Proposed Smart Application for Eye Care

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Approval Certificate

This thesis titled "**Proposed Smart Application for Eye Care**" submitted by Touhid Ahmed Munsi, Student ID:011132059, Suraia Jabeen, Student ID:011132083, Md. Readowan Arafeen, Student ID:011132006, Md. Intesar Alam Shawon, Student ID:011131080 has been accepted as Satisfactory in fulfillment of the requirement for the degree of Bachelor of Science in Computer Science and Engineering on [Date].

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Declaration

This is to certify that the work entitled "**Proposed Smart Application for Eye Care** " is the outcome of the research carried out by us under the supervision of Dr. Khondakar Abdullah Al Mamun, Professor, Department of Computer Science and Engineering, United International University

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In my capacity as supervisor of the candidate's thesis, I certify that the above statements are true to the best of my knowledge.

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Acknowledgement

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Abstract

Bangladesh is a densely populated developing country inhabiting more than 160 million people among them more than 70 percent people are living in rural areas. The lack of medical facilities exists all over the remote areas of Bangladesh. Over 6 million people in Bangladesh need vision correction by spectacles and there are about 40,000 visually impaired women and children. The problem with the eye is getting more severe because of unavailability of eye care facility around the area. An easier way of eye screening can be very effective for saving them from a long term consequences. Digital technologies are rarely available in those areas. As the smartphones are increasing rapidly even in the remote areas of Bangladesh, we can utilize them as a tool to test eye and diagnose it primarily. This thesis is where we are proposing an smartphone app that can screen and diagnose the eye resulting refractive error, color blindness and educating people about eye health. These features are not only for the people of rural areas where eye education percentage is very low as well as for the people who are interested to screen eye and want basic education of eye diseases. We have studied literature including journal papers, conference papers and existing smartphone application of eye diseases to address a smartphone application for screening eye and educate unaware people with basic eye knowledge. All the apps that are currently available have limitations. To overcome the limitations, in this thesis we are proposing a smartphone application which includes the feature of Near Vision Test, Far vision test, Symbol and Number Test, Color Blind Test and basic Education of Eye. This proposal is reviewed by users, doctors, and the optics glasses sellers. We hope the implementation of this app can bring new possibilities in the field of eye screening as well as will make people aware of eye health. With the advancement of the technology we hope to improve the application in the future.

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Chapter 1

Introduction

WHO (World Health Organization) roughly calculated in the ear 2010 that 285 million people over the world reveal some form of visual problems. On their proper calculation 39 million are found blind. Among them 80% can be cured and 90% of them live in poor countries where inhabitants have ophthalmic limitations [1]. There was a few number of practicing ophthalmologists in remote areas. Ophthalmologists were the only way to cure eye problems. Underdeveloped Countries have the most amounts of visually impaired people and most of them can be cured and possible to save from being blind. Blindness is more common among the older people because of lack of ophthalmic resources, trained professional and cost of medical equipment's used for eye diagnosis.

Bangladesh is a country in south Asia inhabits 163 million people and considered as one of the most densely populated countries in the world [2]. Among these populations more than 10 million is suffering from Myopias, 8.9 million Hyperopia and 14.6 million Astigmatism [3]. Maximum number of people are living in rural areas who are not provided proper ophthalmologic facility or cannot afford to consult an ophthalmologist on a routine basis. On the basis of a recent statistical result showing that 96% of the population is now under mobile coverage and biased towards internet which leads us to a chance to study mobile application using which a large number of inhabitants can get eye diagnosis even easier than it is now [4].

Currently, there are around 2.16 billion Smartphone users throughout the world who can maintain their lifestyle and health by using healthcare apps [5]. In recent years the use of the features of technological devices are spreading like the wildfire. Due to the near ubiquity of smartphones and tablets among clinicians**,** health specialists are on the verge of using it in practice various health sectors. To give the process a fuel the mobile apps are good sources that could be added to medical usage helping the process of diagnosis of patients. The study has opportunities considering the costs, ease of use, and data mobility [6]. Many built-in features such

as camera, flashlights, audio recorder comes with the smartphones which are the main components of many medical devices comes free with the smartphones. Given the cost and mobility of the smartphone it could become a flipped classroom and open new doors. If the data is taken by the mobile app, we can upload it to the cloud for further purposes of analysis that could be done by the health workers as well as mobile application itself. The ophthalmologic data, the echo cardiogram(ECG) data, fundus image, sounds such as respiration or phonocardiograms etcetera could easily be taken with a phone and sent it to anywhere to enable tele medical opportunity.

Challenges are the main concerns in tele medical sectors in which privacy, cost, evidence, technology dependence and Hypochondriasis are the main challenges of all. Recording and transmitting patient's data could be a problem to the health insurance company. Although each worker of the field supposed to have their own smartphone, it would be a challenge to give them each a device. The app based medical diagnosis opens a new chapter in the medical history but we have to ensure that the potential obstacles above do not manifest in harmful ways.

Snellen equation has a bigger role to play when refractive error comes into consideration .Vision eye card and other studies are being done to solve this problem as well. Further work in accordance to diagnose refractive error, study will try to make easily usable application.

The digitization of medical imaging added a new dimension and exciting possibilities to the eye automated pathology detection, electronic detection and transmission. Ophthalmoscopes which are very expensive in nature now could be easily replaced by the smartphone and some of the ready technology of this kind is already being used by the ophthalmologists. According to its working credentials, it could be divided into low, high and middle-income settings. The mobile photography has changed over time from VGA camera to double lens optical zoom cameras, from VGA video to 4K resolution videos. Assessment from these cameras helped the engineer to create something that can take photos of the eye fundus for further diagnosis. At the very beginning when the mobile phone's camera was in an evolutionary stage ophthalmologists tend to take pictures with the slit-lamps but when the camera came with the flash light it allowed the ophthalmologist to take image without the slit-lamps. Flash light is tend to be surrounding but in order to take the photo we need an slit-lamp alike light to go at a certain point of the eye fundus

[7]. An adopter comes into place with the help of the adopter we get the pointy lights for the eye from the flash itself and it takes high resolution photo of the eye fundus. Smartphones use led flashes and xenon flashes nowadays. Flashes are very bright in nature and it is designed to take the photograph of surroundings not the eye fundus. A higher spectrum can cause harm to the patients and that is why choosing safety for the patients are important. If some phones are not in range of the spectrums then the outer led light should be used.

Understanding the capability and the features of the mobile we aim to answer the following questions:

1. Does the smartphone technology can be used in the medical field?
2. How accurate a smartphone a smartphone can diagnose?

We are now thankful that we live in a such era where technology is growing fast with the help of technology of smartphone we will study some ways to make the ophthalmologic diagnostics easier and available then what we won now.

Chapter 2

Literature review

Abstract

The new age of research and technology has opened up exciting possibilities of eye care through eye automated pathology detection, electronic storage and transmission. In assistance of the previous research and new devices we are able to do some eye test if not all. Although ophthalmologic devices are expensive in nature, eye testing with the smartphone could be affordable if proper study is done on this field. The enthusiasm of this field is partly due to availability of smartphones and tablets among clinicians and smartphone users which can run medical apps with a touch of human hands. High-resolution view of the device camera and the calculation power can be used to diagnostic resources to detect eye conditions such as glaucoma, diabetic retinopathy, eye fundus photo, refractive errors, color blindness, optic disc detection etcetera. In this chapter we are ought to review the related work that is done in this filed and could be processed further to improve efficiency.

2.0 Methodology

The materials that are reviewed in this chapter are selected from various sites, Google Scholar and GitHub. The concern of this chapter is to find out the related works that is done in the field of ophthalmology along with the mobile phone technology in order to achieve low cost diagnosis for the patients of third world country. The selections of the resources are done in steps.

The steps are shown in the figure below.

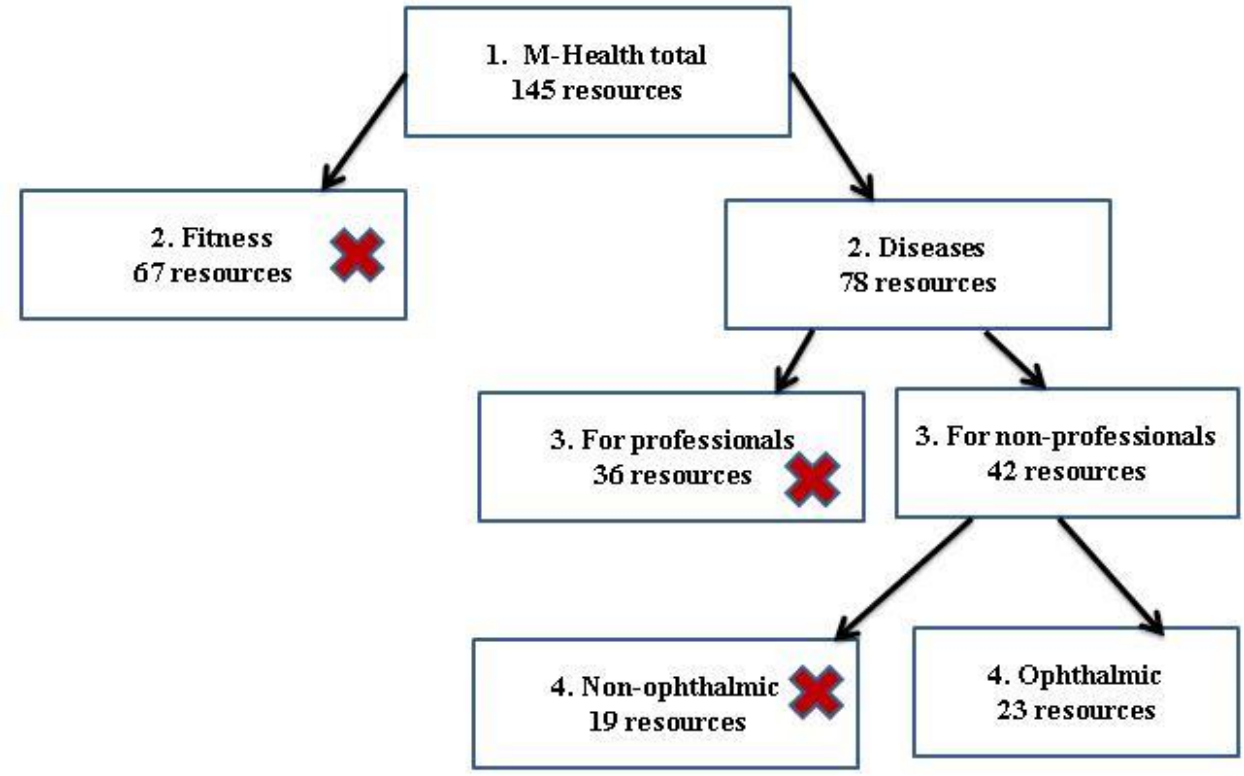

Figure 2. 1: Steps of selection

Firstly, different keywords are searched online, secondly, among the results the resources are selected in steps; finally 23 resources are selected to review in this chapter.

2.1 Visual acuity

2.1.1 Vision loss

Smartphone application has advanced in a satisfactory level where a good level of application is being made by the developers to help the professionals as well as the general health workers. Application has developed to measure visual acuity, retinal imaging, eye detection etcetera. Virtual Eye Doc an Android Based App in Bengali Language for Eye Health & Vision Examination provides an app which is created to test eye power using Snellen Chart which is developed in 1861 and Craig's ophthalmology calculations strategy to compute the eye glass power using 20/20 calculation [8, 9, 10]. The length of testing distance is calculated using reduced Schematic Eye which is a simplified model of the optics of the eye that is useful for calculating both object and retinal image size. Instead of using English alphabet which is given in Snellen chart this app uses a Bengali alphabet to make the app more users friendly as 85% of the total population is native language speaker.

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Participant	Glass power recommended by doctor		Glass power range recommended by our app	
	For left eye	*For right eye*	*For left eye*	*For right eye*
P1	-1.75	-2.25	(-2.0) - (-3.0)	(-2.0) - (-3.0)
P2	-1.25	-0.75	(-0.75) - (1.0)	(-0.75) - (-1.0)
P3	-3.25	-4.75	(-3.0) - (-5.0)	(-3.0) - (-5.0)
P4	-1.00	-1.00	(-0.75) - (-1.0)	(-0.75) - (-1.0)
P5	-3.5	-3.5	(-3.0) - (-4.0)	(-3.0) - (-4.0)
P6	-0.5	-0.5	(-0.75) - (-1.0)	(-0.75) - (-1.0)
P7	-1.00	-1.00	(-0.75) - (-1.0)	(-0.75) - (-1.0)
P8	-1.00	-1.00	(-0.75) - (-1.0)	(-0.75) - (-1.0)
P9	-0.25	-0.25	Eyes are okay	Eyes are okay
P10	-2.5	-2.5	(-2.0) - (-3.0)	(-2.0) - (-3.0)

Table 2 0: Experience comparison chart between doctor's result and the app result [8].

An online survey and an interview were conducted to acknowledge the awareness between people. Later on this is tested among 10 participants. After the test by the app they are sent to eye doctors for examining their eye with the available medical resources. The app was accurate for the 60% of the participants. Rest of 30% is show less errors which is less than 1D and 10% greater than 1D. Considering the fact that it is a mobile app, the result is considered successful. Although the app has given 60% accurate answers, more accuracy of the app is yet to come. Sometimes vision can also be lost by some percentage because of dry eye. Dry eye, known

medically as keratoconjunctivitis sicca or keratitis sicca, is a condition known as lack of production of tears. To evaluate the impact of dry eye syndrome (DES) on vision-associated quality of life with cross-sectional study, it is found that from 450 participants in the Women's Health Study (WHS) and 240 participants in the Physicians' Health Study (PHS) are identified and made a questionnaire asking how much their everyday activities were affected by symptoms of dry eye [11]. How their activities like reading, driving, working at the computer, their professional activity, and watching TV etc. were affected by dry eye symptoms. Logistic regression was used to examine relationships of DES with reported problems of everyday activities. 85% of the patients completed the supplementary questionnaire from 135 of and 55 of PHS participants with DES, and 250 of WHS and 149 of PHS participants without DES.DES has an adverse impact on several common and important tasks of daily living. Eye diseases are very common among elderly people. They experience terrible loss of vision disorders such as glaucoma and cataracts. These diseases can be treated through proper surgery. But age-related change in the eye is too serious and eyes can be permanently destroy or blur of an old person's vision. When a person becomes old the macula of the eye degenerates and it loses its visual acuity [12]. This Diabetic retinopathy and age related macular degeneration diagnosis has vast majority in the study field [13]. A screening is necessary as this process is just to compare the quality of life with visual acuity loss due to diabetic retinopathy and visual acuity loss due to age related macular degeneration [14].

Consecutive patients with diabetic retinopathy and macular degeneration are evaluated with the time trade off method of utility value analysis. Visual acuity level is compared with two scales. If the value is nearest to 1.0 the patient is in better condition but if it is nearest to 0.0, the patient is in worst condition. Utility values collected from the patients that were stratified for visual acuity group were then compared to the t-test and Mann Whitney U-test. No difference was found with the same utility values for visual acuity that were found for diabetic retinopathy and age related macular degeneration. So they had the similar level of reduction of the quality of life. Retinal blindness can be caused due to diabetes and cataract. It is expensive to detect diabetes and cataract from retinal images using fundus cameras as it requires specialists to perform the detection and not portable at all. So a low cost and portable eye examination kit is needed to diagnose the eye diseases of the patients. A smartphone based intelligent system is used along with a microscopic lens to examine retinal diseases [15]. This system uses neural network algorithm to analyze the diseases from retinal images captured by the lens.

The algorithm is trained with infected and normal retinal images in android environment and optimized by the rooted method to improve battery lifetime and processing capability. Two well-known medical ophthalmology databases are used to test and verify the system. The accuracy rate is found more than 87% from its evaluation result.

2.1.2 Vision cards

Scientists and researchers are working for decades to contribute to eye study. They are trying to discover easier ways to diagnose the eye exploring even the trivial features of an eye. Snellen equation, gaze, fundus, vision card, movement of the eye etcetera are being taken into consideration. To use Gaze Capture and a convolutional neural network (CNN) learned end-to-end for gaze prediction as well as training the network with just crops of both eyes and the face it is possible to outperform existing eye tracking approaches in this domain by a significant margin [16]. Eye detection is popular now-a-days to recognize face on a still photo or in a video. iTracker is an app to detect an eye in assistance with Gaze capture. Computer Vision Syndrome (CVS) is a common problem in the "Tech Age", and it is becoming more serious among people as mobile devices and tablets are increasing in people's hands. EyeGuardian which is a framework of eye tracking and blink detection for mobile device users could possibly help the people in that matter [17]. The very same methods could be used for remote eye tracking [18].

The discrepancy between the near visual acuity (VA) measurements using the Eye Handbook smartphone application and the conventional method of using the near vision card it is found that from 100 subjects, near VA was measured and compared using the near vision card and the Eye Handbook app for IPhone 5 [19].The measured data then converted to Log MAR format. Then the relationship between the two techniques was analyzed by paired sample t-test and scatterplot [20]. With a value of $p=0.0001$, results indicate that the Eye Handbook application overestimates the near VA which was compared with the conventional near vision card by an average of 0.11 [19].With the utilization of portable high-definition screens in VA measurements, it should be the concern of the eye-care providers about the potential disparity in VA measurement between different platforms. In this study, it was secondary to the high contrast and brightness of the smartphone's high-definition screen when compared with the near vision card.

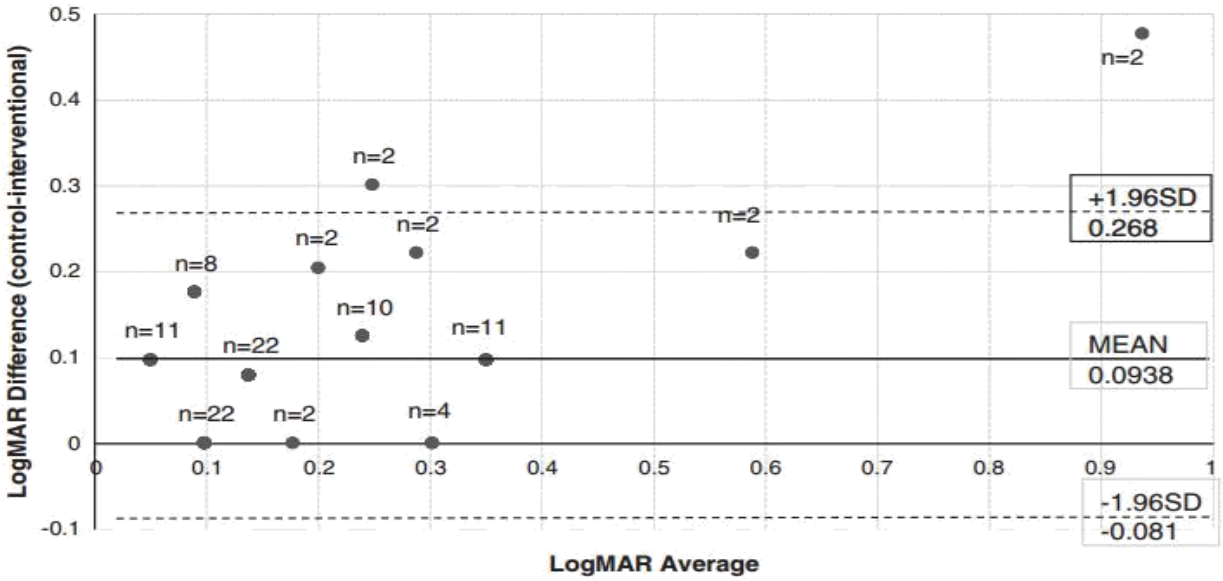

Figure 2. 2: Bland–Altman plot obtained from the available sample pool comparing the relationship between the LogMAR VA measurements from the EyeHandBook app running on IPhone 5 versus the near vison card [20].

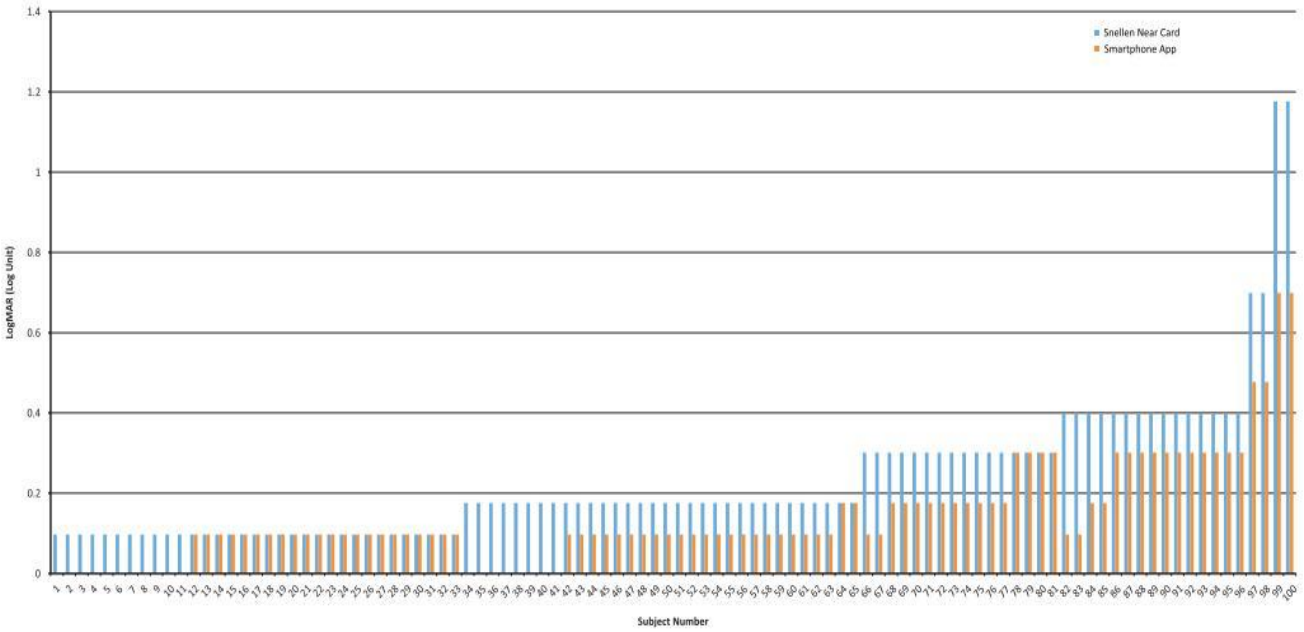

Figure 2. 3: Comparison bar graph of the LogMAR VA measurements from the EyeHandBook app running on IPhone 5 versus the near vison card [20].

Subjects' presentation has been arranged based on increasing LogMAR values measured by the near vision card[20]. This figure excludes subjects with LogMAR value of 0.0 for both EyeHandBook app running on IPhone 5 and the near vison card.

2.1.3 Snelling visual acuity using smartphone

A review of available Snelling chart applications on iPhone was performed to determine the most accurate application based on opt type size. Subsequently, a prospective comparative study was performed by measuring conventional 6SVA and then iPhone visual acuity using the 'Snelling' application on an Apple iPhone 4 [21].

Materials and methods:

This study was conducted in two parts. First, a review of available Snelling chart applications on iPhone was performed. Second, a comparative study between the 6SVA and is VA was conducted.

A Snelling chart is designed such that each line would theoretically subtend an angle of 5° at the distance specified for that line.

By using simple trigonometry, we were able to calculate the predicted opt type height for particular Snelling acuity line, using a chart held at any distance.

$h = Lm * d * \tan(5/60)^c$

Formula used to calculate theoretical opt type sizes.

h—calculated opt type height (mm).

L_m—unit calculated based on the line of the Snelling chart (egg 6/60, line modifier=10, 20/40=2). d—distance chart held (mm).

By comparing the calculated opt type height to the actual letter height, we were able to ascertain the percentage error for each line. The overall inaccuracy for the application was calculated by averaging the error for each line.

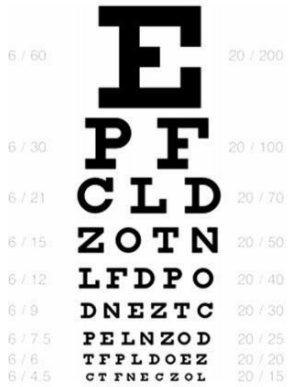

Figure 2. 4 : Screenshot taken of application "Snellen" by Dr. Bloggs Ltd [17].

iPhone application name	*Publisher*	*Rating (n)*[a]	*Cost ($)*	*Recommended distance chart held from patient (m)*	*Average line inaccuracy (%)*
Eye Test	Bokan Technologies (2009)	2.5 (60)	0.99	1.50[b]	4.4
OptOK	Codev Ltd (2010)	N/A (0)	0.99	1.20	4.7
Snellen	Dr Bloggs Ltd (2011)	N/A (0)	Free	1.20	6.6
HOTV Acuity	KyberVision Consulting[c] (2009)	N/A (0)	0.99	1.20[b]	11.9
Eye Test Free	Claire Holmes (2011)	N/A (0)	Free	1.20	15.7
Check My Eyes	Scott Kehrberg (2011)	N/A (0)	0.99	1.20	17.2
iSnellen	Roninside (2011)	N/A (0)	Free	1.50	17.4
Eye Test Dr	Jose Barientos (2009)	2 (6)	0.99	1.50[b]	18.6
Eye Chart	DOK LLC[c] (2009)	2.5 (432)	Free	1.20	20.2
iExam	Corey Canfield (2010)	N/A (0)	0.99	0.60	35.6
Optician	Dimitro Gnyenko (2012)	N/A (0)	0.99	1.20	39.9

Table 2.1: I-phone application comparison to show cost and line inaccuracy from a given distance. iPhone Snelling chart applications [21].

A review of all available Snelling chart applications in the Apple 'App Store' comparing ratings, cost, test distances, and inaccuracy.

Testing protocol:

The acuity was measured only in the right eye, and patients wore their distance correction glasses, if used. A mirror was held at 3 m from the Snelling chart, which was held next to the patient, resulting in a simulated 6 m acuity measurement. This enabled patients who were bed bound to participate in the study. Thus allowing sampling of all hospital patients to ensure results would be applicable to general hospital practice. In order for accurate recording of Snelling acuity, charts should be read in a well-illuminated ambient environment.

Advantage:

For patients with visual acuity equal to or worse than 6/18 it is noted that the largest difference in the mean recorded acuities. An obvious limitation of this group was the small sample of patients that fell into this acuity range, which limits the interpretation of this data in isolation. We compared mean log MAR difference between the two charts using equivalence in Snelling visual acuity lines rather than by log MAR units in order to keep the results clinically relevant.

Disadvantage:

This app is not responsive. This can only be used in the iPhone, iPad, iPod and Mac.

2.2 Imaging

"Fundus" is the Latin word for the bottom. In medicine, fundus refers to the bottom or base of an organ. “Fundus”, when used for the eye it means the interior lining of the eyeball, including the retina (the light-sensitive screen), optic disc (the head of the nerve to the eye), and the macula (the small spot in the retina where vision is keenest). The fundus is the portion of the inner eye that can be seen during an eye examination by looking through the pupil. Ophthalmoscopy, also called funduscopy, is a test that allows a health professional to see inside the fundus of the eye and other structures using an ophthalmoscope (or funduscope). It is done as part of an eye examination and may be done as part of a routine physical examination. It is crucial in determining the health of the retina, optic disc, and vitreous humor. The pupil is a hole through which the eye's interior will be viewed. Opening the pupil wider (dilating it) is a simple and effective way to better see the structures behind it. Therefore, dilation of the pupil (mydriasis) is often accomplished with medicated drops before funduscopy. However, although dilated fundus examination is ideal, undiluted examination is more convenient and is also helpful (albeit not as comprehensive), and it is the most common type in primary care.

Fundus photography involves capturing a photograph of the back of the eye fundus. Specialized fundus cameras that consist of an intricate microscope attached to a flash enabled camera are used in fundus photography. The main structures that can be visualized on a fundus photo are the central and peripheral retina, optic disc and macula.

Ophthalmoscopy can reveal Glaucoma, Diabetic retinopathy, Retinal haemorrhage, Charcot–Bouchard aneurysm, Cone dystrophy, Retinopathy, Vogt–Koyanagi–Harada syndrome, drusen , Stargardt disease, Papilledema , Eales disease, Hypertensive retinopathy, Vitelliform macular dystrophy , fundus albipunctatus. Partial tests are done to confirm the disease but fundus photography is considered as the main test for the diseases .

One of the basic concern regarding the fundus camera is that it is very expensive which makes it unavailable to the remote areas of underdeveloped countries. A portable eye examination kit (Peek) is introduced by University of Strathclyde Research that gives clinical Validation of a Smartphone-Based Adapter for optic disc imaging [22]. Using the kit we can take the photos of fundus that will help the diagnosis of eye disease. The adapter with the smartphone camera becomes the ophthalmoscope.

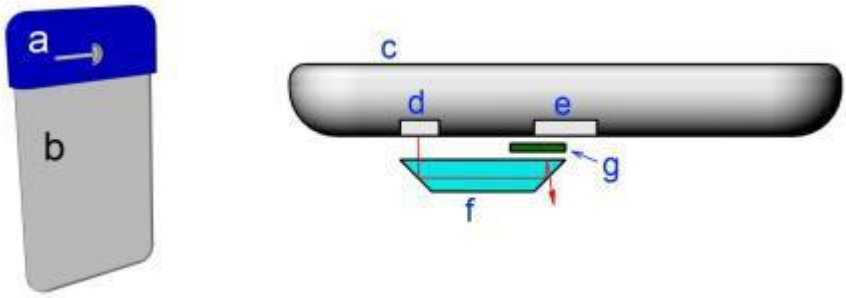

Figure 2.5: The peek ophthalmoscope clip(a) on light d) is captured and deviated in front of phone (b,c), the LED camera(e) by a prism(f) [22] .

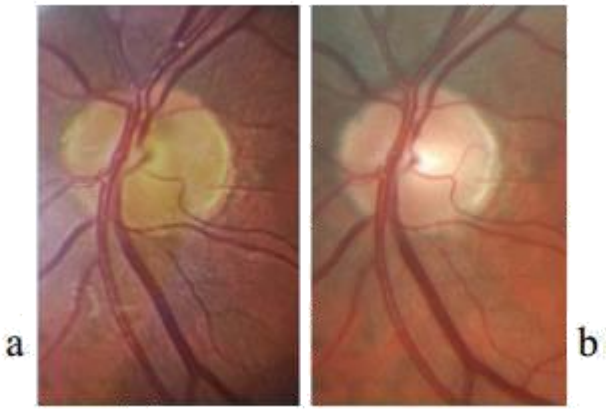

Figure 2. 6: Comparison between Peek (a) and fundus camera (b) [22].

Smartphones have many advantages to use in portable ophthalmoscopy due to their widespread availability and portability. Smartphones have allowed the acquisition of high-quality images compared to expensive conventional fundus cameras. There are many technologies for smartphone fundus photography. Smartphone retinal imaging is one of them and is possible by attaching an smartphone adapter to an ocular piece of a regular or portable slit lamp. Portable Slit Lamp iPhone4 image adapter are those types of adapters [23]. This technique is limited for anterior segment imaging and that's why this is not perfectly used. Direct ophthalmoscopy is also used as fundus photography.

Underdeveloped Countries have the most amounts of visually impaired people and most of them can be cured and possible to save them from being blind. Blindness is more common among the older people and lack of resources, trained professional and cost of medical equipment's used for retinopathy diagnosis is the main reason behind it. Images of Retina are used in the diagnosis & monitoring of many diseases for a long time and fundus photography has made it possible to examine & detect various retinal diseases.

With the advancement of digital photography & far-reached mobile devices, mobile telephone photography has become a promising factor in capturing retinal images while attached with imaging devices. Feasibility of this smartphone adapter compared to desktop retinal camera for capturing retinal image was evaluated in Kenya. Images captured with smartphone adapter came out to be comparable to images captured with desktop camera when graded independently by experts. Ethics approval by the ethics committees & Consent from the participant was taken before the study.

The digitization of medical imaging added a new dimension and exciting possibilities to the eye automated pathology detection, electronic detection and transmission. Ophthalmoscopes which are very expensive in price nature now could be easily replaced by the smartphone and some of the ready technology of this kind is already being used by the ophthalmologists. According to its working credentials it could be divided into low., high and middle-income settings. The mobile photography has changed over time from VGA camera to double lens optical zoom cameras, from VGA video to 4K resolution videos. Assessment from these cameras helped the engineer to create something that can take photos of the eye fundus for further diagnosis.

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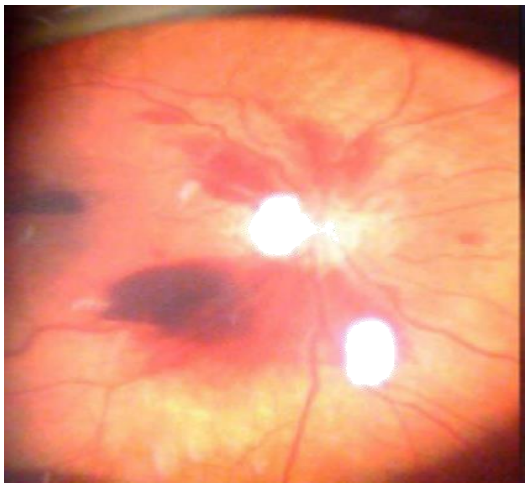


Figure 2. 7 : Fundus image using 20D lens, IPhone[7].

Figure 2. 8 : Capturing fundus image via IPhone 4's camera [7].

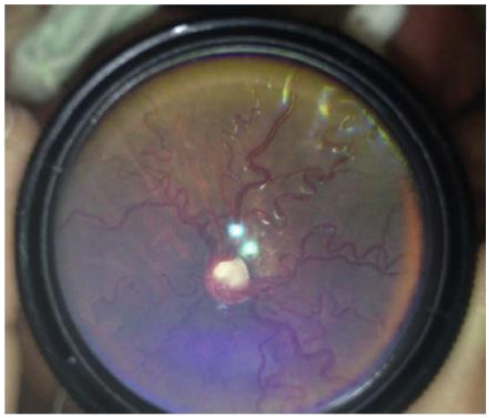


Figure 2. 9: Plus disease in a pre-term could be diagnosed from an image captured using a smartphone's camera and light emitting diode (LED) flash by applying an eyelid speculum and performing scleral indentation [7].

2.3 Diagnosis through neural network

Retinal blindness can be caused due to diabetes and cataract. It is expensive to detect diabetes and cataract from retinal images using fundus cameras as it requires specialists to perform the detection and not portable at all. So a low cost and portable eye examination kit is needed to diagnose the eye diseases of the patients. A smartphone based intelligent system is used along with a microscopic lens to examine retinal diseases. This system uses neural network algorithm to analyze the diseases from retinal images captured by the lens [23]. The algorithm is trained with infected and normal retinal images in android environment and optimized by the rooted method to improve battery lifetime and processing capability. Two well-known medical ophthalmology databases that are also extensive intelligent decision-making applications of classify algorithms on the other side. However, the majority of strategies for the application of AI algorithms is given in the figure below. Three essential factors considered influential to optimization methods including the hardware, development platforms, analyze retinal images and perform diagnosis on the image used to test and verify the system. The accuracy rate is found more than 87% from its evaluation result [15].

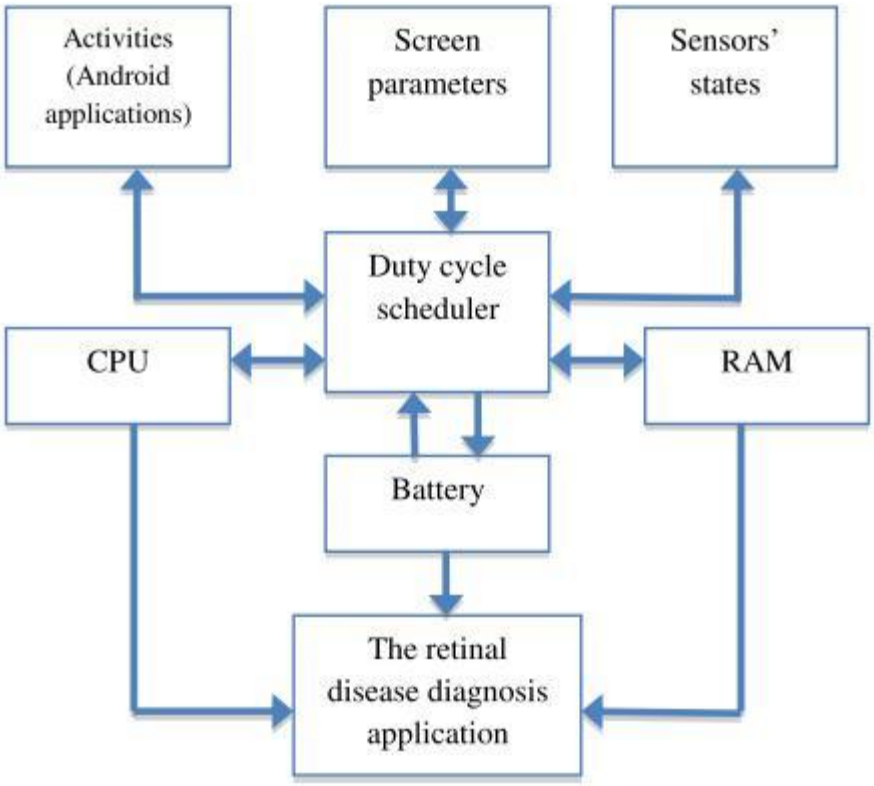


Figure 2. 10: The duty cycle and energy efficient principle [24].

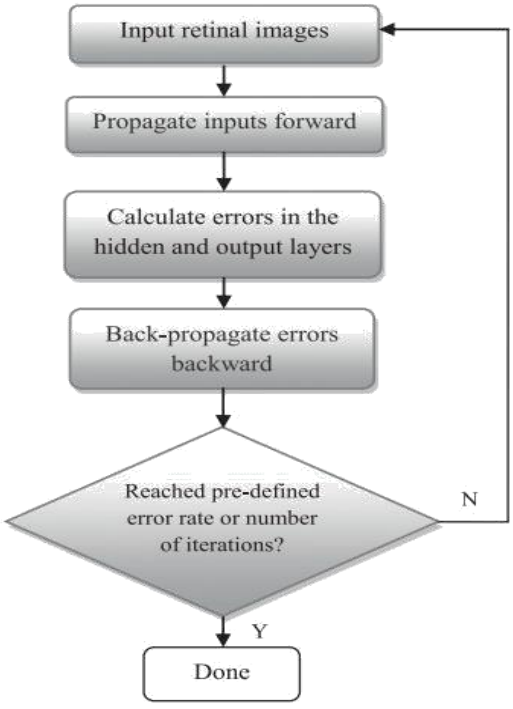


Figure 2. 11: The schematic diagram for the training of the Neural Network [24].

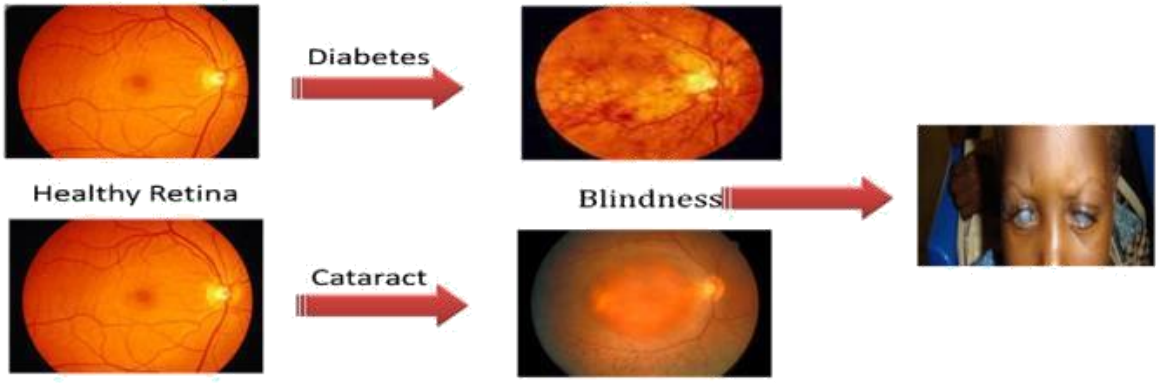


Figure 2. 12: Healthy and infected retinal images that cause blindness [15].

We have reviewed the possible resources that are related to our thesis work. Although all the element is important we are decided to work with only the mobile application that is already published. We ought to modify a theory in which if a application is built, it will be more user friendly. In chapter 3 we will be reviewing the mobile applications related to the thesis.

Chapter 3

Ophthalmic App review

Technology is constantly evolving in new ways to improve patient education and care, and over the last few years, the eye caring app has become an invaluable research and communication tool for doctors. The eye related apps that help the patients to test their eyes for identifying different eye diseases are playing a very important role to assist the patients and the doctors in this field. It also helps the uneducated and inexperienced patient to test their eyes easily and comfortably. Smartphones are widely used nowadays. So, proper study and invention in this field can have an impact on ophthalmology.

3.0 Methodology

The apps reviewed in this chapter are selected from the Google app store searching with the key "eye related apps". The selected 15 apps are reviewed and found only 7 apps that are closely related to our review in this chapter. The apps are selected based on the functionality, low cost, user friendliness and their proper feedback.

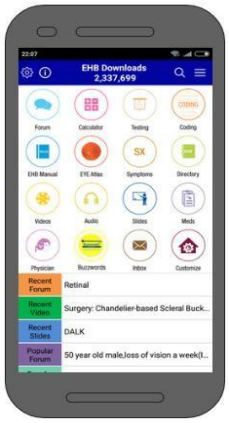
3.1 Ophthalmic Apps

We explored almost all the related apps which have the features such as visual acuity checking, color blind testing, macular testing, color contrast testing, the use of Amsler grid, Snellen chart , color blind testing with the help of cubic games etc.

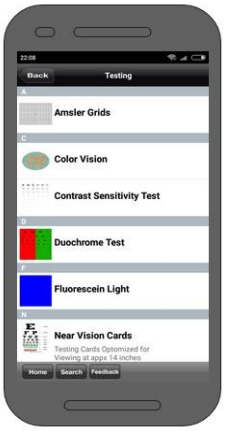
3.1.1 Eye Handbook

The Eye Handbook is a smartphone diagnostic and treatment reference tool for anyone involved in Eye care [24].

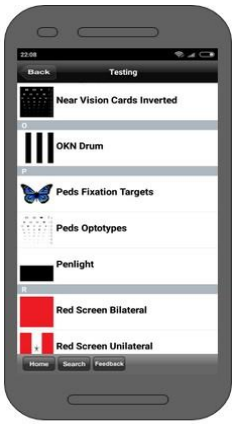
A) Home page



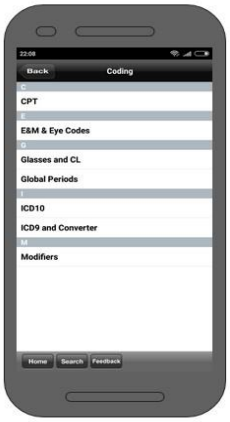
B) Menu p a g e



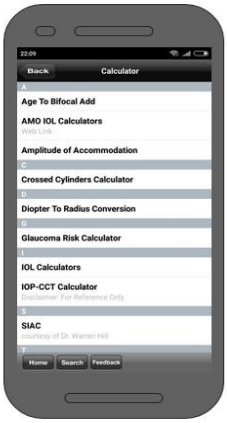
C) Testing features



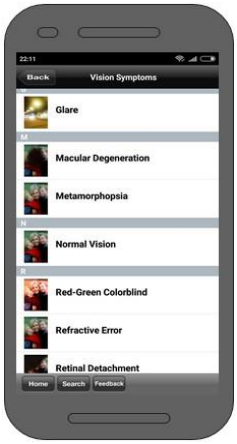
D) Testing features cont.



E) Coding features



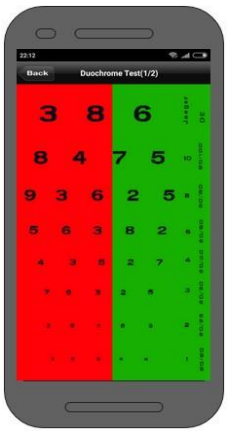
F) Calculator



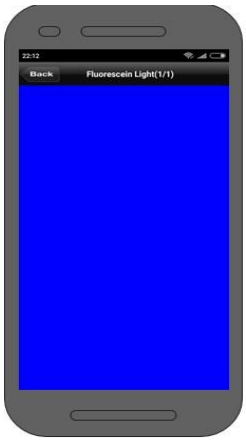
G) Vision symptoms

H) Contrast sensitivity testing

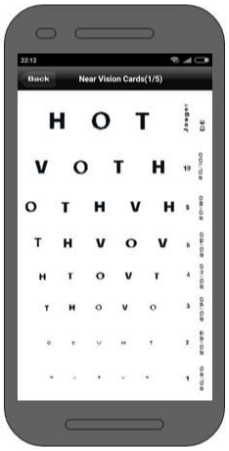
I) Color blind testing



J) Duo chrome testing

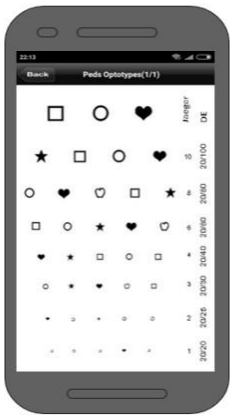


K) Fluorescein light testing

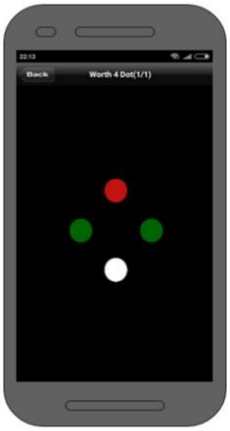


L) Near vision card

M) Near vision card inverted



N) Peds optotypes



O) Worth 4 dot

P) Pegs fixation target

Q) Red screen unilateral

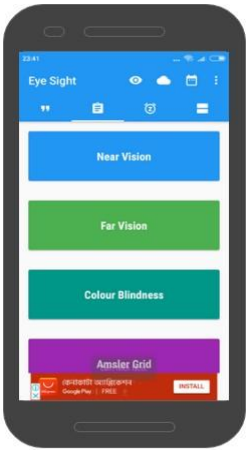
Figure 3.1: Eye Handbook App

From the menu page, we can select any option to explore. We can see from part B of figure 3.1 that there are many options such as Forum, Calculator, Testing, Coding, EHB Manual, EYE Atlas, Symptoms, Directory, Videos, Audio, Slides, Meds, Physician, Buzzwords, Inbox, Customize and some of the recent forums, videos and slides updates. In the testing option, there are many others options to choose for testing. They are Amsler grid, color vision, contrast sensitivity test, duo chrome test, fluorescein light, near vision test, OKM drummed fixation targets, pads optotypes, penlight, red screen bilateral, red screen unilateral. In the coding option, there are other options which are different type of coding that are used. The coding are CPT, E&M & Eye codes, Glasses and CL, Global Periods, ICD10, ICD9 and converter, modifiers. In the physician section, we can find Calculators, Coding, Equipment, Eye atlas, EHB manual, Meds, References, RSS, Testing, Treatment. These options can be used by the physician. Calculator includes Age to Bifocal Add, A MO IOL Calculators, Amplitude of Accommodation, Crossed Cylinders Calculator, and Diopter to Radius Conversion, Glaucoma Risk Calculator, IOL Calculators, IOP-CCT Calculators, and SIAC. The EHB app describes some vision symptoms. In part G of figure 3.1, we can see the symptoms such as Advanced Glaucoma, Astigmatism, Cataracts, Diplopia, Flashes of Light, Floaters, Glare, Macular Degeneration, Metamorphosis, Normal Vision, Red-Green Colorblind, Refractive Error, Retinal detachment etc. To test the colorblind, the color vision option needs to be selected. By visualizing a figure shown on part I of figure 3.1 consequently, we can identify the vision symptoms. To test the contrast sensitivity, we need to check part J of figure 3.1 which is a chart of text with contrast color. And in the duo chrome test, we can check the symptom by relating the reference value of the lines according to our correct visibility. For duo chrome testing, the screen of part K of figure 3.1 is used. And the reference value of the line is used as the evaluation in which line the vision of eye is clear. Part L of figure 3.1 is used for the fluorescein light test. Near vision is known as hyper metopic which causes far objects to be blurry and close objects may appear normal. Other symptoms may include headaches and eye strain. To test near vision, the near vision card option needs to be selected at first. Then the device should be hold at arm’s length. Covering one eye with hand, read the text of screen of part M of figure 3.1. Then test it for another eye. Then the reference value of the line is used as an evaluation for near vision in which line the vision is clear. The near vision card inverted is used on the same way. The testing procedure is same for the peds optotype as the near vision card. The worth four light Test which is shown on part P of figure 3.1, also known as the Worth's Four Dot test or W4LT, is a clinical test mainly used for assessing a patient's degree of

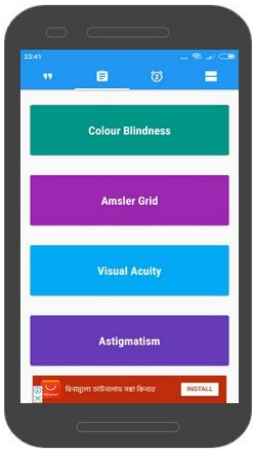
binocular vision and binocular single vision. Binocular vision involves an image being projected by each eye simultaneously into an area in space and being fused into a single image. The W4LT can be performed by the examiner at two distances, at near (at 33 cm from the patient) and at far (at 6m from the patient). At both testing distances the patient is required to wear red-green goggles (with one red lens over one eye, usually the right, and one green lens over the left) When performing the test at far (distance) the W4LT instrument is composed of a silver box (mounted on the wall in front of the patient), which has the 4 lights are arranged in a diamond formation, with a red light at the top, two green lights at either side (left and right) and a white light at the bottom. When performing the test at near (at 33 cm) the 4 lights are arranged in exactly the same manner (diamond formation), with the difference being that at near, the 4 lights are located in a hand held instrument which is similar to a light torch. Because the red filter blocks the green light and the green filter blocks the red light, it is possible to determine if the patient is using both eyes simultaneously and in a coordinated manner. With both eyes open, a patient with normal binocular vision will appreciate four lights. If the patient either closes or suppresses an eye they will see either two or three lights. If the patient does not fuse the images of the two eyes, they will see five lights. For the pegs fixation, you have to hold the mobile screen at arm's length. Then you have to fix the target, the shape of it without looking elsewhere. Then you have to gaze at the target. So the Eye Handbook App has the overall features such as Calculators, ICD9 coding (9^{the} revision of International Statistical Classification of Diseases and Related Health problems, a medical classification.

3.1.2 Eye Sight Test

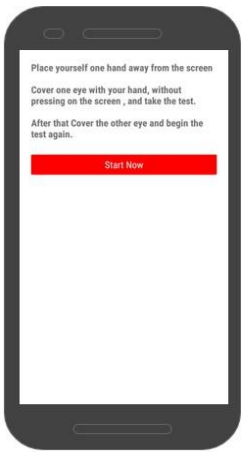
It is free and simple to use tests to screen your vision anywhere and anytime. It keeps track of your eyesight and ensures that you're always on top of your eye health. It is developed with the help of eye care professionals, these tests are based on the most proven techniques in ophthalmology [25]. Eye Test checks for some of the most common vision problems, such as: Near Vision, Far Vision, Color Blindness, Amsler Grid, visual acuity and others.



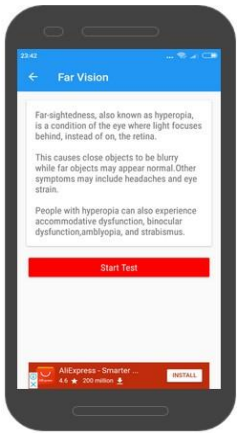
A) Testing methods



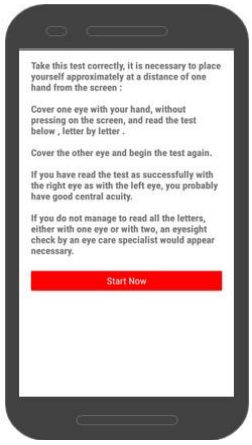
B) Testing methods cont.



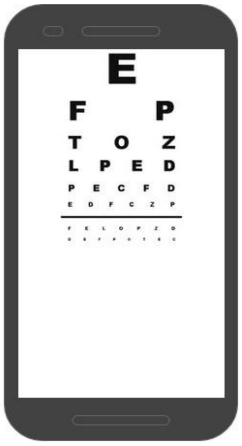
C) Start testing



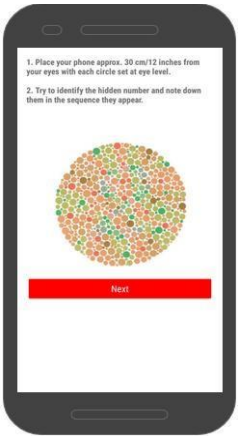
D) Far vision test



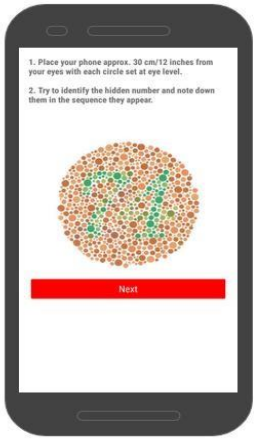
E) Start of far vision



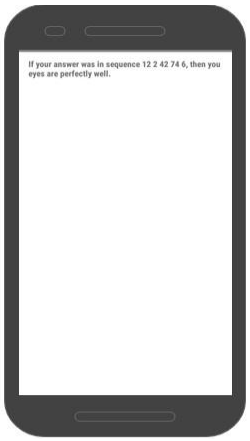
F) Far testing card



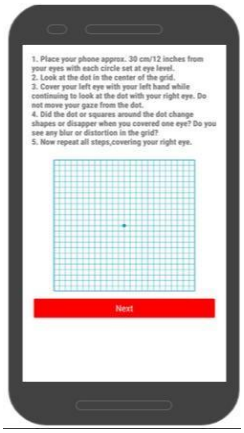
G) Identification



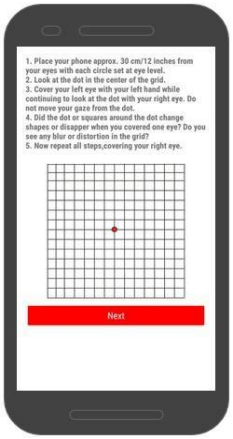
H) Identification cont.



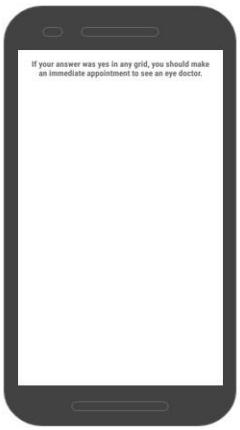
I) Checking of identification



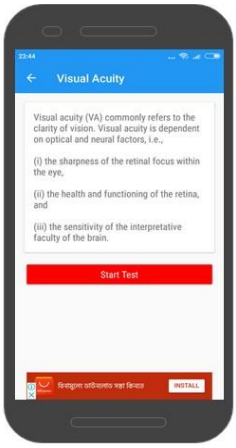
J) Amsler grid test



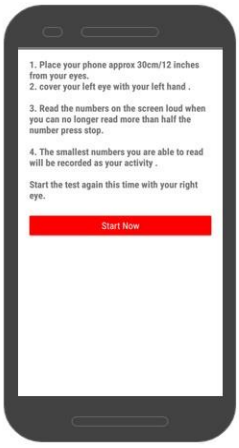
K) Amsler grid test cont.



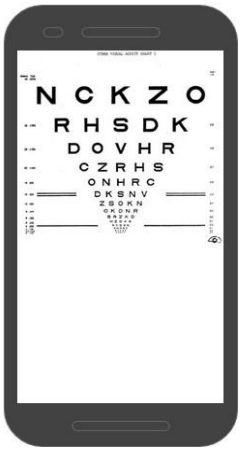
L) Checking of test



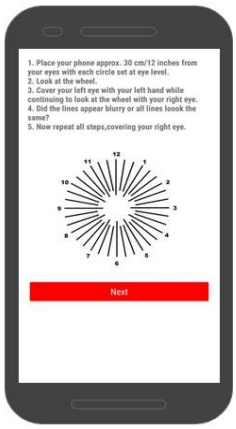
M) Visual acuity test



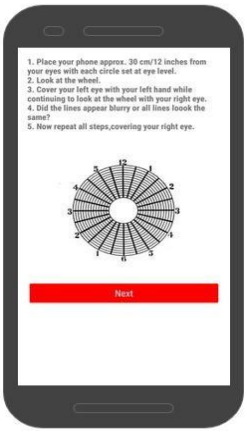
N) Instruction for test



O) Visual acuity testing card

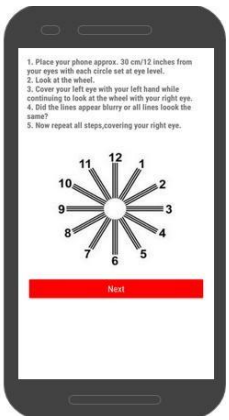


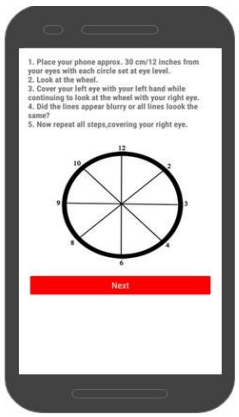
P) Astigmatism

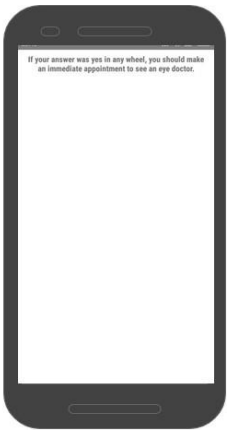


Q) Astigmatism test

R) Astigmatism test cont.







s) Astigmatism test cont. t) Astigmatism test cont. u) Result of test

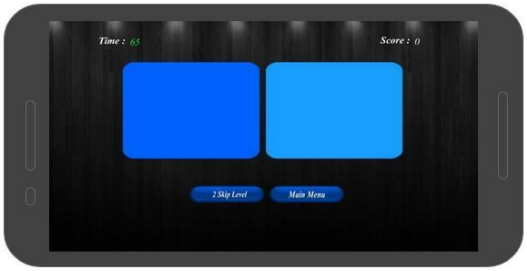
Figure 3.2: Eye sight app test

3.1.3 Vision Test

Vision Test is a 2D game developed by Unity game engine . This game is available on 3 different platforms (Windows, Android, and Web GL) [26].The purpose of this game is to challenge your vision power, this game trying to increase the ability of your focus, visibility and speed [26]. This game contained 30 levels with limited time (70 seconds).In the end of game, according to the player's score, the outcome of the game can between 4 categories: perfect, good, normal, and low [26].

A) Home Page

B) Instructions for testing



C) First Step of Test

D) Next Step of Test

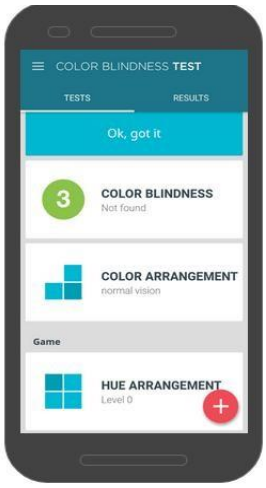
E) Next Step of Figure D

Figure 3.3: Vision Test App

To start the game, the “Start” option of the home page needs to be selected. To know all the detail of the game, needs to select the “About” option of the home page. To know the purpose of playing the game, the “purpose” option needs to be selected and the “exit “option is to exit from the game. You have to find the light cube and quickly touch on it in each level of the game. You have to remember the time limit of the game. Then continue the process in each level.

3.1.4 Blind Test

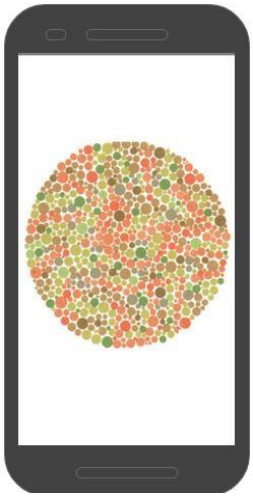
Blind Test helps to identify color deficiency reveals red, green or blue color blindness or any kind of color vision weakness [27]. This Color Blindness Test includes Ishihara Color Vision Test, Farnsworth D-15 Dichotomous Color Blindness Test, and the viral Color Cube game [27].



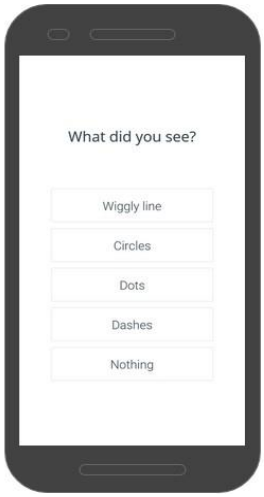
A) Home page

B) Color blindness checking

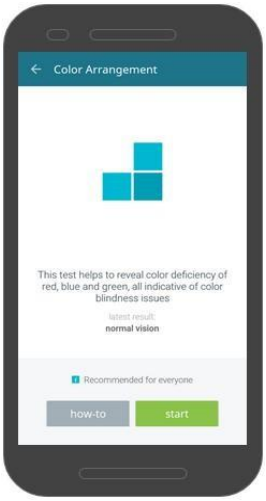
C) Identification



D) Color blindness checking cont.



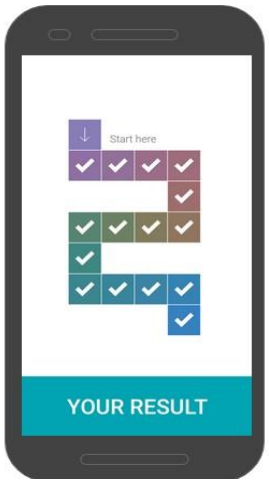
E) Identification



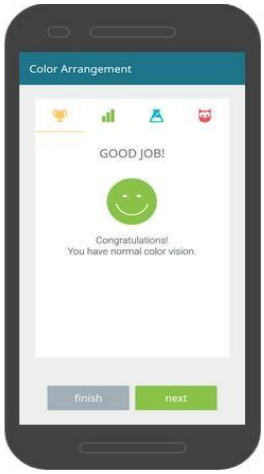
F) Color arrangement test

G) Not sequentially arranged

H) sequentially arranged



I) Arrangement checking



J) Feedback

K) Color huge arrangement

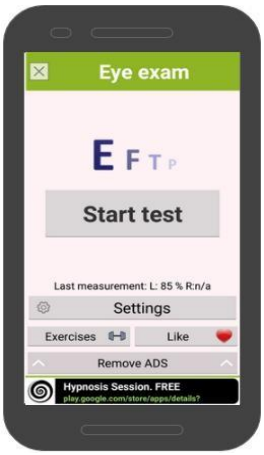
L) Next step of

Figure 3.4: Blind Test App

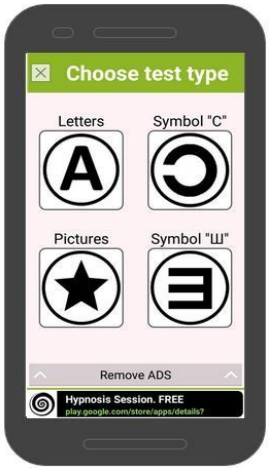
Part A of figure 3.4 is a home page of the app which includes menu. From this page we can select the checking item for vision test. The first option is a color blind testing. This term includes some color blind testing from the identification of different colored number and shapes and we have to answer the identification. From the answer, it can be identified whether the color blindness have or not. The second option includes color arrangement. In this part, we have to arrange the color sequentially. After checking the arrangement, the color blindness cans the identified. The third option is the huge arrangement which is a game, basically the viral color cube game. Playing the game, the color blindness can be identified from the result which is shown on part k and l of figure 3.4

3.1.5 Eye Exam

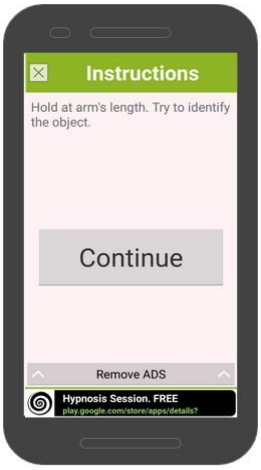
This eye test allows you to check your visual acuity [28]. The App is FREE. Take care of your vision. With this program you can test your vision at home. It can't replace opticians. Regular full examination or advice of ophthalmologist, but with this vision test you may discover that your eyesight deteriorates and you need to visit a doctor. 90% of all information that comes into our brain is visual [28]. That's why eye care is so important [28]. The advantages of this eye test are that it is easy to use, it is totally free, and it provides visual acuity measurement statistics (history, charts and trends) [28]. You can also schedule next eye exam (daily or weekly) [28].Main features include Snellen chart, Landolt C", Tumbling E, chart with pictures for little kids. Objects are shown randomly. Measurements statistics are available.



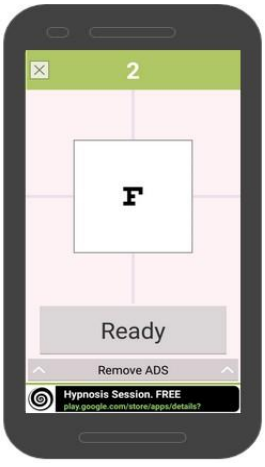
A) Home page



B) Test types

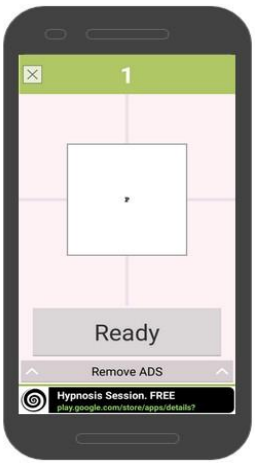


C) Instruction

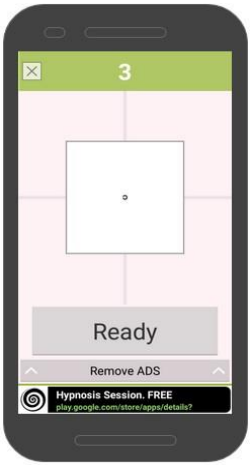


D) Test for letters

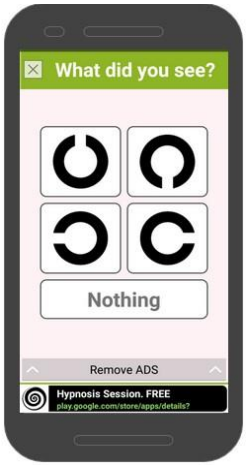
E) Identification



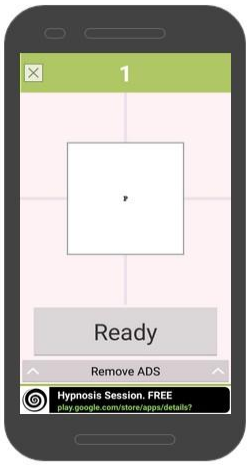
F) Next level of test



G) Test for symbol “c”

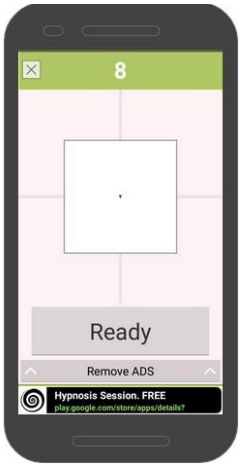


H) Identification



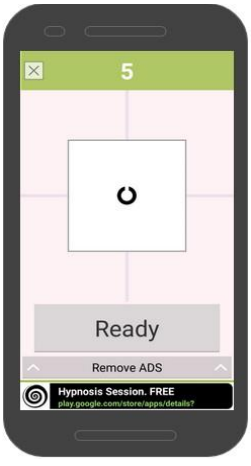
I) Test for letters again

J) Identification

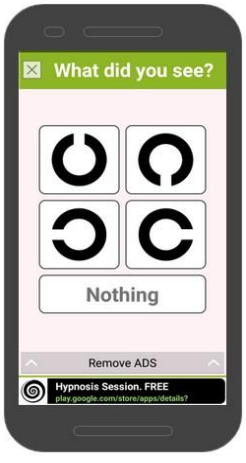


k) Next level of test

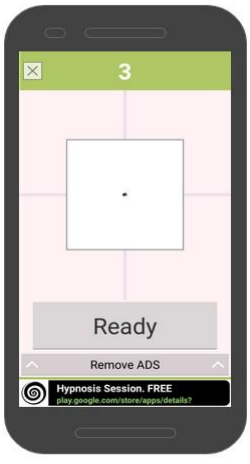
L) Identification cont.



M) Test for “C” pictures

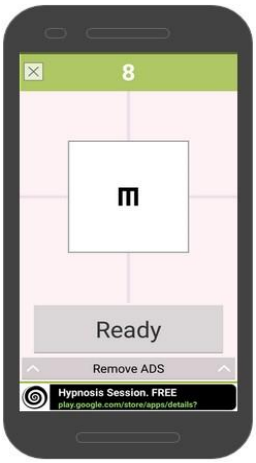


N) Identification cont.

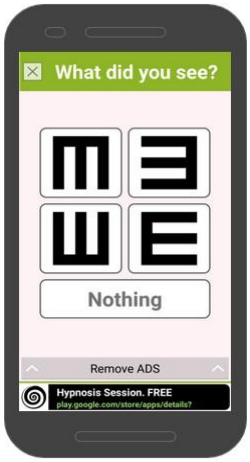


O) Test for

P) Identification cont.



Q) Test for symbol “E”



R) identification cont.

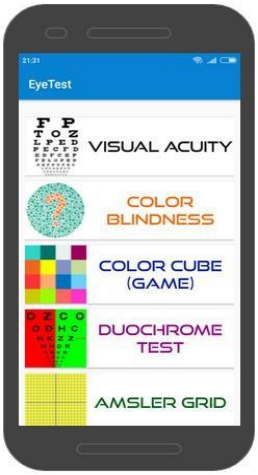
Figure 3. 5 : Eye Exam App

To test your eyes with Eye exam app, hold the phone at arm’s length and you have to select at first the type of test you want to check for your eyes. The test types are of letters, symbol “c”, and pictures, symbol “E” for each type of test you have to observe the symbol/letter at first, then you have to identify the symbol and choose the correct answer. Your wrong answer for the identification will decrease the score of test and mark as vision syndrome. Finally the measurement statistics of your left and right eye will show the acuity of vision of your eyes individually. This application is not intended to replace optician's regular full examination. We recommend you get a full eye test after using it.

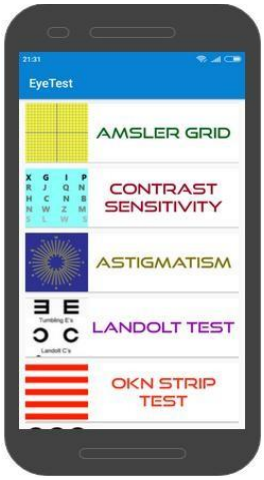
3.1.6 Free Eye Test

Free Eye Test application developed by VR Siddhartha College students under the guidance of Indian Servers [29]. This application is free app which will make out very easily if you are color-blind. After doing the tests you should be able decide whether or not you should see an eye doctor. This Application has totally 10 tests. Visual acuity test, color blindness, color cube, duo chrome test, Amslergrid, contrast sensitivity, astigmatism, Landolt Test, OKN Strip Test, AMD.

A) Home page



B) Different type of test list eye test list



C) Different type of eye

D) Identification

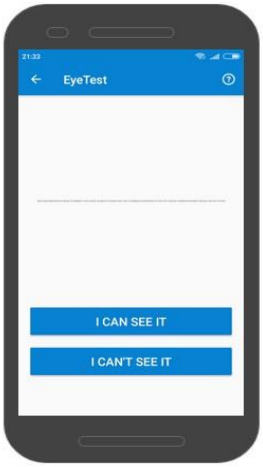
E) Identification cont.

F) Identification cont.

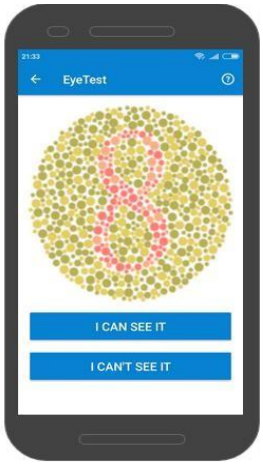
G) Identification cont.

H) Identification cont.

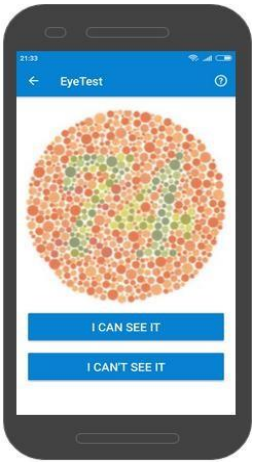
I) Identification cont.



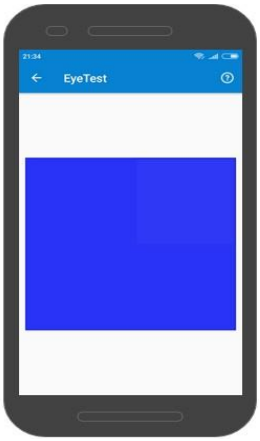
J) Identification cont.



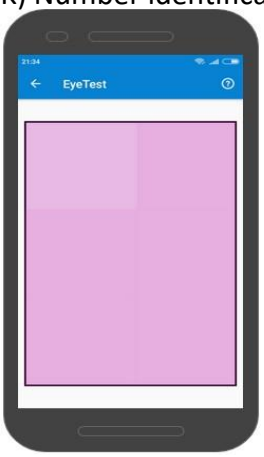
K) Number identification



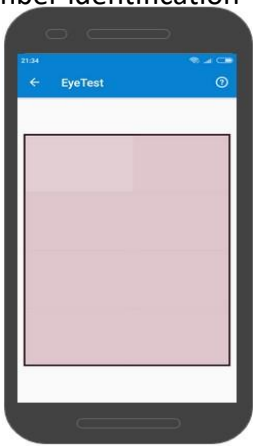
L) Number identification



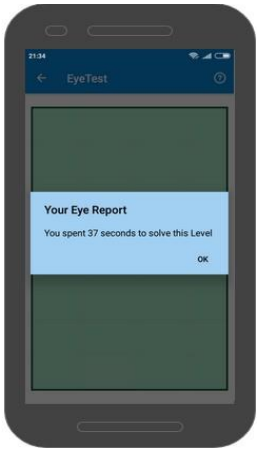
M) Light cube identification



N) Light cube identification cont.

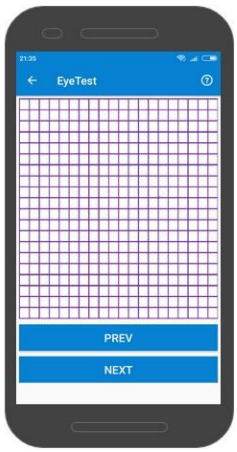


O) Light cube Identification (cont.)



P) Result of color cube game

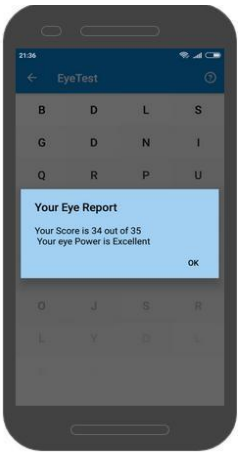
Q) Duo chrome test



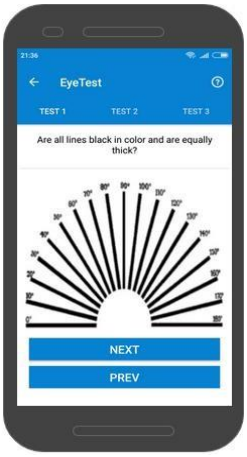
R) Amsler grid test

S) Amsler grid test cont.

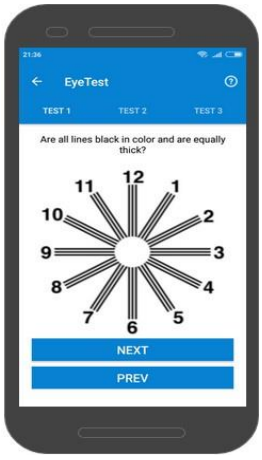
T) Amsler grid test cont.



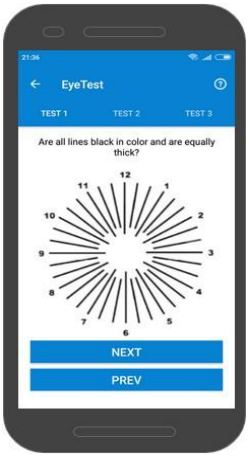
U) Result of contrast sensitivity test



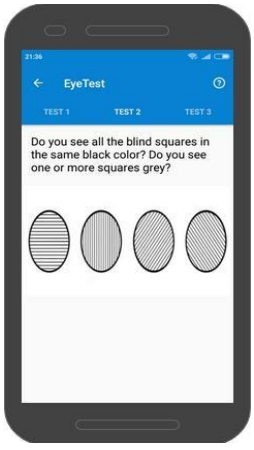
V) Astigmatism test



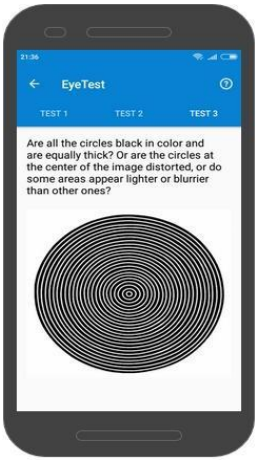
W) Astigmatism test cont.



X) Astigmatism test cont.

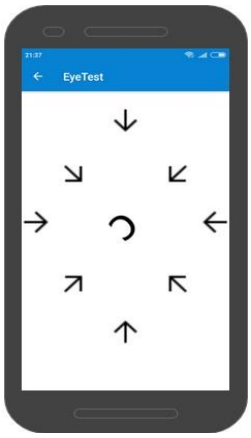


Y) Astigmatism test cont.

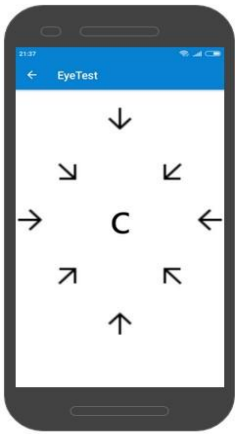


Z) Astigmatism test cont.

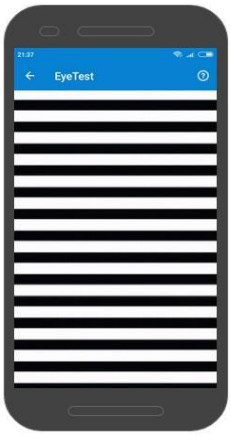
a) Landolt C and Tumbling E test



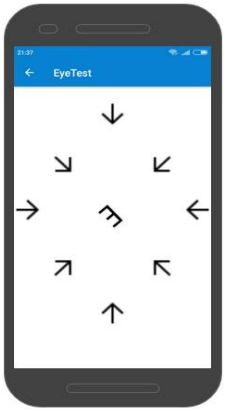
b) Starting of Landolt C test



c) Next level of test



d) OKN strip test



e) Tumbling E test

Figure 3. 6 : Free Eye Test App

The eye test app includes different type of eye tests. The tests are visual acuity, color blindness, color cube, duo chrome, Amsler grid, contrast sensitivity, astigmatism, LANDOLT test, OKN strip test. For visual acuity test, you have to identify whether you can see the numbers shown subsequently on the screen or not. According to your identification, the visual acuity will be scored. For color blindness test, you have to identify the numbers shown on screen like part K and L of figure 3.6. Your identification will be scored and will give feedback about your blindness. For color cube gaming, you have to identify the light cube from the cubes and quickly touch on it. The correct touch on the cube will be highly scored in the minimum time and find out your color blindness through it. For duo chrome testing, you have to fix the screen at arm's length and look on the screen.

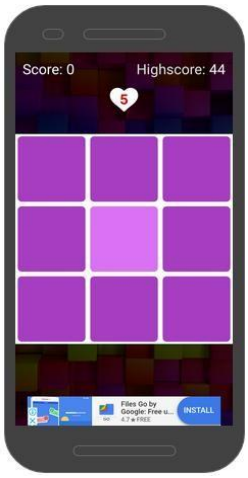
Then you have to fix the line in which your vision is clear enough. In the Amsler grid test method, keep the phone from 30 cm/12 inches from your eye or at the arm's length. Cover your left eye with left hand and look at the dot of the center of the grids with your right eye. Don't move your

gaze from the dot. And try to find out if the dot or squares around the dot change shapes or disappear. Also check if there is any blur or distortion in the grid. Now repeat the steps for the left eye. If the answer is yes for one the eyes or both eyes, immediately consult a doctor. For astigmatism testing, you have to check whether all black lines are equally thick or they are blurring. This will be checked for the pictures of the pages sequentially. You have to check whether all the blind squares are visible in the same black color or they are blurring. For part Z of picture 3.6, you have to notify whether all the circles are black in color and equally thick or the circles at the center of the image are distorted. If one of the answers is found that the lines or circles are not equally thick or distorted, then you have to consult to an eye doctor immediately. In the Landolt C testing, you have to find the direction of letter "C" and have to do it till the end of test sequentially. For this, you have to close your left eye at first and check it for the right eye. If you choose wrong direction in any of the step, the test will end and find your score. According to the score, it will give feedback about your vision quality. The test will be done for left eye also. For OKN strip testing, you have to identify whether the black strips are seem to be burry or clear. If it seems blurry, then you have to consult to a doctor immediately as it recognizes your eye problem. Tumbling test is as same as the Landolt C test. In this test, you have to find the right direction of letter "E" in each step.

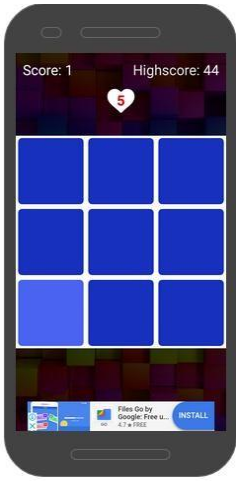
3.1.7 Test Your Eyes 2

Test Your Eyes 2 app will help to determine the square with a different color. By passing the test over and over, you will get better results which will develop your vision [30].

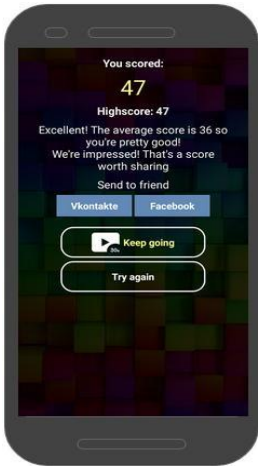
A) Home page



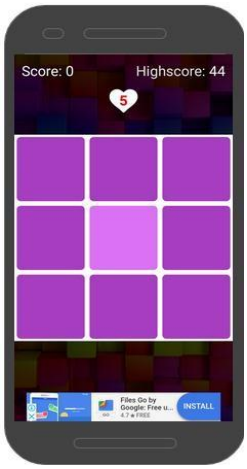
B) Light cube identification



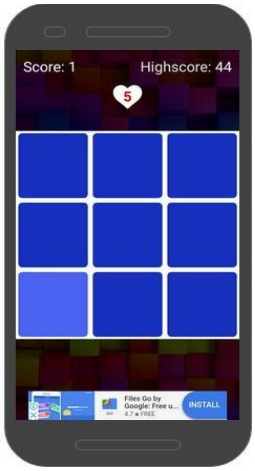
C) Next level of identification



D) Score of the current level

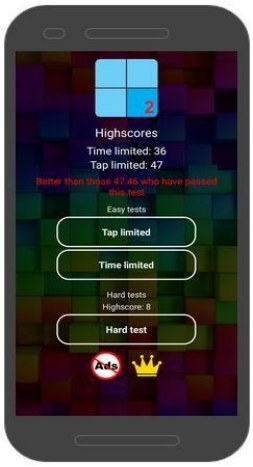


E) Light cube identification



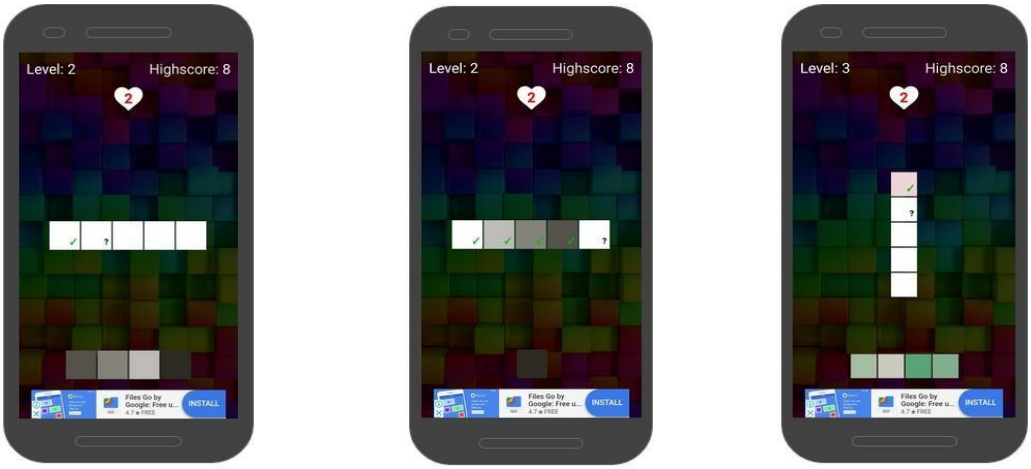
F) Next level of identification

G) Score of current level



H) Total score for tap Limited and time limited

I) Hard test



J) Next level of hard test

K) Next level of hard test Cont.

L) Next level of hard test

Figure 3. 7: Test Your Eyes 2

The home page of the “Test your eyes 2” app includes three types of testing. The tests are” Tap limited”, time limited and hard test. If you choose the tap limited option for testing, you will have to play a color cube game in which you have to select the light cube in each step. The correct choice of light cube will be counted as the score. To complete the game, you have to complete all the steps sequentially. For the “Time limited “option, you have to play as same as the “Tap limited”. But this time, it will be in a limited time. For “Hard test” you have to arrange the colored cubes shown on part I of figure 3.7. In this test, you have to arrange the cube based on the contrast color sequentially.

3.2 Comparison table of ophthalmic mobile applications:

App Name	Testing	Treatment Reference	Vision Symptoms	Near vision card	Calculators	Snellen Chart	Tumbling E	Other Symbols	Amsler Grid	Color Blindness
1.Eye Handbook	yes	No	yes	yes	yes	yes	No	No	yes	yes
2.Eye Sight Test	yes	No	yes	yes	yes	yes	No	No	yes	yes
3.Vision Test	yes	No	yes	No	yes	No	No	No	No	yes
4.Blind Test	yes	No	yes	No	yes	No	No	No	No	yes
5.Free Eye Test	yes	No	yes	yes	No	No	yes	No	yes	yes
6.Eye Exam	yes	No	yes	No	Yes	No	No	No	No	No
7.Test Your Eyes 2	yes	No	yes	No	yes	No	No	No	No	yes

Table 3.2.1: Comparison table of different type of ophthalmic mobile applications with their features:

The above mobile applications are found much more related to our suggested application. The apps have almost all or some of the features that are used in our app also. These features can be able to diagnose most of the eye related problems and can identify the syndromes. But these apps can’t suggest any treatment primarily. So we can find them helpful for the primary eye diseases identification and can suggest doctors for proper treatment.

Chapter 4

User Interface (UI)

Abstract

A good User Interface (UI) makes any app attractive to its users. An app like ‘Eye Med Centre’ can be useful for people of every age groups. So through careful research we tried to design such a prototype UI that attracts everyone and gives them a satisfying feeling while using the application.

4.0 Review

Here we are going to discuss about the User Interface of our proposed application.

4.1 Splash Screen

Splash screen makes the first impression of the app to its users, so a relatable pleasant looking splash screen is the first thing we focused on. Here with the splash screen the user instantly get an idea of what this application is all about.

Figure 4. 1: Splash Screen

4.2 Log-in Screen

As this app is user focused and after a certain eye exam it will generate a report, so users are needed to be logged into the app with necessary information like Email id and Password. It will create a personalized account so the users will be able to view the report history of their previous eye exams. We recommend it to be as min
imalistic as possible.

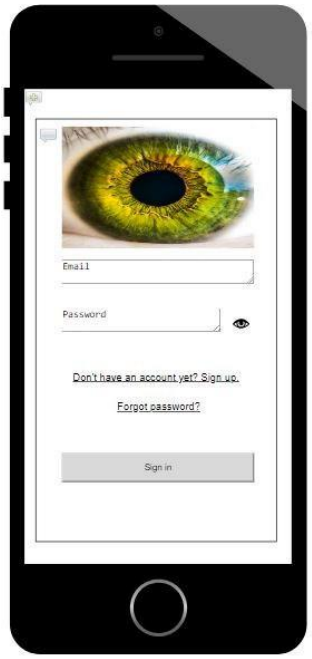


Figure 4. 2 : Basic Log-in Screen

4.3 Home and Menu Screen

After a successful login, users will be redirected to a home page where they can view all the menus and feature list of the application. Right now in our App we have embedded features like:

-Near Vision Test: It a test to check weather a user has near vision problem (also known as Myopia) or not using letters and alphabets.

-Far Vision Test: It a test to check weather a user has far vision problem (also known as Hypermetropia) or not using letters and alphabets.

-Symbol & Number Test: For the uneducated and illiterate users we have also recommended to embed symbol test plus there are test using numbers as well.

-Color Blind Test: This exam tests color blindness through some typical color blind test. **-Eye Tips**

In Future we plan on to integrate more eyes related exercise and tests in this application.

Figure 4. 3 : Home and M

4.4 Options and Test Screens

Every time a user clicks on a test, he will be presented with two options:

[1] Bangla

[2] English

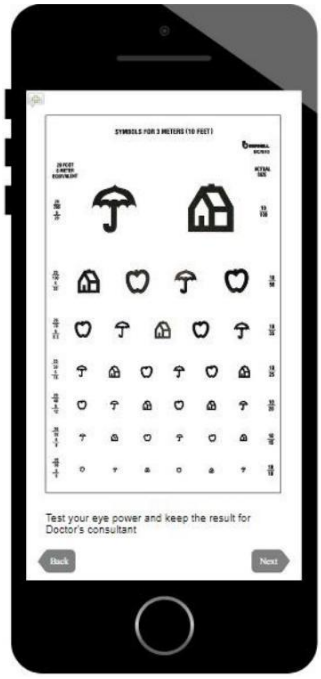
So that botah native and international users will find it convenient to test their eyes.

a) Screen with options b) Test screen when the user c) Test screen when the user

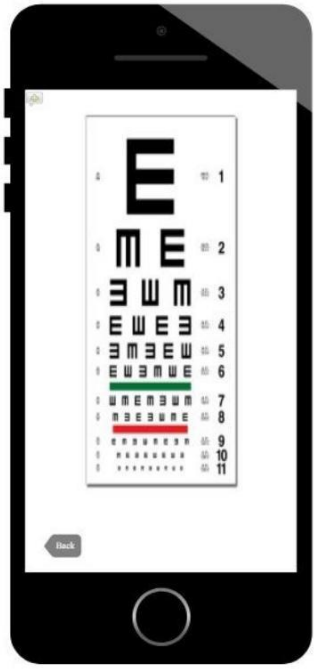
Bangla (sample) English

Figure 4.4: Options and Test Screens

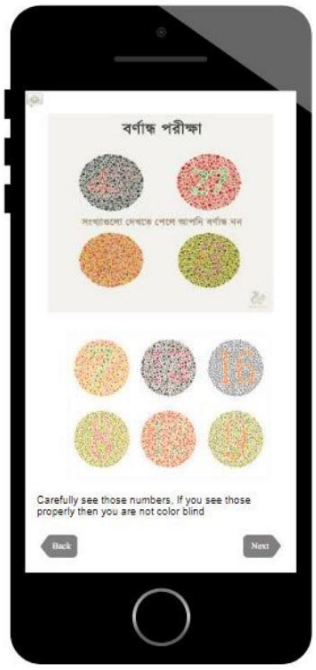
Examples of test screens are following:



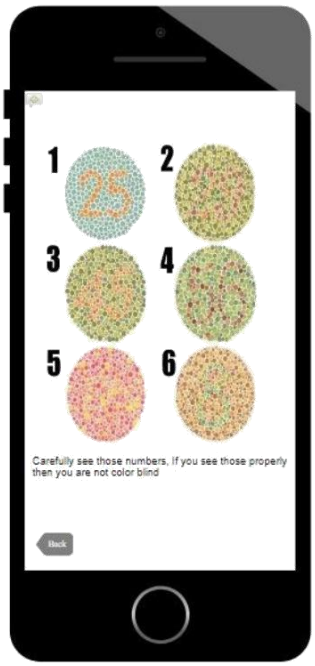
a) Symbol test Screen



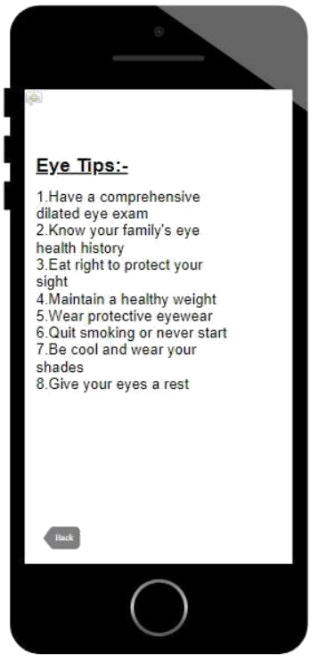
b) Tumbling E test screen



c) Color Blindness test screen



(I) d) Color Blindness test screen (II)



e) Screen with Eye Test

Figure 4. 5: Various Test Screens of the proposed Application

4.5 Result Screen

Figure 4.6: Result Screen

Nowadays, as we are getting more and more used to small screens and mobile devices, so an Eye related application like this with a simplistic UI can be very handy and useful for its users. Specially people who live in rural areas having no education or medical support for the eye health. An app like this can help to detect the initial eye problems for further testing

Chapter 5

User Feedback

Before moving forward with an idea or proposal it's very important to know what the people related to the idea think about it. So, to check the feasibility of our proposed idea of a smart application, we have taken feedback from 3 type of stakeholders.

1. General Users
2. Opticians (Who sells and makes spectacles)
3. Doctors

To take the feedback we had prepared different type of questionnaires for each stakeholder. In this chapter we are going to discuss the result of our survey through illustration and charts.

5.0 Feedback of General Users

For general users we prepared 12 basic questions and got response from more than 40 users. Following is an illustrated representation of the result of each question:

1.

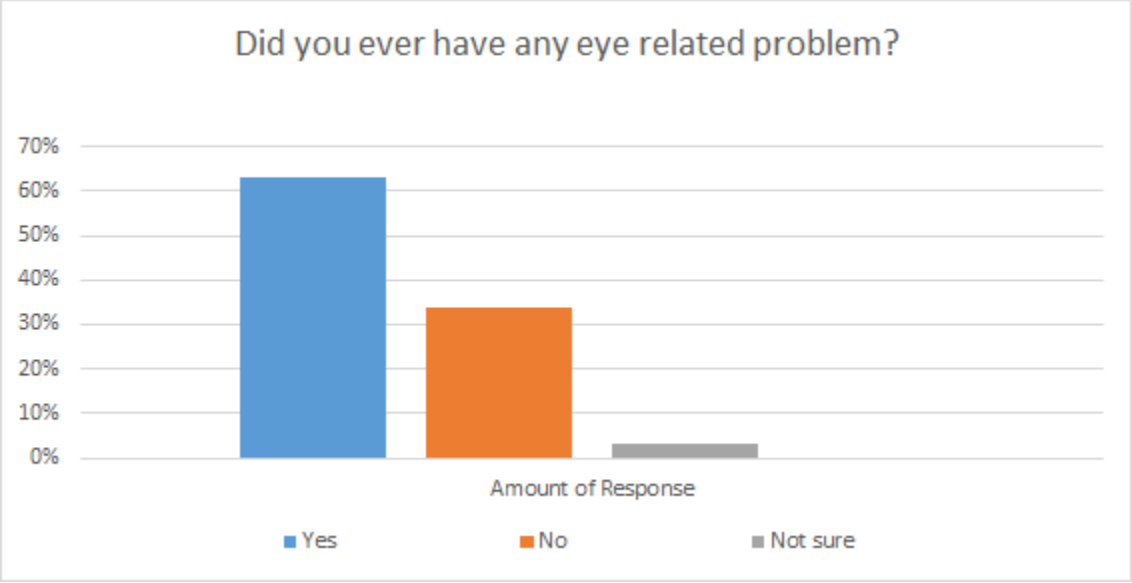


Figure 5. 1: Feedback of user question 1 in histogram

We started with this basic question to have the idea how many people has problems related to their eyes and we found majority of them has some sort of ophthalmic problems.

2.

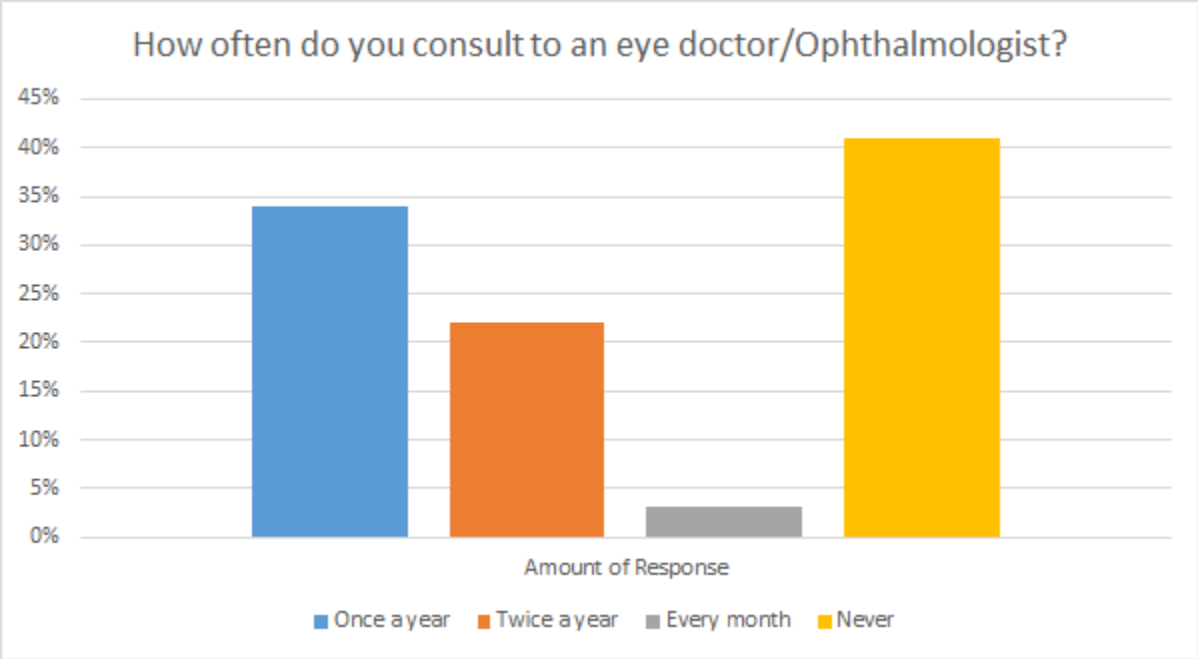


Figure 5. 2: Feedback of user question 2 in histogram

Here you can see majority of people do not consult to an Ophthalmologist although they have eye related problems.

3.

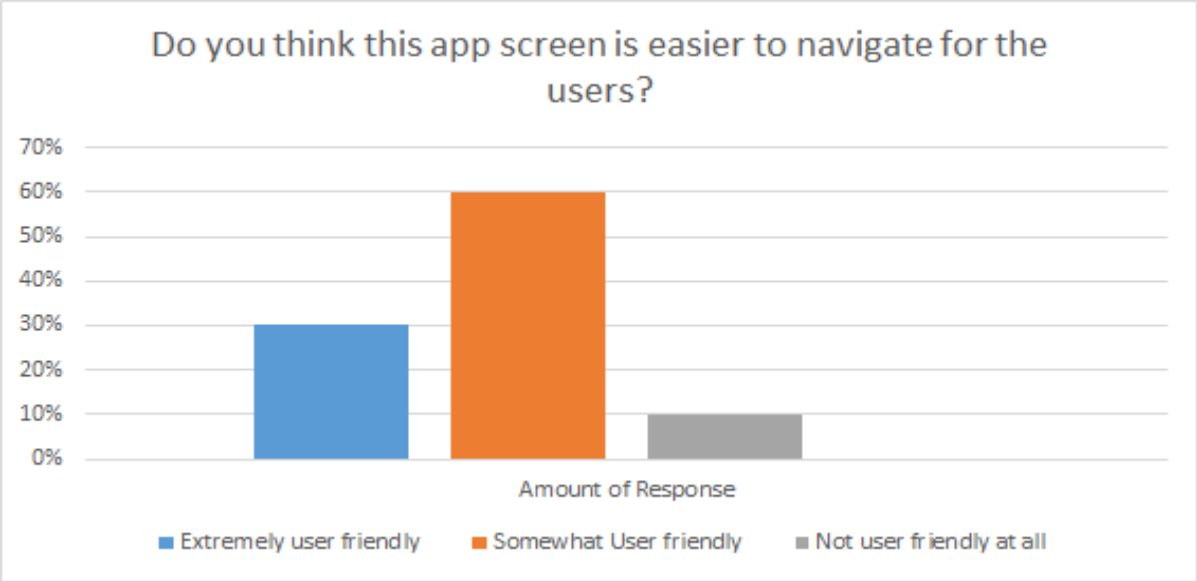


Figure 5. 3: Feedback of user question 3 in histogram

Our proposed user interface seemed easier to navigate for a lot of users. Still we have a lot to improve with more research.

4.

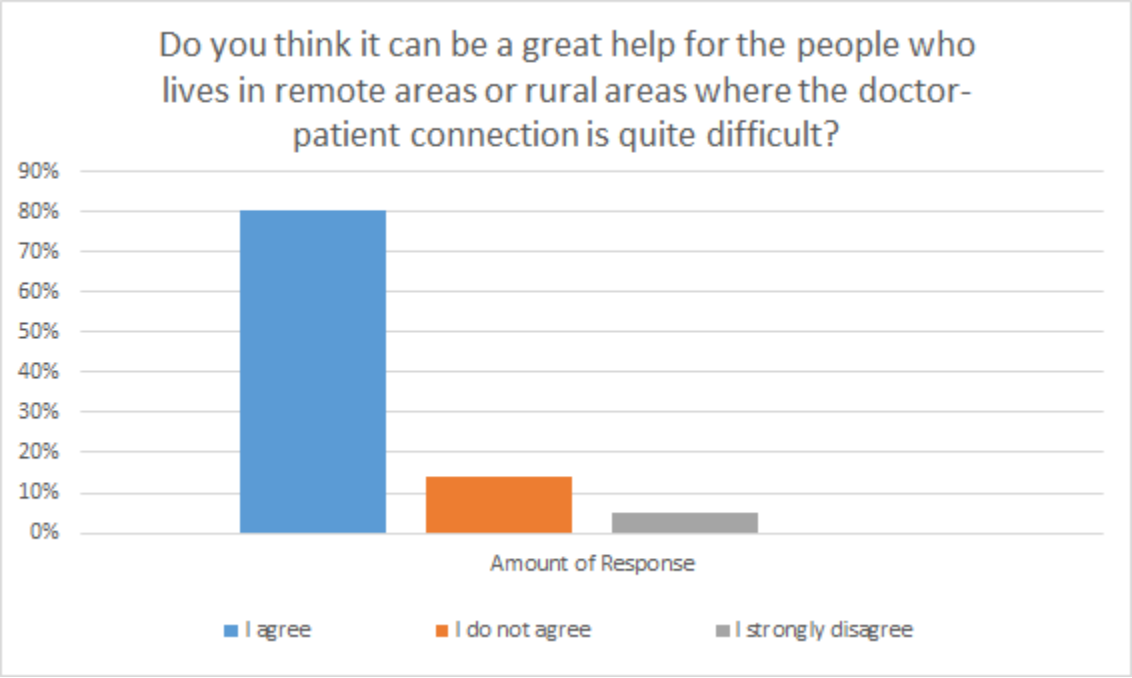


Figure 5. 4: Feedback of user question 4 in histogram

Many people do not like to go through the process of consulting an ophthalmologist when they are confused about the refractive error in their

Here you can see around 80% people believe this proposed application will be a great help for people living in rural areas where medical facilities are very limited and those people are our main target users.

5.

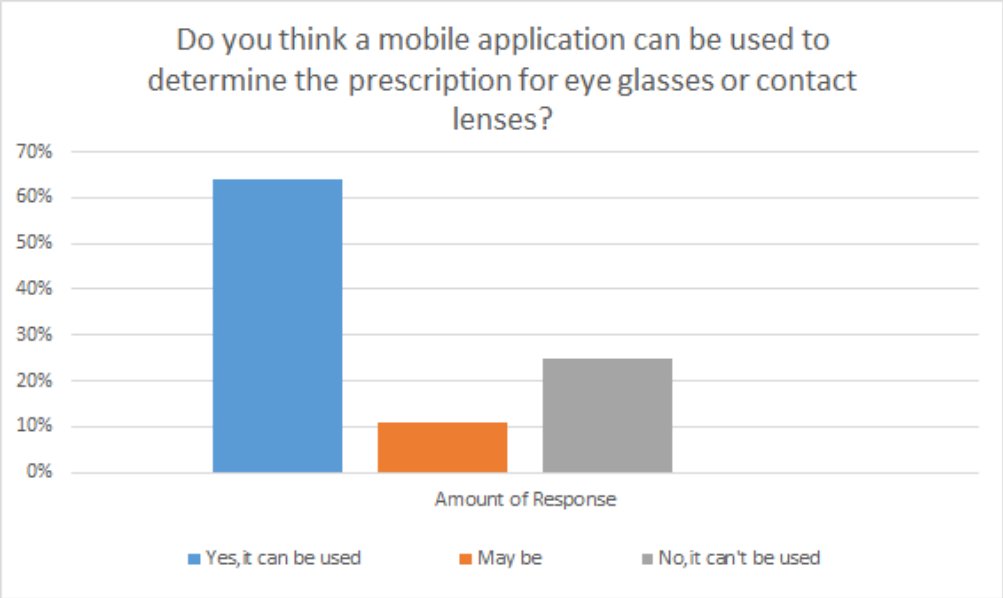


Figure 5. 5: Feedback of user question 5 in histogram.

With the advancement of technology, now more people believe a smartphone application can be used to determine and prescribe eye glasses for them, which is very inspiring for us.

6.

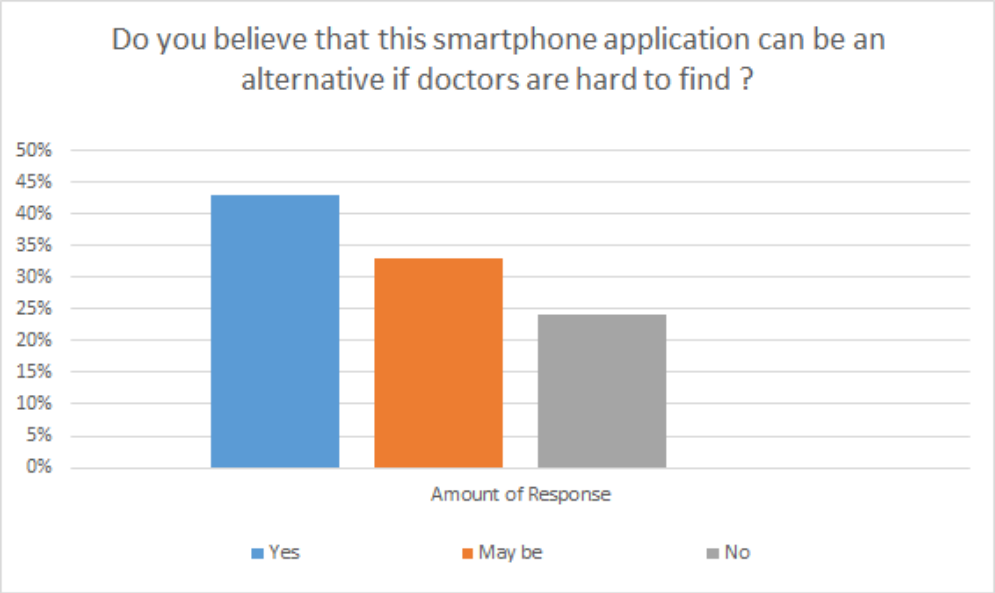


Figure 5. 6: Feedback of user question 6 in histogram

Majority of people believes an application like our proposed solution can be a very useful tool where there is a shortage of Doctors and this is the thing that mainly inspired us to work on our thesis.

7.

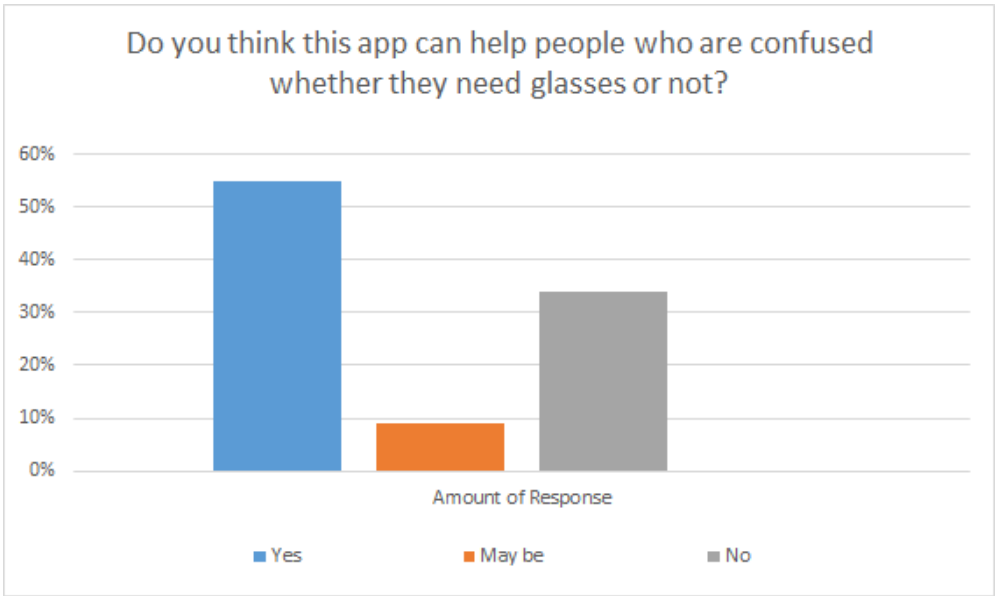


Figure 5. 7: Feedback of user question 7 in histogram.

With an application like our proposed solution, in their smartphone, they can easily get an idea whether they need glasses or not and our survey result exactly reflects that idea.

8.

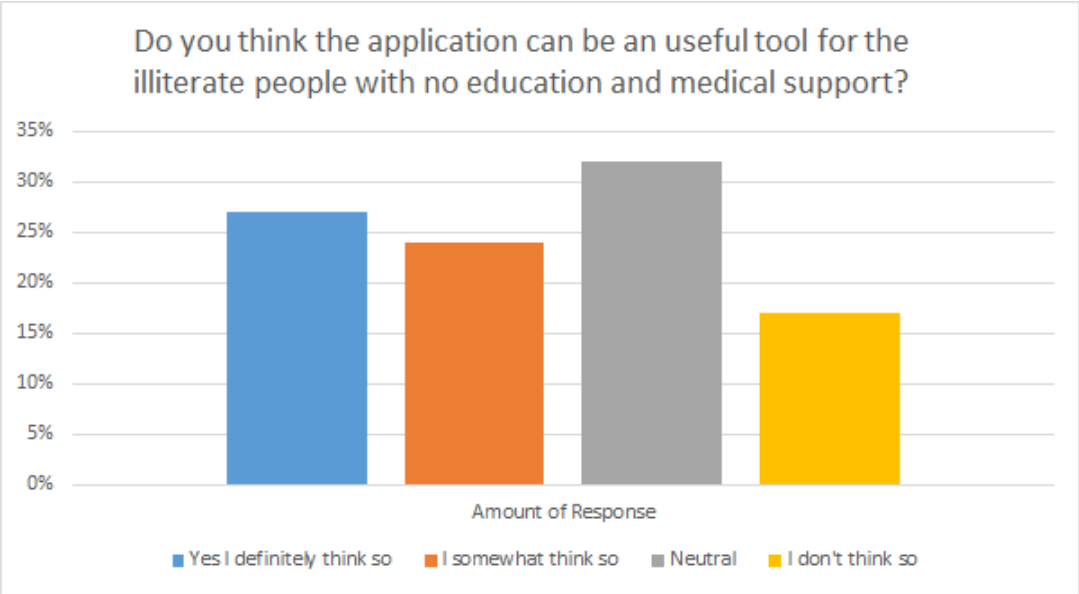


Figure 5. 8: Feedback of user question 8 in histogram.

We have got mixed result on this particular query. Although most people choose to remain neutral, a vast majority believes an app like our proposed solution can be a useful tool for the illiterate people.

9.

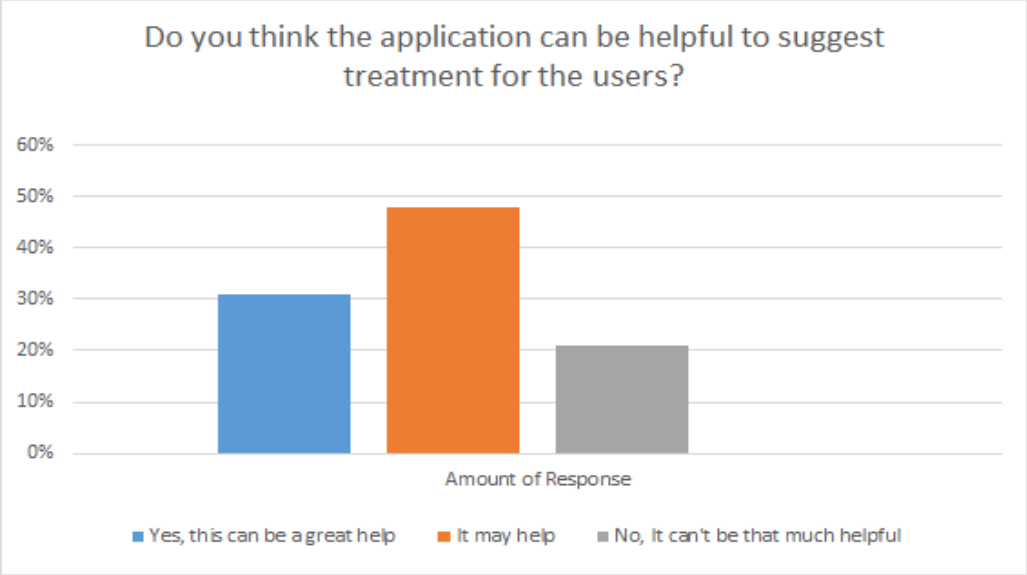


Figure 5. 9: Feedback of user question 9 in histogram.

Through different eye test many believe our proposed application can be able to suggest treatment for them. We also believe the same.

10.

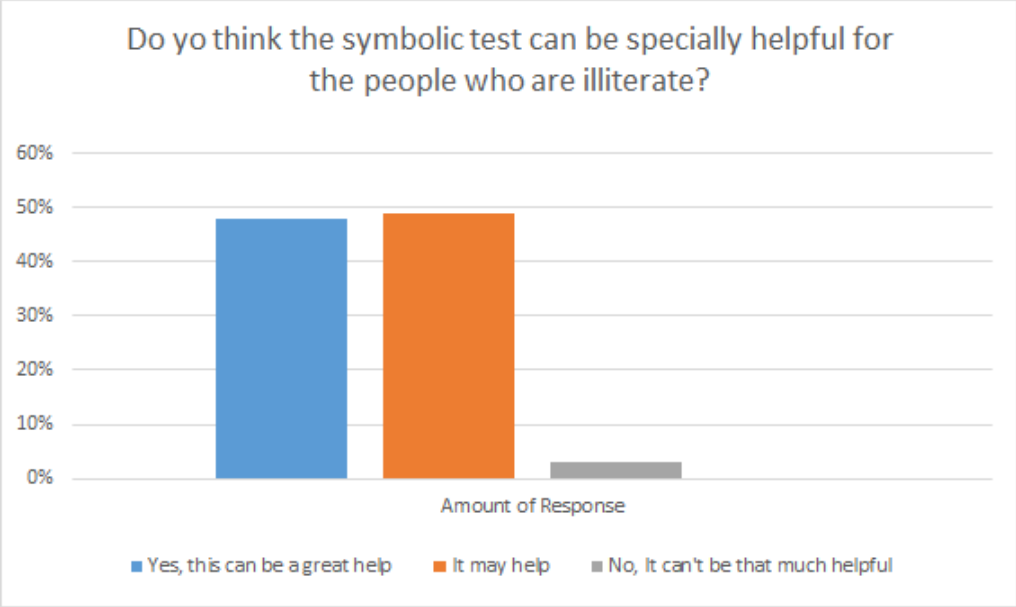


Figure 5. 10: Feedback of user question 10 in histogram

We proposed to integrate a symbol chart for the illiterate people and most users think it will be convenient for them to examine their eye sight through that chart.11.

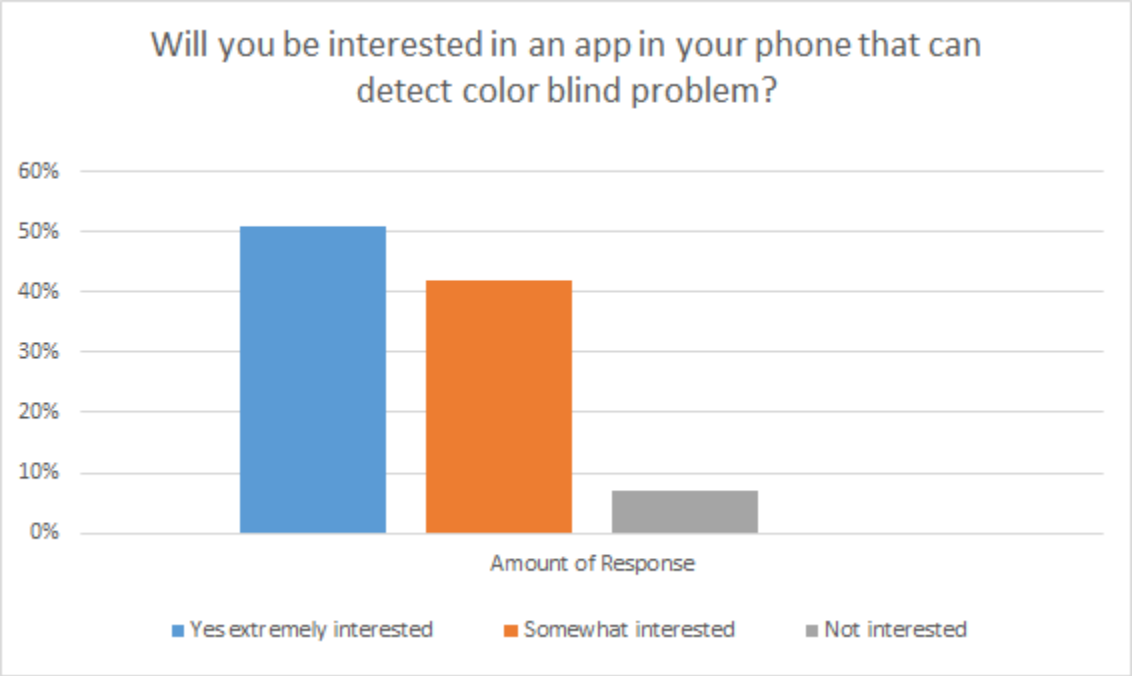


Figure 5. 11: Feedback of user question 11 in histogram**.**

A simple but useful eye test which many users want to have in their eye related application.

12.

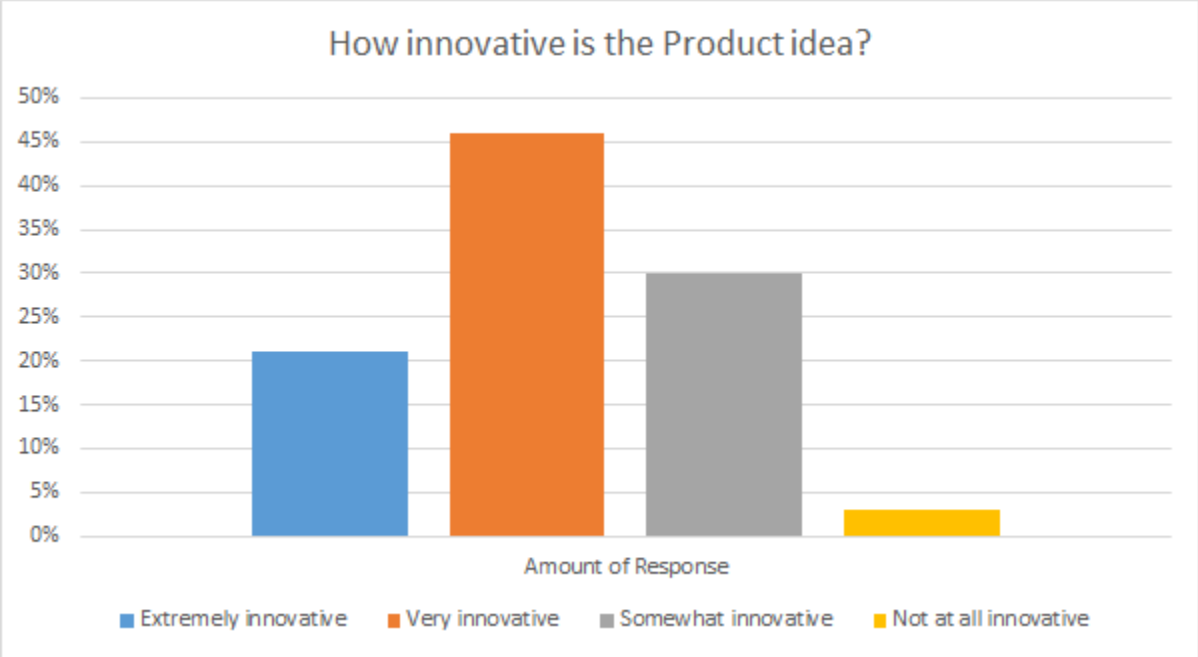


Figure 5. 12: Feedback of user question 12 in histogram**.**

As we can see, Majority of people found the idea useful and new.

5.1 Feedback of Opticians

As Opticians are closely related with our proposed idea, to understand what they think we prepared 10 generic questions for them. To collect their feedback we went to several eye shops where they make and sell spectacles. Their feedbacks are shown in the followings charts. Those Charts are largely self-explanatory.

1.

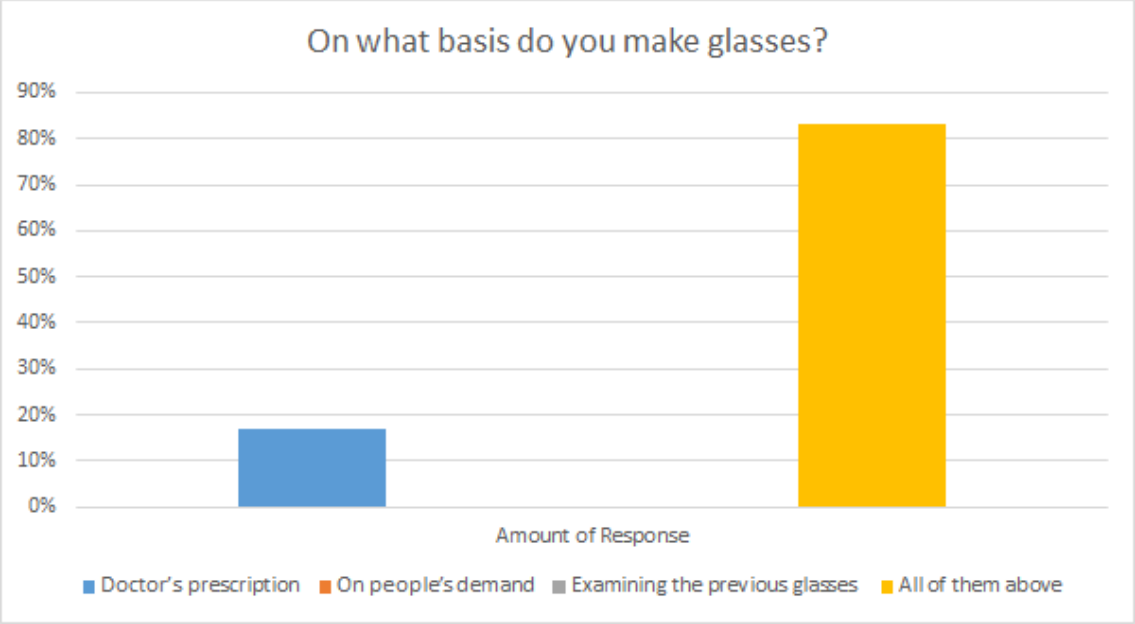


Figure 5. 13: Feedback of optician question 1 in histogram.

As we can see from the results, opticians do not always depend on the doctor's prescription to make spectacles. Sometimes they rely on other means and this is where our proposed smart application can really contribute and help them.

2.

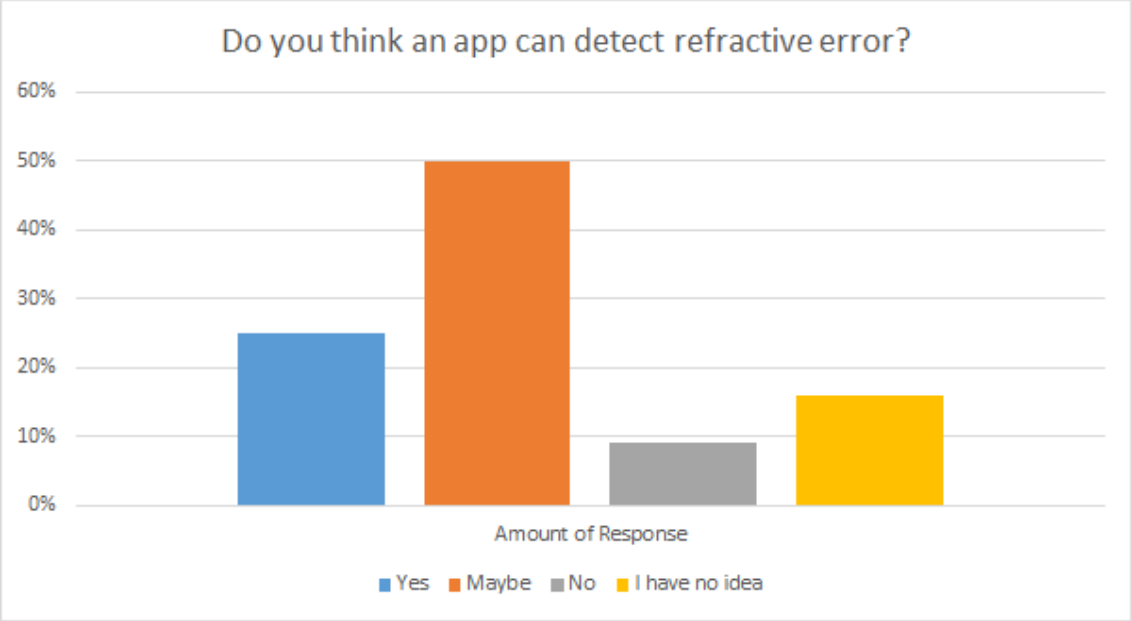


Figure 5. 14: Feedback of optician question 2 in histogram.

They are starting to believe that smartphone application can detect refractive error and this is inspiring for us to work more on our proposed solution.

3.

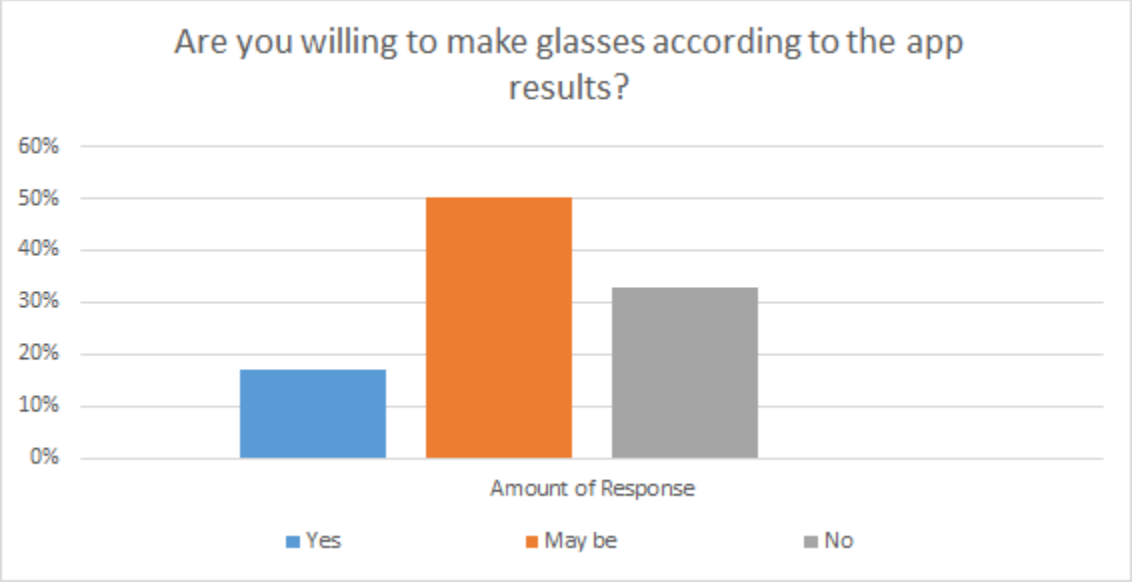


Figure 5. 15: Feedback of optician question 3 in histogram.

Although there is still doubt among many of them, some of them are interested to work with the application result which is inspiring for our thesis.

4.

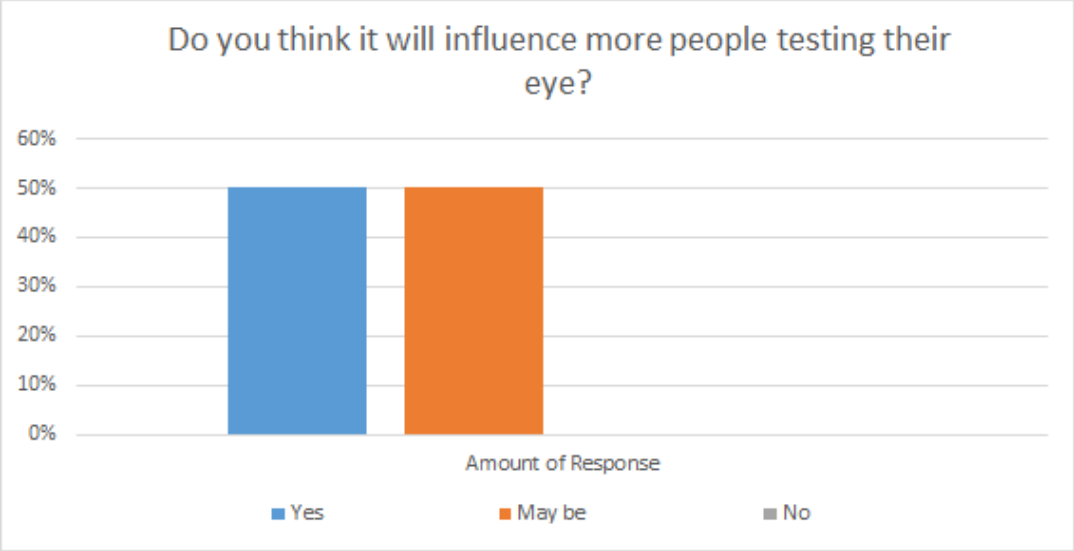


Figure 5. 16: Feedback of optician question 4 in histogram.

As checking eye through a mobile application can be an easier and less hectic process, they think it will definitely influence more people to test their eyes.

5.

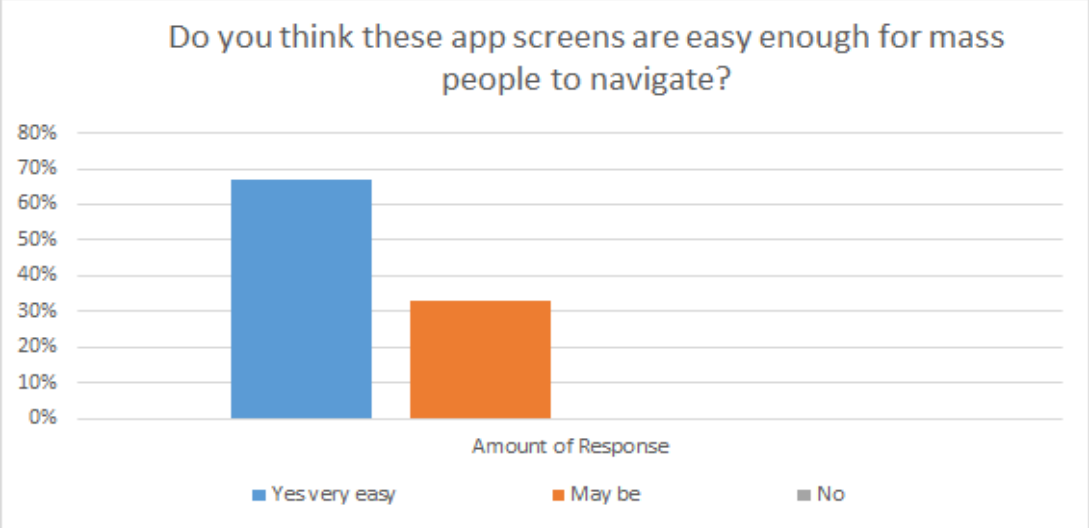


Figure 5. 17: Feedback of optician question 5 in histogram.

Our design of the application screen seemed easy enough to understand to majority of them.

6.

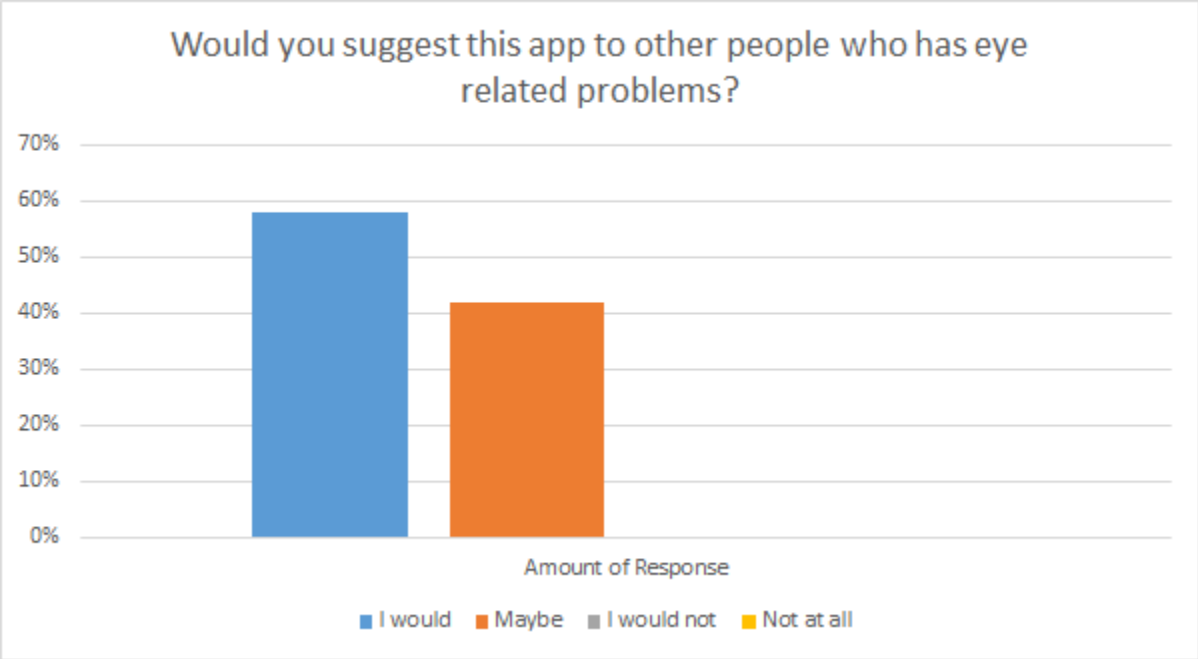


Figure 5. 18: Feedback of optician question 6 in histogram**.**

We got inspiring feedback from them as they are interested to suggest the application to people with eye related problems.

7.

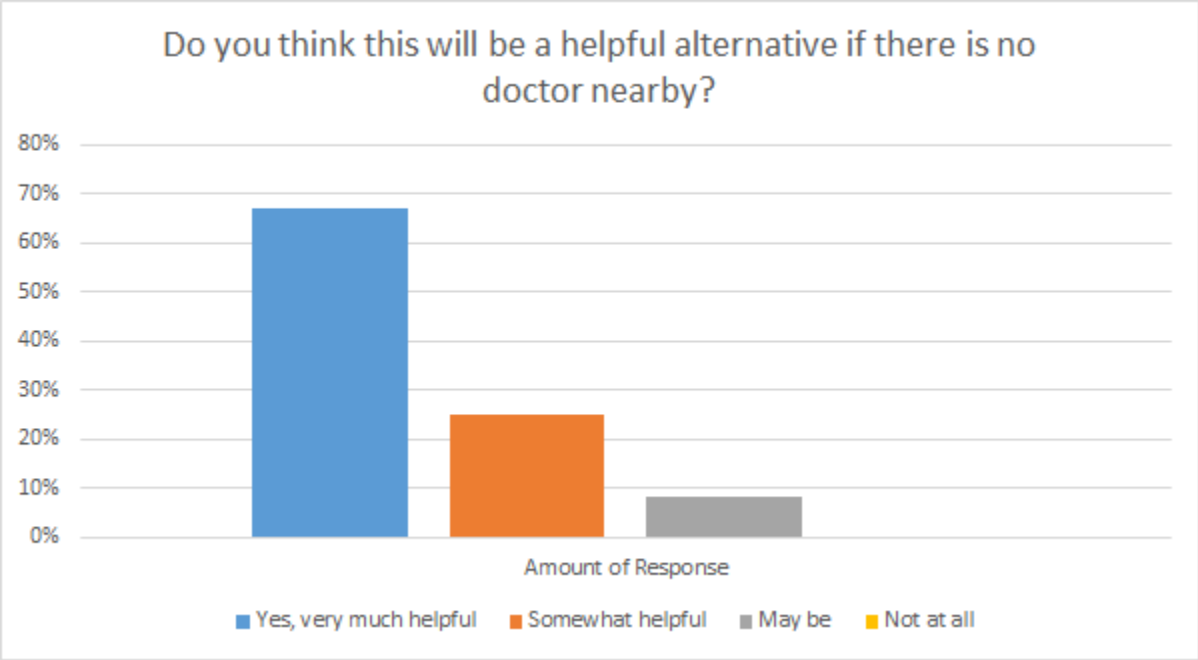


Figure 5. 19: Feedback of optician question 7 in histogram.

As we expected, they all also believe a smart application like our proposed application can really help people where there limited availability of doctors.

8.

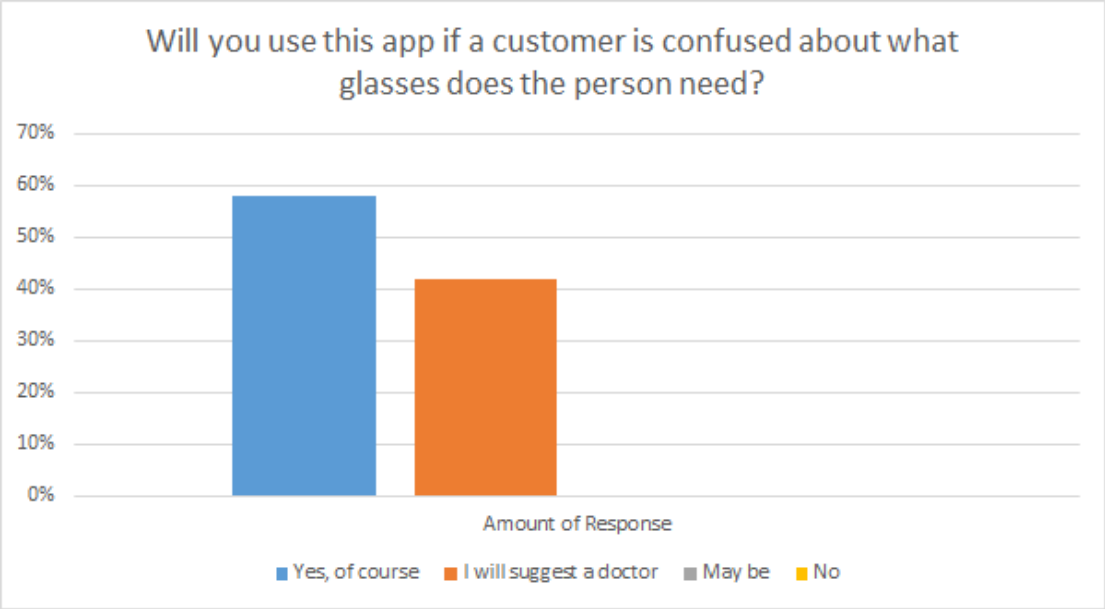


Figure 5. 20: Feedback of optician question 8 in histogram**.**

If there is no doctors nearby, they really would like to take the assistance from the smart application.

9.

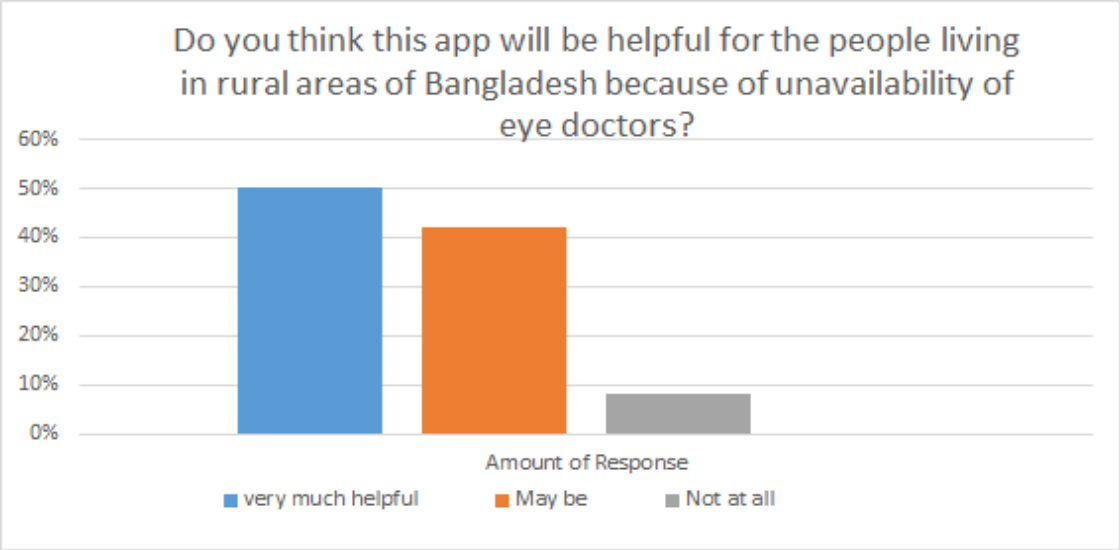


Figure 5. 21: Feedback of optician question 9 in histogram.

Feedback result shows it will be a great help for rural people and they are our main concern.

10.

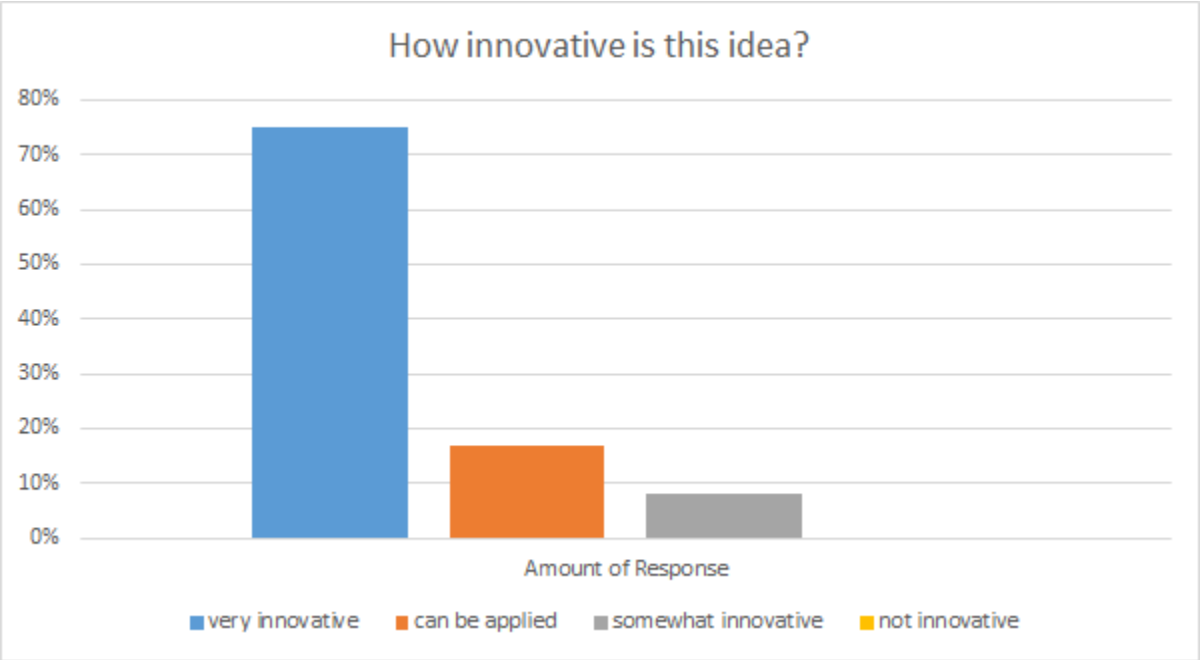


Figure 5. 22: Feedback of optician question 10 in histogram.

Many of them didn't know about the fact that it's possible to do simple screening of eyes with smartphone application and they found it innovative.

Through their feedback we have realized smartphone application can be an easier tool where Doctor-patient connection is very limited and it can be very useful for them to decide spectacles for patients.

5.1 Feedback of Doctors

Finally we also took feedback from several practicing Ophthalmologists. To get their valuable feedback we went to few eye institutes. We asked them 10 generic question related to the use of mobile technology in the field of ophthalmology and also about our proposed design and idea.

The results of their feedback are shown in the following charts which are largely self - explanatory.

1.

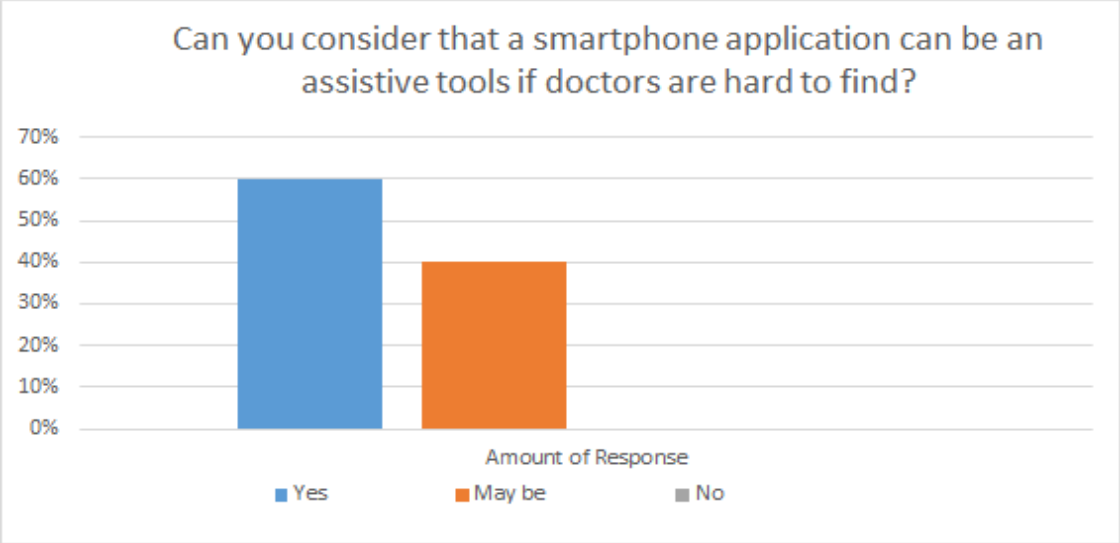


Figure 5. 23: Feedback of doctor question 1 in histogram.

As the result shows doctors are very positive about the use of mobile technology as an assistive tool when there is no doctor nearby.

2.

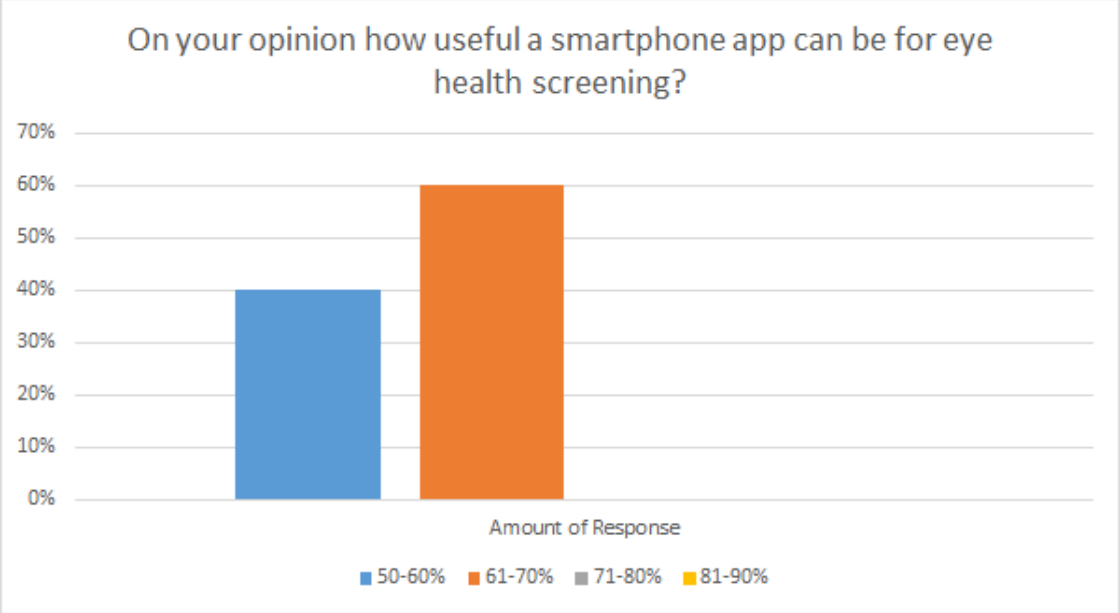


Figure 5. 24: Feedback of doctor question 2 in histogram.

This feedback result shows promise and we have so much room for improvement to make smartphone application better for eye screening.

3.

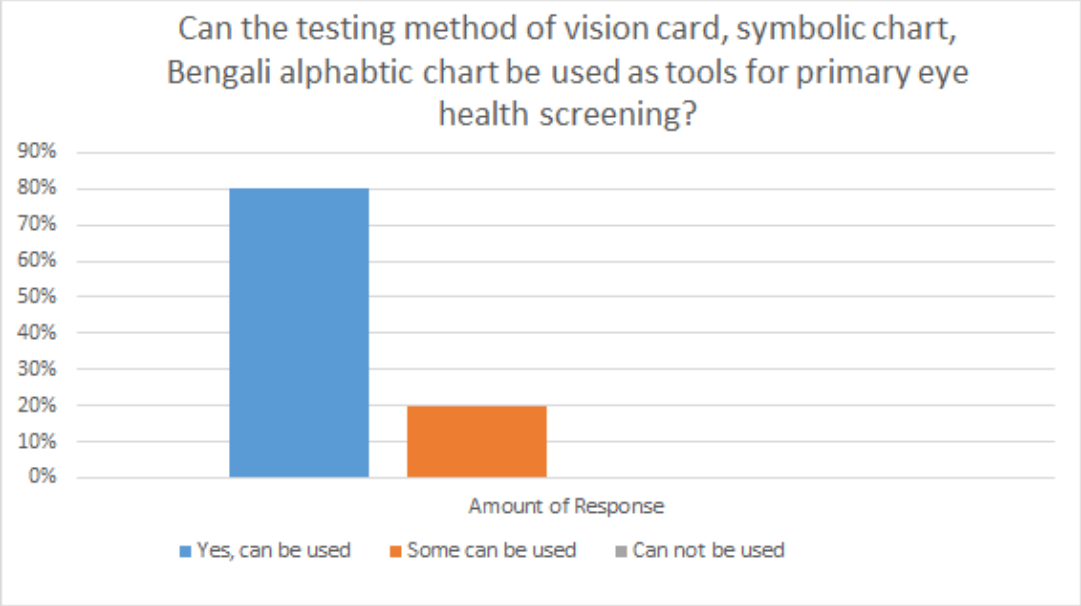


Figure 5. 25: Feedback of doctor question 3 in histogram.

This feedback result shows that it's feasible to use different vision cards and charts to screen eyes using mobile technology.

4.

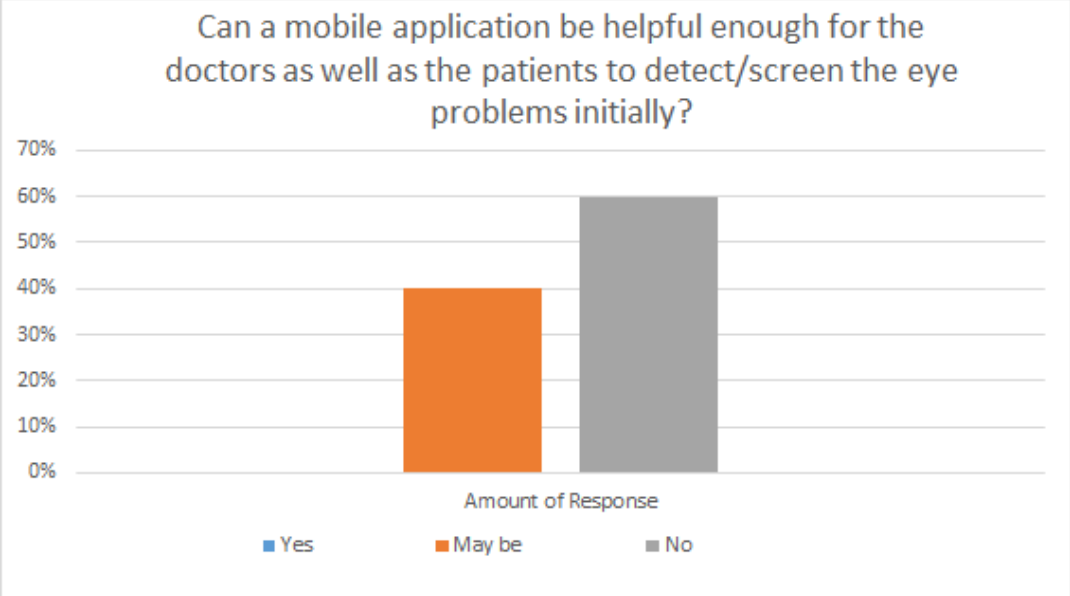


Figure 5. 26: Feedback of doctor question 4 in histogram.

Most doctors think delicate issues like eye health and its problem detection totally depends on medical equipment, while some believe it might be possible to use mobile technology to do that in near future.

5.

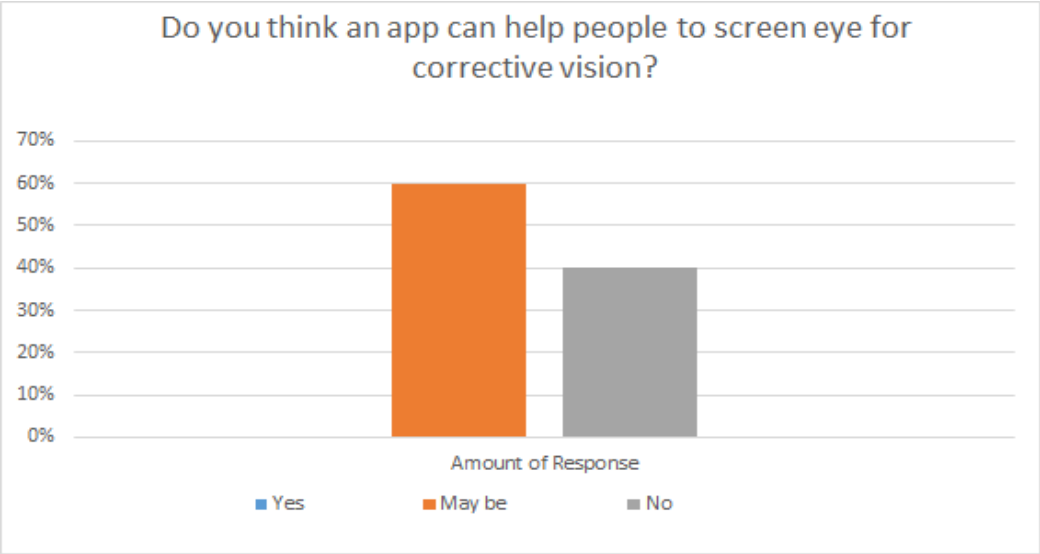


Figure 5. 27: Feedback of doctor question 5 in histogram.

Again most doctors shows doubt about the mobile eye screening process, yet they did not discard the idea and think it has potential.

6.

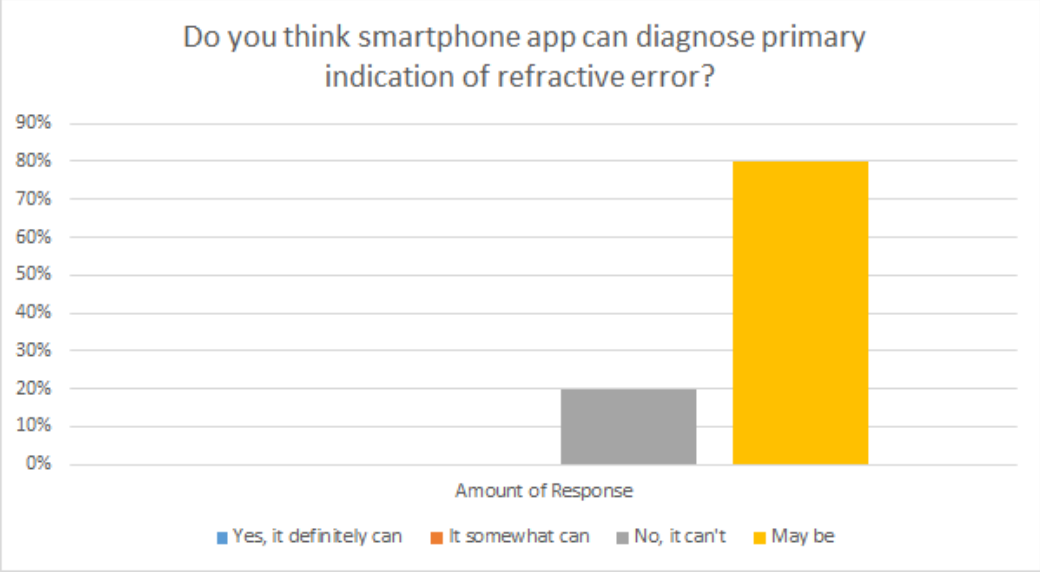


Figure 5. 28: Feedback of doctor question 6 in histogram.

Majority of doctors think it might be a possibility to detect some primary indication of refractive error using mobile technology.

7.

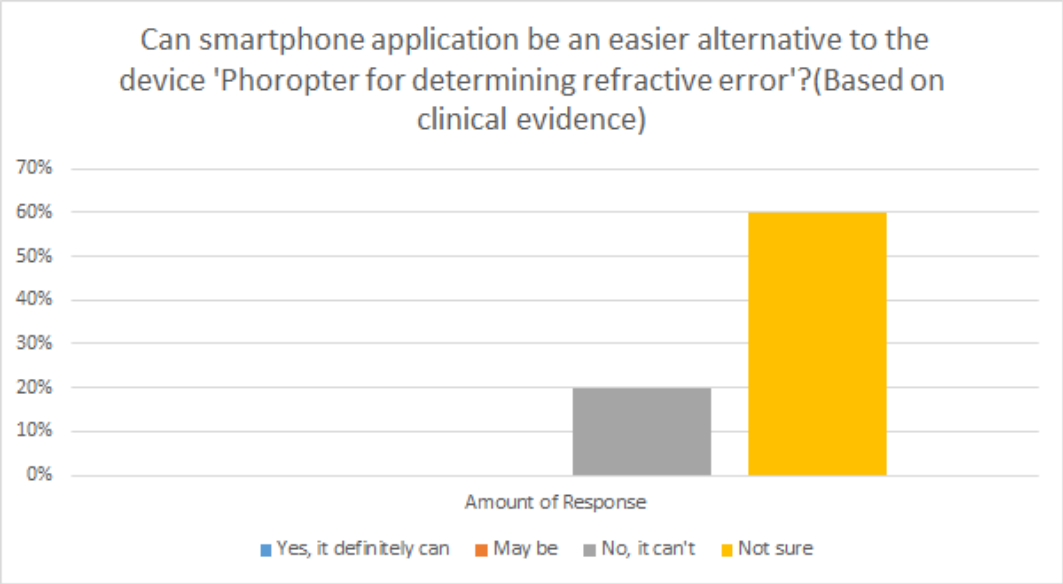


Figure 5. 29: Feedback of doctor question 7 in histogram.

They showed their doubt that it can be an alternative, rather they believe mobile technology might help to identify refractive error to some extent.

8.

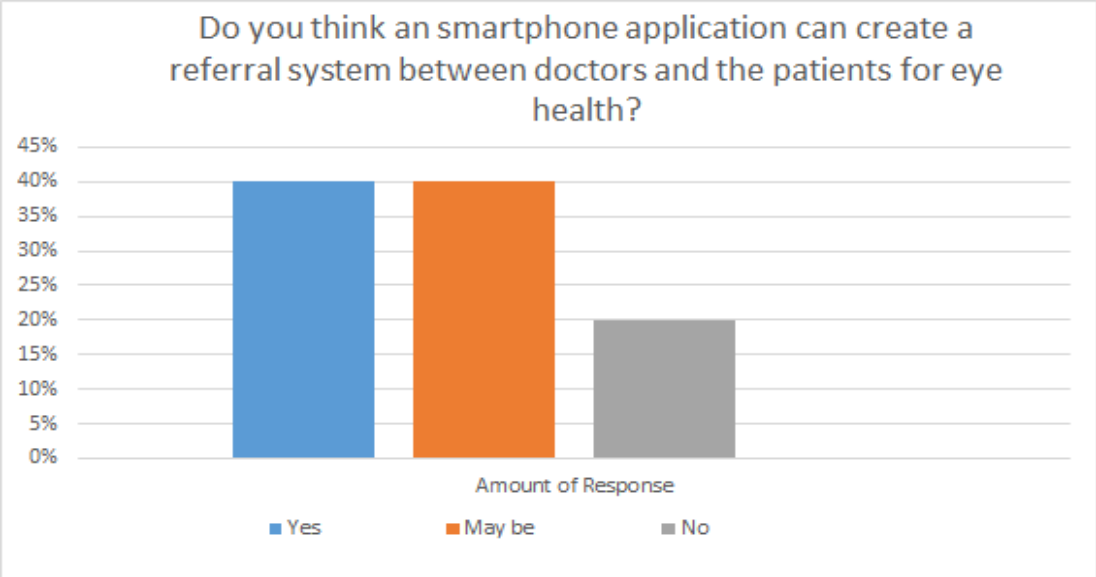


Figure 5. 30: Feedback of doctor question 8 in histogram.

Most doctors think screening on a mobile application can influence more people to test their eyes and through that test it's possible to refer doctors for those patients.

9.

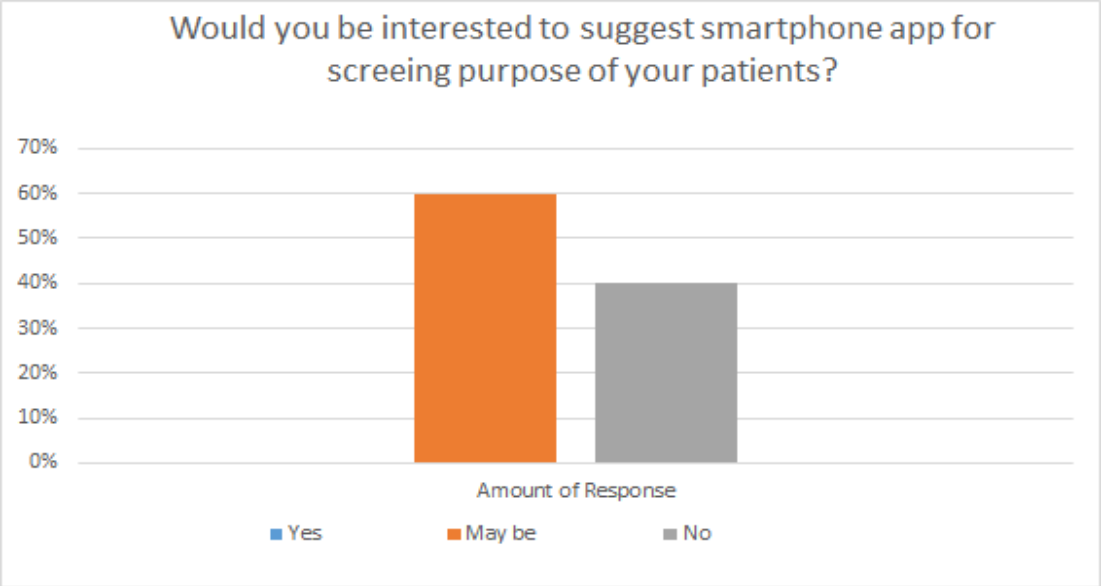


Figure 5. 31: Feedback of doctor question 9 in histogram.

With proper clinical evidence some of them showed interest to suggest this application to their patients and we agree.

10.

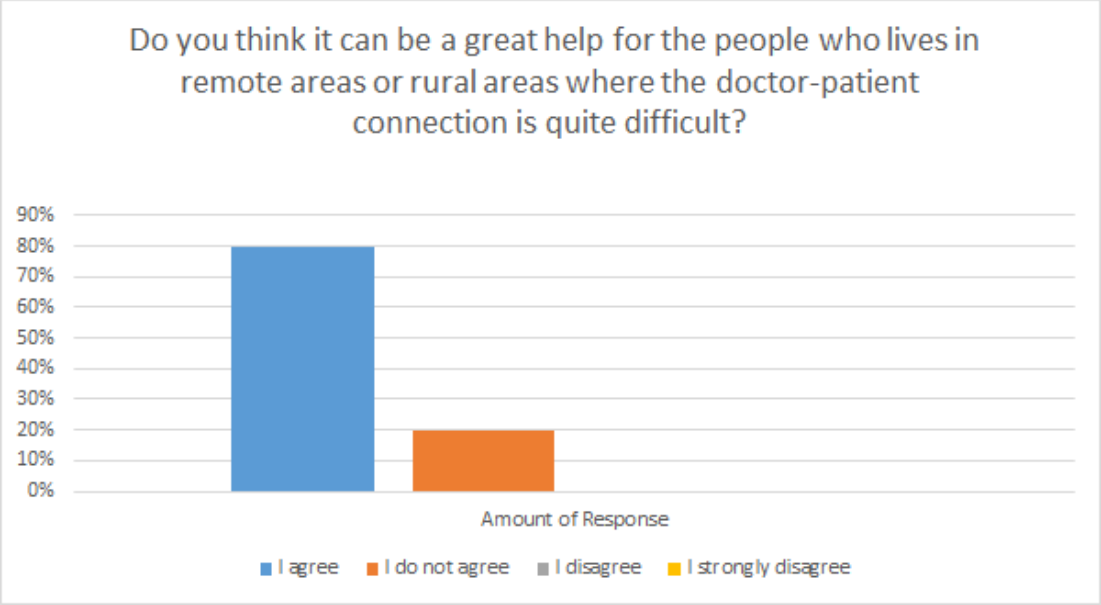


Figure 5. 32: Feedback of doctor question 10 in histogram.

Doctors also believe application like our proposed smart application will be best used in the rural areas where there is no doctors around within miles.

From the above feedback a general comparative table between what we think and what the other stakeholders think is following:

Application Properties	What General users think	What Opticians think	What Doctors Think
1.Simple application screen	Agree	Agree	Agree
2.Can be used for initial eye screening	Agree	Agree	Somewhat agree
3.can be used as doctors alternative	Agree	Somewhat agree	Do not agree
4.Useful tool for people living in rural areas with limited medical support	Agree	Agree	Agree
5.Can be useful to make more people aware of eye test	Agree	Agree	Agree

Table 5. 1: Generalized comparison between the feedbacks from stakeholders

The above feedbacks are all related to our proposed idea. We had some promising feedbacks as well as some doubtful ones. We appreciate all the feedbacks because it will help us to work on and improve our idea. What's our take from these feedback is that we got very inspiring feedback on our core idea which is helping the rural, uneducated people to test their eyes in the simplest possible way with a mobile application where there is shortage of Ophthalmologist. That is the contribution we can make with our proposed smart application.

Chapter 6

Conclusion

It is been a decade since smartphone technology is so successful that we can't imagine a day without it. Apart from making phone calls, nearly all smartphones today can natively provide directions through GPS, take pictures, play music and keep track of appointments and contacts. The eye related apps that help the patients to screen their eyes for identifying different eye diseases are playing a very important role to assist the patients and the doctors in this field. It also helps the uneducated and inexperienced patient to test their eyes easily and comfortably. Our proposed application is very helpful for the illiterate patients to use for primary eye checkups. This application includes near vision test, far vision test, symbol & number test, blind test, eye tips .It helps patients to test their visual acuity with different type of symbolic tests. Right now, none of this test can replace in-person doctors test result. This can only help people initially realize whether they have refractive error or not and so they can go for further diagnosis accordingly. We want to add cloud support to our application to the app so that we can engage doctors with our application in future so that they can see the users test result and give a feedback in real time from anywhere in the world. Smartphones is widely used nowadays. So, proper study and invention in this field can have an impact on different field of eye care. We will try to gradually improve our application. Through the improvement and research it will be much helpful and user friendly to screen patient's eye related problems and this can have a positive impact on eye health. We all should be thankful to the technology that we use and we certainly should study it for the better outcome in the future.

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