Ease and Willingness to Use Smartphone Applications for Visual Acuity Assessment Among Patients in Ahmadu Bello University Teaching Hospital, Zaria

Abstract

Background: Smartphone applications (apps) are increasingly becoming more popular for medical use. **Aim:** The aim of this article is to determine the willingness and ease of using smartphone apps for visual assessment among adult patients attending the general outpatient ophthalmology clinic of Ahmadu Bello University Teaching Hospital, Zaria in Nigeria. **Design:** The study was a hospital-based descriptive cross-sectional design. **Materials and Methods:** New and old adult patients who presented at the clinic and consented to the study were selected. Visual acuity assessment was done using a 6-m Snellen chart and three selected Smartphone visual acuity applications sequentially. A semi-structured questionnaire was used for data collection and then analysed using SPSS version 23. **Results:** A total of 287 patients were studied. Majority (96%) of the patients found the Smartphone apps to be easy to use. A good proportion (76%) of the patients also believed that Smartphone charts were easier to use than the conventional Snellen chart and expressed willingness to use the app again. **Conclusion:** Smartphone visual acuity apps could offer a convenient, easy-to-learn, and easy-to-use means of visual acuity assessment. This coupled with the demonstrated patient's willingness to embrace this technology could be used to encourage the use of clinically validated apps for the early detection as well as monitoring of any impairment of vision, especially in out-of-clinic situations.

Keywords: *Desire to use Smartphone acuity app, ease of use, mobile Health acuity application, Smartphone visual acuity app, Snellen acuity*

Elijah Ndako Peter, Emmanuel R. Abah, Kehinde Kabir Oladigbolu, Elsie Samaila, Farouk Garba, Asimau Eivov-Idris Zubairu

Department of Ophthalmology, Ahmadu Bello University Teaching Hospital, Zari, Kaduna State, Nigeria

Introduction

The World Health Organization estimated that more than 2 billion people suffer from impairment of distant or near vision globally; majority of the causes of this vision impairment are due to avoidable causes.[1] Early recognition and management of visual impairment is a very important factor in the reduction of the high global burden of blindness and visual impairment. Unrestricted access to simple but standardized visual acuity charts everywhere and anytime by the people at risk and medical professionals would help in the early detection of visual impairment. Mobile technology has been applied in various fields of medicine.[2,3] This has led to the conviction that the use of smartphone apps will revolutionize patient education, self-assessment, and remote monitoring of diseases. It has also propelled the interest in the development and use more mobile health apps like the smartphone visual acuity

apps.[4] Conventional visual acuity charts, the gold standard in the assessment of vision, are used by healthcare professionals in clinics and during screening programs. To be able to assess one's vision, a visit to these centres is often necessary. Unlike the conventional visual acuity charts, Smartphones are found in almost every community/home even in rural areas. Smartphone acuity apps are available at little or no cost in app stores and could easily be installed on compatible devices. Thus, Smartphone acuity apps could provide patients with a readily accessible vision screening and monitoring tool in their homes. In terms of usefulness of the smartphone visual acuity apps, efforts have been made to validate their acclaimed accuracy.[4-6] Examples of charts that have been studied by different researchers and found to be in agreement with the conventional charts include the OcularCheck, Peek Eye, and Eye Chart Pro apps.[4-7] Although multiple benefits of the apps to patients are being anticipated and more effort is being dedicated to improve the

accuracy of these apps, a pertinent question however is, are patients (the targeted end users of the apps) readily willing to use these apps?

With the challenge of patient and healthcare provider safety in the era of Covid-19 pandemic, Tele-ophthalmology has resurfaced to the limelight with awakened interests in the use of alternative (non-conventional) visual acuity charts such as the smartphone visual acuity apps (e.g., Peek Eye), web-based charts (e.g., Digivis), and user printable charts (e.g., the Home Acuity Test).[8-12]

Being a clinical measurement, smartphone visual acuity applications have to be designed for optimal accuracy and precision in their assessments. Various factors such as the variability of the smartphone screen sizes, screen resolution, optotype background luminance, and glares may affect the accurate generation of the necessary visual stimuli (optotype) and hence the accuracy of the measurements made across different devices.[13] To avoid this, app developers may use autocalibration by the software itself or manual calibration using a set of given instructions. This process of calibration may however make the user interface of the application to appear complex and unfriendly. Parker *et al*.[14] in a study of the barriers and facilitators to the use of a mobile smartphone application identified the ease of use and user friendliness of an application to be one of the crucial barriers capable of limiting the use and adoption of a smartphone mobile application. Other studies[15,16] are also in agreement with this. There are limited data on patient's use of mobile health applications.[17] This study therefore aimed at assessing the perceived ease and willingness of using an Android Smartphone app for visual acuity assessment among patients attending eye clinic at Ahmadu Bello University Teaching Hospital, Zaria, Nigeria.

Materials and Methods

The study was a cross-sectional prospective study of 287 patients. It was carried out at the General Outpatient Clinic of Ahmadu Bello University Teaching Hospital, Zaria, in Kaduna State of Nigeria between November and December 2020. The study was approved by the Health Research Ethics Committee (HREC) of Ahmadu Bello University Teaching Hospital (ABUTH), Shika-Zaria and carried out after obtaining the patients' written consent. The participants recruited for the study were both new and old adult patients (aged 18–60 years old) who were literate enough to be able to identify alphabets on a Snellen chart. The study subjects were selected using systematic random sampling.

Data collection and analysis

Three smartphone apps were selected for the study: the "Snellen acuity chart" version 3.09 by João Meneses, "Snellen acuity" version 2.30 by the Fonlow group, and "OcularCheck: Visual acuity Exam" version 1.1.0 by Soham Govande. The three apps are available for free download on the Google Play Store® without any compulsory in-app purchase. The apps could be configured for assessment of vision at varying distances. They also have different examination voice guides and commands in order to aid unassisted self-vision assessment. The OcularCheck app has multilingual optotypes and gives recommendations to the users depending on the extent of visual impairment identified at the end of assessment with it, for example, the need for further professional assessment and care. The João Meneses app also has a duochrome chart, Amsler grid, and Astigmatic fan incorporated into it apart from the Snellen chart.

The researchers (healthcare providers) learnt the process of using the visual acuity apps for the assessment of distant visual acuity and found them to be easy to use. The researchers showed the patients the process of assessment of vision with the apps by carrying out monocular visual acuity assessment using the three chosen apps and a conventional retroilluminated 6-m Snellen chart in a randomized sequential order on each of the patients.

The patients were subsequently instructed to sequentially use the three Smartphone apps to attempt monocular distant visual acuity of a third party (a fellow volunteer patient). Assistance was provided if needed.

Assessment with a wall-mounted conventional Snellen visual chart was done with the subject seated at a distance of 6 m from the chart and then instructed to read the alphabets on the chart starting from the top of the chart. Assessments with the apps were done with those installed on an Infinix Note 3 Smartphone and held by the examiner at a distance(s) of 3.05, 6, and 6 m for the OcularCheck, João Meneses, and Fonlow group Snellen apps, respectively. The subjects were asked to read aloud the displayed alphabets, while the examiner controlled the displayed line of optotypes by making use of direction-sensitive swiping gestures (João Meneses and Fonlow group apps) or by choosing the number of correctly/incorrectly identified optotypes (OcularCheck app). At the end of each test, the apps display the visual acuity obtained automatically as already pre-programmed by the app developers.

A semi-structured questionnaire was used for the collection of patients' sociodemographic data (age, sex, and the highest educational qualification), history of eye disease, willingness, and ease of the visual acuity assessments (using a 7-point Likert scale). Face and content validation of the questionnaire was ensured by two medical education specialists and a statistician. Statistical analysis was done using Statistical Package for Social Sciences (SPSS) IBM® SPSS® Statistics Version 21 (International Business Machine Corp., 2012). Summary of the results was done using tables and charts. Tests of associations for the variables were determined using the χ^2 or Fisher's exact test where applicable. Statistical significance was set at 95% confidence interval ($P \leq 0.05$).

Results

There were 287 respondents who participated in this study with a 100% response rate. The age of the participants ranged between 18 and 60 years with a mean of 39.2 ± 14.7 years. One
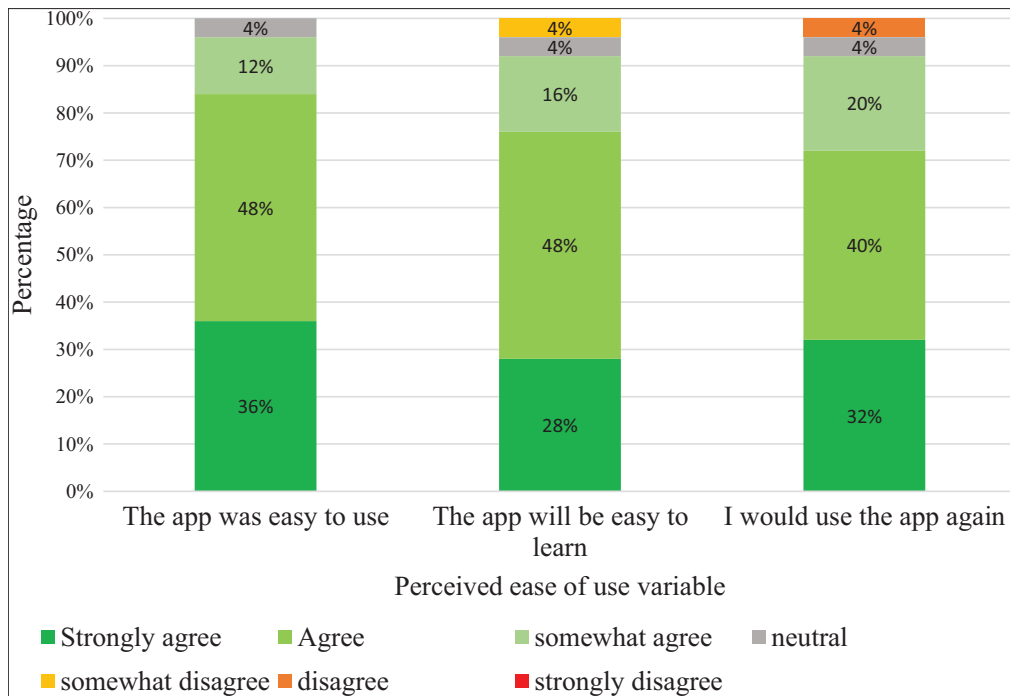
Figure 1: Bar chart showing the perceived ease of using the smartphone apps
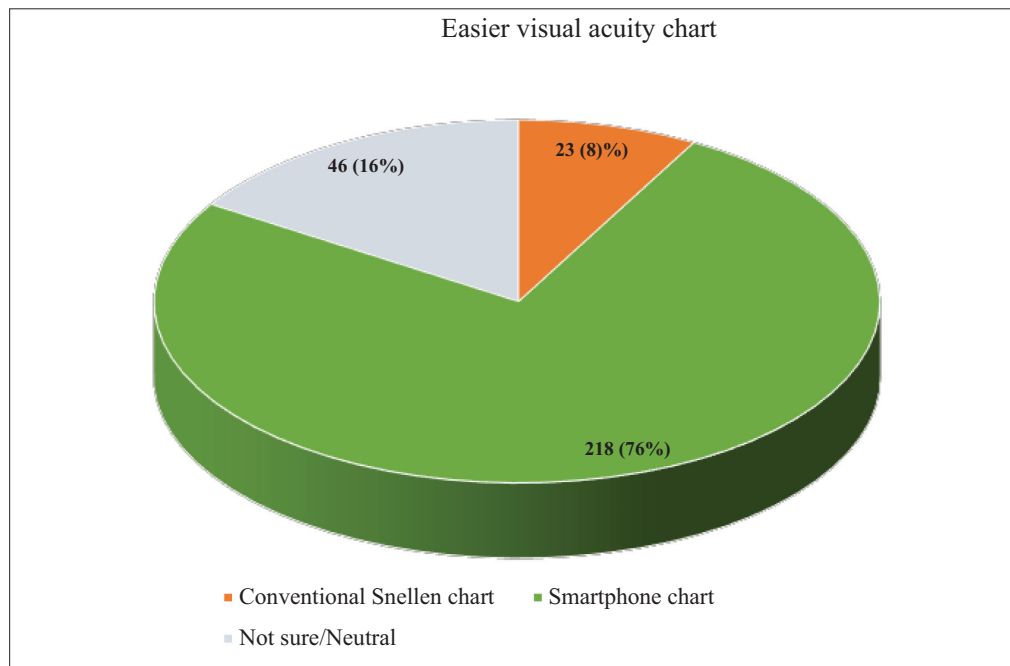

Figure 2: Pie chart showing the patient's choice on the easier visual acuity chart

hundred and fifty-one (53%) respondents were females, giving a male-to-female ratio of 1:1.1, and 241 (84%) respondents had at least secondary school education.

Positive affirmation on the perceived ease of learning and using the smartphone apps for visual assessment were observed in 92% and 96% of the patients, respectively [Figure 1]. Most of the respondents (92%, 264/287) willingly expressed their desire to use the app to test their vision again. About three-quarters of

the patients believed that the Smartphone charts were easier to use than the conventional Snellen chart [Figure 2].

A greater proportion (99%, 177/178) of the relatively younger group showed the willingness to use the Smartphone app than the older group (79%, 86/109). This difference was found to be statistically significant [Table 1]. The ease of using the application also showed statistically significant association with the willingness to use the app again. There was no

Table 1: Association between ease of use and the potential moderating factors (*n* = 287)				
Variable	No (not willing to use the app again)	Yes (willing to use the app again)	Percentage willing to use the app (%)	*P*-value
Age (years)				0.0001*
<45	1	177	99	
>45	23	86	79	
Sex				0.247
Male	14	121	90	
Female	10	142	93	
Education				0.442
Lower than secondary school education	3	43	93	
At least secondary school education	21	220	91	
App was easy to use				**0.0001***
Yes	15	260	95	
No	9	3	33	

*Statistically significant (*P* < 0.005)

statistically significant gender difference on the willingness to use the app. All the health workers who took part in the assessment of the patients found the smartphone apps to be easy to use.

Discussion

This study investigated the ease of use and the willing desire to subsequently use the Smartphone apps for visual acuity assessment by patients. Most of the patients found the Smartphone apps easy to use, with a majority of them also believing that the Smartphone apps were easier to use than the conventional Snellen chart. Similar to the finding in this study, Zhang *et al.*[18] in a study using the Eye Chart Pro app in China observed that all the patients found the procedure easy. In Kenya, Bastawrous *et al.*[6] also reported good acceptance of a similar smartphone app (Peek Eye app) among eye care workers. Han *et al.*[19] documented satisfaction in 98% of elderly patients who had their vision assessed using a Smartphone app among Chinese and Australians.

The patients were willing to be tested by the apps and also expressed the desire to subsequently use the app on their own at home. Furthermore, the study demonstrated that the perceived ease of use could have a significant effect on the willingness to use the visual acuity application in the future by the patients. Consistent with the findings in this study, previous studies by Tubaishat[20] and Hoque *et al.*[16] have also linked the willingness to use the app with the perceived ease of using mobile and electronic health applications. The more an app is perceived to be easy to use, the stronger the willingness to use the app. The study by Tubaishat was carried out among professionals; this study, however, provided the view from the patient's perspective.

The study found willingness to use the apps to be higher in the younger age groups than more elderly ones. In agreement with this, Krebs and Duncan[17] asserted that Mobile health app users tend to be younger. The observed differences could have been

due to higher smartphone ownership by the younger population. It could also be explained partly by the observation that the more adventurous younger individuals who are already users of smartphones for social media and other activities are more likely to want to try out new technology and apps. However, as eye diseases are more prevalent with increasing age, the older age group may benefit more from vision screening with the visual acuity apps. Hence, recommendation of a properly validated app to them will be important to encourage the use of the apps.

Unlike the previous documentations,[16,21] this study found no significant gender differences in the willingness to use the smartphone visual acuity app. Venkatesh and Morris[21] observed that the differences in the desire to adopt a new technology were because males are more driven by the usefulness of the technology, whereas females are more influenced by the ease of use.[21] This study, however, has some limited generalizability, as not all the smartphone apps were studied and the patient's practical use of the applications at home setting was not evaluated. The use of Smartphone visual acuity apps may also be affected by the cost owning a mobile device and the need for electricity, which may be challenging in remote communities.

Conclusion

Conventional charts remain the preferred method of visual assessment. However, in situations in which they are not available or useable (e.g., in patient homes and an unplanned out-of-clinic need for visual assessments), Smartphone visual acuity apps could offer a convenient, easy-to-learn, and easy-to-use means of visual acuity assessment. This coupled with the demonstrated patient's willingness to embrace this technology is expected to positively influence the use of this technology. Hence, the effort being put to the development and validation of accuracy of these applications might not be in vain. App developers should always put user-friendliness of the app

interface into consideration in order to encourage the use of the applications.

Conflicts of interest

There are no conflicts of interest.

References

1. World Health Organisation. Blindness and vision impairment [fact sheet] [Internet]. 2021. Available from: https://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment. [Last accessed on 2021 Nov 26].

2. Batista MA, Gaglani SM. The future of smartphones in health care. Virtual Mentor 2013;15:947-50.

3. Akkara J, Kuriakose A. Innovative smartphone apps for ophthalmologists. Kerala J Ophthalmol 2018;30:138. Available from: http://www.kjophthal.com/text.asp?2018/30/2/138/239988.

4. O'Neill S, Mcandrew DJ. The validity of visual acuity assessment using mobile technology devices in the primary care setting. R Aust Coll Gen Pract [Internet] 2016;45:212-5. Available from: https://www.racgp.org.au/download/Documents/AFP/2016/April/AFP-Research-McAndrew.pdf. [Last accessed on 2019 Apr 24].

5. Govande S, Zak V, Gonzalez VH. Development and validation of a mobile visual acuity examination app for universal use, including remote and rural regions. J Optom Ophthalmol 2021;2:1-7. Available from: https://doi.org/10.37191/Mapsci-JOO-2.

6. Bastawrous A, Rono HK, Livingstone IA, Weiss HA, Jordan S, Kuper H, *et al*. Development and validation of a Smartphone-based visual acuity test (Peek Acuity) for clinical practice and community-based fieldwork. JAMA Ophthalmol 2015;133:930-7.

7. de Venecia B, Bradfield Y, Trane RM, Bareiro A, Scalamogna M. Validation of Peek Acuity application in pediatric screening programs in Paraguay. Int J Ophthalmol 2018;11:1384-9.

8. Malfatti G, Racano E, Delle Site R, Gios L, Micocci S, Dianti M, *et al*. Enabling teleophthalmology during the COVID-19 pandemic in the Province of Trento, Italy: Design and implementation of a mHealth solution. PLoS ONE 2021;16:e0257250.

9. Chen TA, Li J, Schallhorn JM, Sun CQ. Comparing a home vision self-assessment test to office-based Snellen visual acuity. Clin Ophthalmol 2021;15:3205-11.

10. Redmayne JK, Russell HC. Real-world application of home visual acuity testing for pediatric teleophthalmology during the COVID-19 pandemic. J Pediatr Ophthalmol Strabismus [Internet]. 2022:1-10 [Epub ahead of print]. Available from: https://journals.healio.com/doi/10.3928/01913913-20220131-01?url_ver=Z39.88–2003&rfr_id=ori:rid:crossref.org&rfr_dat=cr_pub 0pubmed. [Last accessed on 2022 Apr 11].

11. Satgunam P, Thakur M, Sachdeva V, Reddy S, Rani PK. Validation of visual acuity applications for teleophthalmology during COVID-19. Indian J Ophthalmol 2021;69:385-90.

12. Thirunavukarasu AJ, Mullinger D, Rufus-Toye RM, Farrell S, Allen LE. Clinical validation of a novel web-application for remote assessment of distance visual acuity. Eye 2021;30:1-5. doi: 10.1038/s41433-021-01760-2

13. Mena-Guevara KJ, Piñero DP, de Fez D. Validation of digital applications for evaluation of visual parameters: A narrative review. Vis 2021;5:58. Available from: https://www.mdpi.com/2411–5150/5/4/58/htm.

14. Parker SJ, Jessel S, Richardson JE, Reid MC. Older adults are mobile too! Identifying the barriers and facilitators to older adults' use of mHealth for pain management. BMC Geriatr 2013;13:43.

15. Jebraeily M, Fazlollahi ZZ, Rahimi B. The most common smartphone applications used by medical students and barriers of using them. Acta Inform Med 2017;25:232-5.

16. Hoque MR, Bao Y, Sorwar G. Investigating factors influencing the adoption of e-Health in developing countries: A patient's perspective. Inform Health Soc Care 2017;42:1-17.

17. Krebs P, Duncan DT. Health app use among US mobile phone owners: A national survey. JMIR mHealth uHealth 2015;3:e101.

18. Zhang ZT, Zhang SC, Huang XG, Liang LY. A pilot trial of the iPad tablet computer as a portable device for visual acuity testing. J Telemed Telecare 2013;19:55-9.

19. Han X, Scheetz J, Keel S, Liao C, Liu C, Jiang Y, *et al*. Development and validation of a smartphone-based visual acuity test (vision at home). Transl Vis Sci Technol 2019;8:27.

20. Tubaishat A. Perceived usefulness and perceived ease of use of electronic health records among nurses: Application of technology acceptance model. Inform Health Soc Care 2018;43:379-89.

21. Venkatesh V, Morris MG. Why don't men ever stop to ask for directions? Gender, social influence, and their role in technology acceptance and usage behavior. MIS Q Manag Inf Syst 2000;24:115-36.