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PRACA ORYGINALNA
ORIGINAL PAPER

Mobile phone applications used to monitor age-related macular degeneration

Aplikacje na telefony komórkowe stosowane do monitorowania zwyrodnienia plamki żółtej związanego z wiekiem

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ABSTRACT

INTRODUCTION: Age-related macular degeneration (AMD) is a leading cause of vision loss among elderly individuals. The aim of the study was to analyze the practical value of available mobile applications used to monitor AMD.

MATERIAL AND METHODS: Between March 1–31, 2023, a quantitative and qualitative analysis of smartphone applications – available in Polish and English in the Google Play Store – was conducted using the keywords "age-related macular degeneration" and "AMD". The analysis included four qualitative criteria, scored on a scale of 0–2 points each: 1) disease monitoring capability, 2) user data protection, 3) availability of verbal instructions, and 4) application usability. Based on the total scores, the applications were classified into five quality levels: very high (8 pts), high (7 pts), medium (6 pts), below medium (5 pts), and low (≤ 4 pts). An ophthalmologist tested each app that met the inclusion criteria.

RESULTS: Of the 249 identified applications, only 14 met the inclusion criteria for analysis. Among these, two were classified as very high quality, three as high quality (none of which were in Polish), one as medium quality, and eight as low quality. Only two out of the 14 applications addressed AMD patients' needs, such as vision limitations and the use of verbal instructions.

CONCLUSIONS: The available applications in Polish offered no added value over the traditional paper-based Amsler test. For mobile applications to effectively aid in AMD monitoring, key aspects such as availability (preferably free) and quality, including data security, should be prioritized. Creating evaluation teams that include medical experts, IT specialists, and patient representatives would enhance the development and assessment of AMD-focused mobile applications.

KEYWORDS

age-related macular degeneration, AMD, mobile app, e-health in ophthalmology, mobile patient monitoring, mobile health, usability evaluation

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STRESZCZENIE

WPROWADZENIE: Zwyrodnienie plamki żółtej związane z wiekiem (*age-related macular degeneration* – AMD) jest główną przyczyną utraty wzroku u osób starszych. Celem badania była analiza praktycznej wartości dostępnych aplikacji mobilnych służących do monitorowania AMD.

MATERIAŁ I METODY: W okresie od 1 do 31 marca 2023 r. przeprowadzono analizę ilościową i jakościową aplikacji na smartfony – dostępnych w języku polskim i angielskim w sklepie Google Play – z użyciem słów kluczowych „zwyrodnienie plamki żółtej związane z wiekiem" i „AMD". Analiza obejmowała cztery kryteria jakościowe, oceniane w skali od 0 do 2 punktów każde: 1) możliwość monitorowania choroby, 2) ochrona danych użytkownika, 3) dostępność instrukcji ustnych oraz 4) użyteczność aplikacji. Na podstawie łącznej liczby punktów wyróżniono pięć poziomów jakości aplikacji: bardzo wysoki (8 pkt), wysoki (7 pkt), średni (6 pkt), poniżej średniego (5 pkt) oraz niski (≤ 4 pkt). Okulista przetestował każdą aplikację spełniającą kryteria włączenia.

WYNIKI: Spośród 249 zidentyfikowanych aplikacji tylko 14 spełniło kryteria włączenia do analizy. Spośród nich dwie scharakteryzowano jako bardzo wysokiej jakości, trzy jako wysokiej jakości (żadna z nich nie była w języku polskim), jedną jako średniej jakości i osiem jako niskiej jakości. Tylko dwie z 14 aplikacji odpowiadały potrzebom pacjentów z AMD, takim jak ograniczenia widzenia i stosowanie instrukcji ustnych.

WNIOSKI: Dostępne aplikacje w języku polskim nie oferowały żadnej wartości dodanej w porównaniu z tradycyjnym papierowym testem Amslera. Aby aplikacje mobilne skutecznie pomagały w monitorowaniu AMD, należy nadać priorytet kluczowym aspektom, takim jak dostępność (najlepiej bezpłatna) i jakość, w tym bezpieczeństwo danych. Utworzenie zespołów ewaluacyjnych, w których skład weszliby eksperci medyczni, specjaliści ds. IT i przedstawiciele pacjentów, usprawniłoby rozwój i ocenę aplikacji mobilnych ukierunkowanych na monitorowanie AMD.

SŁOWA KLUCZOWE

zwyrodnienie plamki związane z wiekiem, AMD, aplikacja mobilna, e-zdrowie w okulistyce, mobilne monitorowanie pacjenta, *mobile health*, ocena użyteczności

INTRODUCTION

Age-related macular degeneration (AMD) is an eye disease that is the leading cause of blindness in the industrialized world in people over 65 years of age [1]. Aging causes damage to the macula – the part of the eye that controls sharp, straight-ahead vision. AMD does not cause complete blindness but rather the loss of central vision [2]. In 2020, the number of people with AMD worldwide was 196 million [3]. Statistically, 80–85% of cases are limited to "dry" AMD with slower vision deprivation and statistically more preferable outcomes. The other 15–20% of patients are diagnosed with rapidly progressing neovascular, "wet" AMD, which is associated with the formation of choroidal neovascularization (CNV) and in a short time leads to factual blindness [4]. There are multiple variables, internal and external, that have been shown to increase the chance of AMD development. The risks non-modifiable for AMD include age over 60, Caucasian ethnicity [5], a family history of AMD, and the dysregulation of multiple genetic variants [6,7]. The modifiable factors that increase the risk of AMD are the presence of chronic diseases associated with oxidative stress such as atherosclerosis, and hyperlipidemia [8]. Smoking is the most consistently reported modifiable risk factor for AMD and is associated with a 2–4-fold increased risk for any form of AMD [9,10]. In turn, higher adherence to a Mediterranean diet was associated with a reduced risk of progression to advanced AMD [9,11,12]. In addition, studies have identified 39 proteins associated with visual function deprivation [13]. Gu et al. [14] suggest that defective systemic phagocytosis is associated with both intermediate and late stages of AMD, highlighting a potential role in the accumulation of cell debris that occurs early in the disease process. Another risk factor for AMD is drusen, which appears in the outer layers of the macula, i.e. the photoreceptor layer, the retinal pigment epithelium layer, and Bruch's membrane as extracellular deposits of lipids, proteins, and cellular debris. These sub-RPE deposits are seen with the progression of normal aging; however, depending on the size, number, location, and type of drusen involved, they can be associated with an increased risk of developing AMD [15].

Due to the possible asymptomatic course of AMD in its early, monocular stage, screening tests are essential for early diagnosis and adequate treatment. While no screening test can replace a visit to the ophthalmologist's office, there are simple methods to detect and monitor deformations in the macular structure. The most common is the Amsler grid. Straight lines appear to be curved and wavy in AMD patients and some other retinal pathologies [16]. Self-monitoring in AMD patients has involved the use of an Amsler chart (grid) since the late 1960s. The Amsler grid can evaluate the central 20° visual field when used at a 30 cm testing distance. The identification of subtle changes in visual function (such as distortion) may suggest AMD disease activity or recurrence [17,18]. The Amsler grid is the simplest form of a "remote/self-monitoring" test in chronic macular diseases available on smartphones. Some of these apps have the advantage of marking scotomas or distorted lines on the Amsler grid using the touch screen. Next, the images can be stored locally or digitally transmitted to the ophthalmologist. This can be especially helpful in assessing changes over time [19]. Remote patient monitoring may help facilitate access to specialized care [20].

The benefits of telemedicine are promising in the case of ophthalmology, which is a specialization based on imaging diagnostics [21]. The popularization of ophthalmic programs is an opportunity for better access to screening tools at an appropriate frequency [22]. Nevertheless, a few barriers may occur in the use of teleophthalmology: concern regarding the accuracy, high cost of the initial investment, poor quality of images, and unavailability of trained staff [23,24,25].

The ever-growing variety of available applications for chronic disease management poses difficulties regarding the choice of the most useful app available for both the specialists and patients involved [26].

Usability is a prerequisite for the success of health and wellness mobile apps [27]. Further advances in digital technology is an opportunity to improve the management of AMD [17].

Although applications for the phone are widely available, there are no guidelines assessing the quality of the applications so that they can be used in the best possible way, are adapted directly to a given disease and are safe for the patient.

The aim of the study was to analyze the practical value of available mobile applications used to monitor AMD.

MATERIAL AND METHODS

This study conducted a quantitative and qualitative analysis of AMD mobile applications, those related to the diagnosis and monitoring of the eye disease – AMD. The qualitative criteria were selected based on literature analysis [26,27].

The Play Store and Google Play Store were searched between March 1–31, 2023 for AMD-related applications. Keywords such as "AMD", and "age-related macular degeneration" were used. An ophthalmologist tested each app that met the inclusion criteria.

The data collection included whether the application was available for free or not and in English/Polish language.

The exclusion criteria constituted games and apps on eye diseases unrelated to AMD, and applications in a language other than English or Polish.

The criteria for assessing the quality of the application were as follows: 1) disease monitoring (the ability to save the results) 0–2 pts; 2) protection of user data (password protection) 0–2 pts; 3) presence of oral instructions 0–2 pts; 4) usability 0–2 pts.

The following quality criteria were adopted according to the number of points obtained (range 0–8 pts):

- ≤ 4 pts (≤ 50%) – low quality
- 5 pts (62.5%) – quality below average
- 6 pts (75%) – average quality
- 7 pts (87.5%) – high quality
- 8 pts (100%) – very high quality.

The evaluation criteria for the example of AMD applications are shown in Figure 1.

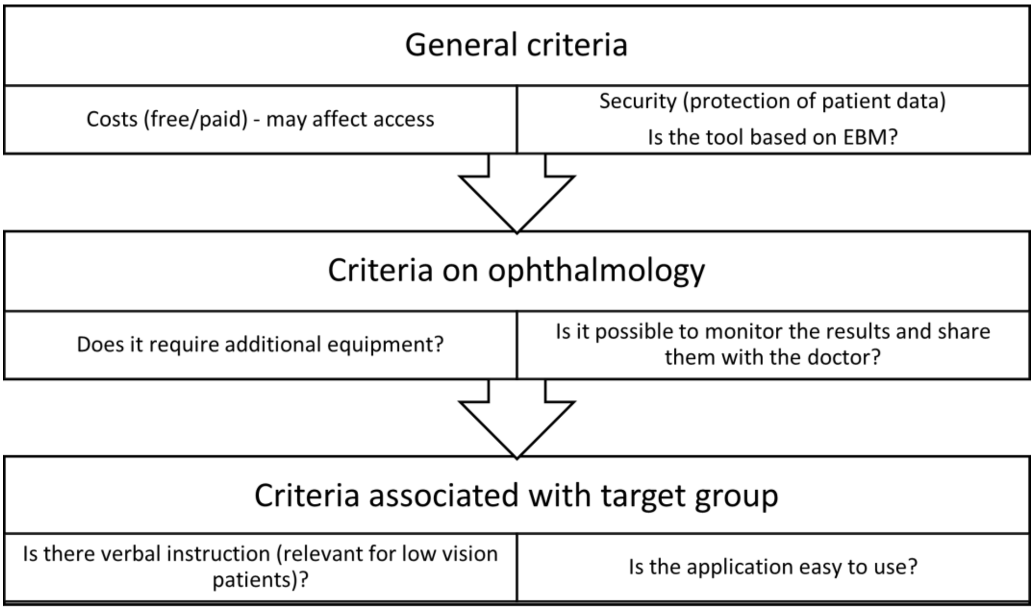

Fig. 1. Application evaluation criteria.

RESULTS

After the first search, 249 applications were found. After the rejection of non-AMD-related applications or in a language other than English or Polish, 48 applications concerning the AMD disease (Figure 2).

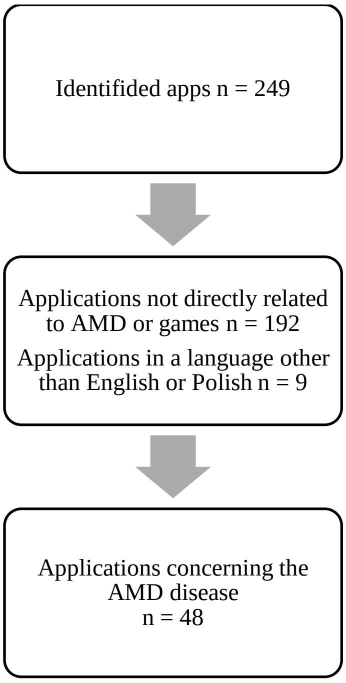

Fig. 2. Application collection process.

Distribution of applications – quantitative evaluation of the application

Out of the 48 applications concerning the AMD disease entity, 20 were related only to education about AMD, 7 applications related to nutrition and herbal medicine in AMD, and 6 applications in optical aid. Finally, applications whose purpose was the self-diagnosis and/or monitoring of AMD were included in the study. All the eligible apps were downloaded to test devices for final evaluation. 1 application was excluded from the study due to the inability to open it. 14 mobile applications were included in the final analysis.

Quality assessment of AMD diagnostic and/or monitoring applications

In this study, we observed that only 2 of the analyzed applications were classified as high-quality, and the majority scored 4 pts or less (57.14%; Table I).

Table I. Quality assessment of AMD diagnostic and/or monitoring applications (N = 14)

Number of points obtained	Number of applications N (%)
8 – very high quality	2 (14.29%)
7 – high quality	3 (21.42%)
6 – medium quality	1 (7.14%)
5 – quality below medium	0
≤ 4 – low quality	8 (57.14%)

AMD diagnostics and monitoring – applications available in Polish

In the analyzed period, only one application was available in Polish. It was an application available for free and had verbal instructions, however, it was not possible to mark the results on the Amsler grid nor to save them, and thus monitor changes in the disease progression.

DISCUSSION

After conducting a quantitative analysis, we showed that out of the 249 available mobile applications from the AMD area, only 14 were dedicated to AMD monitoring, of which only 1 was available in Polish.

When analyzing the available applications in terms of quality, only 2/14 applications took into account the needs of AMD patients, including vision limitations and the need to use verbal instructions. In addition, for applications to be effective tools supporting the treatment monitoring process, it is important to introduce a function that allows results to be saved, which requires the user to set up an account and raise the standards of protection of sensitive data. Therefore, traditional, paper measurement tools (Amsler test) have certain advantages over applications: a) they eliminate the risk of leakage of the patient's data, b) they are easily available in the ophthalmologist's office, c) they do not require a telephone or skills related to it, which is particularly important for this group of patients.

There is now a significant increase in digital health in ophthalmology. As Skrzypecki et al. [28] showed in a study analysis of the market for patient-oriented mobile applications in ophthalmology, the greatest number of applications was found for the subspecialization of macular degeneration (AMD). Lombardo et al. [29] stated that the benefits of prevention and early disease detection for prompt and effective treatment can be enormous to reduce the social and economic burden of AMD. Such activities should require the identification of patients at a higher risk of disease progression and the development of novel diagnostic technologies.

In this study, most of the analyzed applications were free (85.50%). Both the financial costs and language barriers can significantly affect the accessibility of the application. Nonetheless, not only the availability but also the quality of the application is essential for the patient as apps of poor quality can be difficult to use or have low diagnostic value and will ultimately fail to accomplish their goals [30]. Therefore, it is essential to have a set of criteria that can be used by all stakeholders to guide the application development and quality assessment process [31]. Few available health applications have undergone a thorough validation process, which results in a lack of trust in the healthcare profession [32]. Byambasuren et al. [33] suggest that independent and trustworthy sources should evaluate mHealth applications and recommend a set of trustworthy applications for healthcare professionals to refer patients to. Choritz et al. [19] demonstrate in their research that there are currently not enough certified and validated digital health applications for purposes that are already clinically safe for use. One of the solutions to this problem may be prescription-only applications designed for the healthcare environment and home [34].

The first problem observed during the analysis of the available applications is the fact that most of them (80% N = 198) did not refer directly to the disease in question. The process of searching for the right application may demotivate patients from using this technology, especially since AMD concerns the elderly.

In this study, of the 14 assessed applications from the Self-diagnosis applications category, the majority were low-quality applications (57.14%). As in the Yu et al. [35] study, the utility of the ForeseeHome home monitoring of AMD was limited, with a high false-positive rate for detecting AMD. In contrast, the study by Schmid et al. [36] evaluated the Amsler test and showed that the dot alignment test is a reliable, intuitive, and freely available self-monitoring tool that allows patients to screen and monitor their macular function regularly at home using their smartphones or tablets.

Research on mobile applications in AMD disease is promising. Gross et al. [37] showed that patients capable of performing mobile hyperacuity home monitoring benefit in terms of visual acuity and discontinue treatment less often than patients not using home monitoring. Also, Islam et al. [38] compared the results of home monitoring for macular distortion using a smartphone app with a hospital visual acuity (VA) assessment and found that the smartphone-based self-tests for the macular disease could serve as reliable indicators of worsening of the disease. Chen and Adelman [39] evaluated the Hyperacuity App (HAC) as a disease progression screen tool in AMD and concluded that HAC has the potential for screening AMD. In turn, Schmid et al. [36] assessed the reliability and performance of the Food and Drug Administration (FDA) approved application for the self-detection of AMD.

As shown by a systematic review from 2021, the potential for the development of digital technologies not related to artificial intelligence is highly anticipated in ophthalmology. It is helpful to use the full potential of digital health technologies in ophthalmology to correctly identify real clinical problems and match current needs with appropriate innovation in the field of digital health [40].

This study also has its limitations – the analysis does not include applications available on the iPhone. In this study, we only analyzed applications in Polish and English, which is not an analysis of all the available applications in the case of AMD. Future research should consider evaluating the security of data storage in more detail, like profile personalization, and end-to-end data encryption if the results are stored externally, and to use the advantage of the knowledge and experience of IT specialists in app evaluation.

CONCLUSIONS

The optimal characteristics for the AMD screening mobile application were determined: 1) having verbal instruction as AMD patients have impaired visual acuity; 2) being available in the native language of a given country – for easier understanding; 3) free of charge – for availability; 4) with the possibility of saving the results, and thus monitoring changes in AMD progression.

Considering the fact that AMD disease mainly affects people over the age of 60, applications available in English may be an obstacle for Polish patients. The creation of a high-quality application in Polish could positively affect the diagnosis and monitoring of AMD among the Polish elderly population. Due to the large number of available applications, and the long process of finding an application that meets certain requirements, medical personnel should be able to recommend the best possible application customized to the patient's needs. This study shows how important it is to use application quality assessment in cooperation with specific specialists so that the created applications are as reliable and helpful as possible for both the patient and the assessment of the results received by means of the application.

Using the experience of other countries, it is worth introducing legal regulations in Poland regarding mobile applications, and then take action to inform patients at the primary care level about reliable mobile applications, the use of which could bring tangible benefits.

Our research can facilitate the development of high-quality AMD applications necessary for the diagnosis and treatment process – helpful for doctors and patients.

Advantages and limitations

Due to the rapid development of mobile applications and the impossibility of using uniform criteria for evaluating mobile applications for all disease entities, this article presents specific criteria for evaluating applications only for AMD. A limitation of the study is that it included only apps available for smartphones and did not include apps available for iPhones.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author's contribution

Study design – A. Rogalska, E. Kurzak
Data collection – A. Rogalska, E. Kurzak
Data interpretation – E. Kurzak
Statistical analysis – Not applicable
Manuscript preparation – A. Rogalska, E. Kurzak
Literature research – A. Rogalska

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