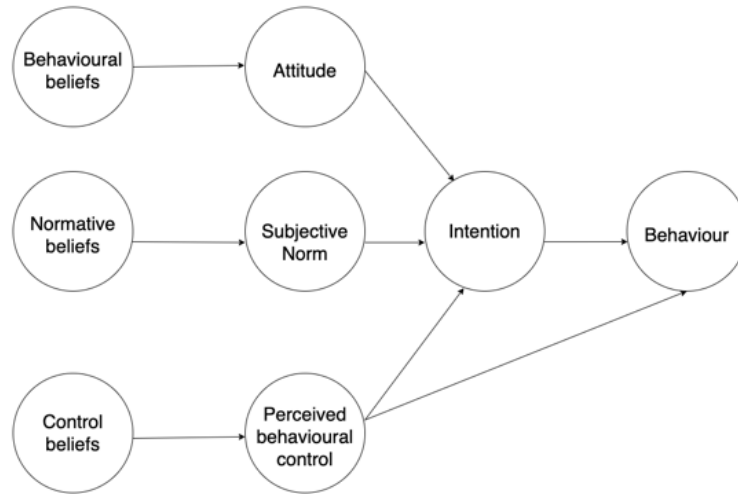


Figure 2.4: Theory of Planned behaviour [21]

### 2.3.3 Transtheoretical Model/Stages of Change (TTM)

Behaviour change does not happen all of a sudden, it usually occurs in stages. Different people are at different stages on a path to forming a new habit. TTM attempts to understand the different stages of behaviour change and proposes that different intervention should be used for people at different stages. TTM has been used to successfully predict the behaviour change in smoking, eating habits and physical activities [18]. Figure 2.5 shows the key construct/stages of change of the TTM.

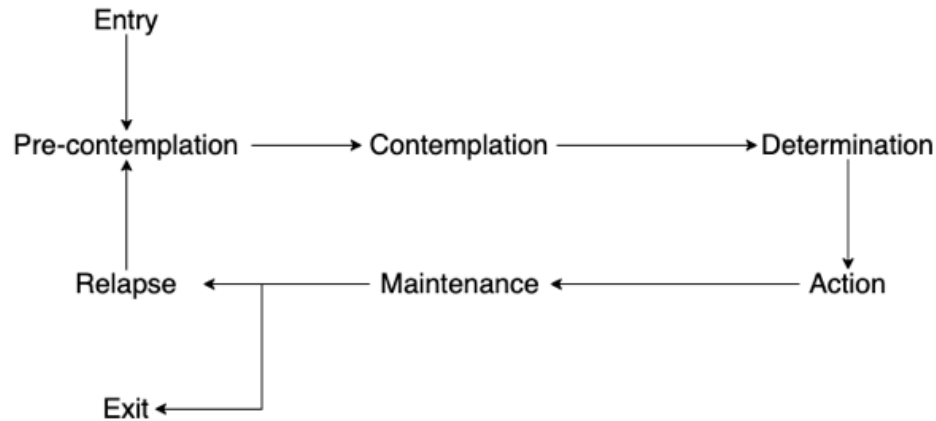


Figure 2.5: Transtheoretical Model (adapted from [18])

### 2.3.4 Social-Ecological Model (SEM)

While other models make use of personal actions and beliefs, SEM considers the interaction of an individual and the environment. SEM attempts to understand the factors responsible for the behaviour and provide interventions at different levels of influence such as interpersonal, organizational, community and public policy [18]. This model has been used to successfully design intervention for smoking, substance abuse, nutrition, physical activities and dangerous sexual behaviour [23].

### 2.3.5 Social Cognitive Theory (SCT)/Social Learning Theory (SLT)

Social learning theory was introduced by Albert Bandura in the 1960s and later developed to SCT in 1986 [19]. Because this is the method adopted in this research, it's discussed in more detail in section 2.4 below.

## 2.4 Social Cognitive Theory (SCT) / Social Learning Theory (SLT)

SLT postulates that acquiring a new behaviour can be a result of directly experiencing the consequence of the behaviour or by observing other people. Also, it recognizes that behaviors that are rewarded are more likely to be repeated and behaviors that are punished are more likely not to

be repeated [24]. SCT, which is an extension of SLT [25] holds that behaviour is determined mainly by expectations and incentives. It explains human behaviour as reciprocal determinism – which is the dynamics and interaction between personal factors, behavioural factors and environmental factors – as shown in Figure 2.6 below. The inter-relationships of all these factors make this model suitable for this research, unlike other models like HBM that does not consider the person’s attitude and its environment. In addition to that, research has also shown that environmental factors (social influence, social norms etc.) are leading factors of binge drinking among adolescent and young-adults [14]. This makes the SCT particularly relevant in this study.

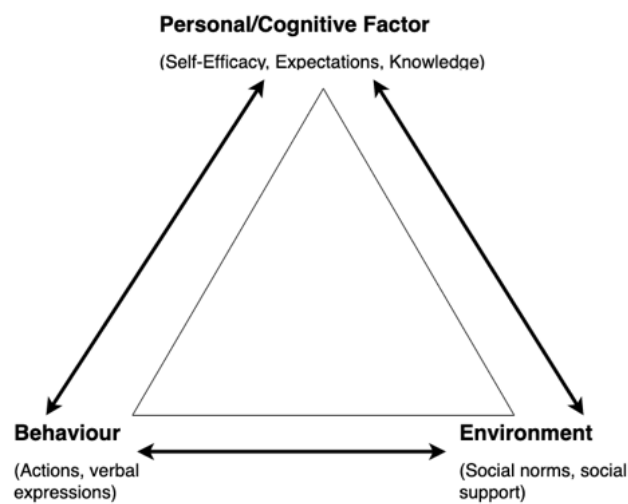


Figure 2.6: Reciprocal Determinism of SCT, Adapted from [26]

The personal factors include *self-efficacy*, *outcome-expectancy* and *self-control*. The environmental factors consist of *social norms*, *social supports* and other external factors that can influence the behaviour.

The most important construct of SCT as it relates to health behavioural change domain include self-efficacy, self-control, outcome-expectancy, and social support. [18]

- a. *Self-Efficacy*: The belief in one’s ability to perform the needed behaviour to influence the outcome. Research has shown that self-efficacy is the strongest construct in behavioural change [18].
- b. *Self-Control*: This is the control of one’s thoughts towards the fulfilment of a goal. It involves goal setting, self-monitoring, planning and organization of one’s activity and behaviour.

- c. *Outcome Expectations*: Expectations about the consequences of one's actions. This involves the opinion about how an action is likely to influence outcomes.
- d. *Social Support*: This construct leverages social influence to motivate behavioural change. It includes social learning, social comparison, competition and cooperation.

Figure 2. 7 below shows the SCT constructs and how they influence behaviour and one-another.

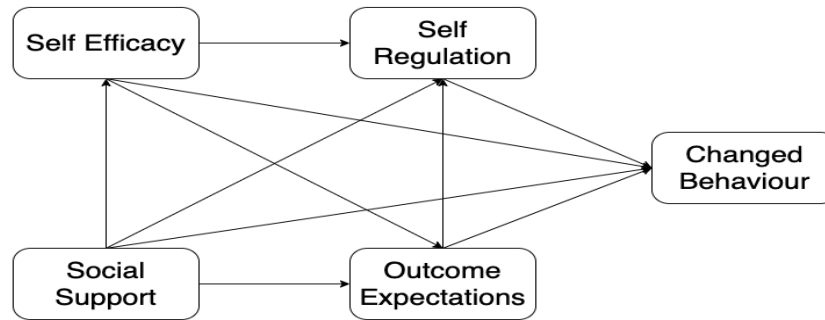


Figure 2.7: SCT Constructs adapted from [27]

## 2.5 Persuasive System Design Framework (PSD)

The computer software that is designed to motivate behaviour change without the use of coercion or deception is known as a persuasive system [28]. The essence of a persuasive system is to *1. Reinforce a behaviour the user has been engaging in before, 2. Influence the user to drop behaviour and start a new one 3. Shape an existing behaviour to form a new pattern* [28]. Persuasive contents can be delivered using either of the following two means:

- a. *Computer-Human Persuasion*: The interaction of a user with the computer to influence the user's behaviour without the involvement of another user, e.g. a mobile app to monitor track alcohol consumption.
- b. *Computer-Mediated Persuasion*: A user influencing other users using the computer as a medium, e.g. social media, discussion forums.

Researchers have laid down the guidelines for the development and evaluation of persuasive systems. The first step is the *understanding of the key issues behind a persuasive system*, the second step is the *analysis of the persuasion context* and the last step is the *design of the persuasive system*. The general overview for these steps is illustrated in Figure 2.8 below.

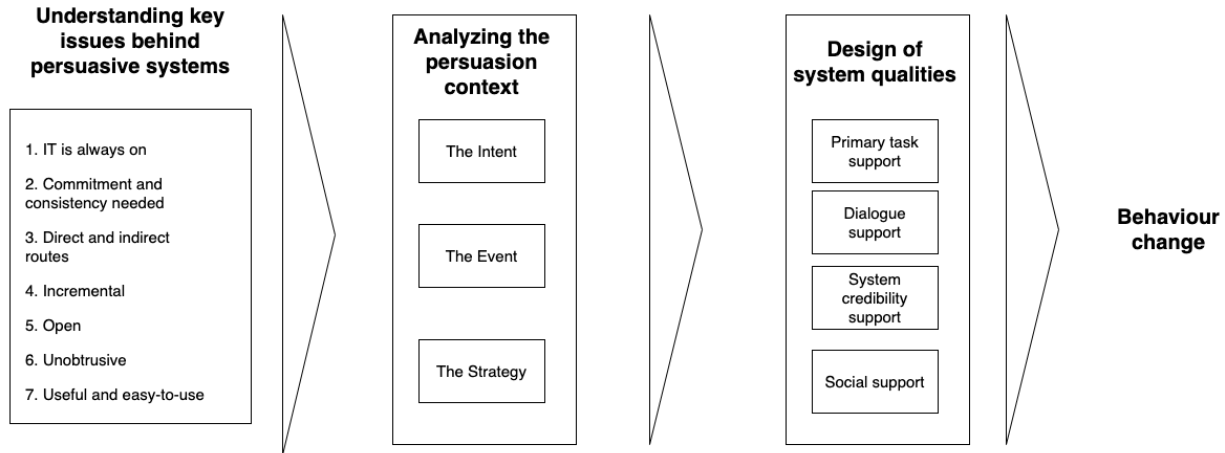


Figure 2.8: Phases in Persuasive Systems Design adapted from [28]

Oinas-Kukkonen and Harjuma[28] extended the functional triad concept introduced by Fogg[17]. They presented how the functional triad can be transformed into a software requirement for easy implementation, design and evaluation and provided the generic steps from analysis of persuasion context to software implementation as shown in Figure 2.9 below.

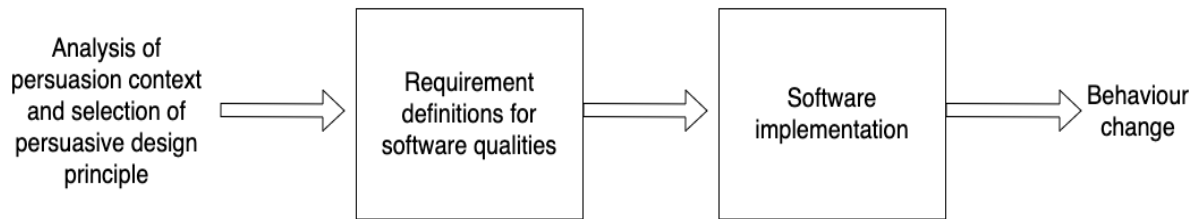


Figure 2.9: Generic Steps in PSD, adapted from [28]

The design qualities of any persuasive system can be categorized into four principles.

- a. *Primary Task Support*: This helps the user to perform the most important task of the behavioural change elements such as tunnelling, reduction, tailoring, self-monitoring, personalisation, simulation and rehearsal. Table 2.1 shows these principles with requirements and implementations as shown in [28].
- b. *Dialogue Support*: Persuasive systems should encourage some form of dialogue with the user. Examples of this principle include *praise, rewards, reminders, suggestion, similarity, liking and social-role*, and discussed in Table 2.2 below.



- c. *System Credibility Support*: Principles under the system credibility include *trustworthiness, expertise, surface credibility, real-world feel, authority, third party endorsement and verifiability*. These principles improve the credibility and reputation which can improve persuasion and are discussed in Table 2.3.
- d. *Social Support*: Consist of principles that can allow users of the system to interact with other users. Social support principles include *social-learning, comparison, normative influence, social facilitation, cooperation, competition and recognition*. These components are described in Table 2.4

Table 2.1: PSD's Primary Task Support

<b>Primary Task Support</b>		
<b>Principle</b>	<b>Example requirement</b>	<b>Example implementation</b>
<b>Reduction</b> A system that reduces complex behaviour into simple tasks that helps users perform the target behaviour, and it may increase the benefit/cost ratio of a behaviour.	System should reduce effort that users expend with regard to performing their target behaviour.	Smoking cessation Web site provides an interactive test that measures how much money a user will save with quitting.
<b>Tunneling</b> Using the system to guide users through a process or experience provides opportunities to persuade along the way.	System should guide users in the attitude change process by providing means for action that brings them closer to the target behaviour.	Smoking cessation Web site offers information about treatment opportunities after a user has taken an interactive test about how addicted (s)he is on tobacco.
<b>Tailoring</b> Information provided by the system will be more	System should provide tailored information for its user groups.	Web site for recovering alcoholics presents stories that are close to the user's

persuasive if it is tailored to the potential needs, interests, personality, usage context, or other factors relevant to a user group.		own story.
<b>Personalization</b> A system that offers personalized content or services has a greater capability for persuasion.	System should offer personalized content and services for its users.	Arguments most likely to be relevant for the user presented first on a professional Web site rather than in random order.
<b>Self-monitoring</b> A system that keeps track of one's own performance or status supports the user in achieving goals.	System should provide means for users to track their performance or status.	Heart rate monitor presents a user's heart rate and the duration of the exercise.
<b>Simulation</b> Systems that provide simulations can persuade by enabling users to observe immediately the link between cause and effect.	System should provide means for observing the link between the cause and effect with regard to users' behaviour.	Before-and-after pictures of people who have lost weight are presented on a Web site.
<b>Rehearsal</b> A system providing means with which to rehearse a behaviour can enable people to change their attitudes or behaviour in the real world.	System should provide means for rehearsing a target behaviour.	A flying simulator to help flight pilots practice for severe weather conditions.

Table 2.2 PSD's Dialog Support

<b>Dialog Support</b>		
<b>Praise</b> By offering praise, a system can make users more open to persuasion.	System should use praise via words, images, symbols, or sounds as a way to provide user feedback information based on his/her behaviours.	Mobile application that aims at motivating teenagers to exercise praises user by sending automated text messages for reaching individual goals. [Toscos et al. 2006]
<b>Rewards</b> Systems that reward target behaviours may have great persuasive powers.	System should provide virtual rewards for users in order to give credit for performing the target behaviour.	Heart rate monitor gives users a virtual trophy if they follow their fitness program.
<b>Reminders</b> If a system reminds users of their target behaviour, the users will more likely achieve their goals.	System should remind users of their target behaviour during the use of the system.	The system will send regular messages to the users especially during weekends and social activities to remind the user to be mindful of his/her drinking.
<b>Suggestion</b> Systems offering fitting suggestions will have greater persuasive powers.	System should suggest that users carry out behaviours during the system use process.	Application for healthier eating habits suggests that children eat fruits instead of candy at snack time.
<b>Similarity</b> People are more readily persuaded through systems that remind them of themselves in some meaningful way.	System should imitate its users in some specific way.	Slang names are used in an application which aims at motivating teenagers to exercise. [Toscos et al. 2006]

<b>Liking</b> A system that is visually attractive for its users is likely to be more persuasive.	System should have a look and feel that appeals to its users.	Web site that aims at encouraging children to take care of their pets properly has pictures of cute animals.
<b>Social Role</b> If a system adopts a social role, users will more likely use it for persuasive purposes.	System should adopt a social role.	E-health application has a virtual specialist to support communication between users and health specialists. [Silva et al. 2006]

Table 2.3 PSD's System Credibility Support

<b>System Credibility Support</b>		
<b>Trustworthiness</b> A system that is viewed as trustworthy will have increased powers of persuasion.	System should provide information that is truthful, fair and unbiased.	Company Web site provides information related to its products rather than simply providing biased advertising or marketing information.
<b>Expertise</b> A system that is viewed as incorporating expertise will have increased powers of persuasion.	System should provide information showing knowledge, experience, and competence.	Company Web site provides information about their core knowledge base. Mobile application is updated regularly and there are no dangling links or out-of-date information.
<b>Surface credibility</b> People make initial assessments of the system credibility based on a firsthand inspection.	System should have competent look and feel.	There are only a limited number of, and a logical reason for, ads on a Web site or mobile application.

<b>Real-world feel</b> A system that highlights people or organization behind its content or services will have more credibility.	System should provide information of the organization and/or actual people behind its content and services.	Company Web site provides possibilities to contact specific people through sending feedback or asking questions.
<b>Authority</b> A system that leverages roles of authority will have enhanced powers of persuasion.	System should refer to people in the role of authority.	Web site quotes an authority, such as a statement by government health office.
<b>Third-party endorsements</b> Third-party endorsements, especially from well-known and respected sources, boost perceptions on system credibility.	System should provide endorsements from respected sources.	E-shop shows a logo of a certificate that assures that they use secure connections. Web site refers to its reward for high usability.
<b>Verifiability</b> Credibility perceptions will be enhanced if a system makes it easy to verify the accuracy of site content via outside sources.	System should provide means to verify the accuracy of site content via outside sources.	Claims on a Web site are supported by offering links to other web sites.

Table 2.4 PSD Social Support

<b>Social Support</b>		
<b>Social learning</b> A person will be more motivated to perform a target behaviour if (s)he can use a system to observe others performing the behaviour.	System should provide means to observe other users who are performing their target behaviours and to see the outcomes of their behaviour.	A shared fitness journal in a mobile application for encouraging physical activity [Consolvo et al. 2006].

<p><b>Social comparison</b></p> <p>System users will have a greater motivation to perform the target behaviour if they can compare their performance with the performance of others.</p>	<p>System should provide means for comparing performance with the performance of other users.</p>	<p>Users can share and compare information related to their physical health and smoking behaviour via instant messaging application [Sohn and Lee 2007].</p>
<p><b>Normative influence</b></p> <p>A system can leverage normative influence or peer pressure to increase the likelihood that a person will adopt a target behaviour.</p>	<p>System should provide means for gathering together people who have the same goal and make them feel norms.</p>	<p>A smoking cessation application shows pictures of newborn babies with serious health problems due to the mother's smoking habit.</p>
<p><b>Social facilitation</b></p> <p>System users are more likely to perform target behaviour if they discern via the system that others are performing the behaviour along with them.</p>	<p>System should provide means for discerning other users who are performing the behaviour.</p>	<p>Users of a computer-based learning environment can recognize how many students are doing their assigned homework at the same time as them.</p>
<p><b>Cooperation</b></p> <p>A system can motivate users to adopt a target attitude or behaviour by leveraging human beings' natural drive to co-operate.</p>	<p>System should provide means for co-operation.</p>	<p>The behavioural patterns of overweight patients are studied through a mobile application, which collects data and sends it to a central server where it can be analyzed at the group level in more detail [Lee et al. 2006].</p>
<p><b>Competition</b></p> <p>A system can motivate users to adopt a target attitude or</p>	<p>System should provide means for competing with other users.</p>	<p>Online competition, such as Quit and Win (stop smoking for a month and win a prize).</p>

behaviour by leveraging human beings' natural drive to compete.		
<b>Recognition</b> By offering public recognition for an individual or group, a system can increase the likelihood that a person/group will adopt a target behaviour.	System should provide public recognition for users who perform their target behaviour.	Personal stories of the people who have succeeded in their goal behaviour are published on a smoking cessation Web site.

## 2.6 Game as a Persuasive Technology

Research has found that playing computer games can have perceptual, cognitive, behavioural, affective and motivational impacts and outcomes [29]. This has led to the categorization of games based on their impacts and outcomes into entertainment games and serious games[29]. Entertainment games are developed primarily for fun and relaxation while serious games comprise of game-based learning systems, persuasive games and any other games that inspire behavioural/attitudinal change. Persuasive games use procedural rhetoric to present information in video games [30]. Procedural rhetoric is defined as a visual-based method of presenting information to users in an interactive way to change their opinion. Some of the most prevalent benefits of using games as PT tool include improved interactivity, ease of accessibility and intuitiveness [30]. Video games designed to promote healthy behaviors have shown positive results even among children [31]. Baranowski et al. [31] evaluated the outcome of playing video games on children's diet, physical activities and adiposity. The result showed an increase in healthy food consumption (vegetables and fruits, but not water) and a moderate improvement in physical activities.

## 2.7 Technology Acceptance Model

The technology acceptance model has been used to explain users' adoption of information system in health, business, education and other domains. TAM was proposed by Fres Davis et al. [32] and

was based on Ajzen and Fishbein's theory of reasoned action (TRA) [33]. The theoretical model contains an important construct for interpreting the acceptance of a new system by users. TAM holds that the actual usage (AU) of a system is dependent on the intention to use (ITU) of the user. Furthermore, perceived usefulness and perceived ease of use influence the intention to use. i.e., if a user believes that a system is useful and the system is easy to use, the said user would have a stronger intention to use it. Moreover, external factors such as aesthetics and credibility influence perceived ease of use and perceived usefulness, as shown in Figure 2.10 below.

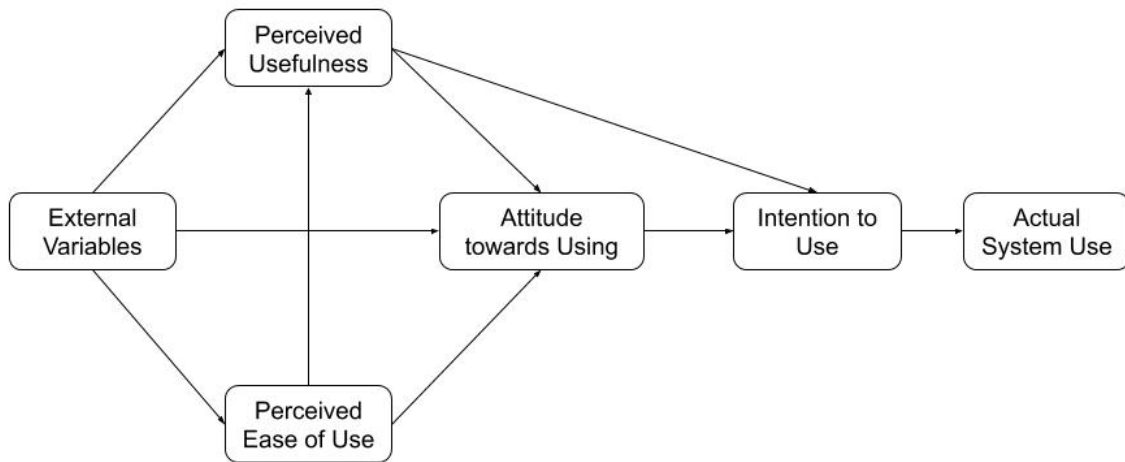


Figure 2.10: Technology Acceptance Model Adapted from [32]

Previous studies that have looked into the acceptance of a persuasive systems found perceived ease of use and perceived usefulness to be the strongest factors associated with intention to use. Tameka et al. [34] investigated the feasibility of a web-based alcohol management system in community sport, the result showed ease of use and usefulness to be the strongest factors among all other TAM constructs.

## 2.8 Alcohol Use Disorder

AUD is a mental sickness characterized in the *Diagnostic and Statistical Manual of Mental Disorders*, 5th edition, as alcohol use causing clinically significant impairment or pain. Alcohol is considered as the most widely utilized drug by Canadians with an expected 20% of drinkers consuming over Canada's low-risk alcohol drinking guidelines [35]. A 2016 report by the World



Health Organization (WHO), which evaluated alcohol consumption levels among the Canadian populace aged between 15 years and above, found the pervasiveness of AUD at 12% and 4.1% in males and females, respectively [36].

## **2.9 Adolescent Alcohol and Substance Use Disorder**

The term ‘adolescent’ is used to describe a young person or teenager forming from a child into an adult or grown-up. Regular use of alcohol, excessive drinking and other hazard risk-taking behaviours and practices, for example, smoking, substance use and risky sexual conduct are rising among adolescents [37]. Data from the 2014-2015 Canadian Student Tobacco, Alcohol and Drugs Survey (CSTADS) observed an 82.8% prevalence of previous year liquor use (or drinking) among young-adults aged 18, 19 and 24, whilst from age 25 and above, the prevalence was 77.8%. [38]

Overconsumption of liquor in young people has extreme wellbeing and social outcomes including alcohol dependence and emotional and mental health problems. *“Intoxication, memory loss and blackouts, injury, violence, accidents, domestic abuse, suicide, alcohol toxicity, and death”* are some of the short-term effects of alcohol use. While some of the long-term effects include *“alcohol dependence; increased risk of cancer (e.g., cancers of the mouth, throat, liver, breast and digestive tract); mental health problems (e.g. depression, anxiety), as well as social problems (e.g. lost productivity, unemployment, and family problems)”* [38].

## **2.10 Alcohol Use Disorder Identification Test**

Excessive drinking causes substantial risks or damage to the individuals, for example, significant drinking every day, repeated episodes of drinking to intoxication, drinking that is causing physical or mental harm, and drinking that has brought about the individual becoming dependent or addicted to liquor [36]. Consequently, excessive drinking causes illness and distress to the drinker and his or her family and friends. It was on this premise that Alcohol Use Disorder Identification Test (AUDIT) was created to screen for excessive drinking and specifically to assist specialists to distinguish people who would benefit from reducing or stop drinking. Most of the inordinate consumers are undiscovered.

AUDIT was created in 1982 by the WHO to recognize people whose liquor utilization has gotten unsafe and hurtful to their wellbeing. WHO defined AUDIT as *“a list of 10-item screening questionnaire including 3 questions on the amount and frequency of drinking; 3 questions on*

*alcohol dependence; and 4 on problems caused by alcohol*” [39]. The AUDIT items are shown in Table 2.5 along with the scores for each response type. Studies have bolstered the utilization of AUDIT in identifying potential AUDs [40]. It can help in recognizing exorbitant drinking as the reason for introducing ailment. Likewise, it provides a system for mediation to enable dangerous and hurtful consumers to lessen or stop liquor utilization and along this line keep away from the destructive outcomes of their drinking [41].

WHO conducted an initial study with 1888 participants to evaluate the AUDIT tool. Saunders et al. reported “*among participants diagnosed as having hazardous or harmful alcohol use, 92% had an AUDIT score of 8 or more, and 94% of those with non-hazardous consumption had a score of less than 8.*” [42]. AUDIT provides a simplified and most basic method of early detection of hazardous and harmful alcohol widely adopted in primary health care settings and is the first instrument of its type to be derived based on a cross-national study [34].

Table 2.5: WHO AUDIT Interview Questions, adapted from [41]

S/N	Item	0	1	2	3	4
1.	How often do you have a drink containing alcohol?	Never	Monthly or less	2 to 4 times a month	2 to 3 times a week	4 or more times a week
2.	How many drinks containing alcohol do you have on a typical day when you are drinking?	1 or 2	3 or 4	5 or 6	7, 8, or 9	10 or more
3.	How often do you have six or more drinks on one occasion?	Never	Less than monthly	Monthly	Weekly	Daily or almost daily
4.	How often during the last year have you found that you were not able to stop drinking once you had started?	Never	Less than monthly	Monthly	Weekly	Daily or almost daily
5.	How often during the last year have you failed to do what was normally expected from you	Never	Less than monthly	Monthly	Weekly	Daily or almost daily

6.	How often during the last year have you needed a first drink in the morning to get yourself going after a heavy drinking session?	Never	Less than monthly	Monthly	Weekly	Daily or almost daily
7.	How often during the last year have you had a feeling of guilt or remorse after drinking?	Never	Less than monthly	Monthly	Weekly	Daily or almost daily
8.	How often during the last year have you been unable to remember what happened the night before because you had been drinking?	Never	Less than monthly	Monthly	Weekly	Daily or almost daily
9.	Have you or someone else been injured as a result of your drinking?	No		Yes, but not in the last year		Yes, during the last year
10.	Has a relative or friend or a doctor or another health worker been concerned about your drinking or suggested you cut down?	No		Yes, but not in the last year		Yes, during the last year

## 2.11 Alcohol Use Disorder Measures and Interventions

Binge drinking has been identified as a public health issue [3] among adolescents and young adults. As a result, many researchers have conducted studies to better understand possible solutions. These studies reflect three broad categories of interventions: educational/awareness, developing cognitive/behavioural skills, and motivational/feedback-based interventions [7]. All the studies captured in this review are individually focused on intervention strategies.

### 2.11.1 Educational and Awareness Programs:

Studies categorized under the educational and awareness program were further subdivided into three:

a. *Information or knowledge programs:*

Lysaught [43] conducted research on an intervention which makes use of educational pamphlets containing information about the risks of drinking. The result showed a reduction in the number of drinks per week but noted limited small sample size and attrition as a limitation of the study. Neighbors[44] and Smiths[45] also used the educational/awareness approach by sending alcohol-risk awareness card to participants a week prior to their 21<sup>st</sup> birthday. The result showed no significant effect on the alcohol consumption of participants during the 21<sup>st</sup> birthday and was also limited by low response rate. Several other studies has revealed that the use of information-only intervention techniques is not effective for changing drinking behaviour [9]– [12].

b. *Normative re-education program:*

McNally [46] tested in-person normative re-education intervention. The authors administered a brief intervention to three mixed-groups — two intervention groups and a control group — of drinking and non-drinking students. The intervention groups were defined as:

*Self-norm discrepancy group:* focused on increasing a sense of divergence between one's drinking patterns and the realistic, normative drinking patterns of others through the provision and discussion of normative and other educative information.

*Actual-ideal discrepancy group:* focused on the enhancement of a sense of divergence between one's actual drinking and ideal drinking patterns through an empathic and non-confrontational group discussion.

The result recorded a significant reduction in heavy alcohol drinking episodes only in the self-norm group while the self-norm and control-group recorded a reduction in alcohol-related problems. The actual-ideal group shows no difference in alcohol drinking and alcohol-related problem. This study concluded that self-norm discrepancy intervention may be more effective than actual-ideal discrepancy strategies when used in mixed drinking group.

Peeler[47] evaluated the effectiveness of a self-management program (a curriculum to teach self-management skills to reduce high-risk sexual behaviours) only and self-management plus normative re-education (an additional module that focused on the peer norms correction of college students' perceptions of campus drinking and their actual drinking behaviour) within 2 groups and

the result showed a greater reduction in perceived drinking norms among participants of the normative re-education group, but no reduction of alcohol use and its consequences.

Smith[48] and Stamper[49] also recorded lower perceived norms (perception of college students overestimating how much alcohol their peers consume) among participants when they compared two groups of participants:

The intervention group: This group implemented a brief motivational intervention (messages to demotivate excessive alcohol use), value clarification (an interactive presentation focusing on clarifying the values of standard alcohol and risks of heavy drink), and normative re-education strategy (an intervention designed to change the perception of alcohol norms).

The control group used the same strategy as the intervention group minus normative re-education intervention.

Smith [10] found no change in the drinking behaviour of both groups and there were no negative alcohol-related consequences reported. The intervention group recorded a lower alcohol perceived norm than the control group. Stamper[49] reported that the intervention group for their study (a replicate of Smith[10]) showed reduced drinking frequency post-assessment and no noticeable difference in the control group.

Other studies such as [44], [50] evaluated the effects of normative-feedback (correcting overestimated peer drinking norms) and recorded favourable results in terms of reduced alcohol consumption of users after the studies. Hence, normative re-education programs appear to be an efficacious intervention in positively influencing and motivating drinking behaviour.

### **2.11.2 Cognitive/Behavioural Skills-Based Program:**

#### *a. Expectancy Challenge Intervention (ECI):*

Expectancy challenge intervention is a technique that is associated with challenging the expectancy that a participant associated with a behaviour to influence the actions of the participant regarding the said behaviour.

Musher-Eizenman et al.[51] defined alcohol expectancy as the individual's beliefs about the physiological, psychological and behavioural effects of alcohol on themselves and others. The

authors conducted a study to evaluate the effectiveness of the ECI in college women with moderate to high alcohol use. The result showed the participants' alcohol expectancy reduced over the six-week experimental period but there was no reduction in alcohol consumption.

Corbin et al. [52] evaluated alcohol expectancy using a series of questionnaires that assesses participants' beliefs about outcomes of alcohol use, past alcohol consumptions, and daily drinking pattern, in a study that involved males and females and the result shows a significant reduction in alcohol expectancy for both genders, and also reported that females in the ECI recorded an increased alcohol consumption to a greater degree. Lastly, Wiers [53] studied the effect of a multisession ECI in a mixed-gender sexual/social group, the outcome of the experiment shows a significant decrease in positive expectancies in women rather than men, but no significant evidence for a difference in drinking. Also, Wiers et al. [54] conducted studies on the effects of ECI in mixed-gender groups, and the result shows men recorded a significant decrease in heavy episodic drinking and weekly drinking, while women recorded decrease only in weekly, but not heavy episodic drinking. Overall, more studies suggest ECI being more efficacious for men than women.

*b. Self-monitoring/self-assessment:*

Carey et al.[55] conducted an interview involving six groups, three of which received a timeline follow-back (TLFB)[56] interview – a drinking assessment tool for estimating participant's daily drinking – alone and the others received TLFB and brief motivational intervention (BMI). The TLFB group only demonstrated a significant reduction in drinks per week and drinking days, a reduced peak blood alcohol content, and reduced heavy drinking episodes. No differences were recorded between the groups after a 12-month follow-up.

*c. Multi-components Alcohol skills training:*

Studies that evaluated multi-component intervention, a combination of more than one intervention technique, such as [57]–[64] provided support for this approach although with less strong evidence [65]. Lachance [63] suggested that the multi-component approach is more efficacious than educational intervention only, or assessment intervention only approach.

### **2.11.3 Motivation/Feedback-based program:**

This approach uses a feedback mechanism as a means to motivate users and influence behavioural change. Studies that employed this approach can be subdivided into two:

#### *a. Brief Motivational Intervention (BMI):*

BMI is a technique used in motivating behaviour change for risky drinking behaviour. It involves screening using the standardized Alcohol Use Disorder Identification Test (AUDIT). It aims at helping users to understand how alcohol puts them at risks and provide them with the required skills needed to consume alcohol without causing harm to themselves or society. Studies that evaluated the efficacy of these techniques have shown continuous support for this approach especially for college drinking students [65]. Larimer et al.[65] suggested that this approach may be the most useful especially when combined in particular with personalized normative feedback (by showing that people's performance is aligned with social expectations, and relatedness, by showing people that there are others in similar situations).

#### *b. Mailed or computerized motivational feedback:*

Studies show that mailed and computer-delivered feedback have significant results in reducing hazardous drinking as highlighted in the review of Larimer et al.[65]. However, Jander et al.[66] noted high attrition as a limitation for computer-based interventions. While all the above-mentioned studies have identified and tested different interventions, it is important to note that the studies were carried out with college students.

## **CHAPTER 3: PERSUASIVE TECHNOLOGY AS AN INTERVENTION FOR ALCOHOL USE DISORDER**

This chapter describes the purpose, research context of the intervention and the persuasive principles employed such as *self-monitoring, self-efficacy, social-learning, social-comparison and competition*.

The teenage years comprise one of the most important periods in one's life. This is the stage where people begin to transition into adulthood and undergo changes in emotions, personality, hormones and physical appearance. The teenage years is a phase in life when some important decisions like education and career choices are made. The internalization of messages that promote the use of alcohol, drugs and sexuality through movies, internet, adverts and billboards can lead to a distraction and result in making bad choices like addiction or engaging in dangerous sexual activities. Accidental death is one of the leading causes of death of young adults in Canada, and many of which are as a result of driving under the influence of alcohol [35]. Several interventions have been developed to address this problem. However, it seems that there is scarce research exploring how social learning can be employed to develop appropriate and effective interventions and how mobile technology can be used to deliver them. This study investigates the use of persuasive strategies (social learning) to develop an intervention using the mobile phone as a persuasive tool to delay the onset of alcohol use and curtail the harms associated with high alcohol consumption. This study received behavioural ethics approval from the University of Saskatchewan REB under of Saskatchewan under Nr. Beh-1565. The certificate of approval is included as Appendix I.

### **3.1 Research Context:**

With the prevalence of Alcohol Use Disorder (AUD) in society especially among young adults, AUD screening should be part of young-adults routine care. One of the ways to determine one's alcohol risk is by taking the alcohol use disorder identification test (AUDIT). AUDIT has been validated and supported by research to be suitable for young adults [67]. This tool is usually



administered using the traditional pen and paper means. This can limit the number of people that can access the tool and how often the test can be taken because it requires getting a fresh copy, taking the paper-based test (AUDIT) and manually recalculating the scores. Going this manual route can be tedious and discouraging and there's a need for a better and seamless way to determine one's alcohol risk level.

I developed a cross-platform mobile called CHEERS application that implements AUDIT and deployed it to the Google play store. The application was not approved for the Apple store even after meeting all the Apple marketplace requirements, so it was only available for Android phones.

The choice of a mobile application as against the use of other platforms (such as website) is because of the capabilities that is native to mobile devices. The ability to be able to nudge users using push notification is one of the important features of the mobile application, and this feature is not available on other platforms. Another important advantage of a mobile app is offline access. Most of the features of built into CHEERS does not require internet connectivity to function, and there is offline support for the features that need internet to function.

CHEERS can keep records/logs of alcohol consumption, inform users about their risk level based on the data provided on the app. Users can also see their performance level reflecting how well they are restraining from irresponsible alcohol use and observe the performance of other users of CHEERS. The application also offers a visual cue into the standard measurement of alcohol - what one standard drink represents based on the alcohol percent of the drink -- and contains educational resources about the dangers of alcohol abuse, and the best way to respond to alcohol emergency situations. The main functionalities of the app are briefly described below.

- a. *Audit Calculator*: This feature of the application helps the user to calculate their AUDIT score and determine the risk level automatically. This is an important feature as the traditional means has been the use of pen and paper which is error-prone, not easy to collate and difficult to scale.
- b. *Drinks Logger*: The app allows user to log their drinks and be able to visualize their drinking pattern over time
- c. *Standard Drink Estimator*: One of the biggest limitations of paper-based AUDIT is estimating what represents a "standard drink". A standard drink is any beverage that

contains approximately 14g of pure alcohol. The mobile app gives a visual representation of a standard drink quantity for different alcohol types.

- d. *Risk Reminder*: A nudge, inform of a notification that reminds the user when there is an increase in the number of drinking reported over a period of time, or when the user's alcohol risk level becomes harmful. It will also recommend to the user to seek medical attention when necessary.
- e. *Different ways to say "NO"*: Another feature of the application that is particularly useful for young adults is how to say "NO" when offered a drink especially at social gathering. This feature was developed as a game that simulates a social gathering and teaches the user on different ways to reject an alcohol offer under different circumstances.
- f. *Health risk resources*: The app also serves as a repository of resources that explains the health and societal risks associated with alcohol abuse.

The initial plan was to engage high-school students within the Saskatchewan province in Canada as the participants for this study, as the students' demographic represents the target of the intervention proposed in this study (teenagers and young adults), and there was an existing collaboration with the school districts in Saskatchewan, Canada. However, after securing an approval from the ethics committee of the Regina Roman Catholic Separate School (RRCSC) Division, the novel coronavirus pandemic hit, and schools and several other activities were shut down. This made the planned experiment in the schools impossible and forced me to open up the study participation to the general public that are above the legal drinking age of 19 (The Saskatchewan province legal drinking age). The next sections describe the methodology used to design the CHEERS persuasive application.

### **3.2 Design Methodology:**

The design, implementation and evaluation of a persuasive systems is a challenging endeavor, since it involves using the best theoretical and empirical results to guide the design of the system, and an iterative process of evaluation with end users, and changing the design to reflect the evaluation results. The Design Science Research (DSR) framework provides a suitable methodology, because it provides a mental model for presentation and evaluation of an information system through its stepwise processes shown in Figure 3.1 below. Each of the processes is explained below.

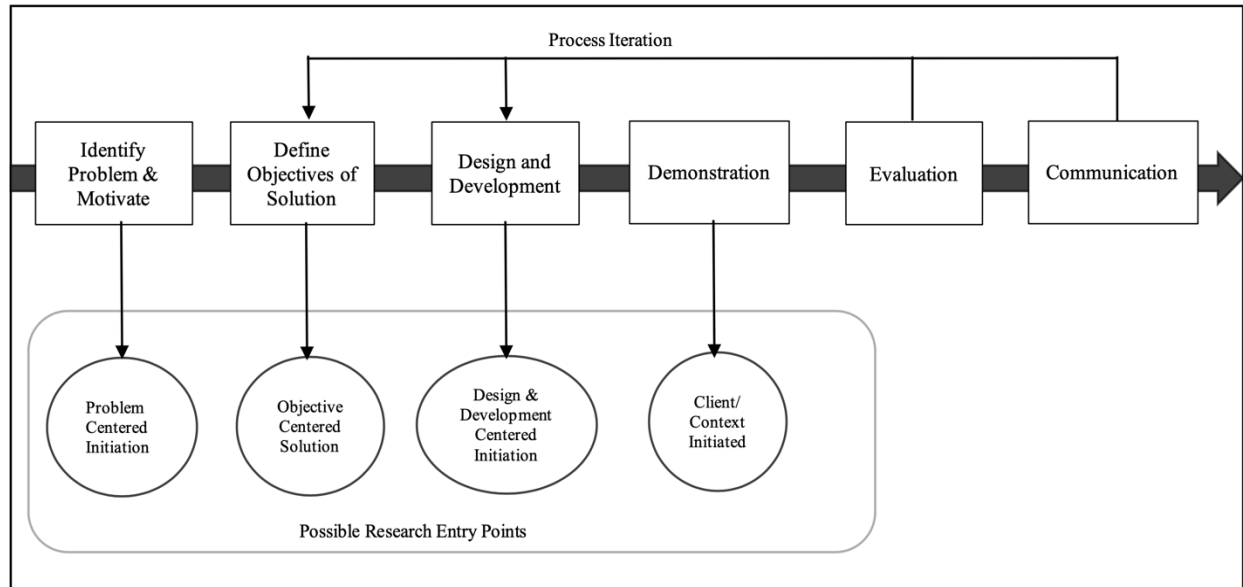


Figure 3.1: Design Science Research (DSR) Framework, adapted from [68]

### 3.2.1 Problem Identification and Motivation

This phase comprises the identification of the problem and the motivation. This has been explained in detail in Chapter 1. The major objective of my research and the question I am trying to ask is to look for new intervention approaches for mitigating harmful alcohol use disorder among young adults using persuasive technology.

### 3.2.2 Definition of Objective for Solution

While several studies have examined the relations between social influence (a social persuasive strategy from the PSD model), and the prevalence of binge drinking among young adults, none of the papers I have found have investigated the efficacy of social influence strategies such as social comparison and competition in delivering a more effective intervention. Social influence emphasizes learning via observation of the behavior of others [69]. Social influence strategies are the most-widely used in persuasive technologies that address behavioral and attitudinal change in health-related domains [70]. Moreover, research has found that multicomponent intervention can

be more effective [71] and also highlighted that studies that include personalized feedback, moderations strategies, and goal-settings are effective in reducing alcohol-related behavior issues among teenagers. Hence, I intend to explore how open will teenagers and young-adults be to the idea of using a mobile phone as a means to dissuade AUD and also investigate the efficacy of social comparison and competition in effecting a positive alcohol use behaviour while keeping other strategies such as self-monitoring, goal setting and reward constant.

### 3.2.3 Design and Development

From the research context discussed above, and the analysis of the literature on persuasive technology and behaviour change theories presented in Chapter 2, I decided that the mobile application will have the following persuasive strategies.

- i. *Self-Monitoring*: Self-monitoring is one of the components of self-control, a construct of the social cognitive theory discussed in section 2.3. It is a way to keep track of one's performance towards the actualization of a goal. Self-monitoring increases the sense of responsibility of people and causes a behaviour reflection. Hustad et al. [72] conducted a study to test the relationship between self-regulation, alcohol consumption and alcohol-related consequences on a group of 170 participants. The result showed that alcohol-related consequences and alcohol consumption is lower for participants with a higher ability to monitor and observe themselves. Self-monitoring is implemented in PT with a feature or set of features that allow users to track their performance or status [28]. The ability to monitor calories burnt, heart rate or other metrics during an exercise in a mobile app that encourages physical activities, or the ability to monitor the number of drinks and blood alcohol concentration in an application that discourages alcohol abuse are ways self-monitoring has been implemented in PT.

In my application, participants can log and keep records of their drinking; the type of drink (Light beer, malt liquor etc.), the volume of the drink (e.g. 12oz), the alcohol percentage (e.g. 5% for Light beer), and the quantity (number of drinks, e.g. 2 light beers). This information is aggregated and can be visualized in a way that can allow participants to notice their pattern of drinking over time.

ii. *Social Learning*: Social learning is the acquisition of knowledge and understanding by observing the behaviour and the consequences of the behaviour of others. Bandura [24] explains social learning as a reciprocal interaction between behaviour, a person and the environment. The continuous learning and reinforcement of drinking behaviours can be either active (i.e., alcohol offers) or passive (i.e., social modelling, normative behaviour, etc.) [73]. The level of exposure in the conventional and social media to the advertisement and promotion of alcohol messaging helps to influence the norms about alcohol use. This exposure particularly affects teenagers and young-adults as it leads to an increase in underage drinking according to a study conducted by Grenard et al. [74]. The study assessed 3890 students from grade 7 to grade 10 every year for 4 years. The result showed that exposure to alcohol-related adverts from an early age increases their alcohol consumption, and an increase in alcohol consumption increases significantly, the chances of alcohol-related problems.

In PT, social learning can be implemented by providing a means for the users to observe the behaviour of others or the consequences of the behaviour of others. For example, visualising, via a mobile app that encourages physical activities, the number of calories burnt by users that actively engage in physical activities over some time can persuade people to engage more in physical activities as it creates a positive expectation (cognition) about performing these activities. Social learning does not necessarily equate to competition or cooperation as the person learning from behaviour is not always required to engage in the said behaviour. Social learning can be through modelling, imitation and observation [75]. In our application, participants can observe how other participants are faring as regards to abstaining from alcohol use.

iii. *Social Comparison*: Social comparison is one of the components of social support construct of SCT. People evaluate themselves by comparing their performance to the performance of others around them. More importantly, they compare themselves with people that are similar to them and share many characteristics like age, year in school, environment etc. [76]. Research has found social comparison as a strong social influence moderator for alcohol consumption among adolescents [77]. In PT, social comparison is implemented by giving the user a way to compare their performance with the performance of other users like the ability to share and compare information related to their physical health and smoking behaviour via instant messaging

application [28]. In our application, participants can compare their performance as regards abstaining from alcohol with other participants in the study.

- iv. *Competition:* Competition is a form of intrinsic motivation. It is the desire to outperform other participants in achieving a goal. In PT, competition is implemented in a way that motivates users to adopt behaviour by leveraging human's natural drive to compete [28]. Competition can be with the system, or with other users. In our application, users are encouraged to outperform the aggregate of all other users in their performance score, and in doing so, they earn a virtual reward.
- v. *Feedback:* This mobile phone application feature provides real-time on a user's current progress and gives the user personalized feedback on the alcohol effect on their body. This feature helps to nudge the user towards healthy drinking behaviour.
- vi. *Goal Setting:* Goal setting has been demonstrated to be a powerful technique for behaviour change [78] hence, utilizing goal setting in PT could be a viable method to encourage behaviour change. In our application, participants have a goal to maintain a score of 100 points in alcohol abstinence, consuming more alcohol reduces the score and they only gain points when they abstain from drinking for every 24 consecutive hours.
- vii. *Rewards:* The user receives a 'golden bar' for achieving the set goal of 100 points, this gives credit to the user for performing the target behaviour – healthy drinking behaviour.
- viii. *Reminder:* The application reminds users at least once a week the status of their alcohol consumption, if their consumption rate is increasing and if they need to re-evaluate themselves by taking the AUDIT again to re-ascertain their risk level.
- ix. *Simulation:* Simulation in PT is a system that provides a means for users to observe the cause and effect of an action or behaviour [28]. In CHEERS app, I integrated a game to simulate situations where users are offered a drink and the effect on their body as they consume the drink. Also, when users are adding new drinks, the expected effect of the drink on their body organs are presented to the user.

This thesis aims to explore the potential of CHEERS app in addressing the issue of irresponsible alcohol use amongst teenagers and young adults. It has been established that at this age bracket peer opinion is a strong factor in behavioural patterns. Furthermore, it is safe to presume that in a peer construct, deception and or coercion is rarely employed. Therefore, the PT framework is an

ideal model in the creation of CHEERS such that it could stimulate healthy alcohol usage, while been backed by the power of peer involvement (comparison and competition etc).

#### **3.2.4 Evaluation**

The system is evaluated based on the effectiveness of the proposed strategy. A t-test statistical method is used to compare the AUDIT score of all participants before and after using the application, and also to compare the scores of the participants that uses the version of the application that contains the social strategy to that of the participants that do not contain the social strategy.

Also, the Fishers exact test is used to determine what drives the intention to use and the intention to continue using a mobile-based intervention mechanism that reduces alcohol risks by reducing AUDIT score.

#### **3.2.5 Communication**

This stage entails the writing and publishing of the findings of my research. This will include the outcome of the proposed intervention and the result of its receptiveness.

This thesis aims to ascertain the efficacy of CHEERS app in solving the issue of AUD amongst teenagers and young adults. It's been established that at this age bracket peer opinion is a strong factor in behavioural patterns. Furthermore, it is safe to presume that in a peer construct, deception and or coercion is rarely employed. Therefore, the PT framework is an ideal model in the creation of CHEERS such that it could stimulate healthy alcohol usage, while been backed by the power of peer involvement (comparison and competition etc).

## CHAPTER 4: DEVELOPMENT AND IMPLEMENTATION

This chapter highlights among other things the Framework, which includes the design and implementation of an actual persuasive health application (in this case CHEERS; with the purpose of causing a shift in how users consume alcohol). Furthermore, the application's architecture and the component will also be discussed in this chapter.

As earlier alluded to, the name of the application is CHEERS. This name came about following the interactions with some of the high school students in Saskatoon, Saskatchewan, who felt that it had a ring of positivity to it. Moreover, worldwide, wherever alcohol is been consumed on a social scale, the word 'cheers' or its literal meaning in the Lingua franca is echoed by many.

The main technology stack employed in the implementation of CHEERS discussed below.

- a. **Visual Studio (VS) Code:** This is one of the most popular code editors, developed by Microsoft and is widely employed by developers and software engineers. It supports several programming languages like JavaScript, Python, Java, C#, Ruby, Go etc. It has a built-in Git, a version control system for tracking code changes. Visual Studio (Figure 4.1) also integrates seamlessly with other technology tools such as GitHub, Docker and Kubernetes. I used VS Code version 1.40 to develop CHEERS. I decided to use VS Code as the code editor because



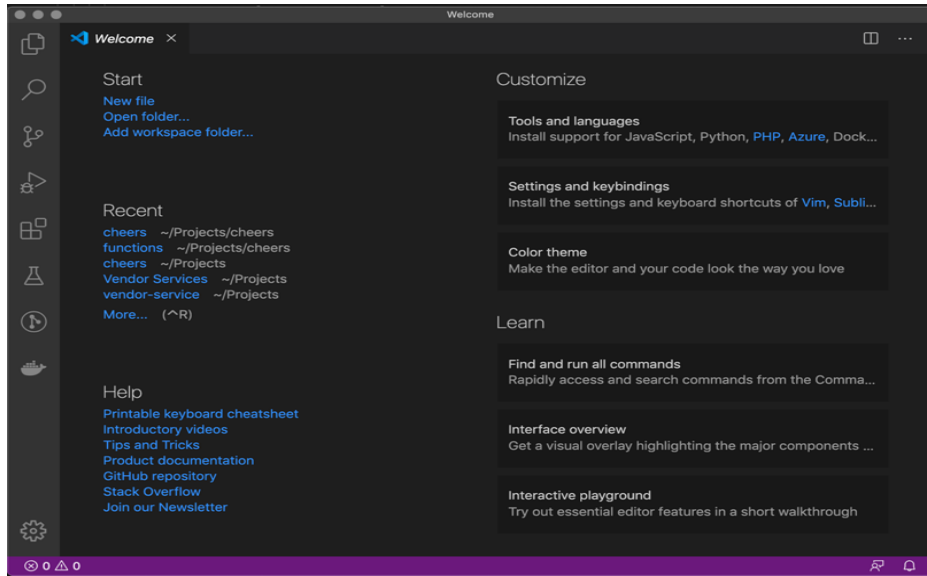


Figure 4.1: A Screenshot showing my VS Code Set-up

of its popularity and extensibility. VS Code is light weight and easily extensible. There are also many resources and documentations available which makes it easy to set up.

- b. **GitHub:** GitHub is an online service that provides hosting for software development version control as one of its primary functionality [79]. Projects are created in repositories and can be shared easily with other developers and engineers for collaborations and contributions. It is one of the most popular source code management hosting platform with over 100 million repositories and 40 million users [79]. Figure 4.2 shows the GitHub repository for CHEERS.

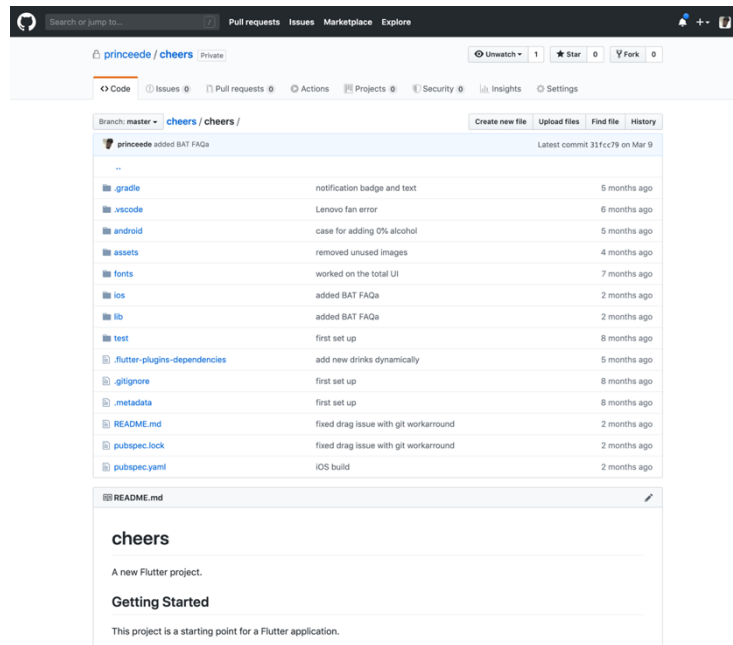


Figure 4.2: A Screenshot showing the CHEERS Repository on GitHub

GitHub allow users to create private repositories and also has a robust documentation, which makes a very good option for the CHEERS project.

- c. **Google Firebase Service:** Google Firebase is a collection of services created by Google; providing developers with cloud-based tools and services to help with the development of backend and server-side applications. Some of the main services provided by Google's Firebase, which was utilized in the development of the CHEERS app include *Cloud Firestore Database*, *Cloud Functions*, *Cloud Storage*, and *Cloud Messaging*. Figure 4.3 below shows the Google Firebase Console.

Firebase is a backend platform for building Web, Android and IOS applications and allow developers to focus on maximizing user experiences. Firebase serves as server, API and data storage, all of which is written generically so that it can be modified to suit most needs, this is why it is a perfect choice for the CHEERS project. The services of Firebase employed in the development of CHEERS is discussed below.

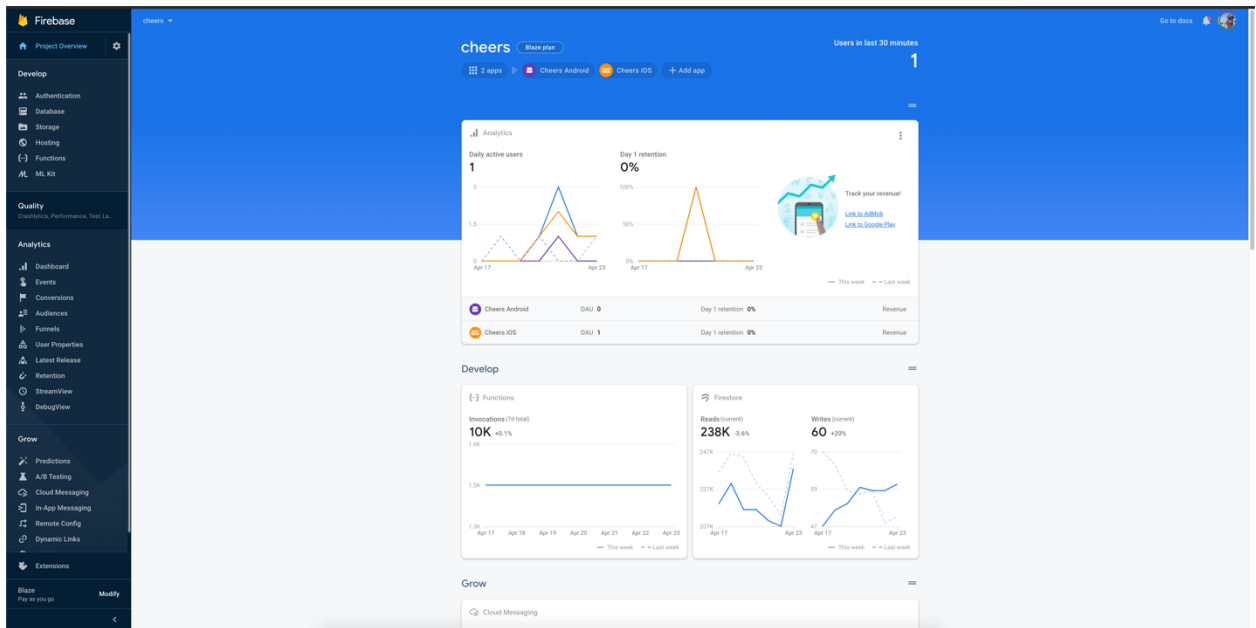


Figure 4.3: Google Firebase Console Interface

- i. *Cloud Firestore Database*: It is a NoSQL database for storing and syncing user's data in real-time. It also has offline accessibility by storing a cache of the database on the user's device and uploading it when the user connects to the internet [80]. This offline support makes the database a suitable option for the CHEERS project.
  - ii. *Cloud Functions*: Cloud functions eliminates the processing for developers to spin-off and manage their own servers. Backend codes can be written and deployed to cloud functions. The cloud function is triggered by events which can be emitted by google services or external (third-party) services [80].
  - iii. *Cloud Messaging*: This is a firebase service to send messages and notifications to users across different platforms. Messages can be sent to all users, a single user, a group of targeted users based on attributes such as platform (Android/iOS), topic (grouping users to topics such as gender, age, ethnicity, interest etc.) [80]
- d. **Flutter Software Development Kit (SDK)**: Flutter is an open-source user-interface (UI) SDK created by Google using the Dart programming language. It is a cross-platform SDK that is used in the development of applications for multiple platforms such as Android, iOS, and the web. Flutter has a very robust widget library that can be very useful in developing

beautiful user interfaces. This robust widget libraries is the major reason I decided to use flutter as the SDK for cheers.

- e. **Android Studio:** This is the official environment for developing android applications. It is built on IntelliJ IDEA software and available for Windows, Mac and Linux OS [81]. It comes with an in-build emulator that allows developers to test-run their applications without bundling it to an external device. In the development of CHEERS, I used android studio version 3.3.
- f. **XCode:** XCode is Apple's equivalent of Google's android studio. It is the official development environment for Apple operation systems (macOS, iOS, iPadOS, watchOS and tvOS). It was developed and currently being managed by Apple. XCode also comes with iOS simulator that allows developers to run their code on a simulated iOS device without connecting and bundling the code to an external iOS device. I used XCode version 11.3 in developing CHEERS.

#### **4.1 Android and IOS platforms**

This section describes briefly the android and the iOS platform.

##### **4.1.1 Android Operating system**

Android is a mobile operating system designed and developed by Google which was released in 2008 and intended to run mobile devices such as smartphones. The operating system utilizes tactile inputs such as dragging, tapping to exploit display objects and virtual keyboard [78]. As of March 2020; the Android OS has the largest installed base on all mobile operating systems, accounting for 72.26% [82]. From its inception in 2008 to now, the Android OS has had many upgrades that have been gradually improved its operating system by adding new features and fixing errors in previous versions.

##### **4.1.2 Google Play Store**

The Google Play Store is the official marketplace for distributing Android applications. It is been managed by Google and android application developers will have to submit their applications through the Google Play Console dashboard (Figure 4.4) for the app to be listed on Play Store. The dashboard also shows analytics about app usage and coverage and comments from users.

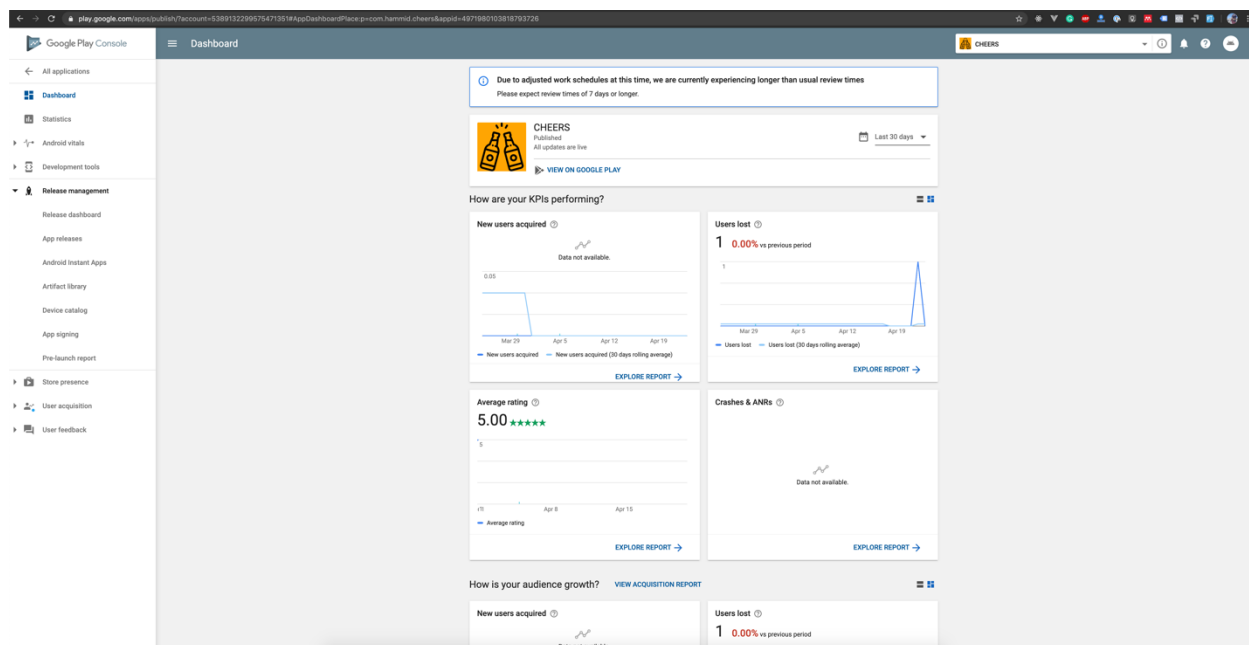


Figure 4.4: Google Play Console Dashboard for CHEERS

### 4.1.3 iOS Operating System

iPhone operating system popularly known as iOS is a mobile operating system developed in 2007 by Apple Inc., which runs exclusively on Apple's mobile devices such as *iPhone*, *iPad*, *iPod touch*, *Apple TV* and *Apple watch*. As at January 2017, Apple's App Store contained more than 2.2 million applications, all of which had been downloaded over 180 billion times [82]. Furthermore, the operating system had 710 million active devices running in the year 2017.

### 4.1.4 Apple App Store

Apple App Store is the official marketplace for iOS applications, and iOS app developers will have to submit their applications via the Apple Play Store Connect Console (Figure 4.5) for review by Apple. Only applications that have been successfully reviewed and approved can be listed on the Apple App Store.

## 4.2 Cross-platform mobile application Technologies

Cross-platform mobile application technologies are Software development kit (SDK) that allows for the development of mobile applications that can run across various mobile operating system, usually Android and iOS. This makes it possible to write code once and run it on more than one platform, the implications of which are most beneficial including but not limited to the quick release or update of an application. Some popular cross-platform mobile applications development kit includes Adobe PhoneGap, Appcelerator, Cordova, React Native, Xamarin, Flutter etc. to name a few. On the other hand, we have native platforms that are used to create apps solely on only one platform like Android Studio for android and XCode for iOS described above.

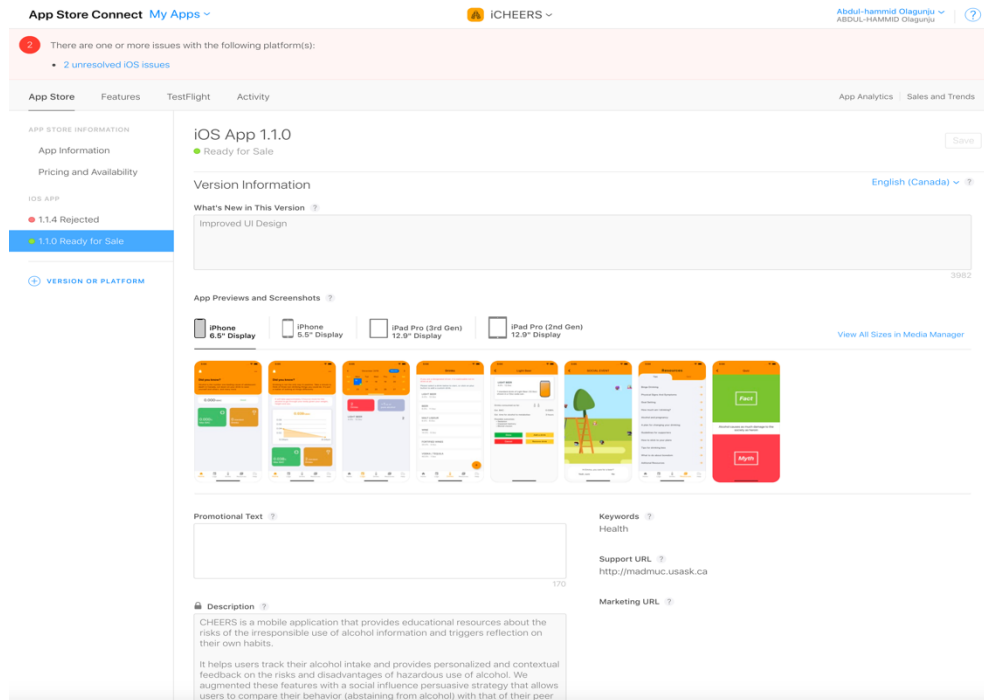


Figure 4.5: App Store Connect Console Dashboard for CHEERS.

## 4.3 Architecture of CHEERS

The app utilizes cloud-based technology to maximize its functionalities. Shown below in Figure 4.6 is a schematic of the interaction between CHEERS cloud-based component and its mobile client.

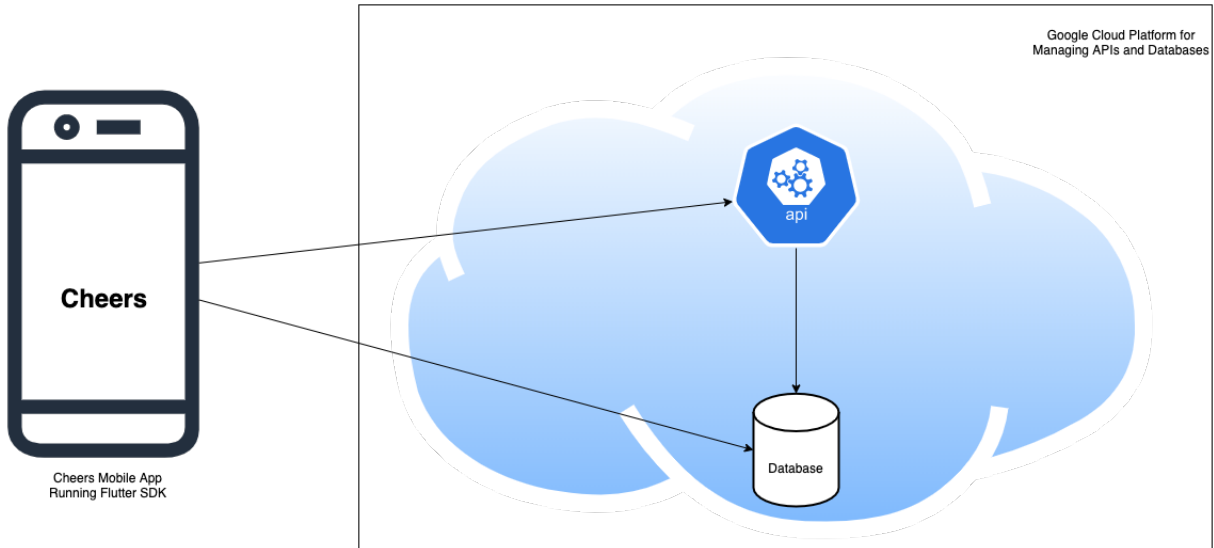


Figure 4.6: Architecture of CHEERS app

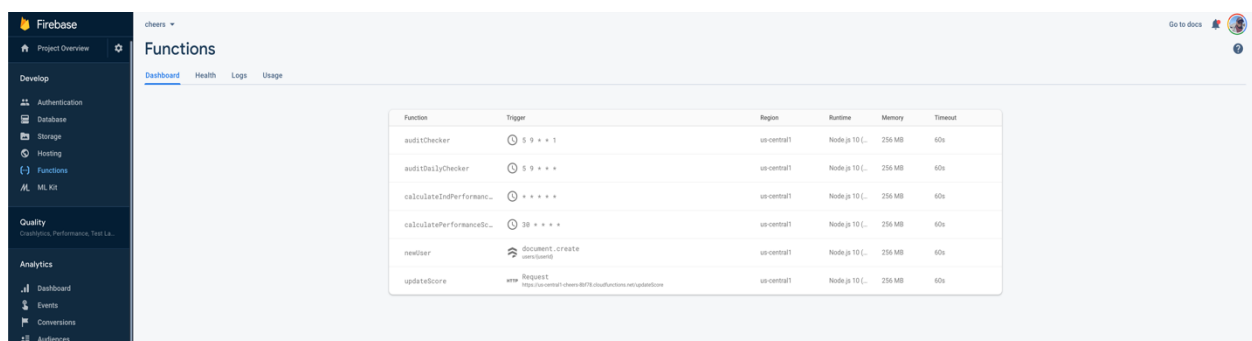
*Mobile Client:* This is the mobile device (smartphones and Tablets) on which CHEERS app is installed and run by the user. These mobile devices operating systems can be powered by either Google’s Android or Apple’s iOS, which accounts for 72.26% and 27.03% of the world’s mobile operating system respectively [82]. The users download and install CHEERS from Google’s Play Store (Android) only as the application was not approved for Apple App Store (iOS).

*Application Programming Interface (API):* The APIs component represents backend codes stored in the cloud, which are activated by requests via Hypertext Transfer Protocol (HTTP) between the mobile client and the server hosting the APIs. Furthermore, the API makes it easy to update the app using the cloud-based backend code without releasing a new version of the app to the marketplaces (Play Store and App Store). Some of the APIs used in CHEERS are shown in Figure 4.7 below.

*Database:* The cloud-based database component is both flexible and scalable database that is used to store the user’s data (e.g., demographic data, logs etc.) in the cloud. It allows user data to be

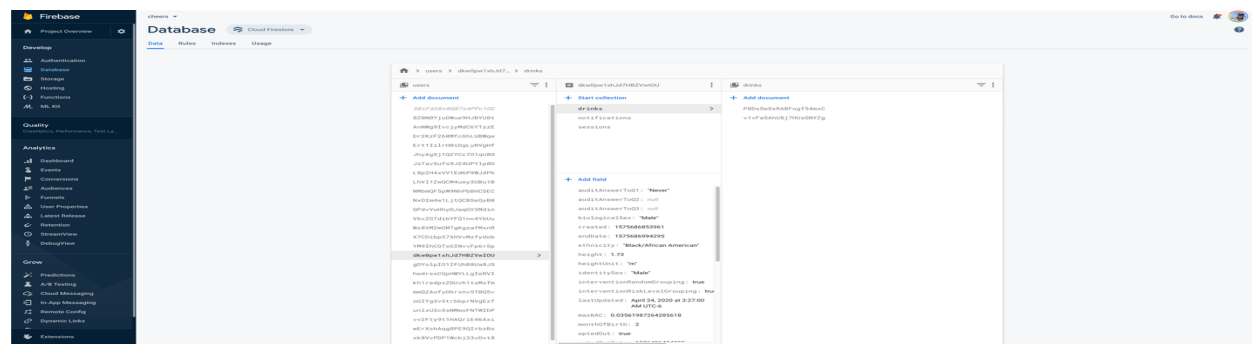
pushed and retrieved from the cloud through an Internet connection. It keeps user data in sync and supports offline capability as well. The screenshot of the database is shown in Figure 4.8

To improve data security, firebase encrypts data in transit using the hypertext transfer protocol secure (HTTPS) and also encrypt the data at rest (when stored). The database service used for this project is also certified under major privacy and security standards such as the international organisation for standardisation (ISO) 27001, 27017, 27018, and systems and organisation controls (SOC) 1, 2 and 3.



Function	Trigger	Region	Runtime	Memory	Timeout
auditChecker	⌚ 5 9 * * *	us-central1	Node.js 10 L	256 MB	60s
auditDailyChecker	⌚ 5 9 * * *	us-central1	Node.js 10 L	256 MB	60s
calculatePerformance...	⌚ * * * * *	us-central1	Node.js 10 L	256 MB	60s
calculatePerformanceC...	⌚ 28 * * * *	us-central1	Node.js 10 L	256 MB	60s
newUser	📄 document_create (firebase)	us-central1	Node.js 10 L	256 MB	60s
updateScore	🌐 Request (https://central1-chunks.firebaseio.com/functions/updateScore)	us-central1	Node.js 10 L	256 MB	60s

Figure 4.7: Google Cloud Function Interface Showing Some of the Cloud Function APIs



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Figure 4.8 Sample Data on Google Firestore Database.

#### 4.4 User interface (UI) of CHEERS:

The UI of the application is optimized for both smartphones, tablets and the phablet. The App spots 4 navigation buttons situated at the lowest end of the screen with a horizontal layout namely (Home, Logs, Drinks and Resources). Some of the screens are briefly discussed below.



*Home:* This is the main user interface; it also serves as the app's dashboard providing a general overview of information ranging from performance chart, quick facts and quantity of number of drinks consumed on the app (Figure 4.9 below).

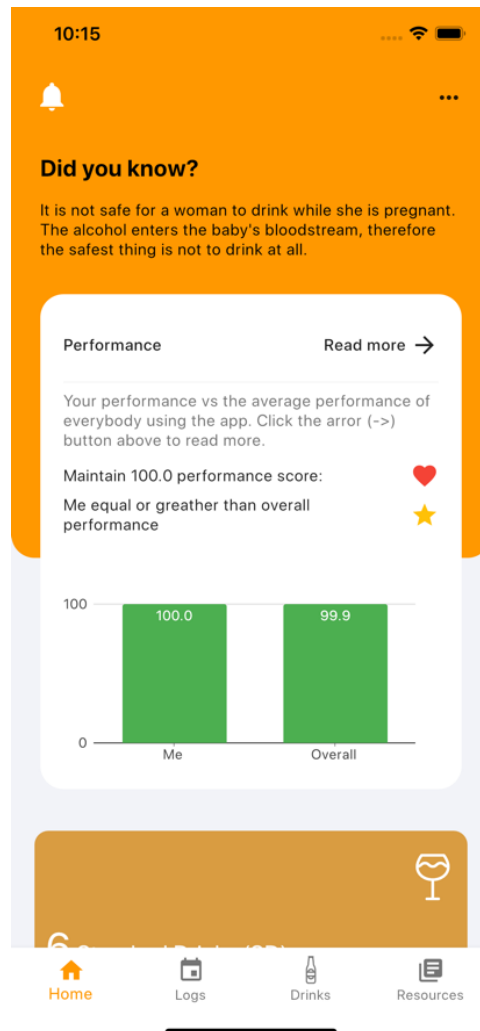


Figure 4.9 Home page of the CHEERS application

*Logs:* This page (Figure 4.10) highlights the users previous drinking pattern. It is displayed in the form of a bar chart so that participants have a visual cue of their drinking pattern over a while. Moreover, each bar on the chart can be selected individually to provide more information on the types and quantity of drinks consumed within the period in view.

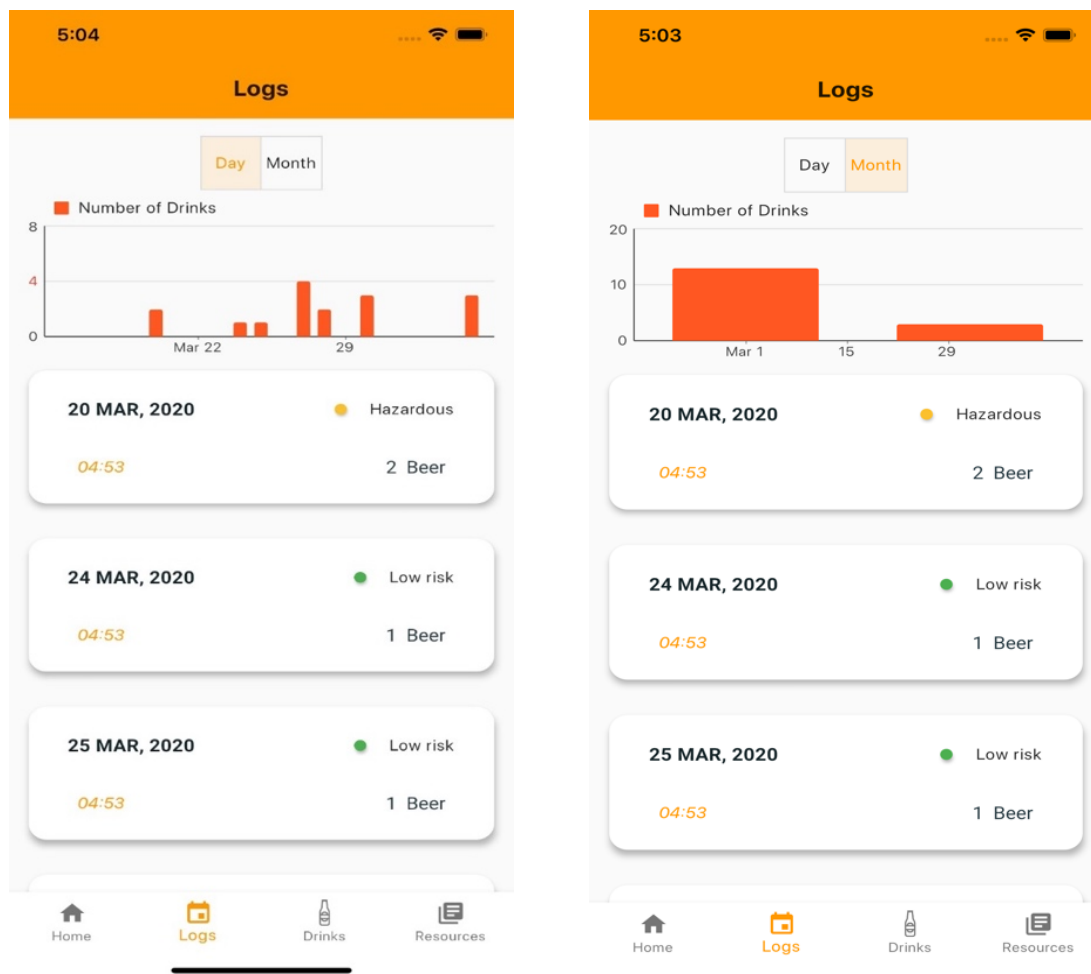


Figure 4.10: Logs Page Showing Day and Month View

*Drinks page:* This page shows a list of popular drinks (light beer, beer, Malt Liquor, Wine, Fortified wines and hard alcohol etc.) with their alcohol percentage and the volume that constitutes one standard drink. Users are required to select any of these drinks depending on when/if they are having the drinks (Figure 4.11 left).

*Drink details:* This is page is an extension of the drink page, it appears when a drink is selected from the drink page. It shows an estimate of the volume of drink in a soda can. This is to give the user a visual cue of volume consumed (12oz, 5oz etc.) and associated outcome and impairments (e.g. visual impairment, lack of coordination or slurred speech etc.) (Figure 4.11 right).

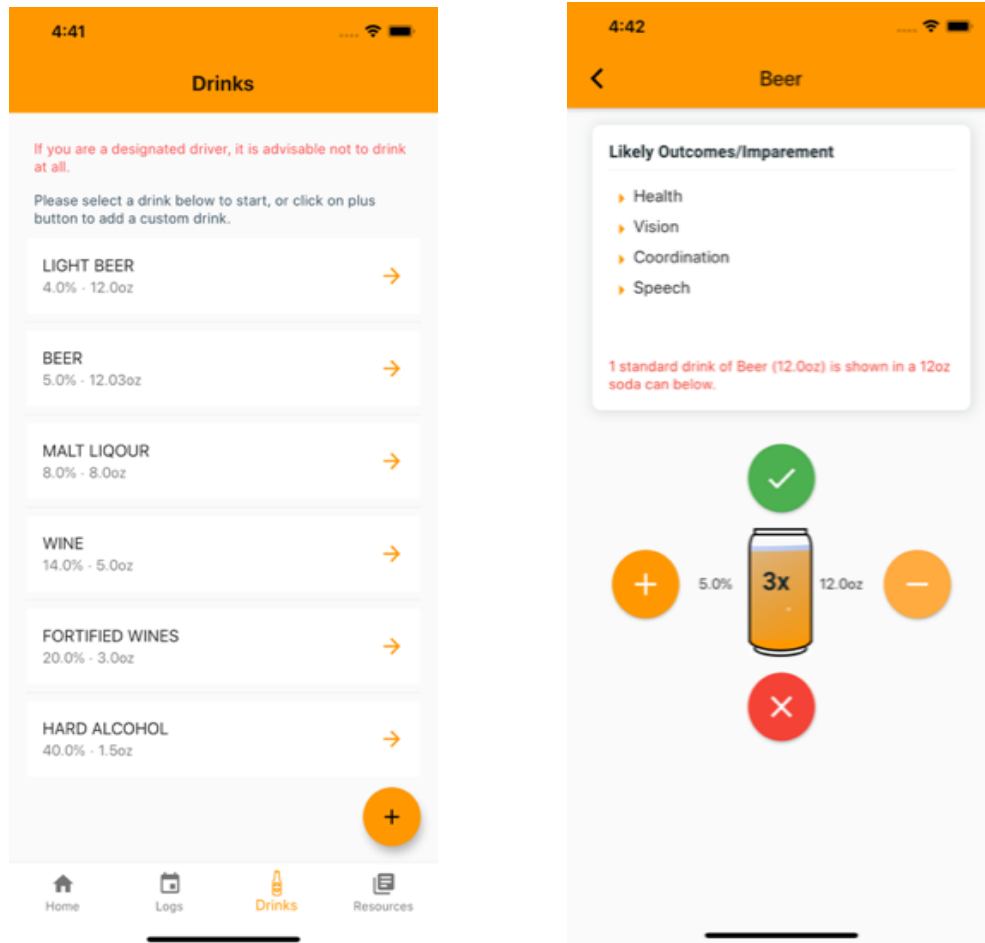


Figure 4.11 Drinks and Drinks Details page

*Resources (Tips):* This page contains an array of information tagged tips, and quiz. The information was extracted from reputable health institutions like aeprogram.ca, drugs.ie with permissions to use the resources (Appendix G). The list of tips and an example of the tips details is shown in Figure 4.12.

*Resources (Quiz):* The quiz contains 7 questions where the users are to decide if it's a myth or a fact as shown in Figure 4.13.

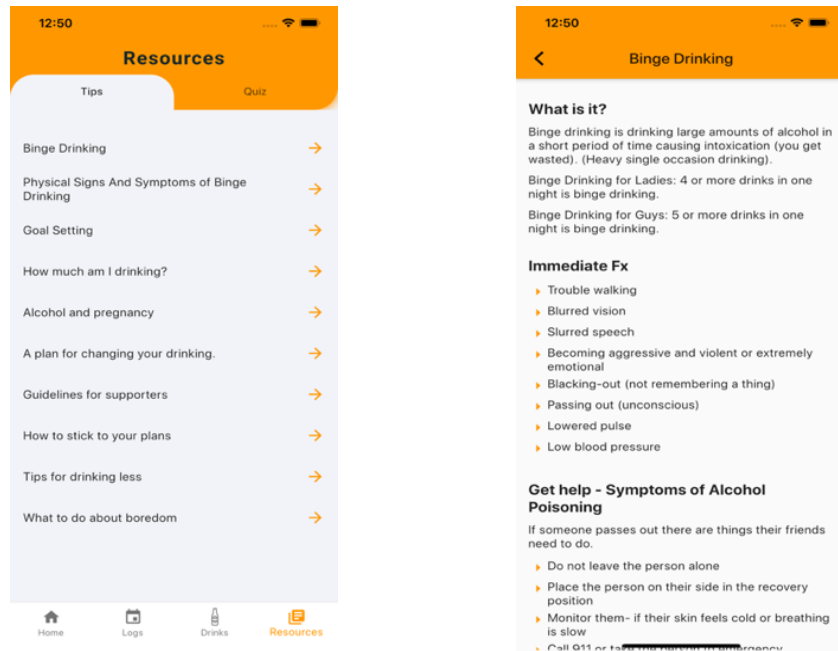


Figure 4.12: Screenshot showing resource list screen and resource details screen

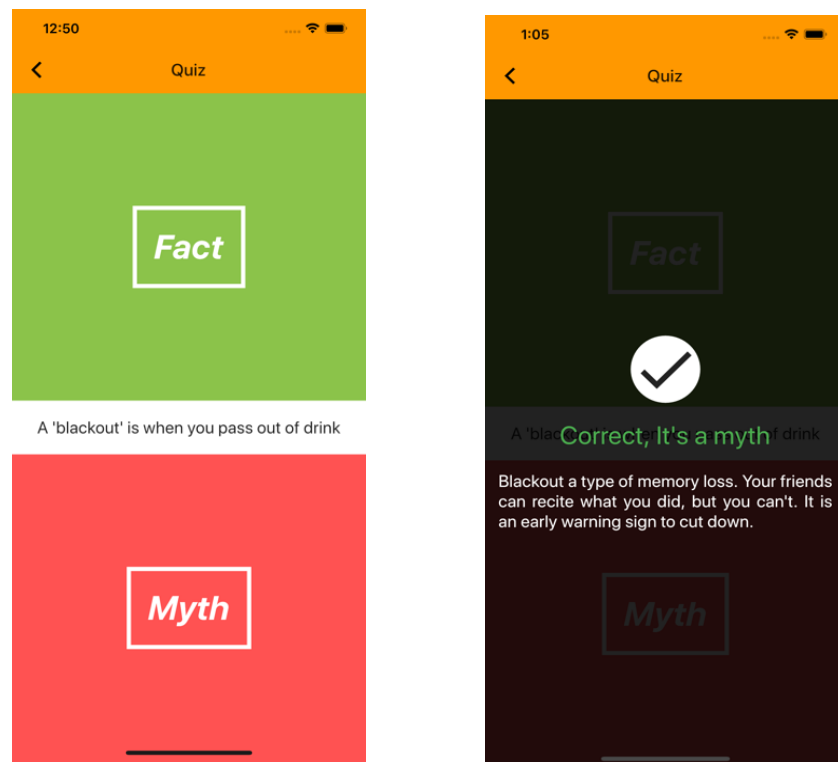


Figure 4.13: Screenshot for quiz and quiz explanation.

*Game:* The CHEERS game is designed to simulate a social gathering situation where users can find themselves and educate them on possible ways to say “NO” with alcohol and likely excuses. This represents the implementation of simulation, primary task support of PTs. This implementation is shown in Figure 4.14 below.

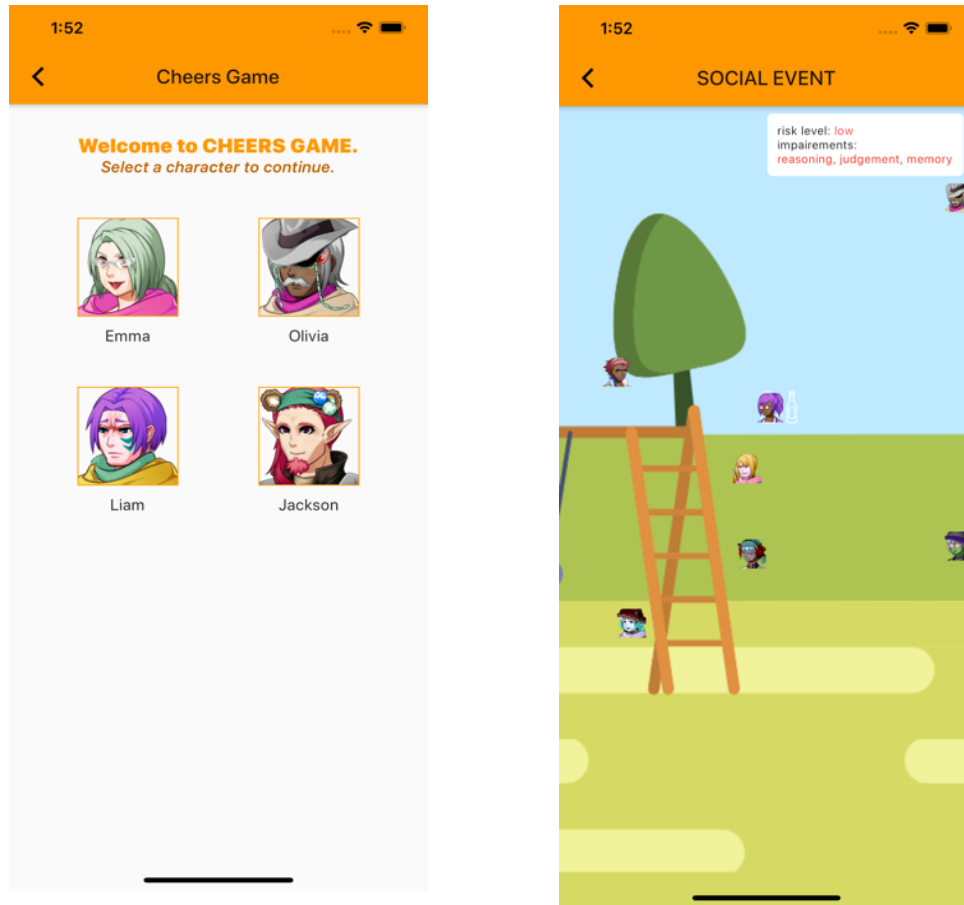


Figure 4.14: Screenshot showing the CHEERS Game

## CHAPTER 5: EXPERIMENT DESIGN, TOOLS AND PROCEDURE

This section describes the experimental design and procedures, participants demographic and location, participant consent form and tools used in this study.

### 5.1 Participants

Participants of this study are adults from Saskatchewan above the legal drinking age of 19. To be eligible to participate in this study, all participants were required to have a personal Android device. I recruited participants through the use of social media, word-of-mouth and PAWS (University of Saskatchewan internal portal system). People that showed interest gave consent to participate in the study and answered an online pre-qualification questionnaire about their demographics and alcohol use. The aim of the pre-qualification questionnaire was to filter out participants that are below the age of 19, do not have an android device and/or are at no risk to alcohol use disorder (people that have never consumed alcohol). The items on the pre-qualification questionnaire are explained below:

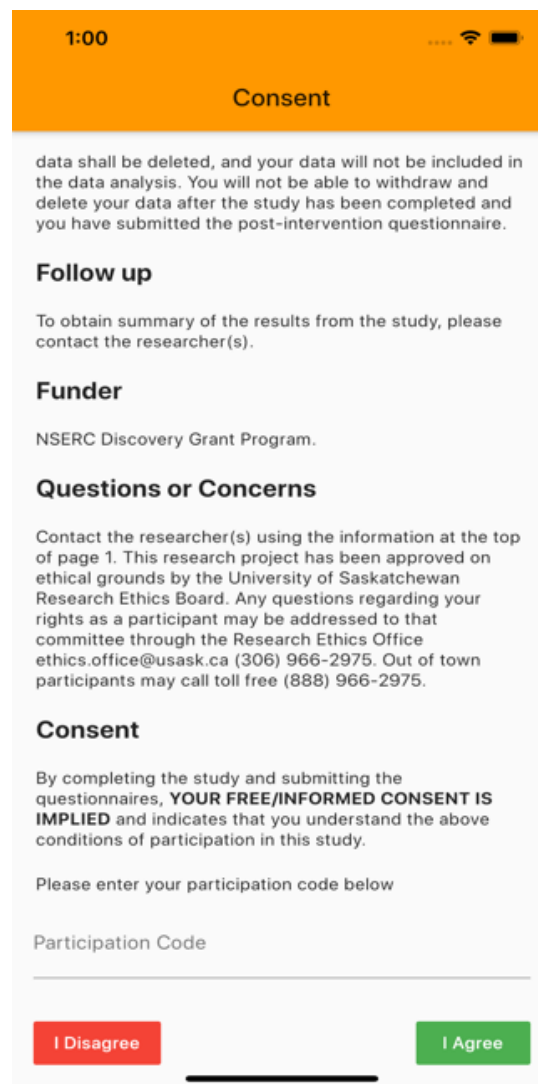
- i. *If you consent to participate in the study under the above conditions, please, check the “Yes” box, check “No” if otherwise to proceed:* This question is to seek the consent of the participant after reading the terms on the consent form (APPENDIX D). Participants that answers “NO” were disqualified from the study and participants that give their consent by answering “YES” proceed to the next question
- ii. *What is your age?* This question has two options
  - a. *Under 19*
  - b. *19 and above*

As the study is only looking for participants that are 19 and above, all participants that selected Under 19 were screened out of the study.

- iii. *I have a personal Android device:* This is a “Yes” or “No” question. CHEERS is only available for android, as a result, the study can only accommodate participants with android

device as clearly stated in the recruitment form (APPENDIX E). Participants that selected “No” were screened out of the study.

- iv. *Please enter your email address or phone number:* This is the last question from the prequalification form. Participants that gave their email were sent a link to download the CHEERS application alongside a participation code. This participation code is required for authentication to use the app after downloading it (Figure 5.1), and this also ensures that only authorised participants can participate in the study and prevent unintended participants from downloading and using the app. Participants that made it to this stage have met all the preliminary requirements to participate in the study.



1:00

**Consent**

data shall be deleted, and your data will not be included in the data analysis. You will not be able to withdraw and delete your data after the study has been completed and you have submitted the post-intervention questionnaire.

**Follow up**

To obtain summary of the results from the study, please contact the researcher(s).

**Funder**

NSERC Discovery Grant Program.

**Questions or Concerns**

Contact the researcher(s) using the information at the top of page 1. This research project has been approved on ethical grounds by the University of Saskatchewan Research Ethics Board. Any questions regarding your rights as a participant may be addressed to that committee through the Research Ethics Office ethics.office@usask.ca (306) 966-2975. Out of town participants may call toll free (888) 966-2975.

**Consent**

By completing the study and submitting the questionnaires, **YOUR FREE/INFORMED CONSENT IS IMPLIED** and indicates that you understand the above conditions of participation in this study.

Please enter your participation code below

Participation Code

**I Disagree** **I Agree**

Figure 5.1: Consent Page of CHEERS App showing the required participation code

## 5.2 Experimental Design

The CHEERS app has 2 versions, the Control Version (CV) and the Experimental Social Version (SV). The CV is the baseline version of the app, and includes self-monitoring, feedback, goal setting, reward, reminder, and simulation. The SV contains the social components (*social learning, comparison and competition*) in addition to the baseline CV components. The PSD components implemented in both versions are summarized in Table 5.1 below.

Table 5.1: An Overview of The Strategies Implemented in CHEERS

Strategies	Control Version (CV)	Social Version (SV)
Self- Monitoring	Yes	Yes
Social – Learning	No	Yes
Competition	No	Yes
Comparison	No	Yes
Tailoring	Yes	Yes
Feedback	Yes	Yes
Reward	Yes	Yes
Reminder	Yes	Yes
Simulation	Yes	Yes

Participants that passed the pre-qualification test were randomly assigned into two groups. Participants assigned to the SV will have access to viewing their performance score and the aggregate of the performance scores of all other participants using the CHEERS application, while participants assigned to CV have access to viewing only their performance score without the aggregate of the performance scores of all other participants. These social and control group home screens are shown in Figure 5.1 below.



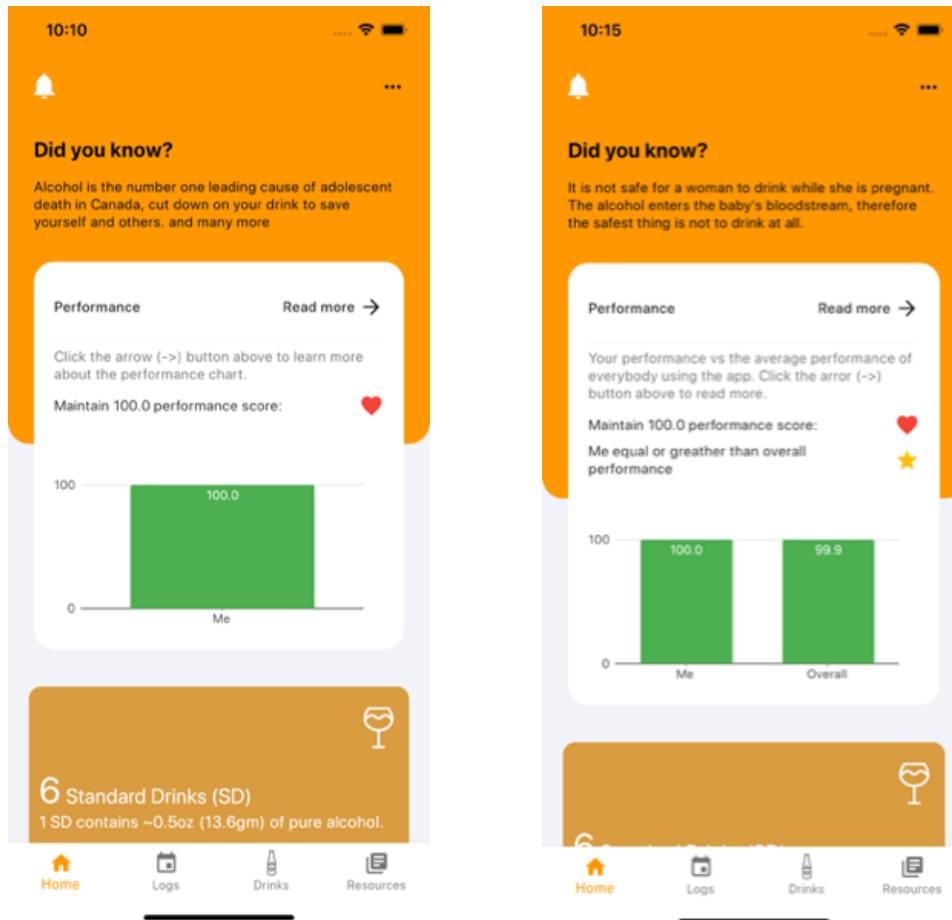


Figure 5.2: Home screen for the control version (left) and the social version (right)

### 5.3 Experiment Tools

This section discusses all the measurement tools used in data collection which include SCT tool, TAM tool and AUDIT tool.

#### 5.3.1. SCT TOOL

SCT is a popular theoretical-based model that is widely used in developing interventions for behavioral problems [18]. These constructs employed in this research have been validated by researchers [83]. The constructs measured are *comparison*, *competition*, *environment*, *self-efficacy*, *self-monitoring* and *social influence*.

A total of 16 items from SCT were adapted for relevance to the alcohol use setting. Similar adaptation of the SCT has been employed in other research settings [84]. Participants were asked to rate on a 7-point scale (1=strongly disagree, 2 = moderately disagree, 3 = slightly disagree, 4=

undecided, 5 = slightly agree, 6 = moderately agree and 7=strongly agree) their comparison (1 item) and competitive nature with respect to alcohol (1 item), environmental factors (2 items), outcome expectancy. (2 items), self-efficacy (2 items), self-monitoring (2 items), and social influence (4 items). The constructs and the items measured before and after the use of the app are shown in the Table 5.2 below.

Table 5.2: SCT Constructs and Corresponding Items Adapted For Alcohol Use Setting.

<b>Constructs</b>	<b>Item on Scale</b>
Comparison	1. It is important for me to know how much my friends are drinking
Competition	2. I will like to participate in a competition to challenge people on good drinking habits
Environment	1. It is easy for me to buy alcohol if I want to 2. Alcohol is always available and easily accessible for me at home
Outcome Expectancy	1. Alcohol can help how well I get along with others 2. Alcohol hurts how people think, and it hurts their coordination (run into things, act silly, have a hangover)
Self-Efficacy	1. If I want, I could easily limit my alcohol consumption over the next one month 2. I am confident that I could abstain from alcohol over the next month
Self-Monitoring	1. I have control over whether or not I take alcohol 2. I usually keep track of how much alcohol I consume while drinking 3. It's hard for me to notice when I have had enough alcohol
Social Influence	1. I usually drink alcohol with my friends 2. I usually drink alcohol with my family

	3. I consume alcohol because others do the same 4. When I go out with friends to drink, I usually drink whatever they are drinking
--	---

### 5.3.2. TAM Tool

TAM is a validated tool to examine user's intention to use a new technology or persuasive system. *Usefulness*, *Ease of Use* and *Aesthetics* are factors associated with intention to use a technology.

A total of 13 items from TAM were adapted for relevance to the alcohol use setting. An image of the home screen of the CHEERS was shown to participants before they started interacting with other components of the app to determine their perceived usefulness, ease of use, aesthetics and intention to use the app to demotivate alcohol use disorder. The application was described to participants as follows

*“Imagine you want to improve your alcohol consumption habits and the ‘CHEERS App’ has been developed, to support you. The app can help you to keep logs of your alcohol consumption and contains educational resources about developing a responsible drinking habit”.*

Similar adaptation of the TAM has been employed in other research settings [84]. At the end of the study, participants were also asked about their intention to continue using the app.

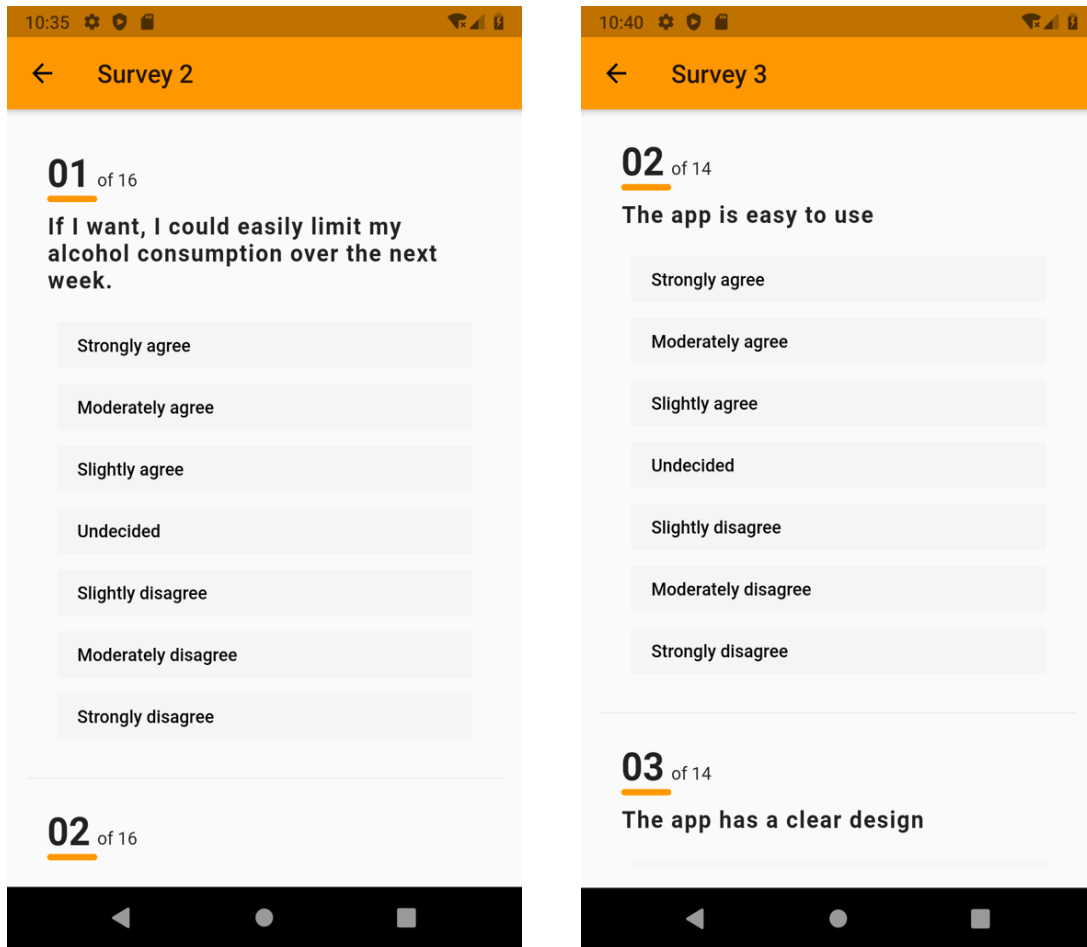


Figure 5.3: A Screenshot showing how the SCT and TAM tools were shown to participants

Participants were asked to rate on a 7-point scale (1=strongly disagree, 2 = moderately disagree, 3 = slightly disagree, 4= undecided, 5 = slightly agree, 6 = moderately agree and 7=strongly agree) the perceived usefulness of a mobile-based alcohol use disorder application (3 items), the perceived ease of use of such application (2 items), perceived aesthetics (4 questions), and their intention to use such application (1 question). The constructs and the items measured before and after using the app are shown in Table 5.3.

Table 5.3: TAM Constructs and Corresponding Items Adapted For Alcohol Use Setting

<b>Constructs</b>	<b>Pre-App Usage Item on Scale</b>	<b>Post-App Usage Item on Scale</b>
1. Perceived Usefulness	<ol style="list-style-type: none"> <li>1. The app will help me to reduce the amount of alcohol I consume</li> <li>2. The app will help me achieve my goal as regards to my alcohol use</li> <li>3. The app will be useful in monitoring my alcohol consumption</li> </ol>	<ol style="list-style-type: none"> <li>1. The app helped me to reduce the amount of alcohol I consumed</li> <li>2. The app helped me to achieve my goal as regards alcohol use</li> <li>3. The app is useful in monitoring my alcohol consumption</li> </ol>
2. Perceived Ease of Use	<ol style="list-style-type: none"> <li>1. The app is easy to use</li> <li>2. The app is easy to understand</li> </ol>	<ol style="list-style-type: none"> <li>1. The app is easy to use</li> <li>2. The app is easy to understand</li> </ol>
3. Perceived Aesthetics	<ol style="list-style-type: none"> <li>1. The app has a clear design</li> <li>2. The app is visual</li> <li>3. The app is clean</li> <li>4. The app is pleasant</li> </ol>	<ol style="list-style-type: none"> <li>1. The app has a clear design</li> <li>2. The app is visual</li> <li>3. The app is clean</li> <li>4. The app is pleasant</li> </ol>
5. Intention to Use	<ol style="list-style-type: none"> <li>1. If given the opportunity, I would like to use the app</li> </ol>	<ol style="list-style-type: none"> <li>1. If given the opportunity, I would like to continue using the app</li> </ol>

### 5.3.3. AUDIT Tool

All Participants answered the AUDIT questionnaire (APPENDIX F) before and after using the app. The result of the test was used to determine the risk level of the participant. The risk levels are classified as either low risk (Audit score < 8) or high risk (Audit score  $\geq$  8).

Based on the risk level, participants get a recommendation to seek medical or counselling help when the risk level is high. Figure 5.4 shows the feedback a participant with a high-risk level get after taking the AUDIT questions.

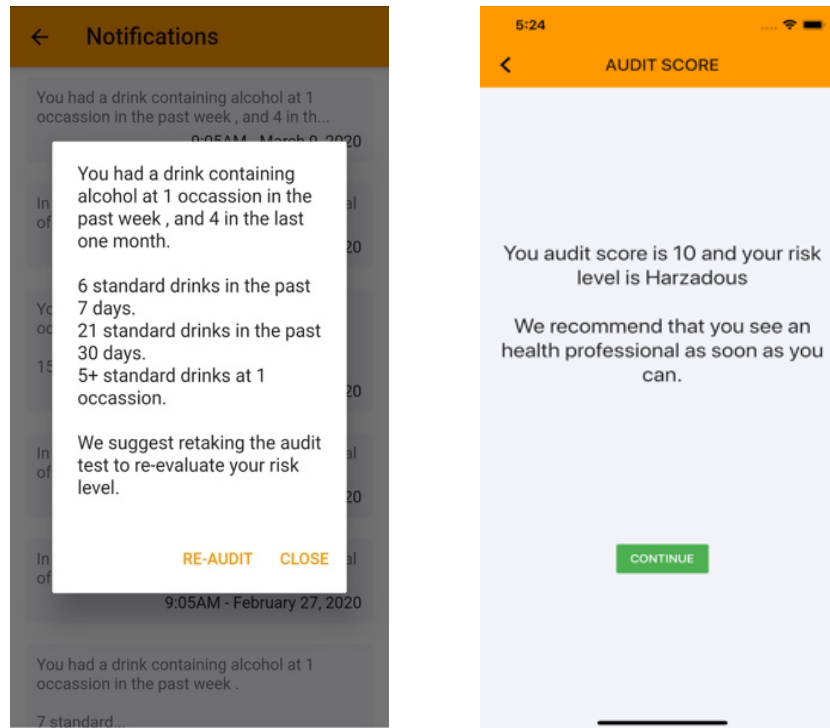


Figure 5.4: Example of Cheers Notification (left) and AUDIT Score (right) Shown To participant.

The participant's drinking that is recorded through the app as shown in Figure 4.11 is monitored, and notification is sent every week as a reminder to participants that have recorded a higher weekly cumulative number of drinks than the amount recorded in the previous AUDIT. Participants that fall into this category are encouraged to re-evaluate themselves and take the AUDIT test again to re-ascertain their risk level.

#### 5.4 Pre- and Post-App Usage Questionnaires

All the tools developed were administered twice through a – pre- and post-app usage questionnaire. The pre-app usage questionnaire was administered immediately after authorizing the participants and before any other interaction with the app, while the post-app usage was administered after the study had ended.

The pre- and post-app usage tool both assessed the constructs of SCT (*self-efficacy, self-control, outcome-expectancy*), TAM (*aesthetics, usefulness, intention to use*) and gather drinking lifestyles of the participants using the standardized AUDIT. They were developed by adapting the three

(SCT, TAM and AUDIT) validated tools explained above to suite the context of this study. The complete pre-app usage questionnaire is shown in APPENDIX A, while the post-app usage questionnaire is shown in APPENDIX B.

## **5.5 Procedure**

I solicited for volunteers to participate in an alcohol use disorder study. The recruitment form was posted on social media and the University of Saskatchewan PAWS system. Interested participants answered an online pre-qualification survey as explained in section 5.1. Participants that qualified and used the application answered a pre-app usage questionnaire explained in section 5.4 above, and afterwards used the application for 30 days.

The information recorded from the application for all participants include app usage and drinking information (*type of drink, volume of drink and time drink was recorded*). All participants had an initialized point (performance score) of 100 at the beginning of the application usage. For every drink consumed, the participant lost 10 points. The performance score on the flip side increased by 5 points when no alcohol was consumed for 24 hours. Conversely, this means that to recover the lost 10 points, the participant had to abstain from alcohol for 48 consecutive hours (2 days).

On the completion of the entire 30 days of the application lifecycle, participants were prompted to complete the post-app usage questionnaire as explained in section 5.4 above. Participants were also advised to delete the application at the end of the study, after submitting their responses in the post-app usage questionnaire.

## **CHAPTER 6: RESULTS AND DATA ANALYSIS**

This chapter describes the result of the data analysis done to determine the acceptance of a mobile application as a means to demotivate alcohol use addiction and the evaluation of the persuasive strategies implemented in the CHEERS. I investigated the users' perception of a mobile-based alcohol use disorder prevention application before and after using the mobile app. I also examined whether the social influence persuasive techniques included in the design described in Chapter 3 were correlated with demotivating alcohol use disorder. To answer these questions, I used the responses from the pre-app usage questionnaire (APPENDIX A) and the post-app usage questionnaire (APPENDIX B).

There were 94 participants recruited, out of which 70 completed the online prequalification form and met the all the requirements. 55 participants downloaded the application, and 42 completed the study (answered the pre-qualification form, downloaded and used the application, and submitted the pre- and post-app usage questionnaires). 22 of the participants (55%) belong to the control group (used CV) and 20 (45%) were in the social group (used SV). The study lasted for 4 weeks, and at the end of the study, participants were asked to answer the post-app usage questionnaire using the mobile app (the questionnaires were already included and deployed as part of the mobile app). Figure 6.1 below presents a summary of the participants involved in the study. All the participants gave consent to participate in the study.



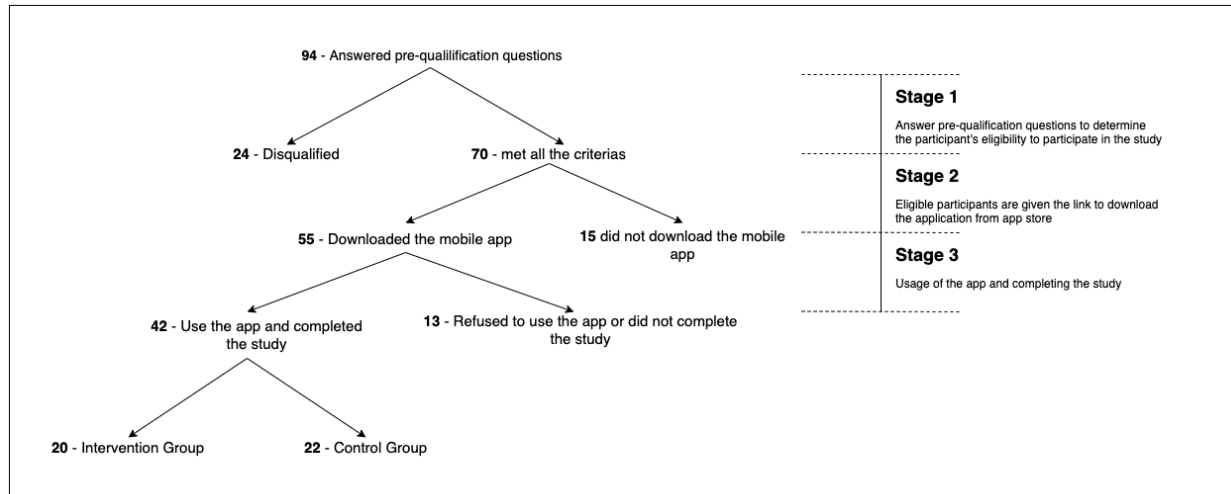


Figure 6.1: Participants Summary

## 6.1 Determining the Driver for Intention to Use A Mobile-Based Alcohol Use Disorder Prevention Application:

This section presents the analysis of the TAM tool (described in section 5.3.2) used in the pre- and post-app usage survey. The research question here is to determine the effects of each of the TAM constructs in the acceptance of a mobile-based alcohol prevention application.

### 6.1.1 Measures

Quantitative measures were employed to answer the research question by collecting data using the TAM standardized tool.

- The TAM tool which contains a total of 10 items as highlighted in section 5.3.2 was used to collect data before and after using the app. This tool measures the *usefulness*, *ease of use* and *aesthetics* constructs of TAM using a 7-point scale (1=strongly disagree, 2 = moderately disagree, 3 = slightly disagree, 4= undecided, 5 = slightly agree, 6 = moderately agree and 7=strongly agree).

The tool contains 3 items about participants *perceived usefulness* of a mobile-based AUD app, 2 items about *perceived ease of use*, 4 items about *perceived aesthetics* and 1 item about *intention*

to use such application. The constructs and the items measured before and after using the app are highlighted in Table 5.3

### **6.1.2 Data Analysis**

To investigate the factors associated with intention to use, similar to other TAM studies [34] [85], I dichotomised the constructs (*perceived usefulness, perceived ease of use and perceived aesthetics*) along the median score of 5.9. All scores between 1 – 5.9 are categorized as disagree and scores between 6 and 7 are categorised as agree. Using this median score as the cut-off point offers two advantages as reported from previous studies [34]

- i. It makes it easier to interpret the results, and
- ii. Differentiates between those who disagree or slightly agree and those who strongly agree with the items.

The Fisher's exact test was used to determine the statistical the significance of association between intention to use, perceived usefulness, perceived aesthetics and perceived ease of use.

### **6.1.3 Result**

The section presents the result of the analysis performed on the responses received from the questionnaires.

## **Change in Embracing the Use of Mobile-Based Alcohol Use Disorder Prevention**

### **Application**

The descriptive statistics shows that there are differences in the participants perceptions of embracing a mobile based alcohol use disorder application before and after using the application. These differences are highlighted in Table 6.1.

Table 6.1: Summary of TAM Constructs for Pre and Post App Usage

	Pre-App Usage	Post-App Usage
Construct	Mean / Std. Deviation	Mean / Std. Deviation
Perceived Ease of Use	6.49/0.79	5.19/2.46
Perceived Usefulness	5.75/1.19	4.87/1.88
Perceived Aesthetics	6.43/0.79	5.15/2.25
Perceived Intention to Use	6.125/1.20	5.05/2.05

Fisher's exact test was used to determine the association between the TAM constructs and the intention to use the app and intention to continue using the app for pre- and post-app usage respectively. Fisher's test uses crosstab table (also known as contingency table) to show the relationship between categorical variables. Fisher's exact test is useful when we have small dataset. One of the assumptions of Fisher's test is that 20% or more of the crosstab cells have an expected count that is less than 5, when this assumption is not met, a Chi-Square test might be more appropriate. Expected count represent the frequency that is expected if there is no relationship between the independent variable and the dependent variable. Table 6.2 shows the expected counts for our dependent variables (ease of use, usefulness, and aesthetics).

Table 6.2: Crosstab Table Showing the Expected Counts for The TAM Constructs

(\* represents cells with expected count less than 5)

		Intention To use (ITU)	
		High	Low
Ease of Use	Agree	25.4	9.6
	Disagree	3.6*	1.4*
Usefulness	Agree	17.4	6.6

	Disagree	11.6	4.4*
Aesthetics	Agree	26.1	9.9
	Disagree	2.9	1.1*

The relationship between the ITU and all measured dependent variables are explained below.

1. *Ease of Use*: The chart below (Figure 6.2) illustrates the relationship between the ease of use and ITU. The chart shows that there is a positive association between ease of use and ITU. Most of the participants that agree the that the application is easy use to also agree to use the app. The value of the Fisher's exact test also confirms this relationship with a high significant value of 0.015 ( $p=0.015$ ).

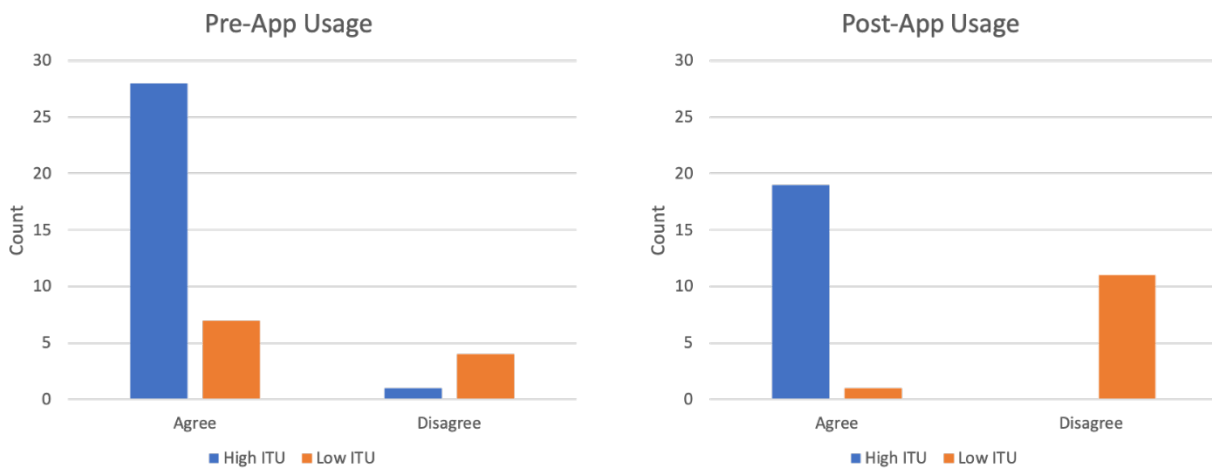


Figure 6.2: Ease of Use vs ITU for pre-app usage(left) and post-app usage(right)

2. *Usefulness*: The usefulness vs ITU chart shown in Figure 6.3 below illustrates the relationship between the usefulness construct and ITU. This chart also shows that there is a positive relationship between usefulness and ITU. Most of the participants that agree the that the application is useful also agree to use the app. The value of the Fisher's exact test confirms this relationship with a high significant value of 0.001 ( $p=0.001$ ).

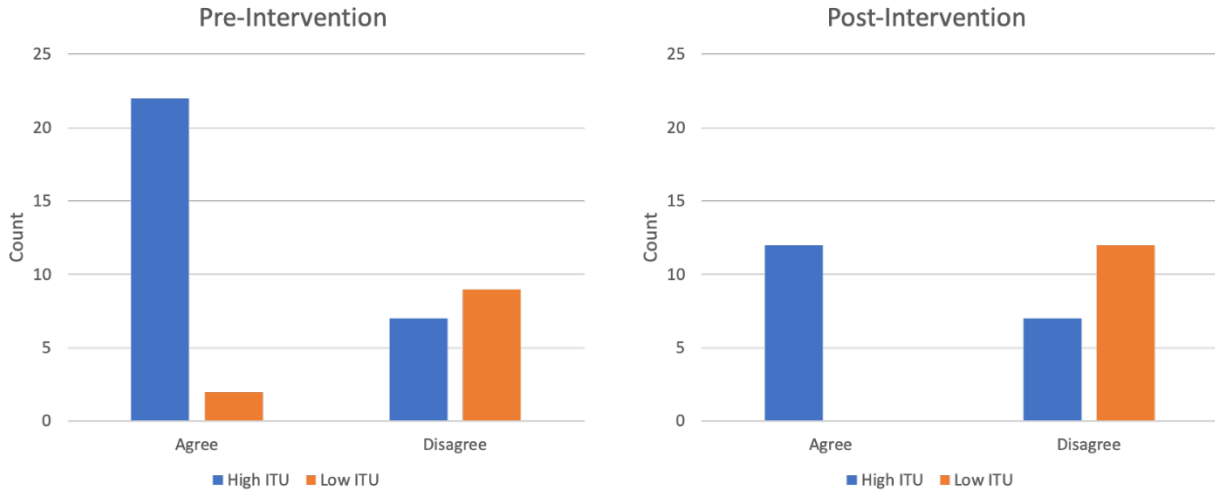


Figure 6.3: Usefulness vs ITU for pre-app usage(left) and post-app usage(right)

3. *Aesthetics*: The aesthetics vs ITU chart shown in Figure below also shows that there is a positive relationship between aesthetics and ITU. Most of the participants that agree the that the application is pleasant and offers good user experience also agree to use the app, while all the participants that did not find the app aesthetically appealing have low/no intention to use. The value of the Fisher's exact test also confirms this relationship with a high significant value of 0.001 ( $p=0.001$ ).

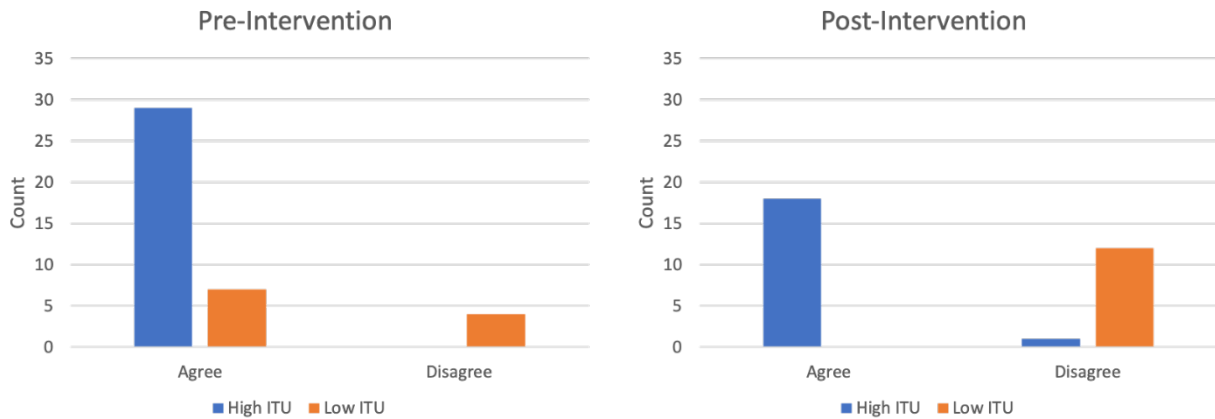


Figure 6.4: Aesthetics vs ITU for pre-app usage(left) and post-app usage(right)

## Effect Size

To get the strength of this relationship, I carried out Crammer's V test for symmetric measures. Crammer's V value ranges from -1 to +1 (for a 2x2 table which is the case in this study), and the farther the value is from 0, the stronger the relationship. Table 6.3 below shows the Crammer's V for all the constructs.

Table 6.3: Effect size for the TAM construct. Small=0.1, medium=0.4, large=0.5 for one degree of freedom[86]. \* represent medium, \*\* represent large.

		Pre-App Usage	Post-App Usage
Constructs	df	Crammer's V	Crammer's V
Ease of Use * ITU	1	0.444*	0.933**
Usefulness * ITU	1	0.526**	0.632**
Aesthetics * ITU	1	0.541**	0.935**

With our Crammer's value having medium to large strength of relationship, we can say with confidence that there is a significant association between the determinant variables (ease of use, usefulness, aesthetics persuasiveness) and the outcome variable (ITU).

### 6.1.4 Discussion and Summary of Findings

The majority of our participants reported high behavioural intention to use a mobile based alcohol use-disorder prevention application (72.5%) with an average score of 6 or more (on a scale of 1 - 7) and 63.3% reported intention to continue using the app after interacting with the CHEERS app for 30 days. The TAM constructs (ease of use, usefulness, and aesthetics) were significantly associated with an intention to use for pre-app usage and intention to continue using the app (post-app usage).

From the results presented in this study, I have been able to show that aesthetics has the strongest effect on intention to use followed by usefulness. This statement has been confirmed even further after using the application. The implication of this can be likened to the fact that as mobile devices

become more powerful, mobile application developers are building more beautiful and aesthetically appealing applications and the participants, are expecting nothing short of good user interface and user experience.

Usefulness is the second strongest component that effects intention to use. This suggest that in the design of mobile applications, application designers/developers should put efforts in features that users care about like ability to monitor users' alcohol consumption and the implication on users' health.

The findings in this study corroborate the findings of similar studies from other domains. For example, high intention to use a mobile-based system in the implementation of persuasive health application [87] is significantly associated with usefulness and aesthetics. The high response rate for intention to use CHEERS app and high positive association for intention continue using the app suggest that there is a very high potential for mobile applications as a means to deliver intervention for reducing alcohol risk and also demotivate irresponsible alcohol use.

Finally, the lower result recorded for post-app usage, when compared with the pre-app usage result is because of the gap between participant's perception and reality. The pre- app usage tool only describes the app to the participants, and the participants created an image in their head of what they expect the app to look and feel like, and some features they would like the app to have. However, after using the app, these expectations might not have been met and this can create a change in opinion that resulted in the lower scores recorded for the post- app usage results. This conforms with previous studies that highlights high attrition rate of between 30% - 70% for longitudinal studies [88].

## **6.2 Evaluating the Effectiveness of the Persuasive Strategy Employed in The CHEERS Mobile Application**

This section presents the result of the analysis of the persuasive strategy implemented in this thesis. To do that, I used the participants AUDIT Score before and after using the application.

### **6.2.1 Measures**

I employed the quantitative approach to gather data about the participants' AUDIT Score before and after the app.

### 6.2.2 Data Analysis

I investigated the difference in the AUDIT score before and after the intervention for the participants in the CV and the SV group to determine if: 1) there is an effect of the persuasive app and 2) if the social influence strategy helped reduce the risky AUD behaviours in the SV group. To achieve this purpose, all participants took the AUDIT test to score their drinking patterns and alcohol-related behavior twice: before using the app and after using the app. To determine whether the intervention implemented in the CHEERS application has the desired behaviour change effect, the participants' AUDIT score after using the application would have be lower than the AUDIT score before using the application.

Table 6.4 and 6.5 below show the AUDIT Score recorded for the SV and CV, respectively. A total of 24 participants data was used (12 for SV and 12 for CV) after removing the data for participants who recorded 0 AUDIT score for both pre- and post-app usage. One can see that the majority of the participants (11 / 12 in the SV group and 10 /12 in the CV group) had high risky AUD behaviours before the intervention (with AUDIT Scores > 8).

The participants in the SV group had a higher AUDIT score on average and most of them (9) reduced their scores by the end of the experiment, but not below the risk margin. From the participants in the CV group half (6) reduced their scores, one – significantly, and the scores of three dropped to the non-risky or marginally risky zone. In the SV group two participants increased their scores, while in the CV four did.

The descriptive statistics is shown in Table 6.6. This analysis shows that on average, the post- app usage score dropped for both the control and social groups, which is a positive result. There was a larger drop in the mean score in the social version (SV group), from 14.08 to 11.83. The drop in the control version (CV) group was from 13.58 to 13.00, and the drop in the overall mean between the pre- and post- app usage scores was from 13.83 to 12.42. To determine if the changes are significant and not as a result of randomness, I carried out a dependent sample t-test analysis for both the CV and SV. T-Test was selected as the data satisfies the t-test pre-conditions (i. a direct relationship between the pre- and post- app usage measurement, ii. dependent variable is measured on a continuous scale, iii. the data is approximately normal.)



Table 6.4: AUDIT Score for Participants in Social Version (SV)

Participants Number	Pre-App Usage AUDIT Score	Post-App Usage AUDIT Score	Difference
1	19	11	8
2	17	14	3
3	9	13	-4
4	15	13	2
5	5	4	1
6	13	13	0
7	11	13	-2
8	19	13	6
9	17	10	7
10	18	15	3
11	15	13	2
12	11	10	1

Table 6.5: AUDIT Score for Participants in Control Version (CV)

Participants Number	Pre-App Usage AUDIT Score	Post- App Usage AUDIT Score	Difference
1	17	18	-1
2	13	13	0
3	16	11	5
4	12	8	4
5	15	13	2

6	7	8	-1
7	15	13	2
8	7	13	-6
9	18	23	-5
10	23	13	10
11	12	19	-7
12	8	4	4

Table 6.6: Summary of the AUDIT Score for CV and SV before and after using the app

	Pre-App Usage		Post-App Usage	
Group	Mean	Std Deviation	Mean	Std Deviation
Control	13.58	4.80	13.00	5.19
Social	14.08	4.38	11.83	2.89
Total	13.83	4.50	12.42	4.15

Table 6.7: Summary of T-Test Analysis for the CV and SV

	T-Value	P-Value	Mean	Std Deviation
CV	0.406	0.693	0.583	4.981
SV	2.215	0.049	2.250	3.519

The dependent sample t-test analysis showed an average reduction in AUDIT scores by 0.583 and 2.250 in the CV and SV, respectively. The observed decrease in mean value is significant for the SV (p-value = 0.049) but not for the CV (p-value = 0.693).

### 6.2.3 Discussion and Summary of Findings

The evaluation of the persuasive strategies shows that there is a statistically significant improvement in the AUDIT score for the SV group, while the CV did not show statistically significant improvement before and after using the app. This means that the socially driven persuasive strategies (social learning and comparison) can be employed successfully in reducing alcohol risk. This findings conform with previous findings from other domains like health[70], physical activities[89], education[90], and e-commerce[91], where social PT has been employed in encouraging a behaviour change.

Another explanation for the result is the demographic of the participants. 83% of the participants identifies as Black/African. Previous research on culture psychology and persuasive strategy has shown that social strategies are more effective among collectivists society [87]. The findings from this study suggests that social strategies (social comparison, social learning and competition) is a potent strategy that can be employed in demotivating excessive use of alcohol.

Yet, it is important to note that the majority (75%) of the participants in the SV group and half of those in the CV group reduced their AUDIT scores. For three of the participants in the CV, the drop in the score meant moving from higher-risk category to marginal-risk, or low risk category. This means that the persuasive app is generally useful. Future research with more participants may be able to find more significant effects also in the CV group.

## CHAPTER 7: CONCLUSION AND FUTURE WORK

This thesis investigated the receptiveness to the use of a mobile-based PT as a means for delivering persuasive strategy for alcohol use disorder. It also investigated how social influence strategy of PT can be used to reduce user's alcohol risk. To this end, I developed two versions of a cross-platform mobile application, the control version and the social version. The control version deployed the following strategies: self-monitoring, goal setting, feedback, reward, reminder and simulation. The social version contained all the strategies in the control version and in addition, included social influence strategies – comparison and competition. To determine the receptiveness of the mobile app and the effectiveness of the intervention, this thesis employed quantitative approach to data collection by adapting the validated TAM tool to suit the context of this study. The result of the data analysis provided an answer the research question “*What drives the intention to use a mobile-based application the reduces alcohol risks and AUDIT score?*” This result shows that for the adoption of a mobile application that addresses AUD, the application must have an easy-to-use user interface and pleasant user experience (aesthetics), After that, the application must be useful by providing value to the user and helping them to achieve their goal of improving their alcohol use behaviour.

This thesis also evaluated the social influence persuasive strategy. The AUDIT tool was used to characterize participants drinking behaviour. To evaluate the social influence strategy, I analyzed if there is any difference in the reported AUDIT score before and after using the application between the participants of the control group (CV) and the social group (SV). The results show no significant difference in the CV while the SV exhibits positive and significant improvement of the AUDIT score of the participants in the version with the social influence strategy after using the app. Thus, an important contribution of our work that it demonstrates how using social influence persuasive strategy in a persuasive application can be used to reduce risky alcohol use behaviour in a general audience. It is also worth noting that the experiment was carried out during the Covid-19 pandemic measures, which reportedly have led to increase in alcohol use [94].

## 7.1 Contributions

PT has proven to be an effective mechanism for motivating behaviour change. The principles of PT have been applied in building technology solutions across varieties of domains from e-commerce, to health and education, and the results have been positive. To this best of my knowledge, this thesis is the first research to examine the use of PT to improve alcohol risk level or AUDIT score. The details of the research work highlighted in this study answers the research questions regarding the *receptiveness of users to PT that reduces alcohol risks and to explore how PT strategies can be used to improve alcohol use behaviour*” The contribution made to PT and health literature are highlighted below.

### 1. Design, Development and Deployment of a Real-Life PT for Reducing Alcohol Risk

A persuasive mobile application was designed, developed, and deployed. This application gives user insight about their alcohol consumption over time and notifies them when there is an increase in their risk level. It also illustrates what a standard drink represents for any type of drink by giving them a visual representation in a simulated soda can.

### 2. Examination of Intention to Use and Intention to Continue Using a Mobile-Based PT for Reducing Alcohol Risk

This thesis examined what drives the intention to use and intention to continue using a mobile based PT for reducing or preventing alcohol risk. The results of this study, which showed that aesthetics and usefulness are the most important aspects, can serve as a basis for application designer and developers looking into building apps that help users improve their alcohol use behaviour.

### 3. Implementation of Socially Oriented Strategy for Motivating Good Alcohol Use Behaviour

This study also explored the use of two social-influence strategies (comparison and competition) and how they can be implemented in the context of a persuasive application aiming to reduce irresponsible alcohol use. This can provide a starting point for future studies of the usefulness of social strategies for reducing alcohol risks. The significant results recorded in the evaluation of the social strategies and the participants willingness to continue using the

app shows that SCT is can be effective tool in motivating good alcohol use. Future studies can explore and evaluate other strategies as well as improve on the ones highlighted in this thesis.

#### **4. Demonstrating that Including Social Influence Persuasive Strategy in a Persuasive Mobile Application Can Lead to Reduced Risky Alcohol Use Behaviour**

The results of the study showed that the Social Influence Persuasive Strategy can successfully used to reduce risky alcohol use behaviour in a general audience, measured by reduced AUDIT score.

### **7.2 Limitations**

In this section, I present some of the limitations attributed to the research in this thesis.

The intervention implemented in this study adopted the use of one-size-fits-all approach instead of tailoring the intervention based on participant's personality. Several studies from other domains [92] [93] [91] [90] that addresses the use of PT as an intervention mechanism, have found that for a PT to be effective in driving behaviour change, the strategies should be tailored to each participant's personality as against the one-size-fits-all approach adopted in this study. The distribution of participants into the control or social group was done randomly and not based on any characteristics of the participant. More studies will need to be conducted where users' personality traits are considered in the development of persuasive strategies for PT that addresses alcohol risks.

The AUDIT is recommended to be taken annually, that is why a total of five items out of the total ten items in the adult tool asked about participants alcohol use or alcohol related behaviour in the last one year. Also WHO's recommendation states that "all patients should be screened for alcohol use, preferably annually" [41] as against the 30 days interval used in this study. This can serve as an opportunity for longitudinal studies to be carried out.

Blood alcohol concentration (BAC) is a more accurate measure of alcohol in the body and better represent the level of intoxication. As the calculation of BAC takes into account that different people react to alcohol differently depending on gender, weight, whether their stomach has been full or empty before taking the alcohol and the time interval of taking alcohol (in case of multiple shots), using BAC would have presented a more accurate base for comparison and provided a better

insight to participants on their alcohol risk. However, I could not get an ethics approval to include BAC in the app and the iOS platform would not allow any app on the marketplace that measures BAC without an external breathalyzer hardware.

The only difference between the CV and SV was the addition of two social strategies (comparison and competition). These strategies are most effective if applied in a group where users know each other or are aware that the other users are members of the same group, or at least believe that the other users with whom they compare or compete are sharing some similarities with them. However, in this experiment the users were recruited online and did not know at all who the other users were, there was no group to identify with. In such a situation, future studies can evaluate the effectiveness of the social strategies in a setting where participants are aware of the similarities they share with other participants.

Another limitation was the duration of the experiment. Even though in the persuasive technology literature most studies are short, a duration of 30 days may not be sufficient, so the result presented in this thesis may not represent a long-term effect of the persuasive strategies on the participants.

Another limitation is the demographics of participant: 83% of the participants that completed the study were with African ethnicity, the results presented from this study may not be an accurate representation of the demographic represented by other ethnicity, especially as research has shown that culture can have a moderating effect on the effectiveness of persuasive strategies [87].

The participants feedback was not considered in the development of the application. Most of the features suggested and developed into the app were based on the suggestions of focus groups comprising high school students at risk (with high AUD scores) in Saskatchewan, which represents a different demographics that the participants that used the app.

For simplicity, every drink recorded on the app was assumed to be one standard drink and a visual representation was shown as a soda can. Though this is still better form of representation than a number of milliliters, as it gives participants a visual cue of one standard drink, it still does not fully represent a real-life scenario, as participants may have difficulty estimating the amount when they are having a drink, especially for drinks that are not available in a soda can-like container.

In this study, multiple persuasive features were combined in both versions of the app. The control version consists of self-monitoring, goal setting, reward and simulation, while the social version consist of self-monitoring, goal setting, reward, simulation, comparison and competition. The

combination of all these strategies made it difficult identify what really influences behaviour change.

Lastly, the small sample size is another limitation noted in this research. Even though almost 100 people showed interest to participate in this study, only 42 completed the study and this study was conducted during a period when the pattern of alcohol consumption likely differed from normal due to the corona virus pandemic.

### **7.3 Future Work**

This section presents some relevant subject-matter that were not explored in this thesis. I would like to explore them in future studies, and other researchers can follow up along these lines.

#### **1. Tailoring Strategies Based on Participants Personality**

The study presented in this thesis randomly assigned participants into control version or the social version. As literature has shown that PT strategies implemented in different domains are more effective when tailored towards the participants' personalities, it will be interesting to investigate how users are going to react to these strategies when tailored as opposed to the randomization approach employed in this study.

#### **2. Investigating the Effect of the Strategy on Users of Different Risk Groups**

It would be very interesting to analyse the persuasive effect of the CHEERS on participants with different risk (based on their AUD scores). While our study showed an effect in reducing the risk (measured by the AUD score) on average for the experimental version with the social strategies, a larger study would allow comparing the effect of the application's two version on users with low risk (AUD score < 20) and those with high risk (AUD score  $\geq 20$ ).

#### **3. Investigating the Effect of the Strategy on Users with Different Demographics**

In accordance with the initial plan of evaluating the influence of social strategies on young adults drinking behaviour, future research could investigate the effect of these strategies on adolescents and young adults (below the age of 19) as the participants' demographics in this



study only focused on adults that are 19 and above. The mediating effects of the strategies on different gender can also be an interesting future study.

#### **4. Exploring the Use of Breathalyzer to Determine Alcohol Consumption**

This study could not accurately determine the amount of drink consumed by the participants. It was assumed that every drink recorded was a standard drink and the participants' risk level was inferred from that. It would be interesting to examine the effect of the social strategies when a breathalyzer (a hardware device used to measure blood alcohol concentration) is used to measure alcohol consumption, since this will help to calibrate alcohol consumption better and give better and more accurate insight to the participants and the associated risks.

#### **5. Long-Term Effect of The Social Strategies**

This study was only conducted for a period of 30 days, the results highlighted here might not reflect the long-term effect of the strategies. Future research can look into long-term effect of these strategies by conducting the study over several months and years if possible. Also, follow up studies need to be carried out to evaluate the long-term effect of the strategies.

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## APPENDIX A.

### PRE-APP USAGE QUESTIONNAIRE

Please rate your level of agreement with the following statements in a 7-point scale. Choosing 1-Strongly Disagree to 7-Strongly Agree

	1-Strongly disagree						7-Strongly disagree
If I want, I could easily limit my alcohol consumption over the next month.	1	2	3	4	5	6	7
I have control over whether or not I take alcohol.	1	2	3	4	5	6	7
I am confident that I could abstain from alcohol over the next month.	1	2	3	4	5	6	7

	1-Strongly disagree						7-Strongly disagree
I usually keep track of how much alcohol I consume while drinking.	1	2	3	4	5	6	7
It's hard for me to notice when I've had enough alcohol.	1	2	3	4	5	6	7

	1-Strongly disagree						7-Strongly disagree
Alcohol can help how well I get along with others.	1	2	3	4	5	6	7
Alcohol hurts how I think, and it hurts my coordination.	1	2	3	4	5	6	7
Alcohol makes me feel stronger, more powerful and bold.	1	2	3	4	5	6	7

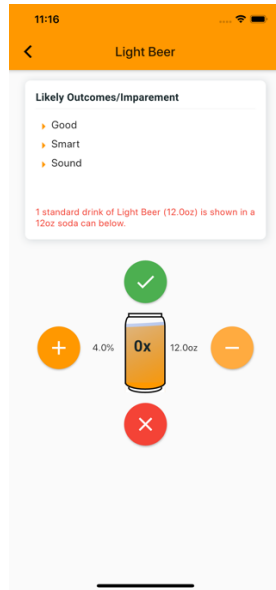
	1-Strongly disagree						7-Strongly disagree
It is easy for me to buy alcohol If I wanted to.	1	2	3	4	5	6	7
Alcohol is always available and easily accessible to me at home	1	2	3	4	5	6	7

	1-Strongly disagree						7-Strongly disagree
I usually drink alcohol with my friends.	1	2	3	4	5	6	7
I usually drink alcohol with my family.	1	2	3	4	5	6	7

Imagine you want to improve your alcohol consumption habits and the "CHEERS App" has been developed, to support you. The app can help you to keep logs of your alcohol consumption and contains educational resources about developing a responsible drinking habit.

Please enter one key feature you would expect the app to have if you were to use it.

The image below shows the home screen of the CHEERS App.



Please comment on your first impression of the app.

Please rate your level of agreement with the following statements in a 7-point scale. Choosing 1-Strongly Disagree to 7-Strongly Agree

	1-Strongly disagree							7-Strongly disagree
The app is easy to use	1	2	3	4	5	6	7	

The app has a clear design	1	2	3	4	5	6	7
The app is easy to understand	1	2	3	4	5	6	7

	1-Strongly disagree						7-Strongly disagree
The app is visual	1	2	3	4	5	6	7
The app is clean	1	2	3	4	5	6	7
The app is pleasant	1	2	3	4	5	6	7

	1-Strongly disagree						7-Strongly disagree
The app will help me to reduce the amount of alcohol I consume	1	2	3	4	5	6	7
The app will help me achieve my goal as regards to my alcohol use	1	2	3	4	5	6	7
The app will be useful in monitoring my alcohol consumption	1	2	3	4	5	6	7

	1-Strongly disagree						7-Strongly disagree
If given the opportunity, I will like to use the app.							

	1-Strongly disagree						7-Strongly disagree
The app will influence my drinking behaviour	1	2	3	4	5	6	7
The app will be personally relevant for me	1	2	3	4	5	6	7

The app will make me reconsider my drinking habits	1	2	3	4	5	6	7
--	---	---	---	---	---	---	---

	1-Strongly disagree						7-Strongly disagree
I consume alcohol because others do the same	1	2	3	4	5	6	7
It is important for me to know how much my friends are drinking	1	2	3	4	5	6	7
When I go out with my friends to drink, I usually drink whatever they are drinking	1	2	3	4	5	6	7

	1-Strongly disagree						7-Strongly disagree
I would like to participate in a competition to challenge people on good drinking habit	1	2	3	4	5	6	7

## APPENDIX B

### POST-APP USAGE QUESTIONNAIRE

Please rate your level of agreement with the following statements in a 7-point scale. Choosing 1-Strongly Disagree to 7-Strongly Agree

	1-Strongly disagree						7-Strongly disagree
If I want, I could easily limit my alcohol consumption over the next month.	1	2	3	4	5	6	7
I have control over whether or not I take alcohol.	1	2	3	4	5	6	7
Whether or not I consume alcohol is entirely up to me.	1	2	3	4	5	6	7
I believe I have the ability to limit my alcohol or not take alcohol at all over the next one month.	1	2	3	4	5	6	7
I am confident that I could abstain from alcohol over the next month.	1	2	3	4	5	6	7

	1-Strongly disagree						7-Strongly disagree
I keep track of how much alcohol I consume while drinking.	1	2	3	4	5	6	7
I doubt if I could reduce my alcohol consumption if I wanted to.	1	2	3	4	5	6	7
It's hard for me to notice when I've had enough alcohol.	1	2	3	4	5	6	7

1-Strongly disagree	7-Strongly disagree
------------------------	------------------------



Alcohol generally has powerful positive effects on me, makes me feel good or happy.	1	2	3	4	5	6	7
Alcohol can help how well I get along with others, makes me look cool.	1	2	3	4	5	6	7
Alcohol hurts how people think and it hurts their coordination (run into things, act silly, have a hangover).	1	2	3	4	5	6	7
Alcohol makes me feel stronger, more powerful and bold.	1	2	3	4	5	6	7
Alcohol helps me relax, feel less tense, and can keep my mind off of mistakes at school or work.	1	2	3	4	5	6	7
Alcohol helps me think better and helps coordination	1	2	3	4	5	6	7

Please enter one key feature you like most about the CHEERS app.

Please comment on your impression of the app.

Please rate your level of agreement with the following statements in a 7-point scale. Choosing 1-Strongly Disagree to 7-Strongly Agree

	1-Strongly disagree						7-Strongly disagree
The app is easy to use	1	2	3	4	5	6	7
The app is convenient to use	1	2	3	4	5	6	7
The app is easy to navigate	1	2	3	4	5	6	7
The app has a clear design	1	2	3	4	5	6	7
The app is easy to understand	1	2	3	4	5	6	7
The app is very intuitive	1	2	3	4	5	6	7

	1-Strongly disagree						7-Strongly disagree
The app is visual	1	2	3	4	5	6	7
The app is clean	1	2	3	4	5	6	7
The app is pleasant	1	2	3	4	5	6	7
The app is fascinating	1	2	3	4	5	6	7
The app is creative	1	2	3	4	5	6	7
The app is sophisticated	1	2	3	4	5	6	7

	1-Strongly disagree						7-Strongly disagree
--	------------------------	--	--	--	--	--	------------------------

The app helped me to reduce the amount of alcohol I consume	1	2	3	4	5	6	7
The app helped me achieve my goal as regards to my alcohol use	1	2	3	4	5	6	7
The app was useful in my alcohol consumption	1	2	3	4	5	6	7
The app made it easier for me not to binge drink	1	2	3	4	5	6	7

	1-Strongly disagree						7-Strongly disagree
The app was credible	1	2	3	4	5	6	7
If given the opportunity, I will like to keep using the app.							

	1-Strongly disagree						7-Strongly disagree
The app influenced my drinking behaviour	1	2	3	4	5	6	7
The app convinced me to be more conscious of my alcohol consumption	1	2	3	4	5	6	7
The app was personally relevant for me	1	2	3	4	5	6	7
The app made me reconsider my drinking habits	1	2	3	4	5	6	7

## **APPENDIX C**

### **DEMOGRAPHIC QUESTIONNAIRE**

1. What is your date of birth?
2. What is your biological sex?
  - a. Male
  - b. Female
3. Which gender identity do you most identify with?
  - a. Female
  - b. Male
  - c. Transgender
  - d. Other
4. What is your continent of birth?
  - a. Africa
  - b. Asia
  - c. Europe
  - d. North America
  - e. South America
  - f. Australia & Oceania
  - g. Prefer not to answer
5. Have you ever ridden in a CAR driven by someone (including yourself) who was “high” or had been using alcohol?
  - a. No
  - b. Yes
6. Do you ever use alcohol or drugs to RELAX, feel better about yourself, or fit in?
  - a. No
  - b. Yes
7. Do you ever use alcohol or drugs while you are by yourself or alone?
  - a. No
  - b. Yes
8. In the last 6 months how often have you played a sport with a coach or instructor at school?

- a. Not Often
- b. Very Often

9. In the last 6 months how often have you played a sport with a coach or instructor outside of school?

- a. Not Often
- b. Very Often

## APPENDIX D



### *Participant Consent Form*

#### DEPARTMENT OF COMPUTER SCIENCE

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You are invited to participate anonymously in a research study entitled: **DE-MOTIVATING EXCESSIVE USE OF ALCOHOL AMONG TEENAGERS.**

**Researcher:** Abdul-Hammid Olagunju, Computer Science, University of Saskatchewan, [aoo075@usask.ca](mailto:aoo075@usask.ca)

**Supervisor:** Julita Vassileva, Computer Science, University of Saskatchewan, [jiv@cs.usask.ca](mailto:jiv@cs.usask.ca)

**Collaborators:**

Marcella Ogenchuk, Health Science, University of Saskatchewan, [marcella.ogenchuk@usask.ca](mailto:marcella.ogenchuk@usask.ca)

Rand Teed, Regina Catholic Schools, Regina, [randteed@gmail.com](mailto:randteed@gmail.com)

**Research Objective:**

The goal of this research is to study the use of a mobile application in reducing use of alcohol among teenagers. To achieve this, we have developed this mobile application called CHEERS.

This app will help you to track your alcohol consumption, give you reports based on your alcohol use and provide you with educational resources that can help you learn more about the dangers of excessive alcohol consumption.

**Funder:** NSERC Discovery Grant Program

**Procedures:** You are invited to use this application for four weeks. At the beginning of this exercise, you will be required to complete a short (~5mins) pre-app usage questionnaire after which you will be randomly assigned to a control or social group. Participants assigned to the social group will be able to see the average performance score of the participants group and how they compare with the aggregate, while the control group participants won't see this information. Everyone starts with a performance score of 5.0 at the beginning of the study.

During this four-week period, we will log your usage of the app and information about the drinks consumed (the type and number of drinks) which you provide. At the end of this six-week study period, the app will prompt you to complete a short (~5mins) post-app usage questionnaire. The data collected will be used to evaluate the effectiveness of the persuasive strategies used in the app design.

At the end of the study, you are advised to delete the app from your phone. If you will like to continue using the app, you will have to download another version, which does not collect data about your usage of the app.

**Potential Risks:** There are no known or anticipated risks to you by participating in this research. However, if you are having any difficulties or having a distress as a result of using the application, you can reach out to your school counselor who will be available to help.

**Confidentiality:** We will not be collecting any personal data that can identify you, such as name, email or phone-number. Collected data shall be stored securely in Google Firebase. This Google service is hosted in Montreal, Canada and subjected to Canadian law. At the end of the study, the data shall be deleted from the Google server after it has been downloaded and stored securely on the researcher's computer for analysis. The location (province and city) of the data collected shall be referenced when publishing the results on this study in scientific journals and conferences.

**Right to Withdraw:** Your participation is voluntary, and you may withdraw from the study at any point during the period of the study. The app provides a feature (inform of a button) to opt-out of this study. You will have to use this feature to opt-out and delete the application from your phone afterwards. Your data shall be deleted and will not be included in the data analysis. You will not be able to withdraw and delete your data after the study has been completed and you have submitted the post-app usage questionnaire.

**Follow up:** To obtain summary of the results from the study, please contact the researcher(s).

**Questions or Concerns:** Contact the researcher(s) using the information at the top of page 1. This research project has been approved on ethical grounds by the University of Saskatchewan Research Ethics Board. Any questions regarding your rights as a participant may be addressed to

that committee through the Research Ethics Office [ethics.office@usask.ca](mailto:ethics.office@usask.ca) (306) 966-2975. Out of town participants may call toll free (888) 966-2975.

**Consent:** By completing the study and submitting the questionnaires, **YOUR FREE/INFORMED CONSENT IS IMPLIED** and indicates that you understand the above conditions of participation in this study.

If you are interested in this study, enter the participation code given to you and click on “I Agree” button below to proceed to answering our pre-app usage questionnaire.





## APPENDIX E

### RECRUITMENT FORM

#### Department of *Computer Science* University of Saskatchewan



#### **PARTICIPANTS NEEDED FOR RESEARCH IN ALCOHOL USE APP TESTING**

We are looking for volunteers to take part in a study of  
***“DE-MOTIVATING EXCESSIVE USE OF ALCOHOL AMONG TEENAGERS”***

As a participant in this study, you would be asked to use our mobile application for a period of four weeks and answer a 5-mins questionnaire through the mobile application at the beginning and end of the study, and you will be required to log your alcohol consumption during this period.

The app also provides educational resources on developing a responsible drinking habit.

Participants who wish to volunteer must be within the ages of 15-18 years and have a personal smart phone, either iOS or Android.

For more information about this study, or to volunteer for this study, please contact:

*Abdul-Hamid Olagunju or Julita Vassileva*  
*Department of Computer Science*  
at

306-966-2073 or

Email: [aoo075@usask.ca](mailto:aoo075@usask.ca) or [jiv@cs.usask.ca](mailto:jiv@cs.usask.ca)

**This study has been reviewed by, and received approval through, the Research Ethics Office, University of Saskatchewan.**



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**usask.ca**


## APPENDIX F


### AUDIT QUESTIONNAIRE


	0	1	2	3	4
How often do you have a drink containing alcohol?	Never	Monthly or less	2 to 4 times a month	2 to 3 times a week	4 or more times a week
How many drinks containing alcohol do you have on a typical day when you are drinking?	1 or 2	3 or 4	5 or 6	7, 8, or 9	10 or more
How often do you have six or more drinks on one occasion?	Never	Less than monthly	Monthly	Weekly	Daily or almost daily
How often during the last year have you found that you were not able to stop drinking once you had started?	Never	Less than monthly	Monthly	Weekly	Daily or almost daily
How often during the last year have you failed to do what was normally expected from you	Never	Less than monthly	Monthly	Weekly	Daily or almost daily
How often during the last year have you needed a first drink in the morning to get yourself going after a heavy drinking session?	Never	Less than monthly	Monthly	Weekly	Daily or almost daily
How often during the last year have you had a feeling of guilt or remorse after drinking?	Never	Less than monthly	Monthly	Weekly	Daily or almost daily


How often during the last year have you been unable to remember what happened the night before because you had been drinking?	Never	Less than monthly	Monthly	Weekly	Daily or almost daily
Have you or someone else been injured as a result of your drinking?	No		Yes, but not in the last year		Yes, during the last year
Has a relative or friend or a doctor or another health worker been concerned about your drinking or suggested you cut down?	No		Yes, but not in the last year		Yes, during the last year
How many drinks do you typically consume when you socialize with friends	I don't keep track	1-2	3-4	5-6	7+
How many drinks do you typically consume when you party	I don't keep track	1-2	3-4	5-6	7+

## APPENDIX G

**RE: Permission To Use Resources on <http://scanmail.trustwave.com/?c=172...>** 

 **drugs.ie** <drugs.ie@hse.ie> Tuesday, July 2, 2019 at 2:12 AM

To:  Olagunju, Abdul-Hamid

 To protect your privacy, some pictures in this message were not downloaded. [Download pictures](#)

Dear Hammid,


Please feel free to quote and reference our resources on drugs.ie. You can reference them as drugs.ie 2019.

You may also find some useful resources on [www.drugsandalcohol.ie](http://www.drugsandalcohol.ie) which is the website of the Health Research Board here in Ireland.


Very best of luck with your studies,

Nicola

The Drugs.ie Team  
National Social Inclusion Office, Health Service Executive, Mill Lane, Palmerstown, Dublin 20, D20 KH63  
Tel: 01 620 1675 | Email: [drugs.ie@hse.ie](mailto:drugs.ie@hse.ie)  
[www.drugs.ie](http://www.drugs.ie) [www.hsesocialinclusion.ie](http://www.hsesocialinclusion.ie)  
An Oifig Náisiúnta don Chuimsiú Sóisialta, Rannóg Cúram Príomhúil, Feidhmeannacht na Seirbhíse Sláinte, Lána an Mhuilinn, Baile Phámar, Baile Átha Cliath 20, D20 KH63.

 Seirbhís Sláinte  
Níos Fearr  
á Forbairt

Building a  
Better Health  
Service



---

**From:** Olagunju, Abdul-Hamid [<mailto:aoo075@mail.usask.ca>]  
**Sent:** 02 July 2019 01:48  
**To:** **drugs.ie**  
**Subject:** Permission To Use Resources on <http://scanmail.trustwave.com/?c=17268&d=tqma3Tj8gzTNifjxxVkdnhQMxzJNhwdmhSW8BZXEdQ&s=343&u=http%3a%2f%2fDrugs%2eie> website

To Whom It May Concern,

My name is Olagunju Abdul-Hamid, a graduate student of Computer Science at the University of Saskatchewan, Canada. I am currently working on a study on mitigating alcohol addiction among teenagers and I came across your website (<http://www.drugs.ie/>) with some useful resources that I would like to include in my study.

I am using this medium to seek your permission to use these resources and I will make references and give credits where appropriate.

Thanks in anticipation of your kind and timely response.

Hammid.

## **APPENDIX H**

### **PRE-QUALIFICATION SURVEY**

1. If you consent to participate in the study under the above conditions, please, check the “Yes” box below, check "No" if otherwise to proceed.
  - a. Yes
  - b. No
2. What is your age?
  - a. Under 19
  - b. 19 and above
3. I have a personal Android device
  - a. Yes
  - b. No
4. Please enter your email address or phone number.

# APPENDIX I



UNIVERSITY OF  
SASKATCHEWAN

Behavioural Research Ethics Board (Beh-REB) 26/Mar/2020

## ***Certificate of Approval***

Application ID: 1565

Principal Investigator: Julita Vassileva

Department: Department of Computer Science

Locations Where Research

Activities are Conducted: Saskatchewan, Canada

Student(s): Abdul-Hamid Olagunju

Funder(s): Natural Sciences and Engineering Research Council of Canada

Sponsor:

Title: ALCOHOL USE DISORDER: INTERVENTION FOR UNDER-AGE DRINKING USING  
PERSUASIVE TECHNIQUES.

Approved On: 26/Mar/2020

Expiry Date: 25/Mar/2021

Approval Of: Behavioural Research Ethics Application

Consent form

Pre-intervention questionnaire

Post-intervention questionnaire

Demographic Form

Recruitment form

Acknowledgment Of: Letter of Support from Regina Catholic Schools

TCPS2 Core Certificate (Olagunju)

Review Type: Delegated Review

### **CERTIFICATION**

The University of Saskatchewan Behavioural Research Ethics Board (Beh-REB) is constituted and operates in accordance with the current version of the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2 2014). The University of Saskatchewan Behavioural Research Ethics Board has reviewed the above-named project. The proposal was found to be acceptable on ethical grounds. The principal investigator has the responsibility for any other administrative or regulatory approvals that may pertain to this project, and for ensuring that the authorized project is carried out according to the conditions outlined in the original protocol submitted for ethics review. This Certificate of Approval is valid for the above time period provided there is no change in experimental protocol or consent process or documents.

Any significant changes to your proposed method, or your consent and recruitment procedures should be reported to the Chair for Research Ethics Board consideration in advance of its implementation.

### **ONGOING REVIEW REQUIREMENTS**

In order to receive annual renewal, a status report must be submitted to the REB Chair for Board consideration within one month prior to the current expiry date each year the project remains open, and upon project completion. Please refer to the following website for further instructions: <https://vpresearch.usask.ca/researchers/forms.php>.

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***Digitally Approved by Diane Martz, Chair  
Behavioural Research Ethics Board  
University of Saskatchewan***