NetraCare

Literature Review

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Table of Contents

Introduction

The speed at which mobile health technologies are expanding has altered the access to testing, such as ophthalmic screening. One of the major problems worldwide is vision impairment and its impact is especially relevant to low-resource environments in which the access rate to specialist care remains scarce. Development of smartphones and the progress of AI and computer vision have brought about new opportunities of digital eye tests, such as visual field, color perception, eye tracking, pupil reaction, and nystagmus. This literature review reviews the available academic literature and digital applications in the area of mobile eye-health assessment, critically analyzes their skills, and gives gaps that result in the need to create the Netra Care mobile application.

Initial Research

1. Mobile Visual Acuity Assessment Using Smartphones

Recent increases in the ubiquity of smartphones and their high-resolution displays have allowed new methods of assessing visual acuity (VA) to be used in non-clinical settings. The growing literature portrays that smartphone-based VA assessment can be similarly accurate as gold-standard tests based on charts and enhances access to and promotes remote monitoring.

The most frequently mentioned instrument in this field is Peek Acuity system which has been tested thousands of times in both low- and middle-income countries (LMICs). In their study, (Nisha Dulani, 2023) compared Peek Acuity to the usual Snellen testing in 162 eyes in the hospital. The authors did not identify any meaningful difference between the best corrected VA (BCVA) in the two approaches, with an average VA in both methods separated by a list of less than 0.003 in the quality (Nisha Dulani, 2023). This implies that VA tests performed using the smartphones can also be accurate substitutes of physical charts when standardized appropriately.

The study by (Suo, et al., 2022) focuses on a wider appraisal and conducts a systematic review and a meta-analysis of 22 articles that included smartphone or tablet-based VA measurements. In six articles included in the quantitative synthesis (N = 24284), smartphone VA(VA) tests in the pooled analysis of sensitivity and specificity were 0.86 and 0.91. The authors underline that smartphone VA tests showed high quality in young and middle-aged adults and slightly lower specificity in children at the age of 3-5 years (Suo, et al., 2022). Markedly, assessments via smartphones demonstrated the same or even the better level of diagnostic resource than the ones that were conducted using tablets, which validates the appropriateness of phones as cost-effective screening instruments.

Further enhancement of smartphone VA technology is observed in those applications based on which automated distance calibration and forced-choice algorithms were implemented. (Ogino, et al., 2023) have confirmed that a new application, vision.app, is an assessment of BCVA that is performed through a handheld distance and real-time scaling of a Landolt C optotype. A test of 40 individuals established no statistically significant differences between measures of apps and Snellen chart ($p > 0.47$). Additionally, there was less than 0.01 logMAR mean difference or lower than the cut point of clinical relevance (Ogino, et al., 2023). The authors emphasize that it is clear that smartphone VA evaluation is more practicable at home involving handheld testing as opposed to fixed-distance testing.

There are a number of previous works confirming such findings. In a study that quantified induced nystagmus with the aid of the EyePhone system, (Bastani, et al., 2025) found out that smartphone-based eye tracking was highly consistent with traditional clinical measures. They also corroborate the effectiveness of smartphone optical methods mainly, as their VA measurement methods are used in a study of nystagmus, though. Taking together, these results demonstrate the importance of strong algorithms, standardized opt typing, and distance calibration of a device to reach a level of accuracy, which is accurate clinically.

In the literature, the main advantages of smartphone VA assessment are portability, low cost, and the possibility to work without the use of specialist equipment in addition to the appropriateness of smartphone VA assessment to the telemedicine workflow. Some of the limitations are device inconsistency, change in lighting, and low performance in very young children or those with literacy factors. However, the evidence is overwhelming in favor of smartphone VA testing both as a reliable community screening tool as well as home monitoring tool and integration of teleophthalmology.

2. Nystagmus Detection and Smartphone Eye-Tracking.

The topic of AI-based eye-tracking on smartphones is one of the fastest developing ones, where it has found use in nystagmus, assessment of a vestibular disorder, or neuro-ophthalmic diagnostics. Video-oculography (VOG) systems are considered valid and conventional and thus expensive making them inaccessible by most settings. In recent years, they have estimated the capabilities of smartphone cameras, together with computer vision models, to produce similar diagnostic information.

(Maximilian U. Friedrich, 2023) proposed ConVNG, a convolutional neural network (CNN)-based architecture that trained on a variety of clinical videos in order to detect the position of pupil trails in the everyday smartphone video. The authors compared slow phase velocity (SPV) measurements of ConVNG to infrared VOG with a standardized optokinetic stimulus in 10 subjects. Their two one-sided t-test (TOST) analysis has shown that ConVNG has passed through statistical equivalence with VOG in all directions of nystagmus with a median of 0.30deg/s, which was better than benchmark algorithms like MediaPipe which had 0.7deg/s (Friedrich et al., 2023). These findings are indicative of the idea that smartphone-nystagmography can come into close to clinical-grade accuracy where mounted on high-quality CV algorithms.

Additional studies, such as that of (Bastani, et al., 2025) with the EyePhone system, confirmed the use of pupil tracking and the presence of induced nystagmus quantification of the smartphone video. Their results are consistent with ConVNG, where even their phone cameras with 30 Hz can measure ocular micro-correlations with a clinically significant level. Such findings are of great relevance considering how episodic vertigo is and the diagnostic significance of nystagmus occurrence when exhibiting symptoms.

These advances notwithstanding, there are still limitations. The video on phones is also not doing so well in low-light situations where infrared VOG is much better and motion artefacts can be added to handheld recordings unless the shot is stabilized. Calibration would be less favorable than VOG systems, but newer models like Con VNG could employ anthropometric modeling and filter models when compensating.

To conclude, eye -tracking with smartphones is getting to an accuracy that can add or partly substitute VOG in some clinical settings, particularly remote assessment, early triage, and tele-neurology.

3. Colour Vision Testing on Smartphones.

Colour vision testing with smartphones Smartphone based colour vision testing has become noticed as a low cost alternative to the print Ishihara plates and other clinical tests like the Farnsworth D-15. The use of colour has uniformity and luminance variation across devices is challenging but recent studies show that well-defined applications may produce satisfactory accuracy.

A major study among the papers you have given was a study which assessed digital versions of the Ishihara test on smartphone screens. The results showed that there were highways of agreement between testing with smartphone and plate-based assessment and high sensitivity of the deficiencies of red-green. The advantages are that it is automated to do the scoring, presentation is standardized, and it is available even in remote locations where one cannot find print charts.

Despite the lower evidence base than VA assessment, the literature indicates that colour vision tests using smartphones can be performed to screen, but not yet fully corroborated to diagnostic-level testing because of limitations to screen calibration.

4. Smartphone Smart Pupil Testing and Light with Smartphones.

Pupillometry and pupil reflex assessment have developed as new useful digital biomarkers not only of neurological disorders but also of ophthalmic disorders. Dynamic pupillary responses can be obtained with modern phone cameras, particularly those that have large frame rates, bright flash LEDs.

In one of the studies of your database, the light reflex testing based on smartphone is reported as being validated with automated flash-based stimulus. The app achieved an accurate measurement of constriction latency, reflex amplitude, and anisocoria relative to the clinical pupillometers. Smartphones are portable, which facilitates community-based testing, and emergency care when investigating the neurological functioning of the patient as quickly as possible.

Frame-rate variability, uneven illumination and absence of infrared imaging are still issues. However, the study shows that smartphone pupillometry is a promising technique in telemedicine, the measurement of concussion, and autonomic functioning.

5. Extended Applications of Smartphones to Tele-Ophthalmology.

Smartphones have taken center stage to digital health plans to lessen disparities of eye care in the world. The research of Cardona et al. (2025) was a scoping review of the eye-care interventions that minimize access among women, older adults, and the rural population in the LMICs. Their results emphasize the importance of smartphone applications during the visual screening, triage, health education and referral support.

Smartphone tele-ophthalmology programmes have been shown to be especially successful in:

1. visual impairment can be measured remotely,
2. screening refractive error in the community,
3. incorporating AI into the detection of early signs of such conditions as diabetic retinopathy,
4. allowing non-expert examination of simple eye screening.

Another application, smartphone based image acquisition of anterior segment and fundus has also grown through low priced clip-on lenses and has increased access to areas where a slit lamp is absent. The assembled evidence makes it possible to claim that smartphones have become a foundation technology of contemporary tele-ophthalmology, which contributes to the national screening programmes and remote clinical workflow support.

Existing System Review (System Analysis)

1. EyePatient

EyePatient falls is mostly the area of mobile visual acuity assessment as it offers simple VA testing, Amsler grid test, and plain reading charts. The application is an educative and self-monitoring system as opposed to a diagnosis platform. It is as static as charts, is not machine-learned, does not track eye-movements, does not test colour-vision or attempt machine-analysis. The major problem with it is that it has its limited sphere, as being easy to use, it is unable to identify the neurological anomalies, subtle eye changes, or dynamic vision defects. Therefore, EyePatient can only be applied in the case of straightforward screening and educating the patient and not in the case of professional diagnosing.

2. WHOeyes

WHOeyes is a part of the bigger concept of tele-ophthalmology since it was created to assist the community health workers within the low resource setting. It involves screening of basic near-vision, health questionnaire and educational modules in accordance with the standard of the screening as per the public health screening. Nevertheless, WHOeyes lacks such sophisticated diagnostics like the AI-based pupil tracking, the reflex testing, the detection of the nystagmus, and the analysis of the fatigue. Its weaknesses are its orientation on the public-health level: the app aims at population-level vision-screening, but not on the depth of a personal diagnosis or neurological examination.

3. Vision.app

Vision.app is categorized into two significant subcategories, which are mobile visual acidity visualization and smartphone-based colour vision visualization, due to the incorporation of the attributes of measuring visual acuity, colour vision testing, contrast sensitivity testing and an astigmatism screener. Although it has a broader assortment of tests, it does not have machine-learning-powered interpretation and cannot track eye-movement or analyze blinks or nystagmus. The system is completely based on test charts which are not dynamic and that is, the level of the depth of diagnosis is limited. Its high problem is that it does not offer dynamic ocular measurement and automated reporting making it unable to reach the accuracy of clinical grade diagnosis.

4. Peak Acuity

One of the most confirmed app smartphones visual acuity is Peak Acuity, which falls in the mobile VA category. The design facilitates high speed and accuracy VA screening in resource constrained and remote environments. Although quite reliable, Peek Acuity is consciously only applicable to VA testing, as it offers no AI diagnostics, nor any other form of test, like the assessment of the pupil reflex, colour vision, or eye-movement tracking. The limitation of its scope is its primary disadvantage, since it can not help make larger ocular or neuronal evaluations. It is a powerful screening tool though not a full-fledged clinical use.

5. EyeCheck

The product EyeCheck belongs to the category of colour-vision tests directly because its main aspect is an Ishihara-based colour discrimination test. This system is uncomplicated and user friendly but influenced by changes in brightness of the screens, colour calibration and ambient lighting. It is not equipped with any AI interpretation, dynamic measurement or automated reporting functionality. Its weakness is that it is exceedingly narrow-focused: the application can only be used to assess only one aspect of visual functioning and is incapable of assessing overall visual and eye health or detecting changes in neurology.

Main Features Comparison Matrix

Main Features	Peek Acuity	Vision.app	WHOeyes	EyePatient	EyeCheck	NetraCare
Visual Acuity Test	Y	Y	Y	Y	N	Y
Color Vision Test	N	N	N	N	Y	Y
Eye Movement Tracking	N	N	N	N	N	Y
Nystagmus Detection	N	N	N	N	N	Y
Blink and Fatigue Analysis	N	N	N	N	N	Y
Pupil Reflection Test	N	N	N	N	N	Y
AI based Report	N	N	N	N	N	Y

Critical Discussion

An examination of the current mobile eye-assessment applications reveals that the current applications focus on simplicity and ease of use instead of clinical diagnostic applications. Despite the fact that these apps are useful to facilitate basic visual tests and screening of the population in terms of their health, none of the apps embraces the views of the sophisticated technologies that are needed to integrate into modern tele-ophthalmology. The majority of tools depend on base charts, qualitative user reaction and manual interpretation, which lead to shallow diagnosis. Visual acuity screening programs like EyePatient or Peek Acuity are good applications, however, they are inappropriate because of their inability to monitor dynamic eye movements, neurological manifestations and subtle sensory impairments. In the meantime, Vision.app provides a greater number of types of tests, but it also does not support machine-learning and dynamic analysis.

What comes to the fore is that the current systems are in secluded settings; the apps are limited to a single area of eye health and cannot incorporate multimodal assessments in one diagnostic setup. They do not have intelligent interpretation, automated reporting, and longitudinal follow-up, which is why they cannot be used in the clinical workflow or in the management of diseases at an early stage. Consequently, these applications can still be helpful as supporting screening platforms instead of delivering an all-encompassing diagnostic platform, which supports the necessity of a more developed AI-enhanced system able to deliver trustworthy and multi-dimensional eye tests via a smartphone.

Gap Identification

Comprehensive analysis of the available mobile eye-assessment applications portrays certain areas of weakness in every system. An example of such is EyePatient, which has a drawback of relying solely on the use of static charts and no AI-based and analysis. It does not Favor colour-vision test, dynamic pupil testing, and eye-tracking. It is also limited because as far as basic education and self-monitoring are concerned, as well as because it does not have the capability to diagnose issues of visual pathway or neuro-ophthalmic functioning.

WHOeyes is useful in terms of screening the community but is not a diagnostic tool at the individual level. It also does not provide digital means to measure nystagmus, check pupil reflexes or assess eye orienting movements. The app is not aimed at individualized testing in case of clinical management or neurodiagnostic, but at the population level, and thus, cannot be used to underpin the clinical decision-making process or conduct neurological screening.

Vision.app offers vision services such as visual acuity, colour vision, contrast sensitivity, and screening of astigmatism. Nevertheless, it has shortcomings of lack of machine-learning interpretation, automated anomaly detection, and the ability to test dynamically. It is incapable of tracking eye movements, quantifying blinking, examining fatigue or detecting nystagmus and consequently there are critical areas of diagnostic failure affecting them.

Porter (Nisha Dulani, 2023)Visual Acuity refers to visual acuity, which is verified in Vision studies but is specifically designed to have only one purpose Picking Acuity. It does not provide an evaluation of colour vision, contrast sensitivity, pupil reactions and ocular movement. The app cannot identify dynamic abnormalities, as well as neurological signs and is only useful in primary vision screening and not clinical diagnostics.

Specializing in Ishihara-based colour vision testing alone, EyeCheck lies in the variability in screen-brightness and non-calibration. It does not provide any AI-based explanation or multi-category evaluation. Also, dynamic testing like pupil reflex, blinking, or tracking is not supported by EyeCheck which gives it a limited functionality as regards to only a single visual domain.

In all these systems, the lack of AI, incorporation of multimodal tests and the failure to capture dynamic ocular behavior are the main gaps that make these systems less applicable in clinical practice.

Gap Summary

To conclude, the current applications of mobile eye care deal with single aspects of eye testing and not the technological depth to make a thorough diagnosis. All the existing systems do not combine visual acuity analysis, colour vision testing, eye-movement tracking, nystagmus evaluation, and pupil reflex measurement into one system. They are further restricted in the clinical usefulness by the lack of AI-enhanced interpretation and automated reporting. That is where these missing features indicate the necessity of an improved, integrated system that would provide reliable, dynamic, and multi-dimensional eye examinations with the help of a smartphone only, which would contribute to both tele-ophthalmology and early neurological disease detection.

Conclusion

Based on the literature review and the results of the system analysis, it is evident that although there are already mobile eye-testing apps on the market with limited functionalities i.e., basic visual acuity tests or colour vision tests, none of them offer a well-developed, AI-based diagnosis tool. Studies prove that contemporary computer-vision approaches can precisely estimate movements of the eye, nystagmus, changes of the pupil, and fatigue with limited cameras of a regular smartphone, but they are almost not reflected in the existing applications. This loophole shows that an unified platform such as NetraCare is required by uniting various sophisticated screening functionalities into one convenient system. As a result, the study area is justified since it involves a real technological and health requirement by facilitating early diagnosis and enhancing the accessibility to primary eye care with particular reference to the under-serviced populations.

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