

# **A MOBILE APPLICATION PROMOTING GOOD CONTACT LENS PRACTICES**



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MINOR DISSERTATION PRESENTED IN PARTIAL FULFILLMENT  
OF THE REQUIREMENTS FOR THE DEGREE OF  
MASTERS IN INFORMATION TECHNOLOGY  
IN THE DEPARTMENT OF COMPUTER SCIENCE  
UNIVERSITY OF CAPE TOWN

MARCH 2021

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## **PLAGIARISM DECLARATION**

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## ABSTRACT

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Contact lens complications pose an ongoing problem for both optometrists and contact lens wearers. Most of these complications are due to noncompliance to good care practices. Education is the first step to ensuring compliance. If good habits are created on commencement of wear, patients are more likely to continue with these habits or practices. The key however, is maintenance and building on this education, as we cannot expect patients to remember all the information given to them initially. Telemedicine is rapidly becoming a wide reaching and convenient way to provide services and support to patients. The aim of this study was to create a mobile application to provide contact lens wearers with knowledge and assistance to empower them to take good care of their eyes and lenses.

A mobile application was built for the study with three main features: a lens change reminder, an information feature, and a diagnosis facility to aid contact lens wearers when they encounter any problems. A PDF version of the application was also created with the latter two features; a secondary aim was to compare its success with that of the mobile application.

After receiving ethical clearance for the study, lens wearers who signed the Informed Consent form, were surveyed about their symptoms, knowledge and habits in relation to contact lenses and their eyes. After being divided into two groups, they were either given the mobile application or the PDF document to use. They were subsequently given a second survey to determine if there were any changes to symptoms, habits and knowledge. They were also questioned about the value and effectiveness of the application and the PDF.

Although, the results of habit changes were inconclusive, there was a decrease in symptoms after using both the app and the PDF. Both were well received and the majority of participants reported that they would recommended them to others. The mobile application was used more frequently than the PDF, led to a slightly better improvement in knowledge, and scored slightly better in its user evaluation, compared to the PDF.

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## ACKNOWLEDGEMENTS

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First and foremost the greatest thank you to my Lord Shiva and Mother Saraswathi. Without whom nothing is possible.

A sincere thank you to my supervisor Prof Sonia Berman. I am so grateful for your patience and guidance especially since this has taken me so very long to complete.

A huge thank you to my family and friends for the support, understanding and being such amazing sounding boards throughout my studies especially my brother Lee.

To my colleagues and participants who contributed to my study.... your interest and contribution mean so very much to me.

The biggest thank you must definitely go to my awesome mother, Shirley. Without your sacrifice, encouragement and steadfast protection I would not have been able to complete this. I love you so much Ma.

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## GLOSSARY

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- *Contact lens* – (abbreviated to CL) is a thin curved lens that is placed on surface of the eye to correct vision.
- *2-weekly disposable* – the same routine as for monthly disposable, but lenses are disposed of every 2 weeks.
- *Daily disposable lenses* – the patient inserts a fresh new pair of lenses every day and disposes the lenses at the end of the day. No cleaning is required as a clean new lens is inserted every time.
- *Daily wear* – the patient wears the CLs during and removes them before going to sleep.
- *Extended wear* – the patient does not remove lenses before going to sleep. A maximum of 6 nights' wear is allowed followed by 1 night's rest.
- *Hydrogen peroxide* – a chemical solution used to clean and store lenses. This does not require the user to physically clean the lenses. The lenses are stored in a basket-like apparatus that has a lead disc attached which neutralises the hydrogen peroxide into saline. It can cause a chemical burn to the eye if the un-neutralised solution comes into direct with the eye. Lenses need to be stored in the apparatus for usually a minimum of 6 hours to be neutralised.
- *Monthly disposable lenses* – a patient wears the same pair of lenses for a month. Lenses are ideally removed and cleaned every evening and the cleaned and reinserted every morning. Lenses are disposed of every month.
- *Multipurpose solution* – a chemical solution used to clean and store contact lenses. It required the user to physically clean the clean by rubbing the lens with the solution. After using this solution, it is safe for direct contact with the eye.

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## **CHAPTER 1**

### **INTRODUCTION**

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#### **1.1 Problems facing Optometrists**

Ocular complications due to poor contact lens (CL) care is a major and frequent problem facing optometrists worldwide. These complications can often have severe and permanent consequences. The damage could range from mild infections, to infections that prevent the individual from ever wearing contact lenses again, to more devastating effects like blindness. Contact lens dropouts result in the individual not benefitting from wearing contact lenses, such as ease and safety during sport, and for cosmetic reasons. It also results in revenue losses of the optometrist. In 2015 the Centre for Disease Control (CDC) stated that 99% of contact lens wearers in the United States reported at least one risky behaviour that could lead to a CL complication [1].

The same study found that many CL wearers were unsure about how to properly care for their lenses. When an individual first starts wearing contact lenses they are supposed to be given a full instruction session on proper handling and care of their CLs and eye health [2]. This information serves to maintain the health of the eye and prevent infections and injuries. It also serves to maintain the integrity of the contact lenses themselves to function in the manner intended. Even if this is given to the wearer, information may be forgotten by the wearer and/or some information may be omitted by the optometrist. Therefore it is recommended that written instructions are to be given to first-time wearers. The possible subsequent problem would be the loss of even the written information.

Therefore the goal of this study was to build a basic mobile application and explore its usage as a method to aid contact lens compliance to good practices and thus decrease the incidence of infections and complications. The maintenance of health can result in less drop-out and more CL wearers. Current wearers will have healthier eyes and can reap and enjoy the full benefit of wearing CLs for many years. The additional benefit could be the increased revenue of Optometric practices.

#### **1.2 Technology influences on medicine**

The ubiquitous nature of technology has impacted the way medical professionals care for their patients. Technology has created newer and more accurate devices and equipment to help practitioners diagnose different conditions earlier and with more accurate differential diagnosis.

Treatment methods are also improved with devices aiding patients to monitor and better manage their conditions. This results in healthier patients, improving quality of life and decreasing the financial burdens of health care. The number of medical mobile applications (apps) are on the increase and provide a convenient source of support for the patient. [3, 4] If accurate and sound information is more readily available, patients are able to find faster solutions to their issues; and many of the potential complications require quick action.

### **1.3 Goals**

This study sought to build a basic mobile application to investigate its usefulness as a potential method of providing support to contact lens wearers.

Further to this a Portable Document Format (PDF) replica of the app was created to compare the two different methods of delivering information and supporting the CL wearer, with the mobile app having interactive functions and the other more traditional printed guide in the form of a Portable Document Format (PDF).

The PDF was given to a control group and the app to the experimental group so that a comparison could be made. The information given in both formats was exactly the same, but presented in different forms. This was done to analyse more accurately the differences in the two delivery methods. If the difference was too great there would possibly be too much of a bias. For example, the instruction page was identically presented in a listed format in both methods. However, in the instance of the Diagnosis page, it was presented differently: the app had the form of a functioning, interactive decision tree and in the PDF it was presented as a flow diagram.

### **1.4 Scope**

The scope of the study is limited to providing the basic information that should be given to the wearer during the initial instruction session, with some support for troubleshooting possible symptoms.

The app's interface design is outside the scope of this work, and kept as basic as possible, as the focus of the study is investigating the potential of a mobile application being a new avenue to support contact lens wearers.

The number of subjects given the app or PDF version was limited to a reasonable but small sample size. To avoid bias, the researcher could not use her own patients.

## **1.5 Ethics**

The researcher is an Optometrist with 15 years of experience. Altogether 12 different optometrists were consulted at different stages of the study to provide feedback on features and methods, and to give approval to ensure the health and safety of all participants was maintained throughout the study.

As this study required the participation of human subjects, ethics clearance was obtained from UCT's Science Faculty Ethics Committee at the outset. Participants were given a detailed description of what the study entailed and informed consent was acquired from each participant. They were assured that study was to their benefit, there was no intended risk in participating and they could withdraw at any time. The privacy and wellbeing of the subjects were fully considered and maintained.

## **1.6 Thesis Outline**

Chapter 2, the Background chapter, reviews the research literature on the problem of contact lens complications and how medical care is being improved by technology.

Chapter 3 covers the Design rationale of the app and PDF. The process, considerations, and reasons why design decisions were made are provided.

Chapter 4 details the Implementation of these design choices. Coding and tools utilised are discussed in detail.

Chapter 5, the Experiment, discusses the procedure followed with the test subjects. This includes the development of the questionnaires and delivering the app/PDF to participants.

Chapter 6 presents and discusses results of the experiment.

Chapter 7 concludes the work and provides suggestions for future development.

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## CHAPTER 2

### BACKGROUND

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#### 2.1 Description of Contact Lens Complications

Several types of complications may occur with wearing contact lenses. The causes may be mechanical (ill-fitting contact lenses), patients not adhering to proper care of the lenses or may be as random as a bout of influenza. However, the risk of these problems can be significantly reduced by following a good and strict care regime.

The most common complications are elaborated upon here:

- *Corneal Neovascularisation*

Ingrowth of new blood vessels in the cornea due to corneal hypoxia (oxygen deprivation) [2]. Hypoxia is due to the patient wearing lenses over the recommended hours per day thus limiting oxygen transmission to the cornea. There are no symptoms but if the vessels penetrate the corneal stroma quite deeply, vision may be affected due to associated opacities.

- *Contact lens Induced Giant Papillary Conjunctivitis (CLGPC) / Giant Papillary Conjunctivitis (GPC)*

CLGPC or GPC is an inflammatory condition of the underside of the upper eyelid [2]. This condition is characterised by redness, papillae, and sometimes in severe cases, a mucus discharge. The most common symptom experienced by patients is a foreign body sensation while not wearing contact lenses. This is caused by improper cleaning of the contact lens which leads to a build-up of protein in the lenses and there follows an allergic inflammatory reaction.

- *Contact lens acute red eye Syndrome (CLARE)*

CLARE is an inflammatory reaction commonly seen in patients that follow an extended wear (EW) regime [3]. The patient will often wake up with a red eye and complain of pain, excessive tearing, and sensitivity to bright light. It most often is due to bacteria being present in the lens or lens solution.

- *Microbial keratitis (MK)*

Keratitis means infection of the cornea, and Microbial Keratitis is a serious infection that has the potential to cause the loss of sight. Therefore, it requires immediate attention. Symptoms include severe pain, sensitivity to light, and a foreign body sensation [5]. The infection most often

includes an ulcer on the cornea. MK in lens wearers is linked to an EW regime, poor hygiene by the wearer, and contaminated lens storage cases [6].

- *Contact Lens related Peripheral Ulcer (CLPU)*

CLPU is found with EW but unlike the above MK associated ulcer, it is sterile. “When deposits develop on contact lenses, the lens surface becomes roughened, and epithelial defects may develop as a result. This disruption of the epithelium, may provide a means of entry for toxins or immunogenic agents [7]”. This causes the ulcer to be formed. There are more surface deposits in patients that follow an EW regime due to less frequent cleaning of CLs. There is very little pain but rather a mild foreign body sensation. The wearer is required to cease wearing CLs to prevent the condition from deteriorating.

- *Acanthamoeba Keratitis*

Acanthamoeba Keratitis is a devastating condition caused by contamination of the lens or the lens case by the protozoa Acanthamoeba which is free-living and a parasite [5]. They are double-walled organisms that can transform into very resistant cysts. This makes the condition very difficult to treat. They are found widely and therefore CL wearers need to be very careful when exposing their lenses and cases to any water environment like baths, showers, swimming pools, and hot tubs. It is also crucial that lenses are not exposed to tap water. The infected patient will experience severe pain, decreased vision, and a very red eye.

- *Dry eye Syndrome*

Dry eye or dryness is the most common complaint by contact lens wearers [5]. In a 2005 study, it was found that “Contact lens wearers were most likely to report dry eye disease (52.3%), followed by spectacle wearers (23.9%) [8].” It is due to a disruption in the tear film layer that covers the surface of the eye. Since one of the functions of the tear film is bactericidal, a disrupted tear film makes one more susceptible to infection. CL patients with dry eye syndrome will complain of a dry foreign body sensation with the lens inserted and often without as well. Blurred vision with the lens, itching, and redness are other symptoms patients complain about. For the CL to remain comfortable and provide clear vision it needs to remain moist. Some of the CL related causes of dry eye are over wearing the lens (both in hours per day and over the prescribed number of days), and not cleaning the lenses properly. Non-CL related factors include medication, age, vocation, and environment.

## 2.2 Incidences of Contact Lens Complications

Contact lens complications are unfortunately very common and could have very serious consequences. Besides the potential to cause damage to vision, they could also cause individuals to stop wearing CLs. In a retrospective study entitled “Corneal infiltrates and ulcers. A retrospective study of 239 eyes” it was found that, “In 134 (56%) of 239 eyes with keratitis, contact lenses were used as visual aids, of which 127 (53%) were soft [9]” contact lenses. 10% of wearers developed a corneal ulcer some with permanent scarring. Therefore it was concluded that the risk of developing keratitis was significantly higher in contact lens wearers. This was caused mainly by Gram-negative bacteria build-up on the lens due to inefficient or lack of cleaning. The study recommended that these incidences should be highly considered in patient education, in particular handling and cleaning of contact lenses, as proper cleaning would prevent these complications. Further to that, a study in Singapore found that the most frequent complication was infectious Keratitis. In their sample, 98.8% with infectious Keratitis wore contact lenses and 73% of them wore monthly disposable lenses. The study stated if lens care and hygiene was not observed, the wearer could develop sight-threatening complications [10]. New material and designs of contact lenses have been developed to try to reduce complications. However, a study in Australia concluded the newer materials did not, in fact, reduce certain complications, specifically contact lens-related Microbial Keratitis (MK) [11]. They also concluded that sleeping overnight with any contact lens (irrespective of material) was associated with a higher risk than just wearing lenses during the day. Although the incidence of contact lens-related microbial keratitis is rare, it could result in permanent vision loss. Daily disposable wear, was the lowest risk of severe cases of MK and they theorised that this could be due to the elimination of the storage case. The case, if not cleaned properly, can increase the severity of MK caused by Gram-negative bacteria.

Physical changes can be seen in the eye structures (cornea and tear film) in patients that sleep overnight with their contact lenses [12]. This is due to oxygen deprivation in the cornea with the corresponding build-up of carbon dioxide. This results in Neovascularisation of the cornea. Further complications include tear film instability, allergy and toxicity, mechanical effects, inflammation and infection, and desiccation. With newer materials that promote oxygen transmission however, these conditions are becoming less common. The Singaporean study mentioned above, noted “With the move toward the use of high diffusion gradient silicone hydrogel lenses, it is thought that such lenses can reduce the incidence of chronic hypoxia, oedema, and neovascularization of the cornea [10]”. In contrast, the Australian study showed there are still complications even with the newer materials. Another supported this and found that complications were due to mechanical trauma [13]. Considering all these factors, one can

conclude that continuous or extended wear, where there is also less cleaning, is still risky behaviour.

An investigation in India found that contact lens-induced papillary conjunctivitis (CLPC) was the most common complication followed by neovascularisation of the cornea [14].

An investigation in England and Wales found that 88% of Acanthamoeba keratitis (AK) cases were contact lens wearers. Among these, 60% were not disinfecting regularly and/or correctly, and 32% had been swimming with lenses. It was also found that soft contact lens wearers were using less effective cleaning solutions and this contributed to the increased risk of infection [15]. In Chicago, in a study of 40 cases of AK between June 1, 2003, and November 30, 2005, 95% wore contact lenses [16]. A more recent study in Egypt found that the most significant risk factors were sleeping while wearing contact lenses and contact with water sources through tasks such as rinsing CL cases in water, swimming and/or showering whilst wearing CLs [17].

## **2.3 Environmental Factors**

Plastic pollution is a major issue in modern times and contact lens wears are inadvertently contributing to the problem by disposing of the lenses via the toilet or sink. They can be easily ingested by marine life as they are transparent, leading to the animal becoming sick or even killing the animal if their digestive tract gets blocked.

In 2018, Arizona State University scientists presented their findings on contact lens pollution: “We found that 15% to 20% of contact lens wearers are flushing the lenses down the sink or toilet ... This is a pretty large number, considering roughly 45 million people in the U.S. alone wear contact lenses, amounting to 1.8 – 3.36 billion lenses flushed per year, or about 20-23 metric tons of wastewater-borne plastic annually [18]”.

Many people do not consider this as pollution and may unwittingly believe that because of the size of a lens it cannot be making an impact. They may even be unaware that it is made of a type of plastic. Optometrists may not mention disposal methods to patients. However, if patients are properly educated and made aware of this environmental consequence they can change their habits accordingly.

## **2.4 Instructions on Contact Lens Care [2, 5]**

To ensure that patients avoid contact lens complications certain methods and precautions need to be taken. Upon a patient beginning to wear contact lenses, detailed instructions and demonstrations are given to the patient on how to insert and remove the lenses and how to take care of the lenses. The optometrist will demonstrate these actions. The patient is then required to do these actions under the supervision of the optometrist, who will guide the patient through this process and advise according to the patient's individual needs. Other factors to be considered are the patient's eye size and if they are left or right-handed. Little mistakes that the patient is unaware of are pointed out. Only once the patient is competent can the contact lenses be dispensed if not, a second session is booked for re-instruction. The patient may be nervous or frustrated and will need more time. If the patient is having a lot of difficulties and is taking a long time, which can also lead to redness and bruising of the area around and in the eye, the patient should be rebooked to avoid injury and possibly put off wearing lenses.

## **2.5 Cyberchondria**

Many people uses the internet to search for symptoms that they might be experiencing and are flooded with unfiltered information. This can have two results, either an overestimation of health and the patient succumbs to the condition as they do not seek treatment, an underestimation of health which leads to unnecessary anxiety. Another problem is that it can be difficult, in some instances, for medical practitioners to set the record straight and convince the patient of the truth. Medical professionals can use their background knowledge of physiology and the information provided by the individual, family history, symptoms and presentation of condition, to make an educated diagnosis. The danger of people underestimating their symptoms and not seeking proper medical attention timeously can often prove to have dire consequences and in some cases be fatal. Many conditions, if diagnosed within good time can be treated successfully, sparing the individual negative symptoms and in some cases saving their lives.

“Cyberchondria is a term used to refer to searching the web excessively for health care information. More recently it was defined as a pattern of excessive and repetitive internet symptom-checking behaviour and purported to be related to underlying health anxiety and non-reassurability [19]”. This anxiety leads to more adverse effects on health. Information on the internet is of “unregulated accuracy” and a nonthreatening symptom query can yield a “disproportionately high rate of statistically unlikely explanations, such as a life-threatening illness [19]”. In 2008, Microsoft conducted a study on Cyberchondria and concluded that there

is a potential for health concerns to intensify due to searching for symptoms on search engines [20].

Since the patients do not have the same background knowledge as medical practitioners they are unable to sift through the information in a logical and holistic manner. A 2008 study revealed that the “efficiency of the search and the usefulness of the retrieved information also depends on the searchers' knowledge base. ...Patients doing a Google search may find the search less efficient and be less likely to reach the correct diagnosis. We believe that Google searches by a “human expert” (a doctor) have a better yield, as Google is exceedingly good at finding documents with co-occurrence of the signs/symptoms used as search terms and human experts are efficient in selecting relevant documents [21]”.

The internet can be useful in a health professional's toolset if wielded in a positive manner thus reducing Cyberchondria and related anxieties. Providing patients sources with reliable information or resources of information will be beneficial to both parties. “A high percentage of patients and parents (83%) want clinicians to provide them with links to reputable websites to improve their healthcare knowledge [22]”.

A study of internet searches on how to treat high fevers in children found the information was highly inconsistent and differed regarding the best way to take the temperature, the temperature that was considered and the best treatment to reduce the fever [23].

## **2.6 Education on Good Contact Lens Practices and Prevention of Complications**

A major problem facing optometrists is patients not adhering to correct contact care practices. This results in complications that cause a great deal of discomfort and inconvenience for the patient and in some cases, permanent damage and /r blindness. It is indeed possible to prevent these complications by following the correct regime and practices when wearing contact lenses. In 2015 the Centres for Disease Control and Prevention (CDC) released a report stating that 99% of survey respondents report at least one risky behaviour [1]. CDC Medical Epidemiologist Jennifer Cope, M.D., M.P.H. stated: “We are finding that many wearers are unclear about how to properly wear and care for contact lenses.”

If wearers are unaware of the correct practices there will be a greater chance of complications. It is a prescribed procedure for first-time wearers to receive training on handling contact lenses. However, this information can be forgotten or not grasped, as the wearer can be overwhelmed by the amount of information and the stress of learning a new skill. Even individuals that have

been wearing contact lenses can benefit from receiving the information. In some cases, patients believe that they are indeed compliant even when they are not [24].

A 2007 study found that the best way to improve compliance is education of patients about contact lenses: “1. Patient education. Simple explanations of how to perform each step of the contact lens care regimen, in written and verbal form, should be developed. An explanation of the reason for each step and potential problems that can occur if there is a break in the required steps should also be given. After receiving instructions, the patient should be able to review the material with the eye care professional and show the correct procedures with regard to lens insertion, removal, and care regimen [25]”. The application developed for this project aims to provide precisely this.

Being compliant will not only prevent the patient from getting complications but will also improve overall comfort for a longer period whilst wearing lenses. This will maintain the patient’s satisfaction with CLs and they will also get their full money’s worth from their lenses. This is especially relevant for monthly and 2-weekly wearers. More compliant patients report better comfort at the end of the day and towards the period when the lenses needed replacement [13].

In other medical spheres, non-compliance can be detrimental as well. In a study investigating adherence to medication in patients with Congestive Heart Failure, long term compliance was only 50% [26]. With the increasing use of mobile device and advances in technology, this should be taken advantage of to enhance compliance.

## **2.7 Improving Compliance through Medical Mobile Applications and Telemedicine**

To help patients searching for convenient and quick solutions to their problems, access to reliable medical care can be provided via mobile apps and regulated websites. People’s lives are becoming busier and often adhering to medical regimes can fall by the wayside. Technology has a great many uses in making our lives more convenient. Encouraging and supporting people to manage health conditions is one such use. The number of smartphone users surpassed three billion in 2020 [27]. This can be taken advantage of by using this to increase compliance in the form of reminders and reliable and accurate information at their fingertips.

Telemedicine is the “use of medical information exchanged from one site to another via electronic communications to improve a patient’s clinical health status. Using this definition every phone call, electronic message or text to a patient could be defined as telemedicine [28]”. A wider explanation would be “the use of telecommunication technologies to provide medical information and services [29]”. The World Health Organisation (WHO) defines eHealth as “the use of information and communication technologies [ICT] for health [30]”. They go on to state

Mhealth or mobile health can be defined as “medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices.”

Several HIV and AIDS studies have shown a positive impact on medication adherence by using technology to remind and support patients. In one study, where the participants were sent dynamically tailored text messages via their cell phones, many patients were open to receiving tailored texts and even reported an improvement in their adherence to medication regimes. T “Overall viral load significantly decreased and CD4 count significantly increased from baseline to follow-up [31]”. Deficiency of compliance to antiretroviral therapy is one of the greatest predictors of progression to AIDS and death among persons living with HIV [32].

Another HIV related study investigated the viewpoints of patients and service providers on a cell phone based system to increase adherence to medication schedules. Feedback received from both parties indicated that SMS reminders would be helpful in adhering to a correct medication regime. However, one reservation was ‘message fatigue’. Other reservations included cost, lack of education, and possible difficult manipulation of a cellular phone [33].

Very little research has been done on critiquing the apps for contact lens wearers on Apple’s iStore and Android’s Play Store.

In 2017 a Canadian study was conducted on the number of eye care related apps on Itunes [34]. Their search found 355 apps for app clinicians and laypeople. About 80 of the apps were categorised as ‘mixed-use apps’. These apps allowed two-way communication between the practitioner and the patient, mainly for marketing purposes and appointment reminders. Contact lens support was categorised under ‘Utilities’, along with other visual aids, and all of these accounted for only 35 apps. This included apps that served as reminders for wearers to replace their lenses. Other eye care related apps were for self-testing, eye exercises, and magnifiers. The search found 18 apps that had educational purposes for laypeople to improve their knowledge of ocular diseases prevention as well as conserving the health of their eyes. This was not specific to contact lens care.

A 2019 study on eye care apps available on the Android OS Play Store found that only 2% of apps were contact lens care and maintenance related [35]. Of all the apps they reviewed only 22.53% mentioned the involvement of eye care professionals in app development. Most of the apps were for the use of eye care professionals and only 28.04% were for the use of the general public.

Other avenues of support for contact lenses wearers via technology present predominately as websites. A google search reveals mainly the sites of contact lens manufacturers. These pages have information on the handling of contact lenses, cleaning instructions, some dos and don'ts and miscellaneous information on contact lenses. The information is very general and very useful to users. However, in the event of a user having a specific problem, finding the solution is not easy as they have to sift through much information without holistic knowledge.

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## **CHAPTER 3 SYSTEM DESIGN**

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### **3.1 Introduction**

A study was conducted to evaluate the effectiveness of a mobile application compared to that of a PDF document for contact lens wearers. To determine the design of these, focus groups were conducted initially. Information and ideas for what features would be beneficial were gathered during two focus groups. One involved a group of general mobile device users and one involved optometrists. Considering this material, the mobile app was developed. A questionnaire was given to users before and after using the app or PDF to determine if there is an improvement in their practices, habits, and knowledge. Data collected was then processed.

### **3.2 Focus Groups**

#### 3.2.1 Optometrists Focus Group

A focus group was held with only optometrists to find out reasons that they feel their contact lens patients are remiss, and ways to encourage compliance. There were 4 participants with an age range of 33 to 45 and all participants were full time employed in private practices. Years of experience in treating contact lens patients ranged from 11 to 24 years. Negligent lens care practices are determined either during the case history or during the examination where clinical findings give evidence of unhealthy and harmful habits. The most frequent issue faced is patients over-wearing lenses for either too many hours in a day, or more commonly wearing lenses over the prescribed time period: that is, wearing a monthly lens for more than a month or a daily lens for more than one day. It was, therefore, suggested a reminder feature to change lenses be included in the app. Another regular issue was patients not cleaning their lenses correctly. To resolve this issue, detailed instructions on cleaning contacts should be included in the app to reinforce instructions demonstrated during the instruction session. When a patient begins wearing contact lenses, an instruction session is given. This session details correct and safe methods to insert and remove lenses, cleaning and storage of lenses, and points on what can and cannot be done to lenses or while wearing lenses. The factor of cost was raised. Further to that, the idea of giving patients incentives in the form of discounts or even a points system to get discounts on future purchases was discussed. The cost of lenses was a common complaint with patients as to why they wear their lenses longer than prescribed. It was deduced that if the cost factor can be reduced patients would more likely adhere to prescribed regimens.

### 3.2.2 Mobile App User Focus Group

The discussion began with an introduction on the purpose of the app that is to improve contact lens compliance to good practices and thus improve patient eye health. Handouts were given to the 5 participants detailing the purpose of the group study with provision for the participants to make notes or draw suggestions.

All participants had a reasonable to good knowledge of contact lenses and their uses. However, all participants were made aware that misuse of contact lenses could possibly lead to blindness. The discussion then went on to contact lenses and their uses (therapeutic or to improve vision). Good practices were also explained, which are proper cleaning methods, wearing modalities, precautions, and dos and don'ts. We then moved on to the consequences of not following good contact lens practices which led to contact lens complications. The most common complications were presented and pictures depicting normal healthy eye and then eyes with complications were showed to the group for better understanding.

Ages ranged from 20 to 55 with all considered middle class in terms of wealth. Education level varied between Ph.D. and first-year University. There was a great variance in terms of technology skills. The oldest member had very limited knowledge but had basic computer skills. One member had some IT training and the others rated their technological knowledge to be very good and used their mobile devices numerous times during the day. A medical professional (physiotherapist) was present as well to provide his view on possible features that would benefit patients.

Members were asked what features and functionalities would be useful to include. A page by page discussion was then done and participants were asked if each page was necessary and their requirements or expectations for the page. Desired functionality, behaviour and design were also discussed for each page. The group brainstormed different ideas and argued the practicality and need for suggested features. Pages that were not presented were also discussed, as well as future expansion and developments to the app. The last activity was for the participants to draw or fill out on handouts any suggestions.

#### *Overall app suggestions:*

- Large bold font to cater for people with very poor vision, as people may not be wearing spectacles or contact lenses when using the application.
- Buttons with words instead of symbols are preferred to cater to inexperienced app users.

- Information page with random and arbitrary information about lenses or eyes. Suggestions for this were information on new contact lenses available, functioning of the visual system and processes, anatomy and health of eyes.

*Future Development and Incentivisation:*

- Contacting optometrist either to make appointments or getting advice.
- Ordering system. The first box could be free. All orders could be at discounted rates if ordered through the app. Features for trying on colour contact lenses which would include using the phone's camera

### **3.3 Development of Mobile Application and Information Sheet**

The mobile application Happy Contact Lens Wearer was developed for this study to aid contact wearer adherence to good practices and to see if this proved more effective than written instructions. The app features three pages, Reminder, Diagnose Me, and Contact Lens Care.

#### 3.3.1 Portable Document Format (PDF) version of the app

In order to assess the effectiveness of the mobile app, a PDF version of the app was created as well. A comparison was done of those that used the app and those that used the PDF. The PDF was drawn up to replicate the app as closely as possible. The Reminder page could not be included in the PDF as it is a dynamic feature in the app. The Diagnose Me page was present in the form of a flow diagram to aid the user to find a solution to their issue. The Contact Lens Care PDF page appears identical to the format on the app.

#### 3.3.2 Usability considerations

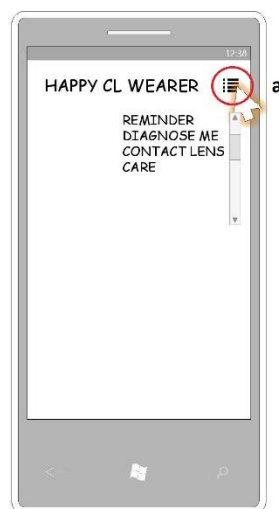
This section outlines the design of the app and the intended user flow.

The overall look and feel of the app was designed to be as simple and as easy to use as possible. The layout and functions were also designed to be as uncomplicated and as basic as possible as the intention was to assess the effect of how information is delivered to the user, be it the app format or the PDF format. The layout was also kept consistent with the menu bar being the same on every page. Familiar user interface features that are commonly known were used. For example, a 'burger icon' was used to indicate the menu, and a 'dropdown arrow' to reveal the calendar date picker was implemented. Built-in features of the Android operating system for which the app was designed, were taken into account. The back button that the user commonly uses on a device can be used to backtrack and navigate through the app.

### 3.3.3 Style considerations

To avoid any disturbances to the user, a clean and simple design with no distractions (such as animations) was created. Ease of use was also a major consideration to ensure that users felt comfortable and actually wanted to use the app. The visual needs of the user were a major consideration as the user could possibly not be wearing a correction (either contact lenses or spectacles) when using the app. Therefore, visual factors like contrast and font size needed careful attention. The layout of the entire app was designed to be as simple and as clean as possible as the user may be in a heightened emotional state when using the app. This may be because first-time contact lens wearers often face difficulties in handling their lenses before they become accustomed to the experience. They are, after all, placing a foreign body into their eyes and fighting the eye's natural reflex to blink when something is very close to the eyes. The Diagnosis page may also be used in a stressed state as the user could be in pain or discomfort due to a problem with the eyes or lenses. Font selection was bold and done in upper case to make it easier to see. A light grey colour was chosen for the background to be soothing to the eyes and to create good contrast to the text.

Each page has the same designed header with menu/navigation bar button on the top right-hand corner. Figure 1 shows the wire framing of the home page. Using an icon aids in hiding the contents so creating less on the screen ensuring that the design is cleaner. The contents on the menu are revealed when the burger icon is touched. [Figure 1, a] This was done consistently on all pages to ensure that the user does not get confused and does not have to learn new ways of using the app on every page. It will help the user learn the interface quickly and prevent the user from being reluctant to use the app because it is either too difficult or irritating. These factors influence the end result of getting the user to be more compliant



**Figure 1:** Wire framing of home page; a) burger icon

### 3.3.4 App icon Design

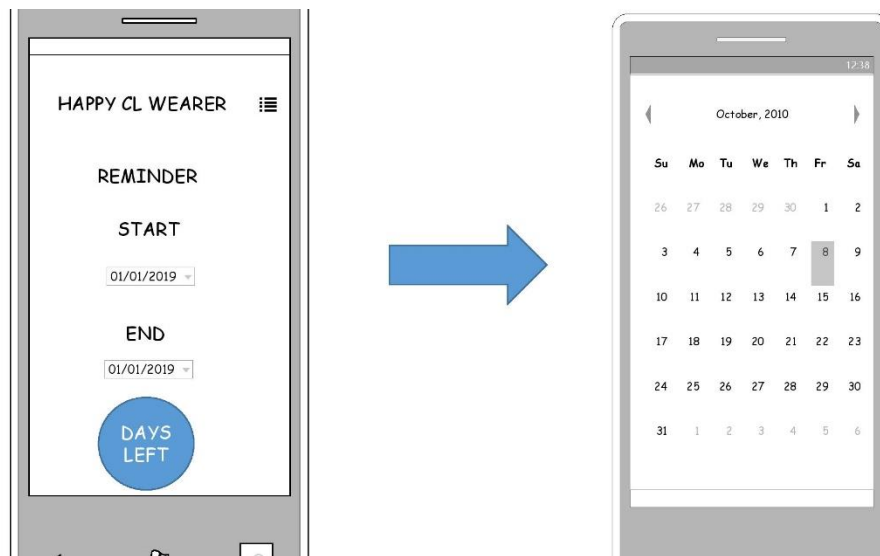
To remain with the “happy” theme cheerful colours of yellow and blue were chosen. The icon needed to give an idea of what the app was related to and thus a contact lens was included. Another reason that the contact lens is depicted in blue is that most contact lenses have a slight blue tint to help the wearer see the lens floating in clear solution. [Figure 2] Therefore the associated colour and shape will remind someone browsing the Play Store of a contact lens.



**Figure 2:** App Icon

### 3.3.5 Reminder page

One of the most common problems encountered by optometrists is patients not changing their contact lenses on time. The purpose of this page is to ensure that the user changes their lenses to a fresh pair according to the instructions given by the optometrist. Initially, a Cordova calendar plug-in was implemented to allow the app to access the phone’s built-in calendar. However, there was concern over the reminders getting lost or not saving correctly on the calendar. Therefore, a simple reminder was created to alert the user to when they have to change their lenses. The user is required to set two dates via two drop-down calendars. The first one is the date they start wearing the lenses and the second is the day they have to stop wearing that particular pair of lenses. [Figure 3] The user is given the option to set these dates to accommodate different wearing modalities, monthly vs 2-weekly. The next day they will have to insert a fresh pair of lenses. The number of days remaining counts down and is displayed below. This countdown gives the user the number of days left and updates daily. This aids the user to know not only how many days they have to wear that particular lens but also serves as a reminder to order more lenses if they are on their last lens or pair of lenses.



**Figure 3:** Wire framing for Reminder Page

### 3.3.6 Diagnose Me

Another common issue is patients not seeking treatment when they have a problem with their lenses or eyes, or googling symptoms and finding inaccurate information. When people Google their symptoms it is often unfiltered and in some cases misleading. This results in users either assuming the worst or not taking symptoms seriously enough. This feature aims to alleviate misinformation which frequently leads to anxiety.

The objective of this page is to allow users to troubleshoot symptoms resulting in them taking necessary action to resolve their issue timeously. The severity of many contact lens complications can be minimized if the contact lens wearer takes the correct action quickly. On the opposite side of the spectrum, this gives the wearer reliable information so as not to cause unnecessary panic.

The flow diagram [Figure 4] shows the “train of thought” or diagnosis to determine what exactly is the patient’s problem and how to solve the problem from the optometrist’s perspective. Six optometrists were interviewed on their differential diagnosis questions to determine the best sequence of questions given to the patient. This train of thought is also guided by textbook recommendations. [2, 5]

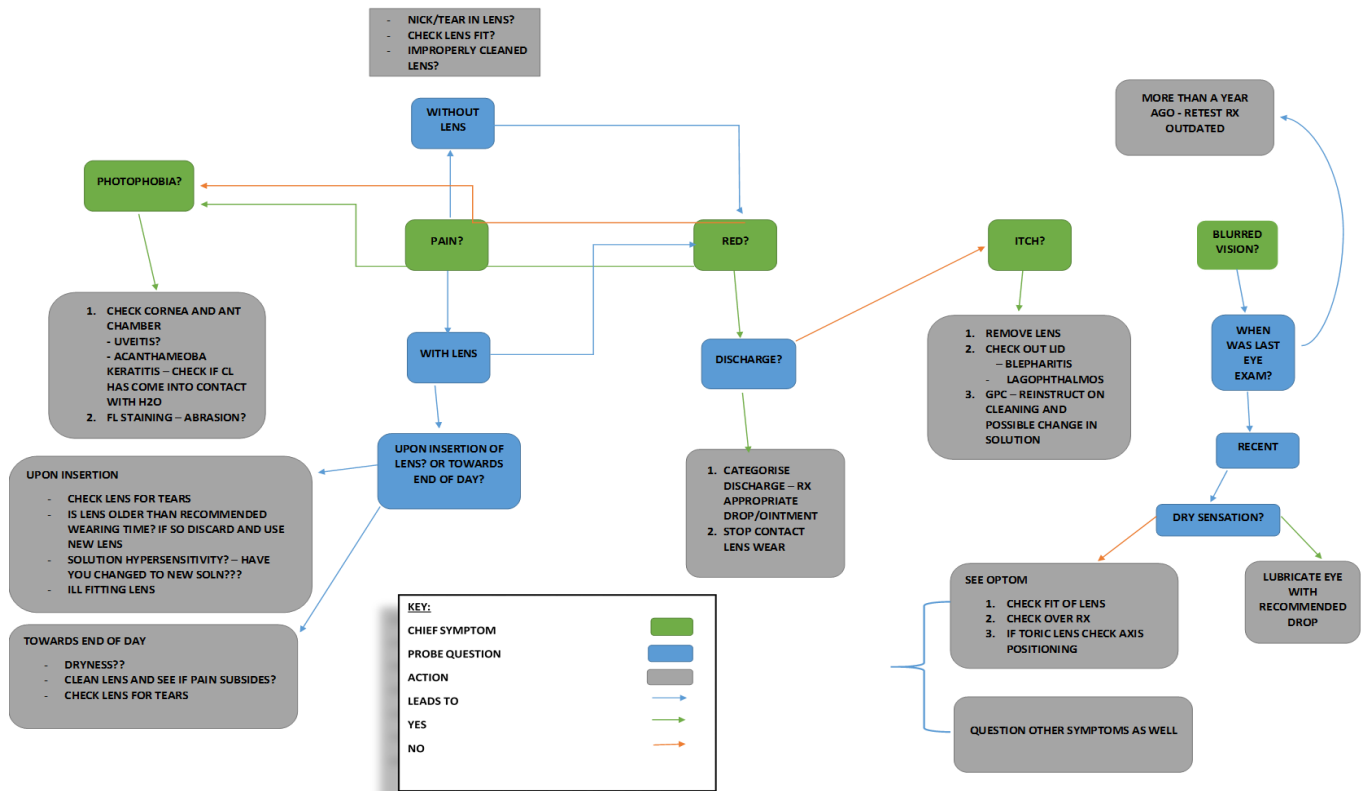


Figure 4 “train of thought” flow diagram

### 3.3.6.1 App format

Users are taken through a series of questions relating to symptoms they may be experiencing. It was developed as a type of Decision Tree [36] with two options at each step, viz. choosing yes or no with radio buttons, as shown in [Figure 5]. The question sequence is dependent on the answer chosen - different answers will result in a different follow-up question. This is done to ensure that the user gets the most relevant result in the end. The subsequent questions remain hidden and the relevant questions are displayed one by one, after each choice is made. At the end of the sequence of questions, the user is given the relevant action they should take.

This end result will give them a plan of action to solve their problem. There are some issues that are very easily solved by the user themselves. Often simply taking out lenses, cleaning them again, and reinserting relieves irritation. Sometimes just removing lenses and giving the eyes a break is what is required. However, some combined symptoms require the user to be examined and treated by an optometrist. This is the case if the user shows signs of infection. Contact lens-related infections have the potential to be blinding and thus immediate action is required. Milder infections especially if treated in good time can be resolved and cleared easily and quickly without causing the user/ patient too much discomfort or inconvenience like taking time off work

or school (because the infection causes them pain or to experience blurred vision). In most cases, even though the infection is due to contact lens abuse, there is a bacterial or viral component to the infection which now becomes contagious and puts people that the user comes into contact with at risk of contracting the infection even though they are not contact lens wearers.



**Figure 5:** Wire framing of Diagnose Me Page

### 3.3.6.2 PDF format [appendix 1]

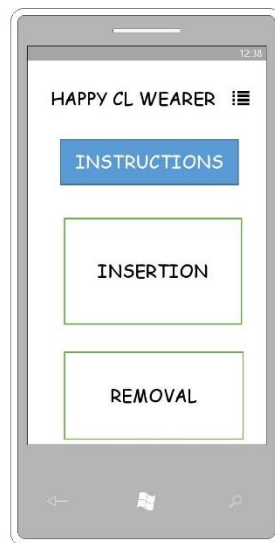
The diagnosis page in the PDF format is presented as a flow diagram. Similarly to the app, the user is presented with questions (exactly the same as app) and yes and no arrows guide the users to the follow up questions and end result.

A different set of 6 optometrists evaluated the flow diagram of questions that was given to users. They were asked if they felt the flow diagram was an accurate representation of determining a differential diagnosis, and they all answered that it was. Upon questioning the safety of the patients using the page, once more they all agreed that it was safe. For improvements and comments on the flow diagram one commented that allergies may cause itching and should be evaluated by an Optometrist. Another commented "Nothing. Kept thinking of possible CL complications and they're all covered."

### 3.3.7 Contact lens Care [appendix 1]

The purpose of this page was to provide written instructions for contact lens care to reinforce or refresh information given to the patient during the instruction session. Contact lenses are considered medical devices and special care needs to be given to ensure they serve their function effectively without causing any damage. During an instruction for a first-time wearer, a large amount of information is given and this can be very overwhelming and some information can be forgotten. Therefore, if the patient has written thorough instructions, they can refer to it and thus make the adaptation process easier and less stressful. It also provides information the optometrist may have forgotten to mention. This page gives detailed instructions on insertion, removal, and proper cleaning of contact lenses. The page also has a list of do's and don'ts so the user will know what is acceptable. If correct and simple instructions are given to the user/patient the likelihood of infections and complications will be minimized.

The design for this page was very simple. Alternate colours were used in each list to aid the user. Four lists were created, Insertion, Removal, Do's and Don'ts.



**Figure 6:** Wire framing of Care page

The 4 lists that were synthesised are shown below:

#### INSERTION

- ALWAYS wash your hands before handling contact lenses.
- Take lens out of right-side vial.
- Clean lens before inserting:
- Place lens in the palm of your hand and pour some solution over it.

- Rub lens on both sides in circular outward movements.
- Rinse lens in more solution.
- Check if lens is on correct side.
- Fold lens between your thumb and your forefinger. If the edges touch it is on the correct side. If the edges curl away from each other it is on the wrong side.
- Place lens on the tip of your right forefinger.
- Pin your upper eyelid of your right eye with your left hand to your brow bone.
- With your right middle finger pull your lower eyelid down.
- Look up or towards your nose and place the lens on the white of your eye. Then look into the lens.
- Look up, down and then side to side to settle the lens.
- Then look down and let go of your eyelids.
- Proceed and repeat steps for left eye.

#### REMOVAL

- ALWAYS wash your hands before handling contact lenses.
- Pin your upper eyelid of your right eye with your left hand to your brow bone.
- With your right middle finger pull your lower eyelid down.
- Look up or towards your nose. Place your forefinger on the coloured part of your eye and slide lens to the white of your eye.
- Pinch the lens off with your thumb and forefinger.
- Clean the lens as described above.
- Place lens back into vial and make sure that you have discarded the solution that was in vial. Fill vial with fresh solution and make sure that lens is fully covered to avoid drying of lens.
- Screw on cap of vial tightly.
- Keep lens in dry cool area.

Patients are also advised on what they can and cannot do to their lenses or while wearing the lenses.

#### DO's

- ALWAYS wash and rinse your hands thoroughly before handling your lenses. Hands should be dried with a clean lint-free towel

- Make sure your lenses and storage cases are cleaned and disinfected regularly
- Replace your contact lenses according to your optometrist's instructions
- If you drop your lens, clean the lens before inserting
- Only use lens cleaning solution to wash and store your lenses
- Change solution in case every time you use your lenses
- Make sure to keep your glasses up to date in the event of you not being able to wear your lenses.
- Always insert your lenses BEFORE applying your eye makeup and remove lenses BEFORE removing makeup.
- Always use eye makeup formulated for contact lens wearers
- If you get any makeup on lenses, remove lens, clean well and re-insert
- Wear goggles when swimming

#### DON'T's

- Use saliva or water to wet your lenses
- Use water to clean your lenses. Water is not allowed to come into contact with your lenses
- Reuse or top-up lens solution in your cases
- Wear lenses if you are unwell
- Wear lenses if they feel uncomfortable or your eyes are red or irritated
- Rub your eyes vigorously especially with lenses in
- Use expired contact lens solution
- Over wear your contact lenses
- Use eye drops that are NOT recommended by your optometrist
- Share contact lens
- Share eye makeup
- Do not fly on aeroplane with while wearing lenses

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## CHAPTER 4

### IMPLEMENTATION

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#### 4.1 Introduction

This chapter discusses the development of the mobile application. It discusses software, platforms, and coding choices. The coding and building of the app are explained in detail. The features and requirements were determined by the focus groups and the researcher's own experience as an optometrist. Three features or pages were decided upon:

- \* A reminder page – a countdown to how many days are left before the user's pair of contact lenses must be replaced
- \* Diagnose Me – a feature to aid users to troubleshoot problems with contact lenses and/or eyes.
- \* Contact Lens Care – instructions on handling their lenses. This is information usually given to a new contact lens wearer during their instruction session.

#### 4.2 Designing and coding of the app

The app was coded using HTML, Cascading Style Sheets (CSS), and JavaScript. It was developed using Visual Studio (VS) as the integrated development environment and Apache Cordova, which is a platform to build Native Mobile Applications using HTML5, CSS, and JavaScript. The app was developed to be used across all platforms and was tested on a Sony Xperia which is an Android device. As the researcher is not an Apple developer, it could not be tested on the Apple devices.

##### 4.2.1 Visual Studio and Apache Cordova

Visual Studio (VS) was selected as the IDE due to its ease of use and because it allows for integration with Apache Cordova so that a mobile app could be developed. VS provides for web and app development in several languages including JavaScript. VS also provides a wide range of web and device emulators so that you can simulate the app and how it would behave on different devices. During the initial Visual Studio installation, there is an option for Apache Cordova installation. There is a wide range of plugins that can be installed, via the config.xml

file, to increase features and enhance the app. Apache Cordova is open source and is able to use a base code for cross-platform development. This saves time and is more efficient if the developer is creating an app for multiple platforms. Although this app is developed for Android users, it can, in fact, be used on other operating systems (Windows and Apple). It also allows the app to access the Native capabilities of the phone, such as the camera, via the plugins.

## 4.3 HTML and JavaScript

JavaScript was used to provide the functionality to the Reminder and Diagnose Me pages.

### 4.3.1 Reminder Page

The purpose of this page is for the user to keep track of how long they have been wearing a particular pair of lenses. The user can set the date they started wearing them and when they must remove them. Whenever the application is opened it tells the user how many days they have left. Figure 7 shows the Reminder Page interface.

A form is created with the input type set as 'date' in order to bring up a calendar for the user to set dates. The first date will be the day they start wearing the lenses "id="insertion"" and the second date will be the day they should discard the lenses "id="removal"". "onchange" event is used to save the dates locally. A <div> is created called "daysLeft" which is the difference in days between the two dates.

The function "getDays" is created in order to find the days inputted and their difference. This is achieved by setting variables "insert" and "remove" to the "getElementById()" method which will return the value of the elements "insertion" and "removal" respectively.

```
var days = 1000 * 60 * 60 * 24;

function getDays() {
    var insert = document.getElementById("insertion");
    var remove = document.getElementById("removal")
```

The dates inputted are then converted to milliseconds via "Date.parse()" to calculate the difference between the variables "dateRemoved" and "today". Variable "dayGap" stores the result of converting the milliseconds to days. "diffSpot" is the difference between the two dates. We display this to the user via ".innerHTML".

```

var today = new Date();

    var timeinmilisec = dateRemoved - today;
    var dayGap = (Math.floor(timeinmilisec / (1000 * 60 * 60 * 24)));

    var diffSpot = document.getElementById("difference");

    diffSpot.innerHTML = dayGap;

```

The dates inputted by the user are saved locally so that they can be referred to during the course of the lens wear. The dates set by the user will be retrieved and the number of days left will be calculated every time they open the app.

On loading the page the function “loadDates()” checks if any dates were previously saved. The dates for insertion and removal as well as the calculated number of days left, are handled by the method “.getElementById”. If the user’s system does not support the “localStorage.getItem” method, the message “**Sorry, your browser does not support Web Storage...**” is displayed. Otherwise the dates are retrieved and the calculations proceed. The function “getDays” and the variables “insert.value” for the date of insertion and “remove.value” for the date of removal are set from local storage.

```

function loadDates() {

    var diffSpot = document.getElementById("difference");
    var insert = document.getElementById("insertion");
    var remove = document.getElementById("removal");
    console.log(insert.val);

    if (typeof (Storage) !== "undefined") {

        var i = localStorage.getItem("insertion");
        var r = localStorage.getItem("removal");
        console.log(i, r);

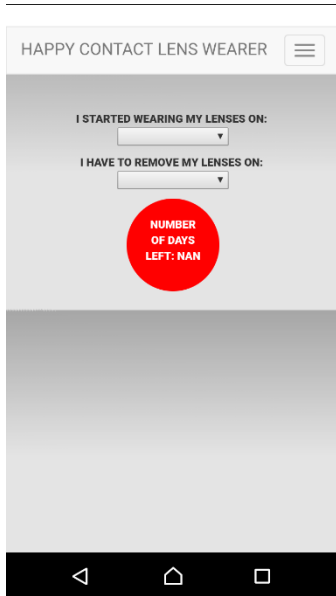
        insert.value = i;
        remove.value = r;

        getDays();
    } else {
        diffSpot.innerHTML = "Sorry, your browser does not support Web
Storage...";
    }
}

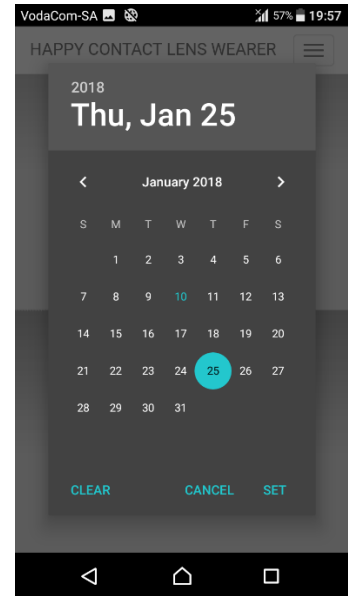
```

Saving the dates is done similarly by the “saveDates” function =. The same variables for the difference, insertion and removal are used and browser supported for saving is checked. The method “localStorage.setItem()” is used to save the dates every time the user changes the dates.

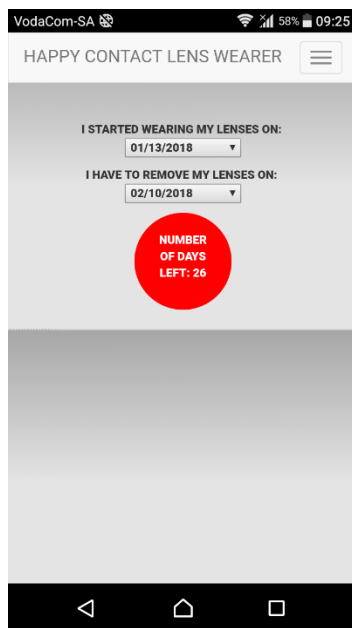
```
function saveDates() {  
    getDays();  
    var diffSpot = document.getElementById("difference");  
    var insert = document.getElementById("insertion");  
    var remove = document.getElementById("removal");  
  
    if (typeof (Storage) !== "undefined") {  
        localStorage.setItem("insertion", insert.value);  
        localStorage.setItem("removal", remove.value);  
    } else {  
        diffSpot.innerHTML = "Sorry, your browser does not support Web  
Storage...";  
    }  
}
```



a



b



c

**Figure 7:** Screenshots showing functioning of reminder; a) form with start and end dates for user to set; b) calendar revealed when drop down touched; c) end result with number of days left

### 4.3.2 Diagnose Me

A Decision Tree approach was used to aid the user to troubleshoot the symptoms they may be experiencing. A jQuery Decision Tree tool was adapted for this purpose [37]. The user would be asked a question and given two options, yes or no, in the form of radio buttons. Each subsequent question is based on the answer provided by the user. The end result is a solution to the user's problem. Figure 10 illustrates how the mobile screen appears to the user and how this changes when the user answers a question.

A form was created with `action="#"` to ensure that the form remains on the same page so that the list of questions that the user has answered is visible to the user. The subsequent question is hidden using the "hide class" function. Each question, with its yes/no options, was grouped and bracketed together using the form element `<fieldset>`. The question was put in `<legend>` tags to define the caption or title of the fieldset. The class "productFilter" was created to provide the correct interaction with the user. The HTML for the beginning and ending of the form is given in in Figure 8 and Figure 9 respectively.

```
<h2>What is the problem?</h2>
<form action="#" id="unique_id" class="productFilter">
  <fieldset class="step1 option0">
    <legend>Are you eyes red?</legend>
    <p>
      <input id="question_1" name="group_1" type="radio" />
      <label for="question_1">Yes</label>
    </p>
    <p>
      <input id="question_2" name="group_1" type="radio" />
      <label for="question_2">No</label>
    </p>
  </fieldset>
  <!------->
  <fieldset class="hide step2 option1">
    <legend>Are you eyes itching?</legend>
    <p>
      <input id="question_1_1" name="group_2" type="radio" />
      <label for="question_1_1">Yes</label>
    </p>
    <p>
      <input id="question_1_2" name="group_2" type="radio" />
      <label for="question_1_2">No</label>
    </p>
  </fieldset>
```

**Figure 8:** Beginning of HTML

```

<fieldset class="hide step13 option1221">
  <legend>How long have you been wearing this pair of lenses?</legend>
</fieldset>

  <p>
    <input id="question_12_1_1" name="group_17" type="radio">
    <label for="question_12_1_1">If longer than prescribed change 1
enses to new fresh pair.</label>
  </p>

  <p>
    <input id="question_12_1_2" name="group_17" type="radio">
    <label for="question_12_1_2">
      If shorter than prescribed:<br>1.Check if there are any tea
rs in lenses.<br> 2. Remove and clean lenses again. <br> 3.If no resolution
then see your Optometrist.
    </label>
  </p>
</fieldset>

<fieldset class="hide step13 option1222">
  <legend>See your Optometrist</legend>
  <p>
    <input id="question_12_1_3" name="group_17" type="radio">
    <label for="question_12_1_3">OK</label>
  </p>
</fieldset>
<!-------
----->

</form>

```

**Figure 9:** Ending of HTML

When HTML is loaded the function “productFilterSetup()” loops over each element of the ‘.productFilter’ class performing the same function on each. To ensure that it will be used in the callback when receiving input from the user via the radio buttons a function “setup()” loops over each radio option and calls “update()” on click with the keyword “this” as parameter.

```

$(filter_group).find('input[type=radio]').bind('click', function () {
  me.update(this);
});

```

The next function finds all the fieldsets with radio buttons and counts the number of steps in the fieldsets

```
me.update = function (target_radio) {  
    var fieldsets = $(me.target_element).find('fieldset'),
```

```
    for (i = 1; i <= num_of_steps + 1; i += 1) {  
        if ($('#fieldset.step' + i).length > 0) {  
            num_of_steps += 1;
```

It then loops over the steps again and checks if the currently clicked radio button's parent fieldset has other radio buttons, and unchecks all the radio buttons after the current one and those might have been selected previously.

```
    for (i = 0; i < num_of_steps; i += 1) {  
        if ($(target_radio).parents('fieldset.step' + (i + 1)).length > 0) {  
            for (j = i; j < num_of_steps; j += 1) {  
  
                $('#fieldset.step' + (j + 2) + 'input[type=radio]').attr('checked', false);
```

The next `for` loop find the position of the radio button clicked, and pushes that index (question number) onto the "options" list so as to move the user to the next relevant question. At this point, the variable "options" has all the options to display.

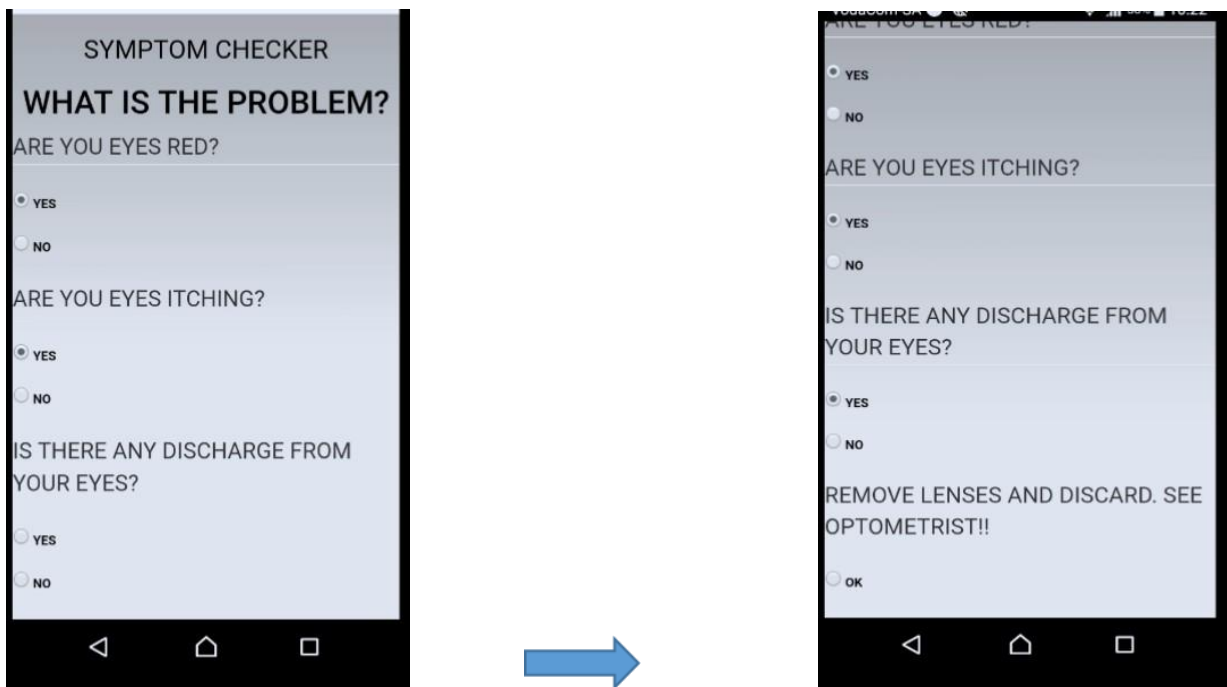
```
        for (i = 0; i < len; i += 1) {  
            radios = $(fieldsets[i]).find('input[type=radio]');  
            radios_len = radios.length;  
            for (j = 0; j < radios_len; j += 1) {  
                if ($(radios[j]).is(':checked')) {  
                    options.push(j + 1);  
                }  
            }  
        }  
    }  
}
```

The final requirement is to reveal the relevant question and keep the irrelevant ones hidden. CSS class `'hide'` is added to the hide the irrelevant fieldsets. However, it is removed for option0 because that first question is always displayed and this is done using `removeClass('hide')`. This entire process is repeated until the user comes to the final options which are possible solutions to the problems they are experiencing with their eyes or contact lenses.

```
fieldsets.addClass('hide');

$('fieldset.option0').removeClass('hide');

for (i = 0; i < options.length; i += 1) {
  options_buffer += options[i];
  $('fieldset.option' + options_buffer).removeClass('hide');
}
```



**Figure 10:** Screenshots showing functioning and an example of sequences of answers in Diagnose Me page

## 4.4 Style considerations

Bootstrap3 was used as the CSS framework as it favours mobile development and is very responsive especially to factors such as screen size. It was implemented by adding the following content delivery network (CDN) link from MaxCDN which also gives JavaScript support. JQuery must also be included. These are the links included:

```
<!-- Latest compiled and minified CSS -->
<link rel="stylesheet"href="https://maxcdn.bootstrapcdn.com/bootstrap/3.3.7/css/bootstrap.min.css">

<!-- jQuery library -->
<script src="https://ajax.googleapis.com/ajax/libs/jquery/3.2.1/jquery.min.js"></script>

<!-- Latest compiled JavaScript -->
<script src="https://maxcdn.bootstrapcdn.com/bootstrap/3.3.7/js/bootstrap.min.js"></script>
```

It was decided that this method was more reliable than hosting Bootstrap. According to the w3schools website, "One advantage of using the Bootstrap CDN: Many users already have downloaded Bootstrap from MaxCDN when visiting another site. As a result, it will be loaded from cache when they visit your site, which leads to faster loading time. Also, most CDN's will make sure that once a user requests a file from it, it will be served from the server closest to them, which also leads to faster loading time."

When a Cordova app is generated by Visual Studio there is basic provision for the web-based code to function in a mobile app. Therefore the index.css file was unaltered.

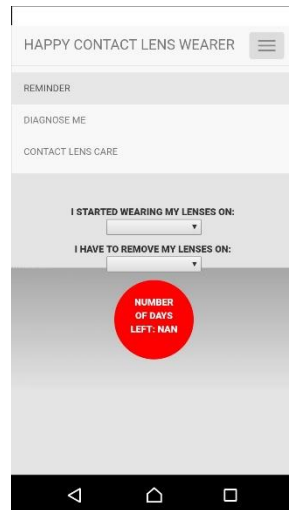
### 4.4.1 Icon design

The icon for the app was created using Gravit Designer which is a cross-platform design application.

### 4.4.2 Menu Bar

Each page has the same designed header with menu/navigation bar button on the top right-hand corner. The menu was designed using the Bootstrap Collapsible Navbar feature, to hide

the items and only reveal them when the button is touched in a drop-down fashion (as shown in figure 11). This was done consistently on all pages to ensure that the user does not get confused and does not have to learn new ways of using the app on every page. This should prevent the user from being reluctant to use the app because it is too difficult or irritating to use, hampering the goal of making them more compliant.



**Figure 11:** Drop down menu revealed when burger icon is touched

#### 4.4.3 Reminder Page Styling

All elements on the “reminder” were centralised and the font made bolder. The <div> “daysLeft” was given a border-radius of 50% to create a circular shape. The background-colour is red to draw attention to it with bold white text for contrast.

#### 4.4.4 Diagnose Me Styling

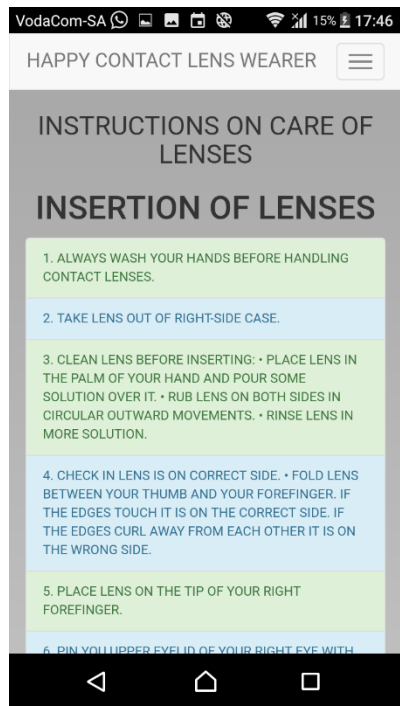
This page has simple styling as the concern was not causing too many distractions for the user. The font was once again bold to allow easy viewing.

#### 4.4.5 Contact lens care Styling

This page was divided into four <div>’s and each given a class of “container”: Insertion of lenses, Removal, Do’s and Don’t’s. For each container, a “list-group” class was then created. To display the content, Contextual classes were used within the list group. This allowed the content to be styled with alternate colours to help the user follow each step. For the instructions for handling lenses, the colours green and blue were alternated as they are considered calmer colours. This was produced by alternating classes “list-group-item-info” and “list-group-item-success”. The Do’s list was created alternating yellow and green produced by “list-group-item-warning” and

“list-group-item-success” respectively and the Don’ts red and blue created by “list-group-item-danger” and “list-group-item-info” respectively. Figure 12 shows screenshots of the result. An example of the code is as follows:

```
<div class="container">
  <ul class="list-group">
    <li class="list-group-item list-group-item-success">1. ALWAYS wash your
hands before handling contact lenses.</li>
    <li class="list-group-item list-group-item-info">2. Take lens out of
right-side case.</li>
```



a



b

**Figure 12:** a) screenshot of Insertion section b) screenshot of Don't section

---

## **CHAPTER 5 EXPERIMENT**

---

### **5.1 INTRODUCTION**

The app created in this study targets Contact Lens wearers. Users were selected randomly by optometrists; the only requirement for an individual to be a participant was for them to wear contact lenses. The participants were initially given a questionnaire to complete before using the app to gauge the level of knowledge of contact lens care as well as their current habits. The users were then required to use either the app or the PDF version of the app for a few weeks. Thereafter, they were given a second questionnaire to determine if there were any changes to their habits and knowledge.

### **5.2 THE QUESTIONNAIRE**

#### 5.2.1 Development

Most of the questions gave options to select from, rather than being open-ended, to ensure that the required information was obtained. One of the objectives was measuring change over time of habits and knowledge, therefore many questions in the initial questionnaire were repeated in the second. The wording of the repeated questions remained unchanged to ensure that the user had the same understanding and thus the same reaction, context and interpretation. The questionnaires were organised in a way where related questions were grouped together to make sense to the participant; for example, habits and knowledge were separate sections.

The questions were whittled down to be concise, to prevent participants from getting bored and losing concentration which could lead to inaccurate responses. This was done to also avoid receiving unnecessary data. In the first version of the questionnaire habit, knowledge, and symptom questions were asked as individual questions (1. Do you experience redness? 2. Do you experience itchiness?). In the final version, these types of questions were condensed into single questions and the participant asked to choose which symptom, for example, applied to them. The wording of the questions was clear and unambiguous. Questions were specific, for example, the number of weeks was clearly indicated.

The number of open questions was limited. If not, it may have confused participants and increased chances of getting irrelevant information. There were instances when these types of questions were important however. Each person is different and their problems may have been experienced differently but may have the same cause. Therefore it was important to afford the

participant the opportunity to express their issues. Their opinions on the app itself are also crucial in the future development of the app. Double-barrelled questions, which is asking for two different pieces of information in one question, were avoided to ensure that responses were more easily interpreted. For example, the question “do you experience pain and redness in your eyes?” asks for two different symptoms that may not be experienced together.

Participants may have a natural tendency to want to show that they have good behaviour and thus give responses that show that their habits are better than they are. To avoid participants feeling like they are being judged, several options are given and the wording is neutral to make the participants feel comfortable and help them to be as honest as possible.

Initially, the questionnaire was going to be distributed as a Microsoft Word document. However, it was decided that it would be easier for both the researcher and the participants if it was hosted via the web. The surveys could be completed from computers and mobile devices. It would also be more convenient to process responses and be easier to have a live list of which subjects had responded and which not.

### 5.2.2 Structure and design

All questionnaires were hosted via the LimeSurvey online tool. It was chosen as it is an open-source survey software and meaningful data could be easily extracted. Each participant had a unique token generated by the system which was an invitation code to identify their survey. This was important when comparing individual results between the first and second surveys to identify any changes in habits and knowledge. The ‘Completed’ feature gave useful information on when the survey was completed and if some of the surveys were not answered fully. Reminders could also be sent to participants from LimeSurvey to those who had not finished the survey and those that did not begin at all. Several settings and restrictions could be placed on the questions/answers to ensure that there were no spoilt results. Restrictions that were used included making some questions mandatory; the form of the answer restricted to numeric, a date picker calendar on some questions, etc. The question types that were used for this survey were:

- Single choice questions – participants had to choose only one option from a predetermined list of answers.
- Short free text – the participant is required to provide a short one-line input
- Long free text – allowed multiple lines of free text.
- Date – this type of question requests the participant to select a date from a “drop-down” calendar

- Multiple choice – allowed more than one selection from a predetermined list of answers.
- List Radio with comment – allows the participant to select an answer from a list of options and add a comment to elaborate on their selection.
- Array – this allows a set of subquestions to be created with the same set of answer options.

Three surveys were created. The first was one given to all participants entitled Contact Lens Wearer. [Appendix 2]. The follow-up surveys were distributed according to whether the participant received the mobile app or the PDF, entitled Survey after using Mobile App [appendix 3] and Survey after using PDF [appendix 4] respectively.

### 5.2.3 Survey 1: Contact Lens Wearer Survey

The questionnaire has been divided into four sections namely, Basics, Current habits, Symptoms, and Knowledge.

- Basics

This section covered demographics such as gender and age. Ratings of cell phone skills and basics on CL wear.

- Current habits

This acts as a baseline of their lens care regime.

- Symptoms

This section was used to establish if the user is experiencing any problem with their contact lenses or the health of their eyes.

- Knowledge

This ascertains the user's level of knowledge on acceptable practices. If the patient has been wearing lenses for several years they may have forgotten the information given in their instruction session. In some cases optometrists do not give all the information or do not explain aspects clearly.

#### 5.2.4 Survey 2: Survey after using Mobile App and Survey after using PDF

These surveys were divided into two sections, basics and feedback.

- Basics

This section now encompassed habits, symptoms, and knowledge. These questions were a repetition of questions that appeared in the first survey to determine any changes.

- Feedback

Usability, design, convenience and recommendations were probed in this section, to determine the most and least effective features of the app and PDF. Future development of the app will stem mainly from these responses.

### **5.3 PROCEDURE**

#### 5.3.1 Ethical clearance

Ethical clearance was obtained from the Faculty Ethics Committee prior to the commencement of the study. The informed consent form [appendix 4] was then emailed to willing participants [appendix 5]. The signed forms were returned via scanned copies or photographs. The informed consent form presented the project and explained the reason it was being conducted. It also told of the benefit to participants to gain useful knowledge on contact lenses. A brief overview of the procedure was given, as well as the reassurance that the activities that they would be required to perform would not be risky. Participants were provided the opportunity to withdraw from the study at any time, and confidentiality of their personal information was promised.

#### 5.3.2 Test Subjects

42 Participants were sourced from independently owned Optometric practices and word of mouth. Being a contact lens wearer was the only criterion that was specified. Participant's locations were Pietermaritzburg, Durban, Johannesburg, New York and Dubai. Contact details were supplied, either contact cell phone numbers or email addresses, and participants were first contacted as an introduction to the researcher with a brief explanation of the study.

All outstanding email addresses were then requested and a detailed explanation of what was required of the participant for the study was sent [Appendix 6]. Hard copies were also made available. The contact details of the researcher were given to the participants so that they were free to make inquiries throughout the study. They were also questioned about the type of mobile device they as the app could only be given to those who used the Android operating system.

Reminders were sent to those that were delayed in returning forms. Of the 42 interested participants, 20 participants returned the consent forms. Questionnaire number one was then given to these participants to complete via email with a link to the initial LimeSurvey questionnaire. . Those that were delayed in completing the survey were sent reminders via LimeSurvey. To further convenience some delayed participants, the link to the survey was SMSed to them. In the end 18 surveys were completed.

The participants were then divided into control and experimental groups. The experimental group was given the mobile app and the control group was given all the information contained in the mobile app but in PDF form. It was emphasised to both groups that if they were to run into any trouble or have any reassurance that they were to use the contact details given.

### 5.3.3 Division of Participants

The 18 remaining participants were divided equally into two groups, one assigned to use the mobile app and the other the PDF. In the end 8 completed responses were received from each group.

Although the app was designed to be cross platform, it could not be uploaded to the Apple iStore as the designer was not a registered iStore developer. However it could be uploaded to the Google Play store. Therefore, if the participant did not have a phone that used the Android operating system (OS), they automatically fell into the PDF group.

Results of the first survey were also considered. Participants were assessed on the how fast and how well they responded during the first few stages. These factors were how prompt they were returning consent forms, if they required reminders for survey completion, and if they provided accurate information on personal details. The more reliable participants were placed in the app group.

### 5.3.4 Releasing of App and PDF

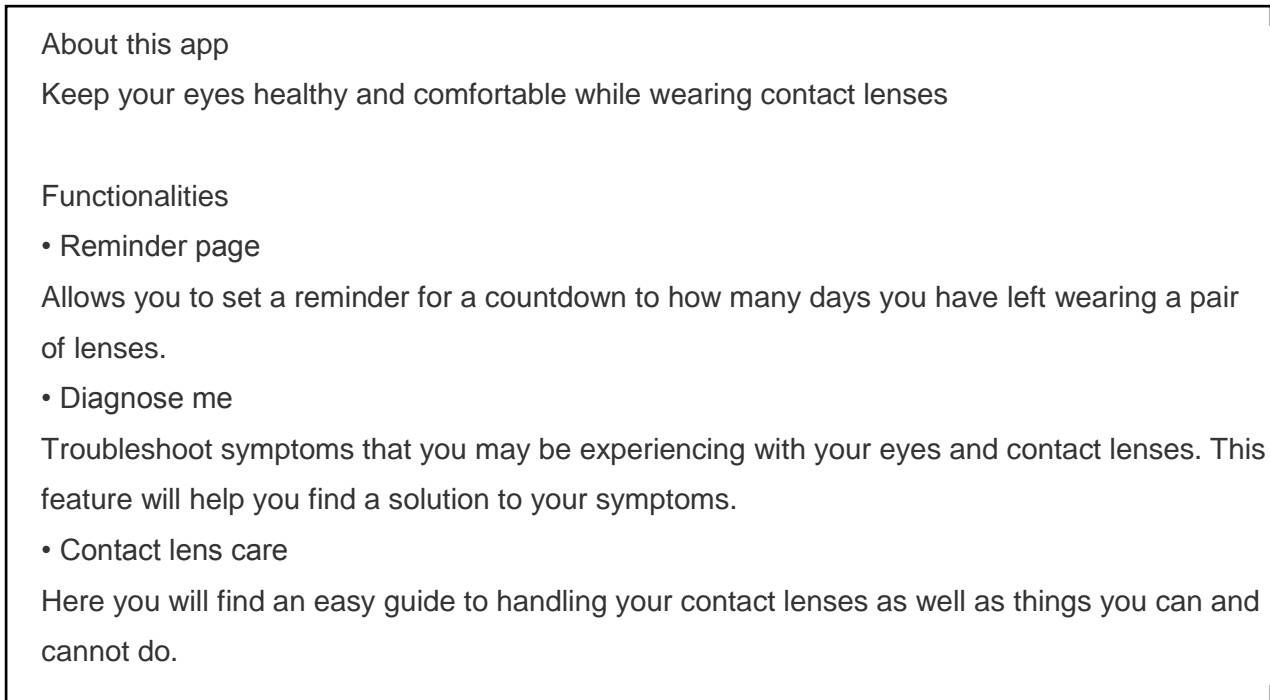
#### *5.3.4.1 The control group*

The participants in the control group were emailed a copy of the PDF to use. However, the only aspect of the app that could not be included in the PDF is the countdown reminder. The control group were asked to review the information on the Care page and also reference the Diagnose Me flow chart if they encountered any problems with their contact lenses or eyes. [Appendix 7]

#### 5.3.4.2 The experimental group

These participants were assigned the mobile app. A link to Google Play Store for the app was sent to them from where they could download to their mobile phones. [Appendix 8]

On Google Play the following description of the app was given:



**Figure 13:** Google Play Description of App

Once more it was emphasised to participants that if they ran into any issues they were to contact the researcher for assistance.

---

## CHAPTER 6

### RESULTS AND FINDINGS

---

#### 6.1 DEMOGRAPHICS AND BASICS: SURVEY 1

Since only 16 of the original respondents completed the second questionnaire, the data from those who completed only the first survey is excluded from the results presented here. Of the respondents that are considered in what follows, due to participating fully, 11 were between the ages 26 to 40, and 5 were over 40. There were 11 women and 5 were men. Most participants rated their cell phone skills above average with only one participant rating their skills as average. Most of the participants reported that they used their phones most of the day with some responses given as “countless”, “almost the entire day” and “20 times”. Thirteen were experienced contact lens wearers with more than 5 years of wearing lenses and 14 on a monthly disposable modality. Only 2 were daily disposable wearers and none were 2-week disposable wearers. All participants had had an eye test within the recommended 18 to 24 months.

Results of the initial survey indicated that the participants were indeed indulging in bad lens usage habits, experiencing problematic symptoms, and lacking in lens wear knowledge. Of the total of 224 responses on current eye care practice (16 answers to 14 questions), 25 were bad habits; while 63 of their 192 answers on knowledge of lens usage were incorrect. The 16 subjects were asked whether or not they had experienced 7 different types of symptoms within the past fortnight; of their 112 answers, as many as 21 were “Yes” answers.

#### 6.2 KNOWLEDGE, HABITS, AND HEALTH

The responses from Survey 1 were separated into those allocated to the app and PDF groups respectively, and then compared to that in the second round of surveys. Each group had 8 participants.

##### 6.2.1 Were there changes in knowledge?

Greater knowledge should lead to better eye health in patients. All participants, during all three surveys, understood their modalities, knew when it was time to dispose of their lenses, and correctly responded that it was not acceptable to lubricate lenses with saliva. There were otherwise many variations of the change in knowledge before and after using the app.

An overall improvement in knowledge was evidenced after using the mobile application, but not after using the PDF. A summary of the number of correct answers (as opposed to wrong or “Uncertain” responses) in each survey is shown in table 1. As can be seen there, the knowledge

that cleaning lenses with water is ill-advised was fairly well known in all surveys. Awareness about not wearing lenses while swimming was also high, with most people knowing it was not acceptable in each survey. Bathing/showering while wearing CLs was also known to be wrong by the majority in every survey. The practices that were less well known are discussed below.

Yes/No/Uncertain Question	Known before App	Known after App	Change after App	Known before PDF	Known after PDF	Change after PDF
Replace less often?	3	5	2 more	3	5	2 more
Clean with water?	8	8		7	6	1 less
Lubricate with saliva?	8	8		8	8	
Swim with lenses	6	6		6	7	1 more
Shower with lenses?	6	7	1 more	5	5	
Fly with lenses?	1	2	1 more	2	2	
Reuse solution?	6	5	1 less	6	4	2 less
Share makeup?	5	8	3 more	8	7	1 less
Sleep with lenses?	7	8	1 more	8	8	
Skip lens cleaning	8	8		8	7	1 less
Max hours of wear per day?	2	2		2	0	2 less
<b>TOTAL</b>	<b>60</b>	<b>67</b>	<b>7 more</b>	63	59	4 less

**Table 1:** Number of correct answers to questions testing lens usage knowledge

Most participants were unaware of the recommended *maximum* number of hours of 12 [2]. The answer of 8 hours was the most common answer across all surveys. The number of participants that said more than 12 hours was acceptable, which could lead to complications, was one in both first and second surveys of the app group. The same participant in this group answered 24 hours in both surveys showing no change in knowledge. In the PDF group, 2 participants gave more than 12 hours as an answer. One in this group gave 14 hours as their answer in both surveys. The other, who answered 24 hours after having the PDF, had given the correct response of 12 hours in survey one.

An example of varied responses involved the changing to a fresh pair of lenses. Subjects were asked whether it was acceptable to replace monthly lenses less often if used only occasionally. This is not advisable as the patient will not be able to easily keep track of exactly how old the lenses are. This can lead to over wear and thus having an excessive amount of deposits on the lenses and subsequently GPC. In the app group, 3 responded correctly in both rounds that it was not acceptable. The number of people that said that it was acceptable increased from 2 to 3. However, in the PDF group, the number of correct people increased from 3 to 5 and the number of uncertain people decreased from 3 to 1. In both the app and PDF participants were advised to follow the optometrist's instructions on wearing schedules and not overwear lenses.

Most people still believed, in all three surveys, that it was acceptable to fly while wearing contact lenses, even though this advised not to do so in the app and PDF. There was also a fair amount of uncertainty about this. More than a third indicated they were uncertain after using the app. In the PDF group, a quarter remained uncertain. There is a possibility that this was new information to participants, or was not relevant to them during the time between surveys, and was therefore not retained well.

There is a great risk in sharing eye makeup as it could cause transmission of infections. In survey 1, in the app group, 5 indicated that it was not acceptable and 3 were uncertain. In the second survey, there was an improvement in knowledge where all participants said it was not acceptable. In the PDF group, in survey one, all participants said that it was not acceptable. Strangely, that number decreased to one being uncertain in survey 2.

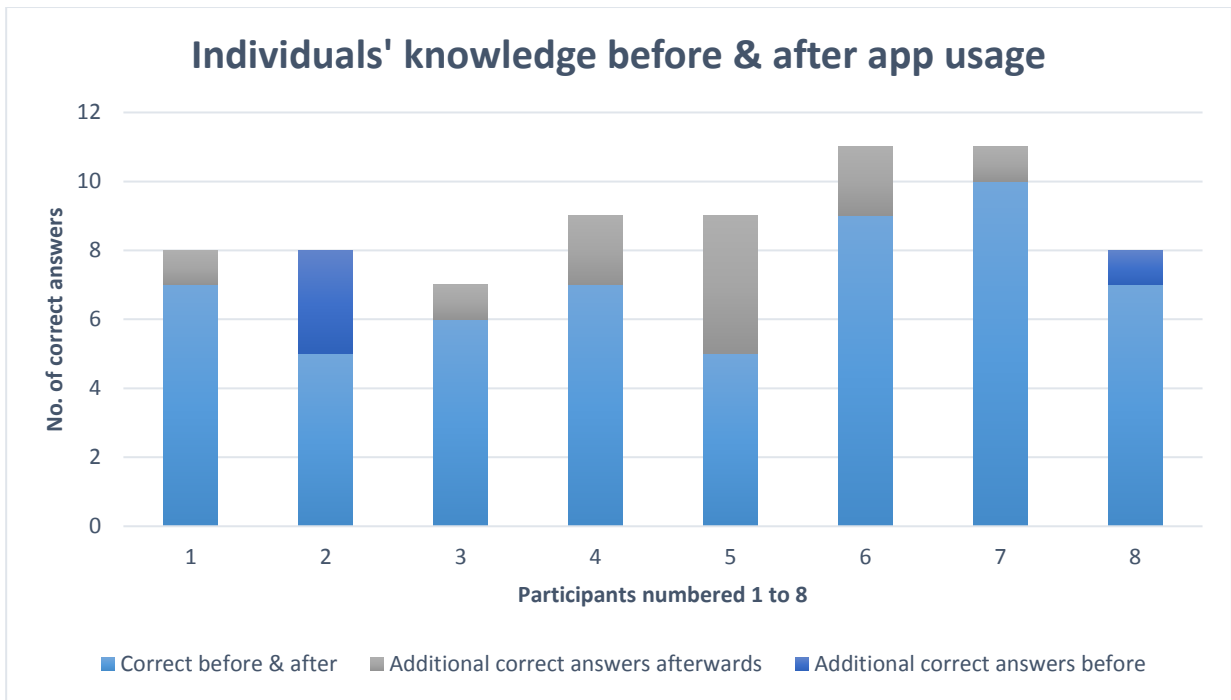
The foregoing discussion has considered each lens usage practice in turn. Figures 14 and 15 show the change in knowledge for each participant. Six of the 8 in the app group had enhanced their knowledge, with one almost doubling the number of correct answers after using it; in contrast only 3 of the PDF group showed greater knowledge in the second survey.

### 6.2.2 Were there changes in wearing habits?

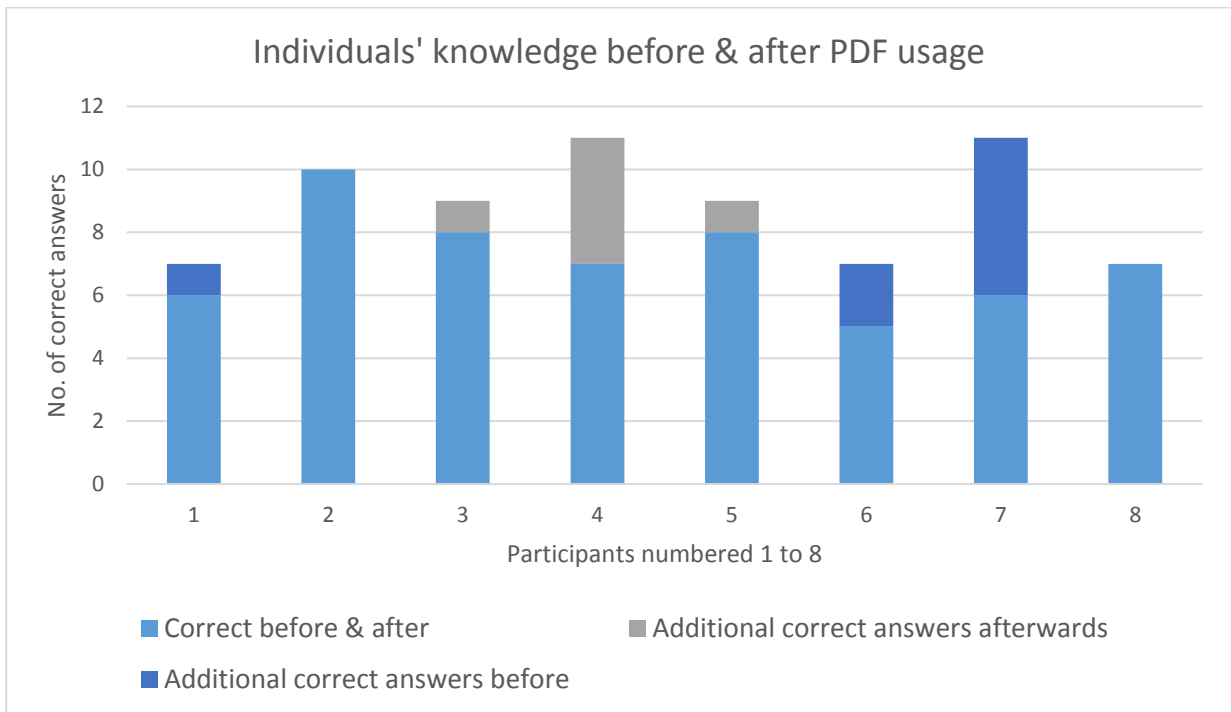
No overall improvement in habits emerged when comparing before and after practices. Participants were asked which of a list of behaviours they engaged in, in the 2 weeks prior to taking each survey. A summary of the number of good practices reportedly followed by participants throughout the fortnight preceding each survey is shown in table 2.

Issue	Correct Practice before App	Correct Practice after App	Change after App	Correct Practice before PDF	Correct Practice after PDF	Change after PDF
Replace less often	5	7	<b>2 more</b>	8	7	1 less
Clean with water	8	8		8	7	1 less
Swim with lenses	8	7	1 less	7	8	<b>1 more</b>
Shower with lens	6	6		4	5	<b>1 more</b>
Fly with lenses	6	6		7	7	
Reuse solution	8	8		7	7	
Share makeup	8	8		8	8	
Lubricate with saliva	8	8		8	8	
Sleep with lenses	8	7	1 less	7	8	<b>1 more</b>
When to clean	4	3	1 less	6	4	2 less
Skip lens cleaning	8	8		6	6	
<b>TOTAL</b>	77	76	1 less	76	75	1 less

**Table 2:** Number of correct habits reported in each survey.



**Figure 14** Change in knowledge after using the mobile application



**Figure 15:** Change in knowledge after using the PDF version

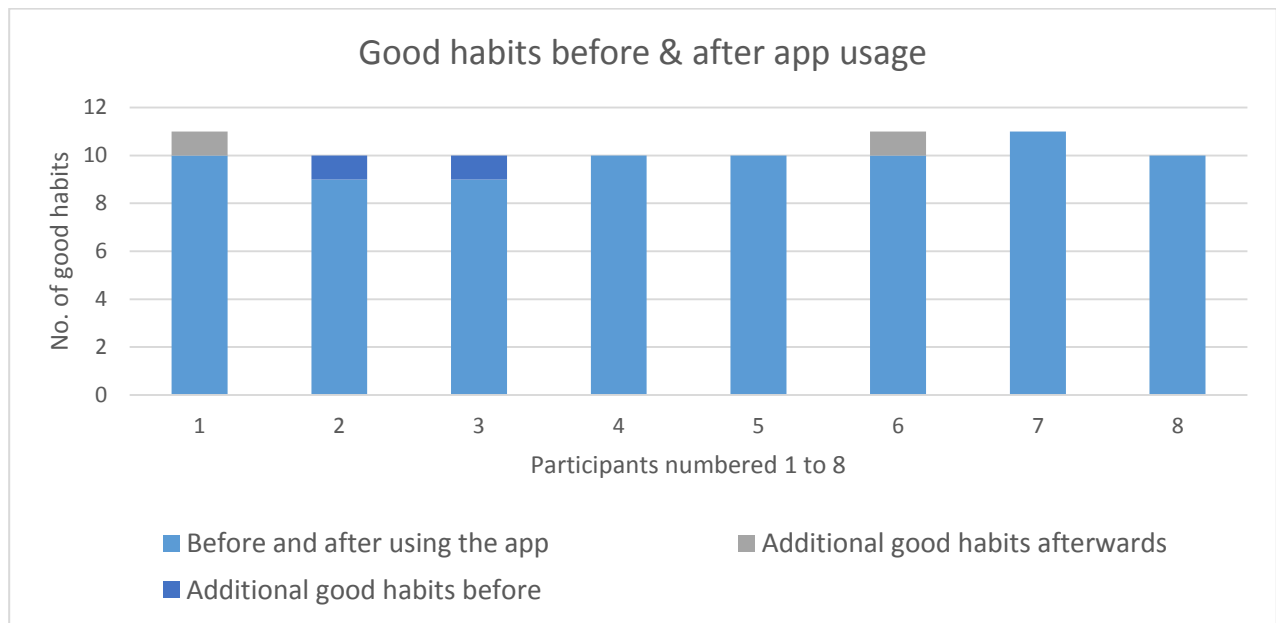
Appreciatively, due to the very high risk of infection, no one reported using saliva to lubricate their lenses in any of the surveys. A risk of transfer of infection from person to person is sharing eye makeup and no one reported doing this either. The responses for the question on “did you wear CLs while flying on an aeroplane?” remained the same in both surveys. The same 2 people in the app group, and the same one in the PDF group, responded that they flew with lenses in both surveys. Most people did not sleep with their lenses in. In the app group, in survey one all responded that they did not. However, one in the second survey responded that they did. It is important to note that when questioned about whether this was acceptable, this individual knew that it was not.

Respondents’ other answers changed from the first to the second survey in a variety of ways, leaving no indication that use of either the mobile application or the PDF had been predominantly beneficial. As an example, CL wearers who are not wearing daily disposable lenses should clean their lenses before and after wearing lenses. [2, 3] Furthermore, cleaning after removal is preferred to before insertion cleaning, as the deposits from the tears are removed from the lens before it is stored for the next wear. In the initial survey, in the app group, 4 of the participants cleaned before and after, 3 cleaned after wearing them and 1 cleaned before. In the second survey, these numbers changed to 3, 3 and 2 respectively. In the PDF group, there were 2 daily disposable wearers so they did not need to clean their lenses. Initially, 5 of the remaining 6 cleaned both before and after, and one cleaned before insertion. In the second survey, the number cleaning before and after decreased to 4 as one now only cleaned after removing lenses.

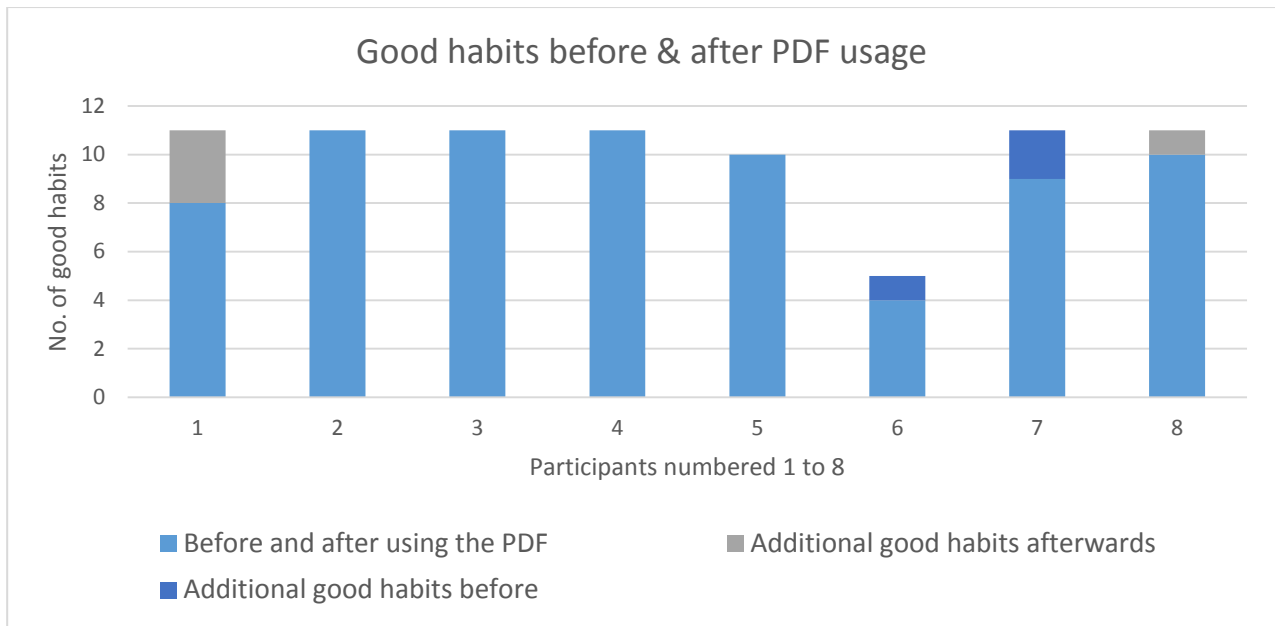
How CLs are disposed of and how it impacts the environment is becoming a significant talking point. The recommended method is in the bin as water-related disposal is harmful to the environment. Therefore the intent to include this information in the app and PDF was to create more environmental consciousness. This question was delivered as an open-ended question (“How do you dispose of your contact lenses?”) to see exactly what people did, instead of providing options and giving leading answers. Unfortunately, due to this, some responses (e.g. “monthly”) did not answer the question suitably. In the app group, 4 answered suitably both times; 2 were using the bin both times; one was using the drain both times, and one had been using the bin initially but replied “flush in toilet or bin” after using the app. In the PDF group, 6 of the 8 gave suitable answers initially; all 6 disposed of lenses in the bin. In survey 2, this number increased to all 8.

A very common issue is people wearing lenses over the number of days or weeks recommended by their optometrists. Among the monthly lens wearers, there was an improvement in the app group as the number of people who replaced their lenses less often decreased from 3 to just one. In the PDF group, initially all said they did not replace lenses less often, but one in the second survey said they did.

The foregoing discussion has considered each lens usage habit in turn. Figures 16 and 17 show the change in behaviour for each individual in turn.



**Figure 16:** Comparing the number of good habits practiced before and after using the application



**Figure 17:** Comparing the number of good habits practiced before and after using the PDF

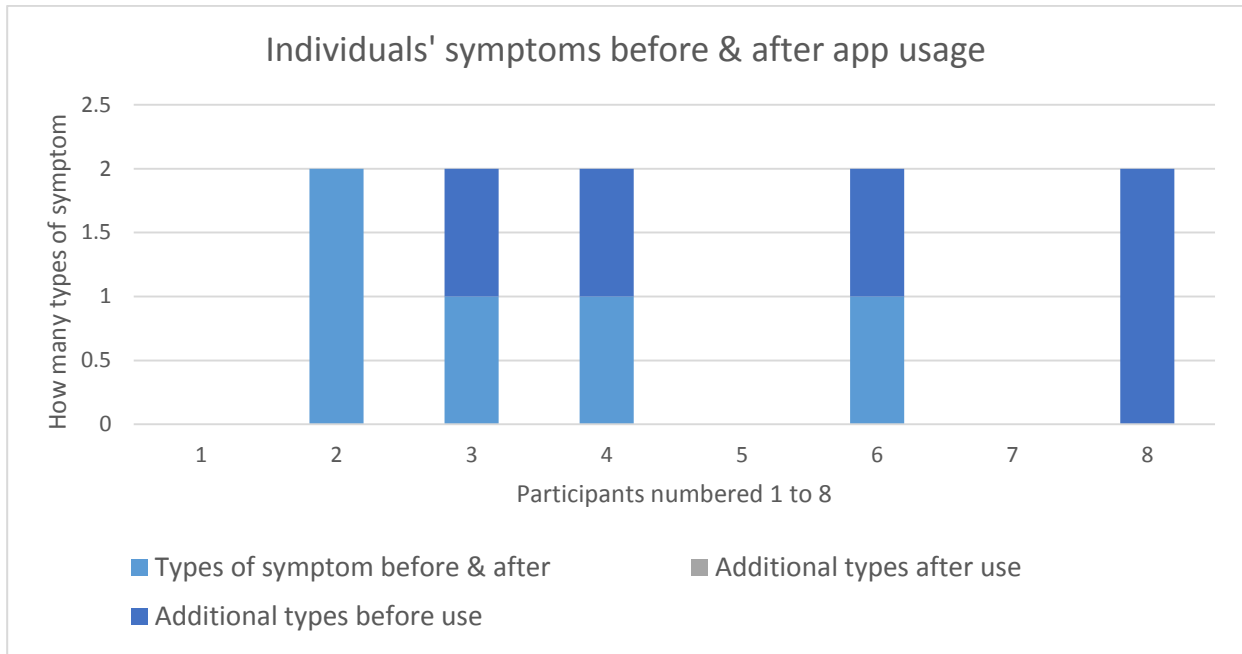
### 6.2.3 Were there changes in symptoms experienced by users?

There was improvement in terms of symptoms experienced by both groups in the second survey compared to the first survey. This can be seen in table 3, which summarises how many participants reported experiencing each of the 7 types of problematic symptom at any stage during the fortnight preceding their completion of each survey. Figures 18 and 19 show this information for each respondent in turn. None of the participants who used the mobile application experienced new symptoms in the second survey, and 4 of them experienced fewer than before. In contrast, after PDF usage, 3 members of that group experienced new symptoms and only 3 experienced fewer symptoms than before.

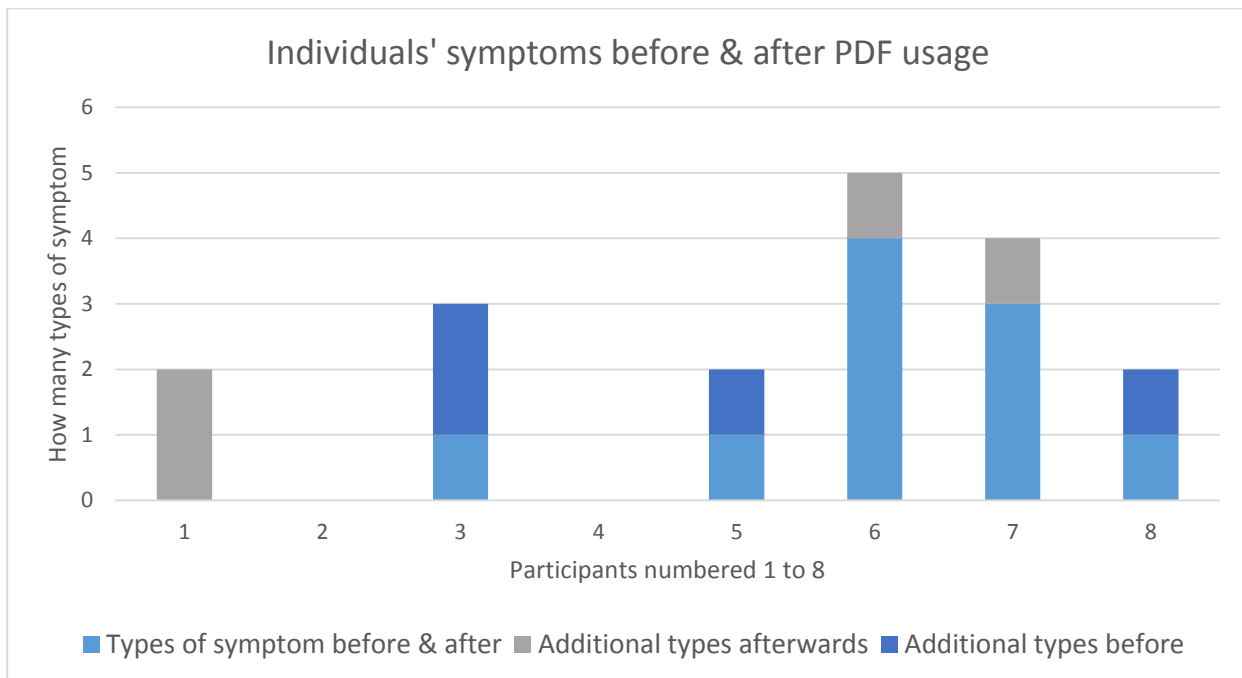
Symptom	Reported before App	Reported after App	Change after App	Reported before PDF	Reported after PDF	Change after PDF
Blurred vision	0	0		2	1	<b>1 less</b>
Discomfort with lens out	2	0	<b>2 less</b>	1	0	<b>1 less</b>
Discomfort with lens in	3	2	<b>1 less</b>	4	3	<b>1 less</b>
Itchy with lens in	1	2	1 more	3	4	1 more
Itchy with lens out	1	1	-	2	4	2 more
Pain with lens in	0	0	-	2	1	<b>1 less</b>
Pain with lens out	0	0	-	0	1	1 more
<b>TOTAL</b>	<b>7</b>	<b>5</b>	<b>2 less</b>	14	14	-

**Table 3:** Symptoms reported in each survey

In survey 1, among those who did experience problems, most used drops to ease their symptoms while the others either cleaned and re-inserted lenses or just removed lenses. In the second survey, no one in the app group thought to consult the app when the symptoms arose, while 2 of those with symptoms consulted the PDF in the PDF group.



**Figure 18:** Symptoms experienced before and after using the mobile application



**Figure 19:** Symptoms experienced before and after using the PDF version

### 6.3 COMPARISON BETWEEN APP AND PDF

Participants were also asked to assess both the app and the PDF and give feedback on their function, and specifically to the app how it can be improved and what features they would like to see added. Participant’s responses to problems they face with the CLs and their eyes are also discussed in this section.

#### 6.3.1 Survey 1 – Internet Searches for Resolution to Eye Issues

In survey one, participants were questioned about they used the internet to find solutions to their health problems. Most, 10, (5 in each group) said they have never searched their symptoms on the internet while 6 (3 in each group) responded ‘yes, once or twice’. None of the participants responded as ‘yes, several times’. Of those that responded yes, 5 (app = 3; PDF = 2) found the information helpful. 3 responded no and felt they required help from a professional. 5 responded that the information was ‘sometimes’ helpful. One responded that they would rather ‘seek the understanding from a professional’. Another found that she/he could not filter the information and another found that the information found was not always applicable to their situation. This supports the previously mentioned common issue where unfiltered information on the internet does not help patients to resolve their problems. Further to that, laypeople do not have the holistic expanse of knowledge and experience as trained medical professionals do. Therefore they are unable to always successfully resolve their issues by just reading unfiltered information on the internet.

#### 6.3.2 Ranking of pages

LimeSurvey advises using the mean of all the ranking value. Table 4 shows the ranking of the three pages by the 8 app users, where 1 is the preferred page and 3 the least appreciated.

	REMINDER	DIAGNOSE ME	CARE
	1	2	3
	1	3	2
	1	3	2
	2	3	1
	1	2	3
	1	3	2
	1	2	3
	2	1	3
<b>TOTAL</b>	10	19	19
<b>MEAN</b>	<b>1.25</b>	<b>2.375</b>	<b>2.375</b>

**Table 4:** App ranking of pages

App users ranked the reminder as most useful and the other two pages, Diagnose Me and CL care equally useful. Changing their contact lenses on time would indeed eliminate many CL complications.

In the PDF group the two pages, CL Care and Diagnose Me, were rated higher by 2 participants each, while 3 found them both equally useful and one respondent omitted the question

### 6.3.3 Ease of use

Participants were asked to rate each page on ease of use by giving them a score out of 5, with 5 being easiest. All pages were given high scores. The average of the 8 ratings by each group of each page was taken as the overall rating. The Reminder, which was featured only in the app, was rated at 4.25. Diagnose Me was rated 4.38 in the app group and 4 in the PDF group – the interactive design scoring better than the flow diagram. CL care was rated 4.63 in the app group and 4.5 in the PDF group. The very small difference, in this case, could be due to both having the exact same layout, only differing in the form that they were delivered. Hence, the app scored better for ease of use overall.

Users were asked to give an overall score to the app and PDF, with 5 being the best score possible. The app was given a slightly better score of 4.25 compared to the PDF which scored 4. In the app group, many did not find it difficult to use and commented it ‘very easy...very informative and useful.’ Others found it ‘user friendly’ and ‘well developed’. In the PDF comments, a participant requested ‘more direction on how long lenses should be kept on’. Another found the information provide ‘understandable’.

On whether they would recommend the app/PDF to others, 7 out of 8 in both groups said they would. In the app group, their reasons would be because they found the reminder and hints helpful and believed others could benefit from using the app. No comments on recommendation were given in the PDF group.

### 6.3.4 Order of action

A plan of action ranking was created to establish in what order participants would look for help in the event of a problem with their lenses or eyes. It was important to understand the thought process of users to best support them.

In the app group the order is as follows:

1. Use the app
2. Phone optometrist and ask advice
3. Search the internet
4. See optometrist
5. Ignore unless it's very bad.

Table 5 shows there were small differences between using the app and phoning the optometrist (0.2) and the internet search and seeing the optometrist (0.625).

	<b>IGNORE</b>	<b>APP</b>	<b>PHONE OPTOM</b>	<b>INTERNET</b>	<b>SEE OPTOM</b>
	5	1	2	4	3
	5	1	4	2	3
	5	2	1	3	4
	5	1	2	4	3
	5	1	2	3	4
	5	1	2	4	3
	4	2	1	3	5
	3	4	1	2	5
<b>TOTAL</b>	37	13	15	25	30
<b>MEAN</b>	<b>4.625</b>	<b>1.6</b>	<b>1.8</b>	<b>3.125</b>	<b>3.75</b>

**Table 5:** App group order of action

The PDF group ranking is as follows:

1. Use the information sheet
2. Internet search
3. Phoning and seeing optometrist ranked equally
4. Ignore unless it's very bad.

Table 6 shows there was also a small difference (0.125) between internet search and contacting the optometrist.

	<b>IGNORE</b>	<b>PDF</b>	<b>PHONE OPTOM</b>	<b>INTERNET</b>	<b>SEE OPTOM</b>
	5	2	4	1	3
	5	3	1	4	2
	3	2	5	4	1
	5	3	2	4	1
	5	1	3	2	4
	5	2	3	1	4
	3	1	2	5	4
	3	1	4	2	5
<b>TOTAL</b>	34	15	24	23	24
<b>MEAN</b>	<b>4.25</b>	<b>1.875</b>	<b>3</b>	<b>2.875</b>	<b>3</b>

**Table 6:** PDF group order of action

From this evidence, we can see that if reliable information, like the app and PDF, is readily available it would be the first choice for users and can prove to be a valuable method to support not only CL wearers but with other medical situations as well. Overall reaching out to optometrists telephonically ranked high in both groups so we can appreciate that users still want the care of a professional when experiencing problems but want a more convenient method of communication rather than going directly to the practice. This can be explored further by giving the users other ways of communication, for example, a messaging service in an app. Internet searches, in the app group, ranked higher than going to see the optometrist - which further shows that people are looking for convenience. Fortunately, the last thing people would do was ignore symptoms which can prove to have serious consequences.

#### **6.4 FREQUENCY OF USE**

None of the subjects consulted the PDF often: 1 never did so at all, 4 read it once, and 3 read it twice. All subjects given the app reported using it: 1 did so only once, 1 indicated “not often”, 3 did so two or three times, and 3 had used it more often. An app, rather than a written document, thus seems more likely to be used by patients. The frequent app users are called Subjects A (used it 5 times), B (used it 12 times) and C (used it 15 times) in what follows.

#### 6.4.1 Subject A

The app had a positive effect on A's habits. Prior to using the app, he cleaned his CLs only after removal. After using the app he correctly cleaned them before inserting them and after removing them. Initially, he wore lenses while showering/bathing, but after using the app he no longer did so – he had learnt this was not advisable since initially, he had incorrectly said it was acceptable to do so, but in the second survey he correctly answered that it was not safe. He found the Reminder the most helpful app feature, and while his first choice in handling eye problems would be to telephone an optometrist; his 2nd choice would be to consult the app, rather than search the internet or visit an optometrist.

#### 6.4.2 Subject B

B had in the past consulted the internet about eye symptoms and found it helpful. B's only inappropriate habit initially was taking longer than a month to change lenses if infrequently worn. Having initially indicated that this was acceptable, after using the app B correctly answered that it was not safe to do so. B also did not know that eye makeup should not be shared initially, but correctly said this was not acceptable after using the app. B's first action on encountering a problem would be to use the app, and secondly to use the internet, in preference to calling or seeing an optometrist.

#### 6.4.3 Subject C

C had in the past consulted the internet about eye symptoms and found it helpful. She answered one question incorrectly initially (that replacing lenses less often if seldom worn is acceptable) and then answered it correctly after using the app. Her preference if problems were encountered would be to use the app, with her second choice being to call or see the optometrist; searching the internet would only be her last recourse. She rated the Reminder feature as the most useful.

## 6.5 DISCUSSION

Among the responses there were 11 situations where a subject's knowledge of a specific dangerous practice was correct, yet they reported indulging in that dangerous habit during the preceding fortnight. These participants knew that their behaviour was risky, yet they still engaged in that behaviour. There can be many reasons and factors for this. In the focus group with optometrists, the issue of cost rose several times. Patients may wear their lenses for longer than the recommended time to save money.

Forgetfulness and laziness may be reasons for sleeping with lenses, or showering with their lenses in. They are fully aware that they should not do this but these factors get the better of them.

Wearers are also restricted by the limitations of their vision. People with very high prescriptions are dependent on their spectacles or CLs which enables them to see and function in the world. They may feel forced to perform unsafe behaviour purely because they feel they do not have a choice due to their condition. There are existing methods that can navigate these problems but have to be done case by case in a clinical setting.

A disappointing change in knowledge and habits from survey 1 to survey 2 should be viewed in light of how often the respondent reported using the mobile application or PDF. The one person given the PDF who reported having never read it (we shall call her X) accounted for the vast majority of incorrect answers in the habits section, while her knowledge was poor in both surveys. While others in the group only read it once or twice, their habits can be seen to improve overall in the second survey if X's data is excluded; although the group's disappointing lack of knowledge improvement remains little changed.

Due to the small sample size that resulted from participants dropping out, no statistically significant conclusions can be drawn. Overall, while knowledge and symptoms did improve after using the mobile application, and improved more for this group than for those given a PDF document, adherence to good practice did not follow as a result of having the mobile application at hand.

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## **CHAPTER 7**

### **CONCLUSION and FUTURE DEVELOPMENT**

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#### **7.1 SUMMARY**

This study aimed to investigate if contact lens wearers' compliance to good habits can be improved by providing a mobile application to support them. Focus groups were conducted to understand the needs of both users and optometrists. A mobile application was created and its use compared to that of a PDF containing the same information. The simple, cross-platform mobile application was built using JavaScript, jQuery, Visual Studio and Apache Cordova with 3 basic features: a reminder to change lenses, with a countdown of how many days remain to wear that pair of lenses; an information page which featured handling and care material; and an interactive troubleshooter interface in the form of a decision tree, to help users when they encountered problems with their contact lenses or eyes. The PDF included the information page as it appeared in the mobile application, and the troubleshooter in the form of a flow diagram. Before these were released to participants to use, a survey was conducted to evaluate their contact lens knowledge and habits. Their knowledge and behavior were then re-evaluated after being separated into two groups and given either the application or the PDF to use. In the second surveys, they were also asked for feedback on the usefulness of the app/PDF and how it can be improved.

#### **7.2 FINDINGS**

There was a decrease in symptoms after using both the application and PDF. Fewer eye problems were reported in the second round of surveys by both groups; and more so by the group that had used the mobile version. For the control group, knowledge of lens wear and care was lower in the second survey than the first; while knowledge increased in the group who had the mobile application, with the number of incorrect answers they gave dropping by 20% in the second survey. The mobile application was also accessed far more than the PDF version. The latter was used no more than twice by any of the control group, while 5 of the 8 subjects who had the mobile application used it more than twice, two of whom used it 12 and 15 times respectively. Neither group's responses gave evidence of an overall improvement in behavior after using the app/PDF; there were also several instances where subjects showed knowledge of good practice, yet nevertheless reported not adhering to this in their recent behavior. In this study therefore, improved knowledge of good practice did not lead to greater compliance.

Both modes of support received positive and encouraging feedback. The application rated slightly better than the PDF, and had more encouraging comments such as ‘informative and useful’ whereas one PDF user felt they “need more direction” on certain aspects. The contact lens care page received the highest rating of the 3 features provided by the application. Seven out of 8 of participants in both groups stated that they would recommend the app / PDF to others.

In both groups, when encountering a problem, participants ranked the app or PDF first in terms of what they would turn to for help. In the app group, this was followed closely by telephoning their optometrist. PDF users’ second choice was searching the internet or contacting their optometrist. Thus we can see that participants are looking for convenient ways of solving their problems. The delivery of sound information does start during the consultation when lenses are first used, but to ensure that this advice and instruction is adhered to, this information needs to be given to the patient in a form that they can regularly and easily refer to.

Some limitations of the study should be noted. Unfortunately, there was a significant drop out in participants and the final sample size of 8 in each group was quite small. There were particular cases, however, where individuals showed positive changes in their knowledge, symptoms and habits which should result in fewer complications in future. A larger study would be beneficial to understand better any change in user habits. This work undertook to pilot the idea using a simple, basic application; it is possible that a more sophisticated interface, and the addition of features such as gamification, might meet with greater success. Lastly, the surveys were completed remotely online, so it is possible that some subjects may have consulted the application or PDF during, or perhaps immediately before, answering the questionnaire. Further to the study itself, participants can be additionally questioned on how they feel their competence and knowledge has improved.

The study has given insight into the user’s needs and knowledge gaps in lens care. The mobile application implemented provides a springboard for future development of technological methods to care for contact lens wearers. Technology opens new avenues of providing treatment, advice and services that will benefit both the patient and the practitioner. This can create greater patient retention if the patient receives superior service. We cannot control patients and their behaviour but we can equip them with reliable knowledge and support to empower them to take the best care of their health.

## 7.3 FUTURE DEVELOPMENT

In order to reach more CL wearers, a web version of the app can be launched. This would be simple to achieve as the app itself is coded with HTML and JavaScript. Further to the study itself, participants can be additionally questioned on how they feel their competence and knowledge has improved. In addition to addressing the limitations noted above, there are opportunities for enhancing each of the features in the mobile application, as outlined below.

### 7.3.1 Reminder page

- Alerts could be added as warnings about the time remaining. Time intervals for monthly wearers could be one week left, 3 days left and then a countdown to day zero. The one week alert will give most users enough time to contact an optometrist and order lenses should it be the last lens in their box.
- A separate alert can be created when the first purchase of the boxes is made, with a reminder for when the reorder is to be done. This can be set by the user depending on how many lenses that particular user's box contains.
- A calendar feature can enable occasional wearers that use monthly lenses, to mark off each day that they wear the lens. This will allow them to track the number of days that they wear the lenses so as not to go over the recommended duration.
- Weekly tips as a pop up may help information retention or spark an "oh did not know that" moment.

### 7.3.2 Care Page

A video can be added demonstrating insertion, removal and cleaning of lenses. A visual aid might be easier to understand for some users. Even though these techniques have been demonstrated to patients, before dispensing the lenses to them, the refresher will be beneficial if they have forgotten, did not absorb, or simply did not understand the information given.

To provide a better understanding of what is required by CL wearers, a virtual reality system could be created so that patients are able to get a more lifelike experience. This would also aid the patient in appreciating the consequences of the complications. For example, if a patient could see their own eyes appearing severely red or having an ulcer on their cornea.

### 7.3.3 Diagnosis

A database of optometrists with their contact information can be provided. This will help the user get more reliable professional advice which may prevent long term damage to their eyes.

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**APPENDIX 1: CONTACT LENS WEARER PDF VERSION**



### **INSTRUCTIONS ON CONTACT LENS CARE**

#### **INSERTION OF LENSES**

1. ALWAYS wash your hands before handling contact lenses.
2. Take lens out of right-side case.
3. Clean lens before inserting:
  - a) Place lens in the palm of your hand and pour some solution over it.
  - b) Rub lens on both sides in circular outward movements.
  - c) Rinse lens in more solution.
4. Check in lens is on correct side:

Fold lens between your thumb and your forefinger. If the edges touch, it is on the correct side. If the edges curl away from each other, it is on the wrong side.
5. Place lens on the tip of your right forefinger.
6. Pin you upper eyelid of your right eye with you left hand to your brow bone.
7. With your right middle finger pull your lower eyelid down.
8. Look up or towards your nose and place the lens on the white of your eye. Then look into the lens.
9. Look up, down and then side to side to settle the lens.
10. Then look down and let go of your eyelids.
11. Repeat steps for left eye.

## **INSTRUCTIONS ON CONTACT LENS CARE**

### **REMOVAL OF LENSES**

1. ALWAYS wash your hands before handling contact lenses.
2. Pin you upper eyelid of your right eye with you left hand to your brow bone.
3. With your right middle finger pull your lower eyelid down.
4. Look up or towards your nose. Place your forefinger on the coloured part of your eye and slide lens to the white of your eye.
5. Pinch the lens off with you thumb and forefinger.
6. Clean the lens as described above.
7. Place lens back into case and make sure that you have discarded the solution that was in case. Fill case with fresh solution and make sure that lens is fully covered to avoid drying of lens.
8. Screw on cap of case tightly.
9. Keep lens case in dry cool area.

## **POINTS TO REMEMBER**

### **DO'S**

- ALWAYS wash and rinse your hands thoroughly before handling your lenses. Hands should be dried with a clean lint free towel.
- Make sure your lenses and storage cases are cleaned and disinfected regularly.
- Replace your contact lenses according to your Optometrist's instructions.
- If you drop your lens, clean the lens before inserting.
- Only use lens cleaning solution to wash and store your lenses.
- Change solution in case every time you use your lenses.
- Make sure to keep your glasses up to date in the event of you not being able to wear you lenses.
- Always insert your lenses BEFORE applying your eye makeup and remove lenses BEFORE removing makeup.
- Always use eye makeup formulated for contact lens wearers.
- If you get any makeup on lenses, remove lens, clean well and the re-insert.
- Dispose contact lenses in the bin.
- Wear goggles when swimming with your lenses in.

## POINTS TO REMEMBER

<b>DON'TS</b>
Use saliva or water to wet your lenses.
Use water to clean your lenses. Water is not allowed to come into contact with your lenses.
Reuse or top up lens solution in your cases.
Wear lenses if you are unwell.
Wear lenses if they feel uncomfortable or your eyes are red or irritated.
Rub your eyes vigorously especially with lenses in.
Use expired contact lens solution.
Over wear your contact lenses.
Use eye drops that are NOT recommend by your Optometrist.
Share contact lens.
Share eye makeup
Dispose of lenses down drains or toilets as this could pose a threat to marine life.
Do not fly on aeroplane with while wearing lenses



## APPENDIX 2: SURVEY 1: CONTACT LENS WEARER

9/24/2018

LimeSurvey Professional - Your online survey service - Contact Lens Wearer

# Contact Lens Wearer

In this survey we would like to understand your contact lens related habits and practices.

Welcome to our Contact Lens Survey 😊

There are 27 questions in this survey.

### 1 How old are you? \*

🗳️ Choose one of the following answers

Please choose **only one** of the following:

- 18 to 25
- 26 to 40
- over 40

### 2 What gender are you? \*

🗳️ Choose one of the following answers

Please choose **only one** of the following:

- Female
- Male
- Other

### 3 How would you rate your cellphone skills? \*

🗳️ Choose one of the following answers

Please choose **only one** of the following:

- Excellent
- Good
- Average
- Poor
- Very poor

#### 4 How often do you use your cellphone in a day? \*

Please write your answer here:

#### 5 How long have you been wearing contact lenses for? \*

❗ Choose one of the following answers

Please choose **only one** of the following:

- Less than one year
- Between one and two years
- Between two and five years
- More than five years

#### 6 What type of contact lens schedule do you follow? \*

❗ Choose one of the following answers

Please choose **only one** of the following:

- Daily disposable
- 2 weekly disposable
- Monthly disposable

#### 7 About how many months ago did you last have your eyes examined by your Optometrist? \*

❗ Only numbers may be entered in this field.

Please write your answer here:

8 Give the approximate date of the LAST time you changed your lenses? \*

Please enter a date:

9 And the approximate date of when you changed your lenses BEFORE that? That is the approximate date of the second last time you changed them. \*

Please enter a date:

10 On approximately how many DAYS did you usually wear your contact lenses in the past two weeks? \*

❗ Only numbers may be entered in this field.

Please write your answer here:

11 In the past 2 weeks, for approximately how many HOURS in the day did you usually wear your contact lenses? \*

❗ Only numbers may be entered in this field.

Please write your answer here:

12 In the past 2 weeks, when did you typically clean your lenses? \*

● Choose one of the following answers

Please choose **only one** of the following:

- I did not clean my lenses
- Before inserting the lenses
- After removing the lenses
- Before inserting and after removing lenses
- I did not clean my lenses as I wear daily lenses

13 In the past 2 weeks, what did you use to clean your lenses? List all if more than one. \*

Please write your answer here:

14 In the last 2 weeks, how often did you sleep with your contact lenses in? \*

Please write your answer here:

15 If relevant to you, do you select your eye makeup based on the fact that you wear contact lenses?

● Choose one of the following answers

Please choose **only one** of the following:

- Yes  
 No  
 Not relevant

16 Which of the following have you done in the last 2 weeks? \*

● Check all that apply

Please choose **all** that apply:

- Wore contact lenses while flying on an aeroplane  
 Lubricated contact lenses with saliva  
 Replaced daily lenses less often if worn for a very short time each day  
 Replaced monthly lenses less often if only worn occasionally  
 Slept wearing contact lenses  
 Wore contact lenses while swimming  
 Skipped cleaning lenses  
 Reused solution in storage containers  
 Wore lenses while showering or bathing  
 Shared eye makeup  
 Cleaned lenses with water  
 None of the above

17 How do you dispose of your contact lenses? \*

Please write your answer here:

18 In the last 2 weeks, did you experience any of the following WITH your contact lenses in? \*

📌 Check all that apply

Please choose all that apply:

- Blurred vision
- Discomfort or irritation while wearing the lenses
- Itchy eyes
- Painful sensation in eyes
- None of the above

Other:

19 If so, what did you do to ease the problem(s)?

Please write your answer here:

20 In the past 2 weeks, did you experience any of the following WITHOUT your contact lenses in? \*

📌 Check all that apply

Please choose all that apply:

- Itchy eyes
- Painful sensation in eyes
- Gritty feeling or sensation of "something" in your eyes
- None of the above

Other:

21 If so, what did you do to ease the problem(s)?

Please write your answer here:

22 If you are a monthly wearer, in the last 3 months, for how many weeks could you wear your contact lenses COMFORTABLY for?

Please write your answer here:

23 Do you ever do an internet search of any health or eye related symptoms you may be experiencing? \*

❗ Choose one of the following answers

Please choose **only one** of the following:

- Yes, several times
- Yes, once or twice
- No, never

24 Do you find the internet information helpful? Please elaborate on your answer briefly.

❗ Comment only when you choose an answer.

Please choose all that apply and provide a comment:

Yes

No

Sometimes

25 When should you replace your contact lenses? \*

❗ Choose one of the following answers

Please choose **only one** of the following:

Every day

Every 2 weeks

Every month

26 One can wear contact lenses at most for how many hours a day? \*

❗ Only numbers may be entered in this field.

Please write your answer here:

## 27 Is it OK to do the following? \*

Please choose the appropriate response for each item:

	Yes	Uncertain	No
Lubricate lenses with saliva	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Replace monthly lenses less often if only worn occasionally	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Clean lenses with water	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wear lenses while flying on an aeroplane	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Replace daily lenses less often if worn for a very short time	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wear lenses while swimming	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sleep wearing contact lenses	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Reuse solution in storage containers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wear lenses while showering or bathing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Skip cleaning lenses	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Share eye makeup	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Thank you so much for your time 😊

Submit your survey.

Thank you for completing this survey.

## APPENDIX 3: SURVEY AFTER USING MOBILE APP

1/4/2019

LimeSurvey Professional - Your online survey service - Survey after using mobile app

### Survey after using mobile app

This quick survey is to see if the app made any difference to your contact lens habits. There will be some repeated questions and some new questions.

There are 27 questions in this survey.

What type of contact lens schedule do you follow? \*

① Choose one of the following answers  
Please choose **only one** of the following:

- Daily disposable
- 2 weekly disposable
- Monthly disposable

Give the approximate date of the LAST time you changed your contact lenses.

\*

Please enter a date:

In the past 2 weeks, when did you typically clean your lenses? \*

① Choose one of the following answers  
Please choose **only one** of the following:

- I did not clean my lenses
- Before inserting my lenses
- After removing my lenses
- Before inserting and after removing my lenses
- I did not clean my lenses as I wear daily lenses

<https://contactlenswearer.limequery.com/admin/printablesurvey/sa/index/surveyid/153337>

1/11

In the past 2 weeks, what did you use to clean your lenses? List all if more than one.

Please write your answer here:

In the last 2 weeks, how often did you sleep with your contact lenses in? \*

Please write your answer here:

If relevant to you, do you select your eye makeup based on the fact that you wear contact lenses?

\*

❗ Choose one of the following answers  
Please choose **only one** of the following:

- Yes  
 No  
 Not relevant

### Which of the following have you done in the last 2 weeks? \*

🗖 Check all that apply

Please choose **all** that apply:

- Wore contact lenses while flying on an aeroplane
- Lubricated contact lenses with saliva
- Replaced daily lenses less often if worn for a very short time each day
- Replaced monthly lenses less often if only worn occasionally
- Slept wearing contact lenses
- Wore contact lenses while swimming
- Skipped cleaning lenses
- Reused solution in storage containers
- Wore lenses while showering or bathing
- Shared eye makeup
- Cleaned lenses with water
- None of the above

### How do you dispose of your contact lenses? \*

Please write your answer here:

In the last 2 weeks, did you experience any of the following WITH your contact lenses in?

\*

🗨️ Check all that apply

Please choose **all** that apply:

- Blurred vision
- Discomfort or irritation while wearing the lenses
- Itchy eyes
- Painful sensation in eyes
- None of the above

Other:

If so, what did you do to ease the problem(s)?

Please write your answer here:

In the last 2 weeks, did you experience any of the following WITHOUT your contact lenses in?

\*

🗨️ Check all that apply

Please choose all that apply:

- Blurred vision
- Discomfort or irritation while wearing the lenses
- Itchy eyes
- Painful sensation in eyes
- None of the above

Other:

If so, what did you do to ease the problem(s)?

Please write your answer here:

If you are a monthly wearer, in the last 3 months, for how many weeks could you wear your contact lenses COMFORTABLY for?

Please write your answer here:

**When should you replace your contact lenses? \***

❗ Choose one of the following answers  
Please choose **only one** of the following:

- Every day  
 Every two weeks  
 Every month

**One can wear contact lenses at most for how many hours a day?**

❗ Only numbers may be entered in this field.  
Please write your answer here:

### Is it OK to do the following? \*

Please choose the appropriate response for each item:

	Yes	Uncertain	No
Lubricate lenses with saliva	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Replace monthly lenses less often if only worn occasionally	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Clean lenses with water	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wear lenses while flying on an aeroplane	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Replace daily lenses less often if worn for a very short time	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wear lenses while swimming	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sleep wearing contact lenses	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Reuse solution in storage containers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wear lenses while showering or bathing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Skip cleaning lenses	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Share eye makeup	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Approximately how many times did you use the app? \*

Please write your answer here:

Which part did you find MOST useful?

\*

❶ Choose one of the following answers  
Please choose **only one** of the following:

- Reminder  
 Contact lens Care  
 Diagnose Me

Which part did you find LEAST useful?

\*

❶ Choose one of the following answers  
Please choose **only one** of the following:

- Reminder  
 Contact lens Care  
 Diagnose Me

How easy is it to use each part of the app on a scale of 1 (very hard) to 5 (very easy) ? \*

Please choose the appropriate response for each item:

	1	2	3	4	5
<b>Reminder</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>Contact lens Care</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>Diagnose Me</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

What did you find most difficult?

\*

Please write your answer here:

How can this be made easier? \*

Please write your answer here:

Would you recommend this app to friends or family? Please say why or why not. \*

Please write your answer here:

Have you used any other contact lens related mobile apps? If so, what are the app names? \*

Please write your answer here:

What score would you give the app on a scale of 1 ( worst) to 5 (best)? \*

**!** Only numbers may be entered in this field.

Please write your answer here:

What features would you like to see in the app? What do you think could make it more useful and helpful? \*

Please write your answer here:

Do you prefer using the app to find a solution to your problem or going immediately to the optometrist? \*

Please write your answer here:

Submit your survey.

Thank you for completing this survey.

## APPENDIX 4: SURVEY AFTER USING PDF

10/12/2019

LimeSurvey Professional - Your online survey service - Survey After using PDF

# Survey After using PDF

Hi! Welcome back 😊

There are 24 questions in this survey.

## Basics

1

Give the approximate date of the LAST time you changed your contact lenses.

\*

Please enter a date:

2

In the past 2 weeks, when did you typically clean your lenses? \*

🗳️ Choose one of the following answers

Please choose **only one** of the following:

- I did not clean my lenses
- Before inserting my lenses
- After removing my lenses
- Before inserting and after removing my lenses
- I did not clean my lenses as I wear daily lenses

3

In the past 2 weeks, what did you use to clean your lenses? List all if more than one.

Please write your answer here:

4

In the last 2 weeks, how often did you sleep with your contact lenses in? \*

Please write your answer here:

5

If relevant to you, do you select your eye makeup based on the fact that you wear contact lenses? \*

● Choose one of the following answers

Please choose **only one** of the following:

- Yes
- No
- Not relevant

6 Which of the following have you done in the last 2 weeks? \*

● Check all that apply

Please choose **all** that apply:

- Wore contact lenses while flying on an aeroplane
- Lubricated contact lenses with saliva
- Replaced daily lenses less often if worn for a very short time each day
- Replaced monthly lenses less often if only worn occasionally
- Slept wearing contact lenses
- Wore contact lenses while swimming
- Skipped cleaning lenses
- Reused solution in storage containers
- Wore lenses while showering or bathing
- Shared eye makeup
- Cleaned lenses with water
- None of the above

## 7 How do you dispose of your contact lenses? \*

Please write your answer here:

## 8

In the last 2 weeks, did you experience any of the following WITH your contact lenses in? \*

🗨 Check all that apply

Please choose all that apply:

- Blurred vision
- Discomfort or irritation while wearing the lenses
- Itchy eyes
- Painful sensation in eyes
- None of the above

Other:

9 If so, did you consult the information sheet? Why or why not? \*

Please write your answer here:

10

In the last 2 weeks, did you experience any of the following WITHOUT your contact lenses in? \*

📌 Check all that apply

Please choose all that apply:

- Blurred vision
- Discomfort or irritation while wearing the lenses
- Itchy eyes
- Painful sensation in eyes
- None of the above

Other:

11 If so, did you consult the information sheet? Why or why not? \*

Please write your answer here:

12

If you are a monthly wearer, in the last 3 weeks, do you feel you can wear your lenses COMFORTABLY for the full month now?

Please write your answer here:

13 When should you replace your contact lenses? \*

● Choose one of the following answers  
Please choose **only one** of the following:

- Every day  
 Every two weeks  
 Every month

14

One can wear contact lenses at most for how many hours a day?

\*

❗ Only numbers may be entered in this field.  
Please write your answer here:

### 15 Is it OK to do the following? \*

Please choose the appropriate response for each item:

	Yes	Uncertain	No
Lubricate lenses with saliva	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Replace monthly lenses less often if only worn occasionally	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Clean lenses with water	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wear lenses while flying on an aeroplane	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Replace daily lenses less often if worn for a very short time	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wear lenses while swimming	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sleep wearing contact lenses	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Reuse solution in storage containers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wear lenses while showering or bathing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Skip cleaning lenses	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Share eye makeup	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

PDF

16 Approximately how many times did you refer to the information sheet? \*

Please write your answer here:

17

Which part of the information sheet did you find MOST useful?

\*

❗ Choose one of the following answers

Please choose **only one** of the following:

- Contact lens Care Page
- Diagnose Me Page
- Both pages were equally useful
- I did not learn anything from either page

18 How easy was it to understand each page of the information sheet on a scale of 1 (very hard) to 5 (very easy) ? \*

Please choose the appropriate response for each item:

	1	2	3	4	5
Contact lens Care Page	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Diagnose Me Page	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

19

What did you dislike or consider needed improving in the information sheet?

\*

Please write your answer here:

20 Would you recommend this information sheet to friends or family? Please say why or why not. \*

Please write your answer here:

21 What score would you give the information sheet as a convenient source of good information on a scale of 1 ( worst) to 5 (best)? \*

❗ Only numbers may be entered in this field.

Please write your answer here:

22 Do you prefer using the information sheet to find a solution to your problem or going immediately to the optometrist? \*

Please write your answer here:

23 What would your plan of action be when having a problem with your eyes or contact lenses? \*

❗ All your answers must be different and you must rank in order.

❗ Please select at most 5 answers

Please number each box in order of preference from 1 to 5

Ignore it unless its very bad

Use the information sheet

Phone Optometrist and ask advice

Search internet

Go see Optometrist

## 24 Do you have any further comments?

Please write your answer here:

Thank you for taking out the time to be part of my study!!! 😊

Submit your survey.

Thank you for completing this survey.

## APPENDIX 5: INFORMED CONSENT

### DEPARTMENT OF COMPUTER SCIENCE

UNIVERSITY OF CAPE TOWN  
PRIVATE BAG  
RONDEBOSCH 7701  
SOUTH AFRICA

RESEARCHER'S  
TELEPHONE: +27-21-650 2668  
FACSIMILE: +27-21-650 3551  
E-MAIL: NDXTER005@myuct.ac.za  
URL:



### Informed Voluntary Consent to Participate in Research Study

#### Project Title:

**Invitation to participate, and benefits:** You are invited to participate in a research study conducted with contact lens wearers and optometrists. The study aim is to develop a mobile app to increase contact lens wearers' compliance to good contact lens practices and thus reduce complications. I believe that your experience would be a valuable source of information, and hope that by participating you may gain useful knowledge.

**Procedures:** During this study, you will be asked to either use a mobile app or read a PDF document related to contact lenses, and answer a questionnaire before and after doing so.

**Risks:** There are no potentially harmful risks related to your participation in this study.

**Disclaimer/Withdrawal:** Your participation is completely voluntary; you may refuse to participate, and you may withdraw at any time without having to state a reason and without any prejudice or penalty against you. Should you choose to withdraw, the researcher commits not to use any of the information you have provided without your signed consent. Note that the researcher may also withdraw you from the study at any time.

**Confidentiality:** All information collected in this study will be kept private in that you will not be identified by name or by affiliation to an institution. Confidentiality and anonymity will be maintained as pseudonyms will be used.

#### What signing this form means:

By signing this consent form, you agree to participate in this research study. The aim, procedures to be used, as well as the potential risks and benefits of your participation have been explained verbally to you in detail, using this form. Refusal to participate in or withdrawal from this study at any time will have no effect on you in any way. You are free to contact me, to ask questions or request further information, at any time during this research.

I agree to participate in this research (tick one box)

Yes     No \_\_\_\_\_ (Initials)

_____ Name of Participant	_____ Signature of Participant	_____ Date
_____ Name of Researcher	_____ Signature of Researcher	_____ Date

## APPENDIX 6: EMAIL SENT WITH INFORMED CONSENT

Mail - Terushka Naidoo - Outlook

### Informed Consent

Terushka Naidoo

Wed 2018/08/08 13:18

To: [REDACTED]

1 attachments (212 KB)

Informed Consent.pdf;

Good day

Thank you so much for agreeing to participate in my study.

The study will involve answering questionnaires and reviewing and giving us your opinion on methods to improve contact lens care.

Please read the attached consent form and sign and return to me. This can be done by scanning and emailing or taking a photo and sending to me. Please also can you tell me what type of cellphone you are currently using e.g Samsung, iPhone, etc.

Please can I also ask that you return the form to me as soon as you can. If you are having these issues when returning the informed consent form to me you can either email to [terushkan@yahoo.com](mailto:terushkan@yahoo.com) or take a picture and Whatsapp it to me on the number **0764060343**.

If you have any questions please contact me on 0764060343 or on this email.

Thank you once more.

Kind Regards,  
Terushka Naidoo

## APPENDIX 7: EMAIL SENT WITH PDF ATTACHED

Mail - Terushka Naidoo - Outlook

### Contact Lens Study PDF

Terushka Naidoo

Tue 2018/11/27 13:51

Bcc:



1 attachments (788 KB)

Happy Contact lens Wearer3.pdf;

Hi there

I hope that you are well.

This the next step in the Contact lens study. It is an PDF to be downloaded to your cellphone or computer to use for the next few weeks.

**If you have any issues downloading it is crucial that you contact me ASAP.**

If you have any problems please contact me on this email or 0764060343.

Enjoy it!!

Warm Regards,  
Terushka

## APPENDIX 8: EMAIL SENT WITH MOBILE APP LINK

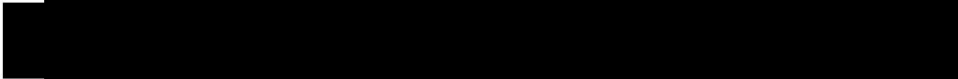
Mail - Terushka Naidoo - Outlook

### App to be downloaded

Terushka Naidoo

Sun 2018/11/04 10:05

Bcc:



Hi there

I hope that you are well.

This the next step in the Contact lens study. It is an app to be downloaded to your cellphone and use for the next few weeks.

**If you have any issues downloading it is crucial that you contact me ASAP.**

If you have any problems using the app please contact me on this email or 0764060343. There is a description of the app on that download page as well.

Please click in the link and it will take you to download page.

<https://play.google.com/store/apps/details?id=io.cordova.myapp75cc21>



### Happy Contact Lens Wearer - Apps on Google Play

play.google.com

Functionalities • Reminder page Allows you to set a reminder for a countdown to how many days you have left wearing a pair of lenses. • Diagnose me Troubleshoot symptoms that you may be experiencing with your eyes and contact lenses. This feature will