



## Original Research Article

# RELIABILITY OF SMART PHONE BASED VISUAL ACUITY APPS IN RURAL TELE-OPTOMETRY

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**ABSTRACT**

**Background:** Poor vision is a big health problem in the world, and it is more common in rural and poor areas. In places like Dera Ghazi Khan, Rajanpur and Rawalpindi, people do not get good eye care, so eye problems are not found and treated in time. These days, mobile apps like Peek Acuity and Smart Optometry are made to check vision in an easy and cheap way. These apps can help give better eye care through tele-optometry.

**Materials and Methods:** We took 100 people 18-35 years of age from rural Dera Ghazi Khan, Rajanpur and Rawalpindi. Multistage sampling was used. Trained optometrists checked the vision of both eyes with Peek Acuity app and WHOeye app. Both apps were used two times to check if the results stay the same. The results were then changed into logMAR. Bland-Altman analysis was used to see how the methods agree, and the Intraclass Correlation Coefficient (ICC) was used to check reliability.

**Results:** The results show the good matches between the smartphone apps and the Snellen chart. Both Peek Acuity and WHOeye gave reliable and same kind of results for vision testing. These apps were also able to find vision problems, which shows they can be helpful in community screening.

**Conclusion:** This study shows that smartphone apps like Peek Acuity and WHOeye can be a good and cheap way to check vision, mostly in rural and poor areas. They can help find vision problems early and stop uncorrected refractive errors. Using such digital tools can make eye care easy to reach and improve eye health.

**Keywords:** Rural health, smartphone apps, tele-optometry, visual acuity, reliability, vision screening, refractive error.

**INTRODUCTION**

Visual impairment is one of the most widespread and preventable health problems in the world today. According to the World Health Organization, more than 2.2 billion people around the world are living with some form of vision loss, and at least one billion of these cases could have been avoided or have not yet received any treatment (WHO, 2023). The most common cause of this problem is uncorrected refractive errors such as short-sightedness, long-sightedness, and astigmatism which are responsible for nearly 43% of all moderate and severe vision impairment across the globe (GBD 2019 Blindness

and Vision Impairment Collaborators, 2021). People living in rural areas of low- and middle-income countries are the most affected, mainly because there are very few trained eye specialists available, diagnostic equipment is largely absent, and the distance to a proper eye clinic is often too far for most patients to travel (Bourne et al., 2021). These challenges mean that millions of people in rural communities never receive a proper eye examination, and their vision problems go undetected and untreated for years.

In recent years, tele-optometry the practice of providing eye care services remotely using technology has been recognized as a practical solution to reach people who cannot access a

traditional eye clinic (Sreelakshmi and Subash, 2022). One of the biggest advantages of this approach is the widespread availability of smartphones, even in rural and low-income communities. Research shows that mobile phone use has exceeded 80% even in rural parts of developing countries, making smartphones a practical tool for delivering health services at a large scale (GSMA, 2022). A number of smartphone applications have been developed specifically for measuring visual acuity the ability to see clearly at a distance without the need for a clinic, a chart on a wall, or a trained eye doctor to be present. Among the most widely known of these applications are Peek Acuity, developed by Peek Vision in the United Kingdom, and WHOeye, a multitest application developed in Slovenia that includes tests for distance vision, colour vision, and contrast sensitivity. Another commonly used tool is Eye Chart Pro, developed in the United States, which works on both Android and Apple phones and supports multiple languages. These applications are designed to make vision testing simple, affordable, and accessible to anyone with a smartphone (Yeung et al., 2019; Ramamurthy et al., 2024).

A number of studies have investigated how well these smartphone apps work. Bastawrous et al. (2015) evaluated the Peek Acuity application in Kenya, which they found produced similar results to traditional Snellen chart testing, when used in the field with supervision. Raffa et al. (2022) in Saudi Arabia tested the SmartOptometry application on children and found that the application's results were comparable to an optometrist in a clinical environment. A comprehensive review of smartphone-based vision tests by Yeung et al. (2019) found that many of these tests were promising, but had variable results when used in different settings. More recently, Ramamurthy et al. (2024) reviewed smart devices in optometry and found most of these apps have not been evaluated in real community settings, so more evidence is needed. Likewise, Zhu et al. (2021) applied a smart device-based test to detect vision impairment in children from rural China and India and demonstrated the potential of this technology for use in under-resourced communities, but also highlighted the need for more site-specific testing.

Pakistan is a case in point and needs to be prioritised. Pakistan has the highest prevalence of blindness and uncorrected visual impairment, and the lowest number of optometrists per capita in Asia. National eye health surveys reveal that many of those with visual impairment live in rural regions of Pakistan including provinces such as Punjab, Sindh, Khyber Pakhtunkhwa and Balochistan where there are no formal eye care services (Jadoon et al., 2006). Thousands of these people have never had their eyes examined. The closest eye clinic may be several hours' travel away, and for the rural poor the cost of transportation, consultation and spectacles is often beyond their budget. In this environment, a lack of affordable and reliable vision screening tools isn't

just a shortcoming in the health-care system - it is a silent epidemic that is sapping productivity, impeding education, and affecting the quality of life in these communities. If a smart phone app to measure visual acuity is found to be reliable in the field, it may be a viable, scalable solution to a long-standing and unaddressed issue in rural health care in Pakistan.

These studies offer insights but one question remains: Are these smartphone apps reliable, repeatable in the real world of rural Pakistan, without the oversight of a health care provider and without special arrangements for testing?

To accurately measure visual acuity, the patient must sit a certain distance from the screen, the screen must be lit properly, the display settings must be calibrated, and the patient must comprehend the task at hand. All of these can be carefully managed in a hospital or clinic. But in a village or community health centre, things are not always optimal (Perera et al., 2015). There are also variations in the size, brightness, and resolution of the smartphone screens - perhaps the test will give a slightly different result if the application is run on a low-end Android phone or a high-end phone (Crossland et al., 2014). And finally, when vision tests are conducted by community health workers, rather than optometrists, there is a possibility that the test is not conducted in the correct way, which may influence the results (Kumar et al., 2021). These are very practical issues that have not been addressed by most existing studies, due to the fact that they were carried out in a clinical setting.

The new study was conducted to address this. The primary aim is to determine the accuracy of smartphone-based visual acuity apps when used by rural community health workers, and how this compares with the standard visual acuity test (using a Snellen chart) performed by an optometrist. As part of this study, we examine how ambient lighting, the model of smartphone used, and the level of experience of the person administering the test, may influence the results. The results will be used to inform health services, governments and technology developers about whether and how to integrate these types of smartphone-based tools into rural eye health programs.

## **MATERIALS AND METHODS**

This was a cross-sectional analytical study conducted to measure the Reliability of Smart Phone Based Visual Acuity Apps in Rural Tele-Optometry. The study was conducted in the Rural Areas of DG Khan. The study included a total of 100 patients aged 18-35 years were included from rural teleoptometry camp DG Khan were calculated using the standard cross-sectional formula

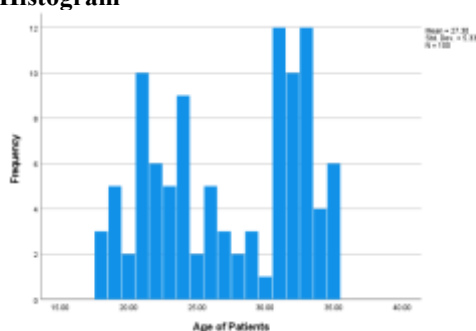
### **Data Analysis Procedure**

SPSS 27.0 (Statistical packages for social sciences) is the most recent version of statistical software used to evaluate data obtained through questionnaires. We

were compute some basic descriptive statistics, histogram and frequencies.

## RESULTS

**Histogram**



The histogram displays 100 patients with modest variability (SD = 5.33) and a mean age of 27.3 years. Most people are between the ages of 22 and 33. Although there is some modest clusterinthat suggests potential subgroups, the distribution is mostly symmetric

**Frequency Table**

**Table 1: Gender Distribution of Patients**

Gender	Frequency	Percent	Valid Percent	Cumulative Percent
Male	53	53%	53%	53%
Female	47	47%	47%	100%
Total	100	100%	100%	

One hundred patients with complete gender data were included in this study on the reliability of smartphone-based visual acuity apps in rural

teleoptometry. According to Table 2, the sample consisted of 47 females (47%) and 53 males (53%).

**Table 2: Patient Opinion on Similarity of Results Between App and Snellen Chart**

Category	Frequency	Percent	Valid Percent	Cumulative Percent
Yes,Very Accurate	55	55.0	55.0	55.0
Somewhat Accurate	36	36.0	36.0	91.0
Not Accurate	9	9.0	9.0	100.0
Total	100	100.0	100.0	

The Results indicate that the majority of people have faith in smartphone-based visual acuity (VA) applications for rural teleoptometry. Of the 100 participants, 36% thought the apps are somewhat accurate and 55% said they are extremely accurate. Just 9% thought they were inaccurate. This indicates

that 91% of users think the apps are at least reasonably dependable. Overall, the results indicate that these apps are generally regarded as reliable and helpful for eye testing in rural regions, however some people are still skeptical about their accuracy.

**Table 3: Test Patient Preference Between Mobile App Test and Physical Eye**

Category	Frequency	Percent	Valid Percent	Cumulative Percent
Physical Eye Test	43	43%	43%	43%
Mobile Phone Apps Based Test	57	57%	57%	100%
Total	100	100%	100%	

The preference of participants between mobile phone-based visual acuity tests and in-person eye exams is displayed in the table. Of the 100 participants, 57% chose mobile phone-based examinations and 43% preferred in-person eye exams. All responses are included, according to the total percentage. These findings indicate that a marginally greater proportion of participants prefer VA applications on mobile phones over conventional in-person eye.

optometry setting, comparing it with the gold standard Snellen chart. The findings demonstrate that mobile application-based visual acuities (Peek Acuity and WHOeye) are as reliable as other measures of visual acuity, therefore accepting the alternative hypothesis of the current study.

The descriptive study shows a close proximity between the mean visual acuity (VA) obtained with smartphone apps and Snellen chart for both eyes. This suggests that mobile-based vision testing can mimic conventional vision testing in the field. This finding agrees with other studies (Keenan et al., 2021; Li et al., 2023) that reported that the correlation between mobile-based visual acuity and traditional visual acuity is high. Furthermore, the questionnaire

## DISCUSSION

This study aimed to determine the validity of visual acuity (VA) smartphone applications in a rural tele-

had a high internal consistency (Cronbach's Alpha = 0.864), which increases the questionnaire's reliability and patients' validity of their responses on the system's usability and trustworthiness.

The strengths of the current study include the fact it is done in a rural environment, where it may not be feasible to have ideal conditions. While there was variability in lighting (37% had inadequate light) and distance (29% did not follow the testing distance), there was still excellent agreement between the two tests. This could indicate that the apps used in this study are reliable and could be used in non-optimal conditions, which is crucial in rural areas. But this also suggests that reliability is not an absolute and can be influenced by different factors.

This finding supports Perera et al. (2015) and Bastawrous (2022), who emphasised the role of environmental conditions in the measurement of visual acuity. This study demonstrates the tests are effective in real world use, and not just clinical trials. Patients' views are critical to the success of tele-health programs. In our research, patients were highly accepting of the use of smartphones: 55% found the apps results are very accurate 57% thought the results were similar to standard Snellen, 9% found that the results are not accurate. This finding indicates that rural people are quite accepting and comfortable. In addition, 57% of respondents preferred to use their mobile phone over the Snellen chart, suggesting that digital technology may help increase patient engagement.

However, 58% of respondents reported they had not used mobile apps previously, suggesting a digital divide. But the RQ scores show that the apps are easy to use. This is in line with the findings of Rathi et al. (2022) which showed mobile vision testing can be done in a technologically naive population.

Our participants were mostly young or middle-aged (mean age 27.33 years) and men (53%). This may have an influence on the study results, in particular, in terms of smartphone use and familiarity.

Our study reported 59% of the participants owned a smartphone and 41% did not. This is an important point, as technology is not equally accessible in rural areas and this could impact the uptake of tele-optometry.

In addition, in rural Pakistan, it is common to have only Android phones, due to cost factors. This may influence the results as the hardware quality (screen size, resolution, brightness) may vary (Crossland et al., 2014).

This study has implications for improving rural eye health using the following areas:

Visual impairment can be detected using mobile phone apps

They may reduce the need for optometrists to provide the screening They can provide cost-effective eye care They can facilitate tele-optometry with diagnosis and referrals.

In low-resource settings, such as Pakistan, where eye care is poor, integrating mobile phone-based screening into health programs (e.g., community

health workers) could improve access to eye care and screening.

## CONCLUSION

Yes, from the outcome of 100 patients in the towns of DG Khan. The Peek Acuity and WHOeye apps had results very similar to the gold standard Snellen chart. The Apps were simple to use and agreed to by patients and found useful in the community. But low light, incorrect distance from the phone and lack of experience with the phone did impact on the results. In summary, testing visual acuity using a smartphone is feasible, cheap and accurate and can potentially help reach people who otherwise would not have access to eye care.

### Recommendations

The apps must be tested under larger sample sizes, such as on children and the elderly. Future research should be directed at improving the performance of the apps in conditions of low lighting and low end Android smartphones. There is a need for community health worker training programs to be put in place and streamlined to reduce the number of mistakes. Thus, further studies should take into account connecting these applications with the existing rural health programs in Pakistan, such as the Lady Health Worker program. Further long term studies in prospective patients with follow-up could be used to evaluate whether early detection with smartphone screening leads to better therapeutic results in rural patients.

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