A Pilot Study on the Validation of *Vis-Screen* Mobile Application for Vision Test

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Abstract

Visual impairment and blindness is a global concern. Poor awareness and late detection are the significant factors contributing to the large number of visually impaired people worldwide. The ubiquitous use of smartphone devices will enable the public to access various eye care services provided. We are developing this application based on the need for early detection to avoid further vision loss. The simple algorithm and user-friendly features will promote any layperson to use it with minimal training. This pilot study revealed the application is highly potential to be a valid and reliable tool for vision screening in the community.

Keywords: mobile application; vision screening; visual impairment; blindness

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1.0 Introduction

1.1 Visual impairment and blindness

Vision is a vital sensory system and plays a significant role in the best performance of every individual. Any problem or impairment encountered within this system can lead to many consequences, such as physical restrictions and limitations of daily activities. Over many decades, blindness and visual impairment have remained as a global issue with myriads of strategies and measures implemented to reduce its prevalence and impact to the community. Not only the physical limitations, but also social and emotional problems are also several other serious problems encountered by those with visual impairment or blindness (Ejiakor, Achigbu, Onyia, Edema, & U, 2019).

The 2019 Vision Report of the World Health Organization (WHO) revealed an estimation of 2.2 billion people affected by visual impairment and blindness globally. In 2015, the reported figure was 200 million people with visual impairment, and another 36 million were blind (Ackland, Resnikoff, & Bourne, 2018). Even though visual impairment may occur at any age, the prevalence was three times higher in older adults compared with the younger persons (Wolfram et al., 2019). Adults aged 40 years and older in Saudi Arabia showed a high prevalence of 14.9% (Zeried, Alshalan, Simmons, & Osuagwu, 2019). Meanwhile, in China, the prevalence of visual impairment was 29.9% among adults aged 80 years old and above, compared to 1.7% for those between 50 to 59 years old (Chen et al., 2018).

The global population is estimated to grow up to 9.7 billion in 2050, with one-fifth of them are 60 years and above. This combination of growing community and increment of the elderly population will consequently increase the number of individuals with visual impairment and blindness (Bourne et al., 2017). Apart from being in the older age group, socioeconomic status is another risk factor contributing to the increment in global blindness. The socioeconomic indicators include the income status and educational level. People with lower socioeconomic status were notable contributors to a higher rate of blindness (Dandona & Dandona, 2001). Hence, parallel with the ample of evidence highlighted by the prior studies, visual impairment and blindness is a significant concern which needs immediate actions and cooperation from all parties to reduce its impact on every individual, societies and the whole country itself.

1.2 Purpose of the study

Despite the availability of eye care services provided by the government and other organisations, the number of visually impaired people within Malaysia is still alarming. From the countrywide survey involving the population of Malaysia aged 50 and above, an average of 1.2% of them was blind, with the highest prevalence of 1.9% identified in Sabah (Chew et al., 2018). The National Health and Morbidity Survey (NHMS) in 2015 also reported that 32.5% of the respondents within a similar age group in Malaysia had visual impairment (Kasim et al., 2018). In the younger age group, 7.5% of the pre-school children within Johor had amblyopia (Min et al., 2018), while only 2.7% of the indigenous primary school children was amblyopic in another study in Negeri Sembilan (Omar, Abdul, & Knight, 2019). The prevalence of visual impairment among school children was highest within the Southeast Asian countries when compared with the other parts globally (Atowa, Hansraj, & Wajuihian, 2019). Late detection of their vision problem is one of the main factors contributing to the growing numbers of people with visual impairment and blindness each year. Timely referral for any vision problem is crucial for the subsequent management to avoid further vision loss and to restore the normal vision. Hence, we are developing a mobile application (app) named *Vis-Screen* for the general public to perform the vision screening test. This pilot study aimed to validate this app to justify its further development as a tool for screening visual impairment and blindness in the community.

1.3 Objective of the study

This preliminary validation of the *Vis-Screen* mobile app involved determining its validity as a screening tool in terms of its sensitivity and specificity level, as well as the positive and negative predictive values. For the inter-rater reliability, we utilized the recently advocated Krippendorff's alpha statistical analysis to determine the inter-rater agreement between five different app users.

2.0 Literature Review

2.1 Causes of visual impairment and blindness

Uncorrected refractive errors and cataract are the two most prominent causes of visual impairment and blindness, affecting millions of people worldwide (Flaxman et al., 2017). Geographically, the prevalence of cataract blindness varied from one country to another. Within the last decade, both the South and South-East Asia countries showed the highest prevalence of over 41% of cataract blindness cases (Lee & Afshari, 2017). The untreated cataract alone contributed about 58.6% of the total blindness cases identified in Malaysia among adults aged 50 years old and above (Chew et al., 2018). Even with the widespread availability of eye care services, the number of patients with cataract remains significantly high.

Factors identified to be associated with delayed detection and timely referral for vision problems were their poor awareness due to the absence of pain (Mutalib, Zin, Shahir, & Hassan, 2018). The Singapore Epidemiology Eye Diseases Study also revealed 68.8% of their study participants aged 40 years and older with cataract were not aware of their conditions due to inadequate knowledge, unemployment status and cultural differences (Chua et al., 2017). For patients with glaucoma, they might not have noticed the vision loss as it may have happened unilaterally, and with a slow rate of progression (Saunders, Medeiros, Weinreb, & Zangwill, 2016).

Worldwide, about 80% of the causes of visual impairment and blindness are avoidable, treatable and preventable with either glasses, simple surgical procedures, or other means of treatment. Indeed, about one billion individuals with moderate to severe visual impairment were due to unaddressed refractive error (World Health Organization, 2019). Hence, early diagnosis and referral of any vision problem are essential to help the eye care practitioners to take the most appropriate action and management. In 2013, the 66th World Health Assembly in Geneva had unanimously approved the action plan to reduce the global avoidable visual impairment and blindness by 25% in 2019. Thus, it demands the highest cooperation from many parties and agencies to aim for the elimination of avoidable blindness. As the state of visual impairment and blindness can affect one's quality of life, it is essential to take the immediate action and the most effective measures to avoid further vision loss and to restore the normal vision.

2.2 Visual acuity testing

Visual acuity is the ability of our optical system to recognize and resolve the fine details. The eye care practitioners need to determine the visual acuity of every individual before performing the ocular examination to detect any refractive errors or diseases which could compromise one's vision. There are numerous types of charts used to test the visual acuity itself. For distance acuity testing, the optotypes used for the charts may vary from letters, numbers or pictures. The Snellen and Early Treatment Diabetic Retinopathy Study (ETDRS) charts are the two most common charts used in clinical practice. Over many years, practitioners continue to utilize the Snellen chart as the method of choice despite some of its design flaws. It is mainly due to the familiarity and less time consuming when compared with the more recently developed ETDRS chart (Kalpana, Karthick, & Jayarajini, 2013).

2.3 The importance of vision screening

Visual acuity measurement is one of the components listed as the routine examination in the primary eye care procedures. The combination of both, the correct identifications of vision problem and appropriate referral, can lead to success in the delivery of primary eye care itself. In the quest to promote healthy vision in the community, many parties were involved in various vision screening programs all over the country to raise public awareness. Among the most recent Prevention of Blindness Program organized by the Ministry of Health Malaysia is the Amblyopia and Visual Impairment Screening (AVIS) program to promote early identification of pre-school children with vision problems to prevent amblyopia (Salowi, Ismail, & Hussin, 2017). The high prevalence of refractive errors among children below four years old, especially in the highly urbanized region, can lead to permanent visual impairment due to the amblyopia. It addresses the necessities for early intervention through health education to increase public awareness, in order to reduce the prevalence of visual impairment in children (Knight, Khairi, Omar, Ramlee, & Isa, 2018). More educational programs, national screenings and improvement in the eye care services providers are required to treat those diseases which are considered preventable by early diagnosis and treatment.

2.4 Mobile application in vision screening

In parallel with the rapidly evolving technology and the myriads of the invention in recent decades, mobile technology is now being incorporated within the medical and health care system for various purposes. With more than a billion users of smartphones worldwide, practitioners can make use of this technology in many ways which will assist them (Lakshminarayanan, Zelek, & McBride, 2015). The emerging and integration of mobile technology in healthcare scope, also known as the *mHealth*, can offer better communication between practitioners for training, education, patient monitoring and many other uses (Ventola, 2014).

The widespread availability of mobile apps within the eye care discipline varies in many ways. Since the last decade, the more innovative and advanced technology mobile devices have provided broader alternatives for practitioners to perform the various primary care assessments, especially in the rural and low resource areas. Colour vision assessment, visual field testing and fundus photography are some examples of the apps that can be readily downloaded to be used by practitioners (Akkara & Kuriakose, 2018). The *EyeSnellen* app, introduced by an Australian ophthalmologist in 2012, is one of the pioneers in the use of a mobile app for vision testing. The Snellen visual acuity assessment obtained from this application is comparable to the traditional Snellen chart, thus introducing a portable type of Snellen charts in tablets or smartphones for the practitioners (Gounder, Cole, Colley, & Hille, 2014).

The invention continued to produce more mobile apps for visual acuity assessment such as the *Peek Acuity* (Bastawrous et al., 2015), *Rapid Eye Screening Test (REST), Eye Chart Pro, EyeXam, V@home* and many others. From the available mobile apps, *Peek Acuity* is the only one currently recognized by the WHO to be used in vision screening. The use of this technology in the developing country like Kenya has been widely accepted by patients and health workers to enhance the accessibility and delivery of eye care (Lodhia, Karanja, Lees, & Bastawrous, 2016). From the previous survey within Australia in 2017, 72% from the adult respondents are willing to utilize the automated smartphone-based visual acuity assessment if the accuracy is almost equivalent to the conventional methods. Indeed, from the clinician’s side, the awareness among the public towards the importance of eye health may be elevated with the introduction of mobile or smart devices vision testing apps (Keel et al., 2019). Therefore, mobile apps are readily acknowledged as part of the strategies to promote healthy vision by overcoming the barriers to eye care services.

3.0 Methodology

3.1 The algorithm of *Vis-Screen* app

The *Vis-Screen* app was developed based on several algorithms by utilizing a single letter ‘E’ as the optotype similarly used in the Tumbling ‘E’ for Snellen and ETDRS charts. Hence, both the literate and illiterate individuals can easily recognize it. The choice of Tumbling ‘E’ chart is also based on its extensive usage, either in the Snellen or ETDRS chart, in studies performed to determine the prevalence of visual impairment within the population (Abokyi et al., 2015; Hashemi et al., 2017; Ma et al., 2016). Besides, the study by Treacy and co-workers also found only 0.02 logMAR difference in visual acuity measurements between the Tumbling ‘E’ and ETDRS chart (Treacy et al., 2015).

To compensate for the limitation in screen size for some of the smaller smartphones, the app displays only one letter at any one time, to comply with the principles of Snellen chart visual acuity testing. The definition for a standardised visual acuity is the ability to view the optotype from a distance of 6 meters or 20 feet when subtended at an angle of 5 minutes of arc. Due to the inconsistency in sizes of the optotypes in Snellen charts, we ensure to incorporate the standardised size of the letter 'E' displayed by the *Vis-Screen* is proportionate with the actual size in ETDRS chart. Based on this principle, the sizes of the optotype in *Vis-Screen* is constructed according to the 5x5 grid for the visual acuity level of 3/60 from 1.5 meters, and 6/60, 6/18 and 6/12 from 3 meters. These visual acuity levels are appropriately selected in consideration with the latest classification for visual impairment and blindness by the WHO (World Health Organization, 2019).

In order to achieve the optimum visual acuity, a black letter 'E' is displayed over a white background to increase the contrast beyond 80% (Ricci, Cedrone, & Cerulli, 1998). The letter 'E' is displayed randomly in four different orientations of 0°, 90°, 180° or 270° for five times at every level of vision to avoid bias or memorization. The study participants need to point out in the direction of the letter 'E' displayed while the examiner will swipe it accordingly until the test stops and auto-generate the final results. The test will always start by determining the presenting vision of the right eye (PVR), i.e. the right vision without any form of correction. It is then followed by the corrected vision of the right eye (CVR), i.e. the right vision corrected with a pinhole. The *Vis-Screen* app (Figure 1) is already available for download from the Google Play Store for Android users only.

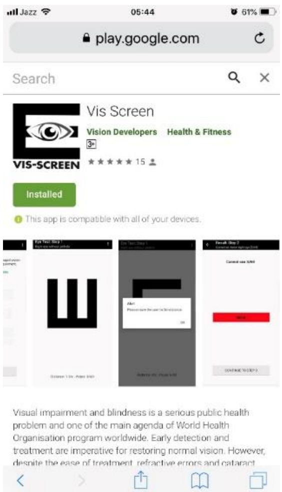

Figure 1: The *Vis-Screen* app

3.2 The study design

We undertook this cross-sectional study between April and August 2019, involving a total of 279 study participants. The locations for this study were selected local communities in

Terengganu, the Mooris Optometrist eye care centre in Marang and the Universiti Sultan Zainal Abidin Medical Centre (UMC) in Gong Badak. The study participants involved individuals aged four years old and above attending the eye care centres and those voluntarily presented themselves for the eye screening program in the selected local communities. The participants involved were divided into two groups, one group for the validity study and the other group for the reliability study.

3.3 Validity and reliability of the *Vis-Screen* app

All of the participants involved in the validity study group had their vision test using the *Vis-Screen* app, subjective refraction, and followed by the basic eye examination. We used the Snellen chart as the gold standard to compare with the vision level obtained using the app to determine its validity by the level of sensitivity, specificity, positive predictive value and negative predictive values (Table 1). As for the reliability study group, the vision test was repeatedly performed using the app by five different users, one at a time for inter-rater reliability. Only basic eye examination was done for every participant following the vision test. The results obtained were analyzed by using the Krippendorff's Alpha statistic given the categorical nature the vision test results to determine its inter-rater reliability.

Table 1. Results of the diagnostic test presented in 2x2 table

Result of diagnostic test	Results of Gold Standard test	
	Disease present	**Disease absent**
Test positive	True positive (a)	False positive (b)
Test negative	False negative (c)	True negative (d)

$$Sensitivity = [a/(a+c)] \ x \ 100$$

$$Specificity = [d/(b+d)] \ x \ 100$$

$$Positive\ predictive\ value = [a/(a+b)] \ x \ 100$$

$$Negative\ predictive\ value = [d/(c+d)] \ x \ 100$$

4.0 Findings

4.1 The validity of *Vis-Screen* app

From the total of 279 study participants, 161 participants were included for the validity study. The mean age for this group was 30.9 years old, the youngest participant being eight years old, and the eldest being 79 years old. A more significant proportion of female participants (72%) were obtained compared to males (28%). For the diagnostic tests on the results obtained by the *Vis-Screen* app against the Snellen chart to detect mild visual impairment for the PVR (vision worse than 6/12) a total of 63 participants were identified to be true positive, and five were false negative, giving the sensitivity of 92.7%. Whereas 85 were identified to be true negative, and eight were false positive, giving the specificity of 91.4% (Table 2).

Table 2: Diagnostic results for the *Vis-Screen* app against the Snellen chart for PVR to detect mild visual impairment (n=161)

PVR by *Vis-Screen* app	PVR by Snellen chart	
	Mild visual impairement	Normal
Mild visual impairement	63	8
Normal	5	85

In the diagnostic tests to detect mild visual impairment for the CVR (vision worse than 6/12), the app diagnosed two participants to be true positive, and one was a false negative, giving the sensitivity of 66.7%. Whereas 144 were true negative and 14 were false positive, giving the specificity of 91.1% (Table 3).

Table 3: Diagnostic results for the *Vis-Screen* app against the Snellen chart for CVR to detect mild visual impairment (n=161)

CVR by *Vis-Screen* app	CVR by Snellen chart	
	Mild visual impairement	Normal
Mild visual impairement	2	14
Normal	1	144

In summary, for the PVR, the sensitivity was 92.7%, 73.8% and 53.3%, and the specificity was 91.4%, 98.0% and 99.3% for detecting mild visual impairment (vision worse than 6/12), moderate visual impairment (vision worse than 6/18) and severe visual impairment (vision worse than 6/60), respectively. For the CVR, the sensitivity was 66.7%, 100% and 50% while the specificity was 91.1%, 99.4% and 96.6% for detecting mild visual impairment, moderate visual impairment (vision worse than 6/18) and severe visual impairment (vision worse than 6/60), respectively. The positive predictive value (PPV) for PVR ranged from 88.7% to 95.7% with the negative predictive value (NPV) of 86% to 95.4%, while the PPV value for CVR ranged from 12.5% to 66.7% with NPV of 96.0% to 100% (Table 4).

Table 4: Summary of the diagnostic test results for *Vis-Screen* app against the gold standard Snellen chart for PVR and CVR in detecting mild, moderate and severe visual impairment (n= 161)

Vision Test	Level of visual impairment	Sn (95% CI)	Sp (95% CI)	PPV (95% CI)	NPV (95% CI)
	Mild	**92.7%**	**91.4%**	**88.7%**	**94.9%**
		(88.6, 96.7)	(87.1, 95.7)	(83.6, 93.6)	(90.9, 98.0)

PVR	Moderate	**73.8%** (67.0, 80.6)	**98.0%** (95.8, 100)	**95.7%** (92.6, 98.9)	**86.0%** (80.6, 91.3)
	Severe	**53.3%** (45.6, 61.0)	**99.3%** (98.0, 100.0)	**88.9%** (84.0, 93.7)	**95.4%** (92.2, 98.6)
	Mild	**66.7%** (59.4, 74.0)	**91.1%** (86.8, 95.5)	**12.5%** (7.4, 17.6)	**99.3%** (98.0, 100.0)
CVR	Moderate	**100.0%** (100.0, 100.0)	**99.4%** (98.2, 100.0)	**66.7%** (59.4, 74.0)	**100.0%** (100.0, 100.0)
	Severe	**50.0%** (42.3, 57.7)	**96.6%** (94.0, 99.4)	**54.6%** (46.9, 62.2)	**96.0%** (93.0, 99.0)

Legend: PVR - Presenting Vision of the right eye, CVR - Corrected Vision of the right eye, Sn – Sensitivity, Sp – Specificity, PPV - Positive predictive value, NPV - Negative predictive value, CI - Confidence interval

4.2 Reliability of the *Vis-Screen* app

From the total of 279 study participants, 118 participants were involved in the reliability study. The mean age for this group was 30.5 years old, ranging from 3 years old to a maximum of 68 years old. Among the study participants, 58.5% were males, while the remaining 41.5% were females. The mean test duration was 60.6 ± 27.2 seconds. The reliability revealed by K alpha value for both PVR and CVR was 0.87 and 0.89, respectively (Table 5).

Table 5: The inter-rater reliability analysis by Krippendorff's alpha between five users of *Vis-Screen* app (n= 118)

Parameter	K alpha	z	p-value
PVR	0.87	40.0	<0.001
CVR	0.89	35.95	<0.001

5.0 Discussion

5.1 The validity of *Vis-Screen* app

The issue of visual impairment and blindness involving more than two billion individuals persisted as a global concern. Thus, regular vision screening activities aim at detecting early visual impairment is vital. The impact of early vision screening during preschool in Sweden had vividly portrayed the reduction in amblyopia cases among their adult population with the prevalence of only 0.9% among the screened group compared with 3.3% in the unscreened group (Thorisdottir, Fax, & Blohm, 2019). Moreover, 93% of the children detected with vision problems and had received proper treatment afterwards, recorded a very significant restoration of normal visual acuity (Garretty, 2017). Therefore, early detection of any vision problem followed by proper management can help improve the life quality of individuals.

Varieties of vision screening modalities are available and may differ between different countries. In general, vision screening and a brief eye examination are intended to detect any presence of vision problems or ocular disorders. Even though with numerous sensitivities and specificities reported from various vision screening tests, there is no standardization of the actual accuracy or effectiveness need to be followed. The accuracy of any test or so-called validity were frequently determined by its sensitivity, specificity and predictive values. For an equally high sensitivity and specificity level, a screening test is considered significant as both values unlikely to produce a large number of false-positive and negative results (Trevethan, 2017). In terms of the device used for vision screening, it will affect the sensitivity and specificity of the outcomes according to the chosen level of visual impairment to be detected (American Academy of Pediatrics Section on Ophthalmology and Committee on Practice and Ambulatory Medicine, 2012). In our study, the visual level cut-off point chosen for normal visual acuity was 6/12, as defined by the WHO. It is consistent with the referral criteria for the distance visual acuity intended for vision screening or visual impairment as published in many other studies (Budenz et al., 2012; Chew et al., 2018; Committee on Practice and Ambulatory Medicine Section on Ophthalmology, 1996).

The purpose of our app is to be easily used by the general public with minimal training; therefore, the expected level of sensitivity and specificity were moderate. The visual level cut-off point of 6/12 was set up wisely by the WHO, for it is necessary to aim for a very high sensitivity level in any screening activities (Murthy, 2000). Among studies to determine the refractive error or pediatric screening within a population, the cut-off point usually set up at 6/9 level. However, the preschool vision screening program within New Zealand with a cut-off point of 6/9, have consistently reported a massive number of unnecessary referral (Langeslag-smith, Vandal, Briane, Thompson, & Anstice, 2015). Therefore, appropriate selection of the cut-off criteria is essential before conducting any vision screening.

From this pilot study, detecting individuals with mild visual impairment or worse for the PVR obtained the highest sensitivity of 92.7% compared with other subsequent vision levels. Sixty-three participants were correctly identified as visually impaired by the app and Snellen chart, as shown in Table 2. The sensitivity to detect mild visual impairment or worse for the CVR was moderate (66.7%) whereas a very high sensitivity (100%) was achieved to detect moderate visual impairment or worse. On the other hand, both the PVR and CVR obtained a relatively high specificity of more than 90% for every level of visual impairment. For many years, the instrument-based vision screening for adult vision screening is least discussed in the literature as more is focused on the pediatric and pre-school groups. Nevertheless, the relatively high sensitivity and specificity achieved by our app in this pilot study promised a high enough validity level to identify persons with all levels of visual impairment correctly. Indeed, the app has also appropriately identified persons without visual impairment to pass the vision test conducted as individuals with normal vision.

Even though with the varieties of mobile app for visual acuity testing were introduced since the last decade, only a few of them were appropriately validated. As a comparison with the other smartphone-based app for vision screening, the *Peek Acuity* had almost similar sensitivity and specificity level with the *Vis-Screen*. In the earlier study, *Peek Acuity* showed the sensitivity and specificity of 85% and 98% respectively for the visual cut-off point of 6/60 among adults aged 55 years old and older (Bastawrous et al., 2015). In the latter study, using the same app among Kenyan school children, lower values of 77% and 91% for sensitivity and specificity were noted accordingly with a visual level cut-off point at 6/12 (Rono et al., 2018). At the same visual level of 6/12, the almost equal level of sensitivity and specificity obtained by our app compared to the Peek acuity suggest that our app is equally valid and suitable for use as a vision screening tool in the community. The short test duration of about 1 minute is likewise an additional advantage.

The purpose of applying the pinhole test in our study is to identify refractive errors as the underlying reason for the visual impairment against the presence of cataract or opacities in the optical media or any other ocular diseases. The low cost, simple and easily operated by non-technical individuals highlights the pinhole test as the method of choice to be widely used in any vision screening within the community (Marmamula, Keeffe, Narsaiah, Khanna, & Rao, 2014). As in the clinical practice, pinhole acts as the time-saver and method of choice over the standard refraction, which is frequently time-consuming. A recent study in urban Indian hospital found a similar visual acuity obtained from both pinhole and best-corrected visual acuity (BCVA) among adults above 50 years old (Kumar et al., 2019). Currently, there is no other mobile app which utilizes the pinhole test for vision screening within their algorithm beside ours. In this pilot study, we have used the BCVA with full refractive correction instead of only the pinhole test for the CVR using the Snellen chart in the clinical setting. Hence, it explains for the less number of cases detected with visual impairment and a lower sensitivity level at 66.7% for the 6/12 visual acuity level cut off point.

Regarding the predictive values, the relatively lower positive predictive value (PPV) for CVR at all visual levels were found compared with the relatively high negative predictive value (NPV) in both PVR and CVR at all visual levels. These values strongly suggest the lower prevalence of uncorrected visual impairments among our study population (Akobeng, 2007). In this pilot study, the sample size was considered small, with only the minority of them had uncorrected visual impairment caused by other ocular conditions. Therefore, a more appropriate sample size number will be implemented accordingly in the subsequent full validation study. Nevertheless, the reasonably high NPV values obtained for the PVR and CVR imply that our app is potential to have high enough accuracy to rule out individuals with uncorrected visual impairment in future vision screening programs.

5.2 The reliability of *Vis-Screen* app

The use of Krippendorff's alpha statistical analysis in this study is because of the data for the visual level results were categorical with five different users (Artstein & Poesio, 2008). The inter-rater reliability for both PVR and CVR were high with K alpha values of 0.87 and 0.89, respectively (p-value of <0.001). The high K alpha values indicate that our app has good agreement or consistency between multiple users; hence, it is potentially reliable and comparable with other mobile apps such as *Peek Acuity* (Bastawrous et al., 2015).

5.3 Limitations of the study

The difficulty in standardizing the screen brightness between different smartphones devices and the ambient lighting around the testing area was the most significant limitations identified during this study. In order to overcome this, a controlled-lighting test area with general lighting between 80 to 300 lux is advised as recommended by the British Standards to avoid unnecessary ambient (Bastawrous et al., 2015). Instruction to examinees also includes not facing or sitting against a bright source of light to minimize the effect of glare.

Due to the many different models of smartphones used among the examiners, the screen brightness and the background colour tone was not able to be standardized accordingly. Nevertheless, similar to the other studies using the mobile device in visual acuity testing, the users were advocated to standardize the screen brightness between 75 to 100% (Bastawrous et al., 2015; Gounder et al., 2014) as the luminance, luminance uniformity and contrast with the mobile devices noted to be higher than the typical retro-illuminated conventional charts (Livingstone et al., 2016; Yang, Tai, Hayes, & Sheedy, 2011). Remarkably, the differences in visual acuity measurement found between mobile devices, and the conventionally retro-illuminated chart was not statistically significant (Gounder et al., 2014).

6.0 Conclusions

This pilot study revealed that the *Vis-Screen* mobile application is highly potential to be a valid and reliable tool to be used for vision screening in the community. With only minimal training needed, it will provide any layperson with a handy tool to perform vision testing on other individuals anytime and anywhere within the community. The vision test results are also easily understood. Thus, it will help in promoting early detection and awareness regarding the visual status hence emphasizing the importance of preventing visual impairment and blindness among the general public. Due to the limited number of participants in this pilot study, a subsequent full validation study is highly advocated.

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