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Application of mobile health (mHealth) in the field of eye care: A scoping review of interventions used by individuals and health services to communicate

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ABSTRACT

Mobile health (mhealth) has the potential to become a powerful tool to support healthcare delivery in various ways, but there is a gap in the understanding on the impact of mHealth interventions used in eyecare. The aim of this scoping review is to collate, synthesise and describe the types of mHealth interventions in eye care. We searched MEDLINE, Embase and Global Health on 2 March 2021, July 13th 2023 and August 8th 2024 for any mHealth intervention that is available within an eyecare service and involves communication between patients and health professionals. Fifty-nine studies were included in the scoping review. The results highlight the extensive areas in eye health where mHealth is currently being applied, including a range of settings, modalities and intervention types. Predominantly, mHealth is used for multiple eye conditions and interventions aiming to increase adherence to treatments, improve appointment attendance, and raise awareness of eyecare. However, the specific modes of delivery and types of interventions (simple or complex) that are most effective remain unclear. This scoping review highlights there is significant interest and potential for mHealth interventions to improve communication between eye care professionals and patients across various settings and modalities. Despite the promising applications of mHealth to eye care, the effectiveness of these interventions can vary widely across different settings. To maximise the benefits of mHealth in eye care, future research should aim to address these gaps, especially within diverse socio-economic contexts.

1. Introduction

Mobile health (mHealth) is a rapidly growing field that is described by WHO as the *use of mobile and wireless technologies to support the achievement of health objectives, which can include the improvement of outcomes, healthcare services and health research.*[1,2] Whilst all mobile technologies that can transmit data are included in the definition of mHealth, mobile phones are currently the most popular for mHealth delivery.

There are more than three billion smartphone users worldwide, with that number expected to rise in coming years.[3] Low- and middle-income countries are leading this growth. It is estimated that by 2025 there will be 600 million new subscribers annually, with 73 % in Latin America, Sub-Saharan Africa and Asia-Pacific (excluding China).[4] This increasing ownership and coverage of smartphones with internet connectivity means that mHealth has the potential to become a powerful tool to support healthcare delivery in various ways. Mobile phones can be used for short messaging service (SMS), voice/video calling and smartphone applications. There are thousands of smartphone applications (apps) available for download under the 'health' category, however, not all of them are created based on evidence-based content.

In 2011, a global WHO survey showed that 8 3 % of the 114 countries surveyed implemented at least one form of mHealth service.[2] Over the past five years, as for other healthcare sectors, the availability, usability,

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accessibility and acceptability of mobile phone and smartphone applications has increased in the field of eye care, particularly in terms of digital clinical guidelines, applications to support clinical skills such as contact lens conversion calculators and vision tests.[5–11]

1.1. Rationale

The WHO classifies mHealth into six categories[2] that are described in Table 1. Based on the World Report on Vision, the WHO would like to 'Raise awareness and engage and empower people and communities.' To our knowledge, there is a gap in the understanding on the impact of mHealth interventions used in eyecare. This review will provide guidance for the WHO on the application of mHealth interventions in eyecare, specifically those focusing on communication between individuals and eye health services (categories 1 and 2 below).

1.2. Aim

The aim of this scoping review is to collate, synthesize and describe the types of mHealth interventions in eye care, where they provide information to raise awareness about services, provide condition specific information or encourage individuals to adopt or maintain a treatment, or to attend an appointment.

1.2.1. Objectives/scoping review questions

We aim to answer the following questions in this scoping review:

- What is the nature and extent of the published evidence on the use of mHealth interventions that involve communication between individuals and eye health services and vice versa?

For each mHealth intervention identified, we aim to answer the following questions:

- What setting has the mHealth intervention been developed for?
- What setting has the mHealth intervention been implemented in?
- Has the mHealth intervention been evaluated and if so, how?
- What is the evidence for effectiveness of the mHealth intervention?

2. Methods

2.1. Protocol and registration

A detailed protocol was registered prospectively with the Open Science Framework on 30 August 2021 (https://osf.io/sx53w/). The scoping review is reported according to the relevant sections of the PRISMA Extension for Scoping Reviews (PRISMA-ScR) guideline (Appendix 1).

Table 1
WHO classifications of mHealth.

Category	Name	Example
1	Communication between individuals and health services	• Health call centres/Health care telephone help line • Emergency toll-free telephone services
2	Communication between health services and individuals	• Treatment compliance • Appointment reminders • Community mobilization • Awareness raising over health issues
3	Consultation between health care professionals	• Mobile telemedicine
4	Intersectoral communication in emergencies	• Emergencies
5	Health monitoring and surveillance	• Mobile surveys (surveys by mobile phone) • Surveillance • Patient monitoring
6	Access to information for health care professionals at point of care	• Information and decision support systems • Patient records

2.2. Article screening

We searched MEDLINE, Embase and Global Health on 2 March 2021 using a search strategy developed by an experienced Information Specialist (IG) to find any mHealth intervention that is available within an eyecare service. Additional searches were performed on July 13th 2023 and on August 8th 2024. The MEDLINE search is included as an appendix to this article. We limited the searches to articles published since 1 January 2000 due to the use of mobile phones and availability and accessibility to mHealth applications being limited prior to 2000. There was no language restriction. The results were exported into web-based review management software Covidence Veritas Health Innovation, Melbourne, Australia; available at www.covidence.org).

Only primary research studies were included; however, reference lists from review studies were used to identify any additional potentially relevant studies. Only manuscripts published in peer-reviewed literature were selected, grey literature (reports, policy statements. We also excluded mHealth interventions in eye care that are used for: consultation between health care professionals; Intersectoral communication in emergencies; health monitoring and surveillance and access to information for health care professionals at point of care. Clinical telemedicine interventions were excluded unless they were used as a category 2 communication tool as defined by WHO.

As the data sourced covered a wide range, the protocol was modified to focus on mobile phone interventions. Therefore, interventions that used radio technologies were excluded, and landline phone calls were included only if they integrated novel mHealth technologies such as automated phone calls. Mobile technology, represents a distinct and evolving area of digital health interventions. While we acknowledge that landline phones and radio technologies have long been used in resource-limited settings, our aim was to examine the unique contributions and implications of mobile-based approaches. Four authors (PM, JM, AH, CB) independently screened the abstracts, full texts and extracted the data using Covidence software (Veritas Health Innovation, Melbourne, Australia (www.covidence.org)). Any discrepancies between the authors were resolved by discussion. If consensus could not be reached, a fifth author was consulted. While we did not formally calculate inter-rater reliability, we ensured consistency through regular calibration discussions throughout the screening process.

2.3. Data extraction

The data charting form was developed in Microsoft Excel and included initially the study characteristics, the broad mHealth mode that was used to deliver the intervention, the setting in which the intervention has been developed and implemented, the intended effect of the mHealth intervention and its effectiveness if evaluated. However, the data charting was an iterative process throughout the review considering that most studies provided very few details on the intervention settings and focused mostly on outcomes. Therefore, protocol was modified during analysis to highlight the characteristics of the interventions to differentiate those with positive outcomes. Moreover, the research questions were redefined based on the obtained data:

- What are the main characteristics of the intervention?
- What mode of delivery has been used for communication between health professionals and patients?
- What is the intended effect of the intervention based on the WHO classification?
- Has the mHealth intervention reached its desired outcome?

Lastly, many mHealth communication interventions were included in more complex interventions, combining them with counselling, discussion groups, printed material etc., To isolate the impact of the communication aspect of the mHealth intervention, it was therefore necessary to classify the intervention as either 'simple 'or 'complex'. A 'simple' intervention was defined as one where the outcome depended on a single-component mechanism with a direct link between the intervention and the outcome, whereas the 'complex' intervention involved multiple interacting components, pathways or behavioural mechanisms . This is in line with the UK Medical Research Council framework.

3. Results

3.1. Literature search

Our searches yielded 5085 studies. After hand searching the reference lists from review papers, we identified one further reference that met our inclusion criteria. Following deduplication, a total of 3709 titles and abstracts were screened, and 207 full-text articles were assessed for eligibility (Fig. 1 PRISMA flow diagram). Of these, we identified 59 studies that fulfilled the eligibility criteria and were included in the scoping review (Table 2).

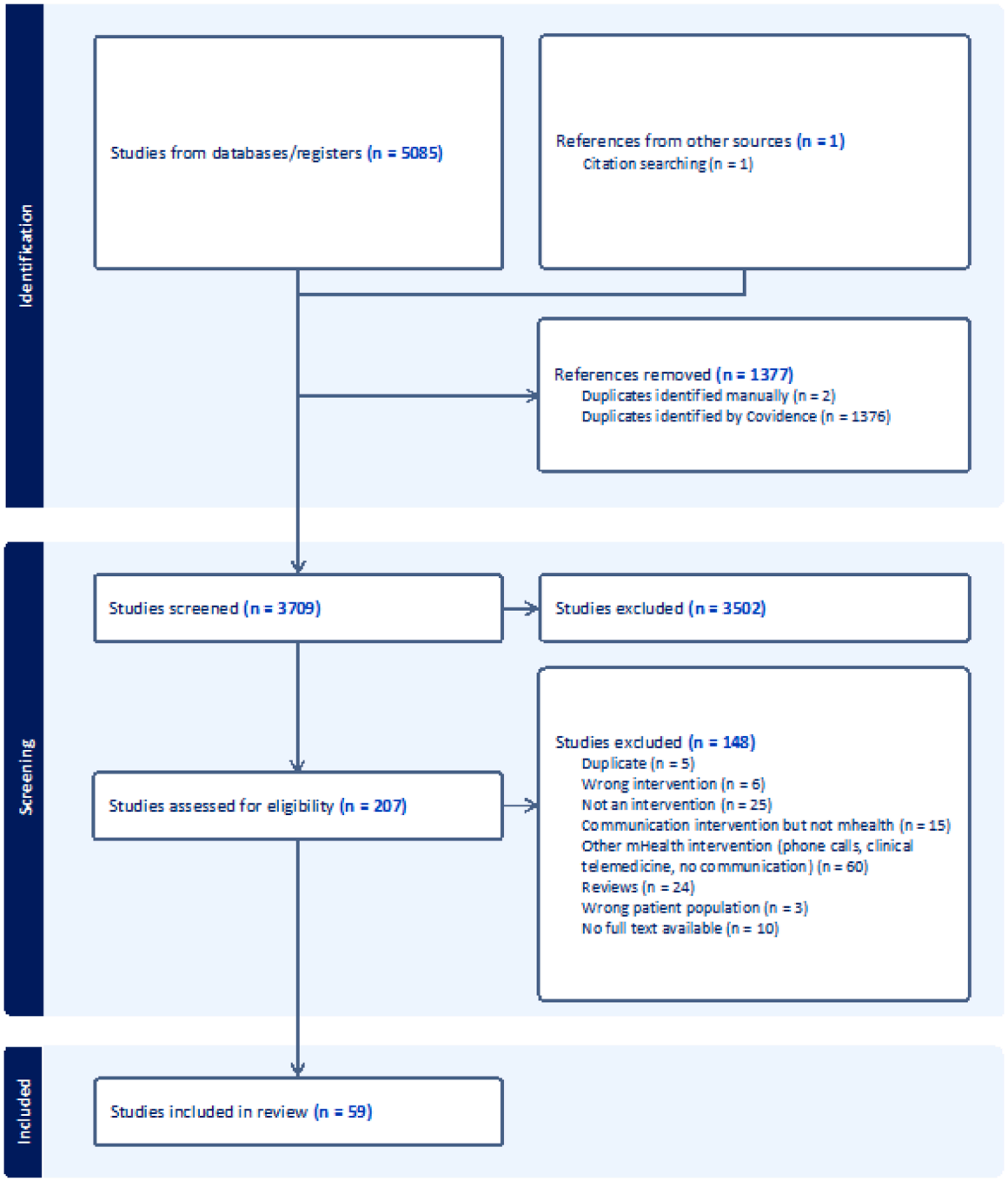

Fig. 1. PRISMA flow chart of literature search.

Table 2
Overview of papers describing mHealth interventions in eye care included in the scoping review.

First author	Title	Year	Country	Study design	Population	Setting
Andersen[12]	Implementing a School Vision Screening Program in Botswana Using Smartphone Technology	2020	Botswana	Before and after quasi-experimental study	Parents of children 6–22 yo testing positive to screening (n = 2065)	Community
Aravich[13]	Exploring the Impact of a Hybrid Telehealth Program for Adults Living with Low Vision: A Descriptive, Qualitative, Exploratory Pilot Program Evaluation	2022	USA	Mixed methods study	15 participants, 19–95 yo in low-vision occupational therapy rehabilitation programs	Low vision rehabilitation centre
Aazami[14]	How Does the Visual Function and GlaucomaRelated Quality of Life Vary After an Educational Intervention?	2024	Iran	RCT	80 participants, glaucoma patients attending an urban outpatient ophthalmology clinic	Ophthalmology clinic
Barbour-Hastie[15]	Teaching home tonometry using a remote video link	2023	UK	Feasibility study	12 patients with glaucoma (mean age 60 yo)	Glaucoma clinic
Bittner[16]	Acceptability of Telerehabilitation for Magnification Devices for the Visually Impaired Using Various Approaches to Facilitate Accessibility.	2022	USA	Mixed methods study	58 visually impaired adults in low vision rehabilitation clinics (average 71 yo)	Low vision rehabilitation centre
Bittner[17]	Telerehabilitation Training to Facilitate Improved Reading Ability with New Magnification Devices for Low Vision.	2022	USA	Pilot study (before and after quasi-experimental design)	14 adults (mean age 68 yo) in low vision rehabilitation clinic	Low vision rehabilitation centre
Bittner[18]	Outcomes of Telerehabilitation Versus In-Office Training With Magnification Devices for Low Vision: A Randomized Controlled Trial	2024	USA	RCT	61 participants, 20–93 yo visually impaired adults attending vision rehabs clinics	Low vision rehabilitation centre
Boland[19]	Automated Telecommunication-Based Reminders and Adherence With Once-Daily Glaucoma Medication Dosing The Automated Dosing Reminder Study	2014	USA	Prospective cohort study	70 glaucoma patients (mean age 62–69 yo) with poor adherence with their medications	Glaucoma clinic
Cao[20]	Evaluation of Social Platform-Based Continuity of Care in Improving Cognitive and Prognostic Effects of Young Patients with Diabetic Retinopathy	2023	China	RCT	'Young' diabetic patients without diabetic retinopathy	Outpatient endocrine and ophthalmology clinic
Chahal[21]	Lifestyle Measures for Glaucoma Patients: An Objective Social Media Content Analysis	2023	Global (The study reviews social media content from various platforms accessible worldwide)	Cross-sectional study (content analysis)	Not applicable (as the study is content analysis, not patient-focused). The study analyzed social media content related to lifestyle measures for glaucoma patients across platforms such as Google, YouTube, Facebook, and Reddit.	Global (The study reviews content from internet-based platforms, including Google websites, Google images, YouTube, Facebook, and Reddit, accessible worldwide).
Chang[22]	Effect of smartphone application assisted medical service on follow-up adherence improvement in paediatric cataract patients.	2018	China	Prospective cohort study	163 parents of children with paediatric cataract	Ophthalmology clinic
Chen[23]	A Mobile Phone Informational Reminder to Improve Eye Care Adherence Among Diabetic Patients in Rural China: A Randomized Controlled Trial.	2018	China	RCT	233 patients diagnosed with diabetes	Ophthalmology clinic
Chen[24]	The impact of an interactive, multifaceted education approach for congenital cataract on parental anxiety, knowledge and satisfaction: A randomized, controlled trial	2020	China	RCT	177 parents of children with congenital cataract	Hospitals
Dhiman[25]	A Pilot Nurse-Led Tele-Counselling Intervention to Parents of Children With Cerebral Visual Impairment on Adherence to Eye Activities During COVID-19 Pandemic: A Pre-experimental Study	2022	India	Before and after quasi-experimental study	21 children with cerebral visual impairment (mean age of 3 yo)	Paediatric ophthalmology clinic
Digin[26]	Effect of Sending SMS, Which Reminds About the Intake of Medication, on Reducing Postoperative Anxiety in Patients	2022	Turkey	RCT	82 patients who underwent cataracts surgery (mean age 57.6 yo)	Ophthalmology clinic

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Table 2 (*continued*)

First author	Title	Year	Country	Study design	Population	Setting
	Undergoing Cataract Surgery: A Randomized Controlled Study.					
Fan[27]	The efficiency of quick response code versus telephone contact for post-discharge follow-up after ophthalmic day surgery: a randomized controlled trial	2023	China	RCT	160 patients 18–60 yo (mean age 24–27 yo) scheduled for monocular strabismus surgery under general anaesthesia	Hospital
Finger[28]	The Retina Hotline: eighteen-month results from a telephone hotline for patients with retinal diseases.	2010	Germany	Cross-sectional study	1384 patients >60 yo with retinal disease	Ophthalmology department of university
Fudemberg[29]	Factors contributing to nonadherence to follow-up appointments in a resident glaucoma clinic versus primary eye care clinic	2016	USA	Retrospective cohort	295 glaucoma and suspect glaucoma patients >21 yo	Glaucoma clinic
Glanz[30]	Impact of a Health Communication Intervention to Improve Glaucoma Treatment Adherence: Results of the I-SIGHT Trial	2012	USA	RCT	312 glaucoma patients non adherent to taking meds, and/or appts (18–80 yo)	Hospitals
Gunasekeran[31]	Population eye health education using augmented reality and virtual reality: scalable tools during and beyond COVID-19	2021	Singapore	Before and after quasi-experimental study	20 outpatients 17–68 yo (mean 33.2) of a tertiary referral eye centre (opportunistic eye screening)	Tertiary referral eye centre
Hoffelt[32]	Glaucoma public service announcements: factors associated with follow-up of participants with risk factors for glaucoma.	2011	USA	Cross-sectional study	6343 participants in a Glaucoma EyeCare Program by calling a toll- free telephone number	Nationwide public announcement
Ihrig[33]	Home Low Vision Ocular Rehabilitation Telehealth Expansion Due to COVID-19 Pandemic.	2022	USA	Retrospective audit	Veterans attending low vision rehabilitation clinic (details not specified)	Low vision rehabilitation centre
Jiachu[34]	Predictors of long-terms cataract surgical patient satisfaction found in cell-phone follow-up in a primarily Tibetan region of China	2015	China	Cross-sectional study	441 patients with ocular pathology or surgical complications (mean 65 yo)	Hospital
Katibeh[35]	Eye Care Utilization in A Community-oriented Mobile Screening Programme for Improving Eye Health in Iran: A Cluster Randomized Trial	2020	Iran	RCT	2520 patients ≥50 yo diagnosed with diabetes	Community
Kayabaşı[36]	Evaluating the quality and reliability of YouTube videos on myopia: a video content analysis	2024	Global (The study analyses YouTube content, which is accessible globally)	Cross-sectional study (content analysis)	Not applicable (as the study is content analysis, not patient-focused). The study analyzed YouTube videos related to myopia.	Global (The study analyzes YouTube videos, which are accessible worldwide).
Khanvadi[37]	User-acceptability of an automated telephone call for post- operative follow-up after uncomplicated cataract surgery	2023	UK	Mixed methods study	177 patients having routine, uncomplicated cataract surgery (median of 76 yo)	Hospital
Koshy[38]	Effectiveness of mobile-phone short message service (SMS) reminders for ophthalmology outpatient appointments: observational study	2008	UK	RCT	9626 first time attendees for any ophthalmology appointment	Hospital
Kumar[39]	Attendance Rate in Patients with Diabetic Macular Oedema Receiving Short Messages.	2021	India	RCT	200 diabetic patients with a diagnosis of centre-involving, sight-threatening DME in a tertiary eye hospital (mean age 59.5 yo)	Tertiary eye hospital
Lai[40]	The Effect of Patient Education and Telemedicine Reminders on Adherence to Eye Drops for Glaucoma	2020	Singapore	RCT	59 glaucoma patients using 3 or more eye drops (average 65 yo)	Ophthalmology clinic
Lai[41]	The use of short message service (SMS) to reduce outpatient attendance in ophthalmic clinics during the coronavirus pandemic.	2021	Hong Kong	Prospective Cohort	Adult patients attending ophthalmology clinics of a tertiary eye centre (no details specified in manuscript)	Ophthalmology clinic (hospital)
Leshno[42]	A novel EyePhone© App for improving adherence to glaucoma therapy	2021	Israel	Before and after quasi-experimental study	133 glaucoma patients who were potentially capable of using the EyePhone© App. (average 62 yo)	Glaucoma clinic
Li[43]	Impact of Mobile-Based Health Education on the Awareness and Knowledge of Glaucoma in Chinese Patients	2019	China	Cross-sectional study	1441 patients >18 yo at eye department diagnosed and not diagnosed with glaucoma	Schools

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Table 2 (*continued*)

First author	Title	Year	Country	Study design	Population	Setting
Li[44]	Effect of School-Based Family Health Education via Social Media on Children's Myopia and Parents' Awareness: A Randomized Clinical Trial.	2021	China	RCT	1525 Grade 1 (6–7 yo) students from public primary schools in Guangzhou	Hospital
Lim[45]	Adherence to Glaucoma Medication: The Effect of Interventions and Association With Personality Type	2013	USA	RCT	80 glaucoma patients using prostaglandin monotherapy	Glaucoma clinic
Lin[46]	Effectiveness of a short message reminder in increasing compliance with paediatric cataract treatment: a randomized trial	2012	China	RCT	258 parents of children diagnosed with congenital and development cataract	Paediatric ophthalmology clinic
Mehranbod[47]	Automated Reminders Improve Retinal Screening Rates in Low Income, Minority Patients with Diabetes and Correct the African American Disparity	2020	USA	RCT	301 diabetic patients due for a DR screening (mean age 57 yo)	Health clinic
Ming[48]	Myopia information on TikTok: analysis factors that impact video quality and audience engagement	2024	Global (The study analyses TikTok content, which is accessible globally)	Cross-sectional study (content analysis)	Not applicable (as the study is content analysis, not patient-focused). The study analyzed TikTok videos related to myopia.	Global (The study analyzes TikTok content, which is accessible worldwide).
Morjaria[49]	Effectiveness of a novel mobile health (Peek) and education intervention on spectacle wear amongst children in India: Results from a randomized superiority trial in India	2020	India	RCT	701 parents of children 11–15 yo requiring spectacles or referral for eye conditions	Schools
Newman-Casey[50]	Personalized behavior change program for glaucoma patients with poor adherence: A pilot interventional cohort study with a pre-post design	2018	USA	Before and after quasi-experimental study (protocol)	Glaucoma patients taking ≥ 1 medication	Ophthalmology clinic
Newman-Casey[51]	The Support, Educate, Empower (SEE) Personalized Glaucoma Coaching Trial Design	2023	USA	Before and after quasi-experimental study (protocol)	Glaucoma patients from two medical centers (low income and minority populations; no details in manuscript)	Ophthalmology clinic
Osahon[52]	Assessment of the impact of medPlan, a medication reminder mobile application, in glaucoma patients in Benin City, Nigeria	2020	Nigeria	RCT	200 glaucoma patients (no details in manuscript)	Hospital
Patel[53]	Patient information videos via QR codes: An innovative and sustainable approach in ophthalmology	2024	United Kingdom	Prospective observational study	Glaucoma patients attending the Ninewells Hospital glaucoma department, United Kingdom. Age range: 32–90 years, median age: 72, sample size: 130.	Glaucoma clinic
Pizzi[54]	Prospective randomized controlled trial comparing the outcomes and costs of two eyecare adherence interventions in diabetes patients	2015	USA	RCT	356 diabetic patients (mean 61 yo) due for a DR screening	Ophthalmology clinic
Rai[55]	Clinical and cost impact of a paediatric cataract follow-up program in western Nepal and adjacent northern Indian States	2014	Nepal	Before and after quasi-experimental study	Parents of children who do not attend follow-up appointment (no details in manuscript)	Ophthalmology clinic
Rono[56]	Smartphone-based screening for visual impairment in Kenyan school children: a cluster randomised controlled trial	2018	Kenya	RCT	897 parents of schoolchildren who need to attend a hospital appointment post vision screening	Schools
Rono[57]	Effectiveness of an mHealth system on access to eye health services in Kenya: a cluster-randomised controlled trial.	2021	Kenya	RCT	128 591 people from 36 communities (age not specified)	Community
Salihu[58]	The Effect of a Reminder Short Message Service on the Uptake of Glaucoma Screening by First-Degree Relatives of Glaucoma Patients: A Randomized Controlled Trial	2019	Nigeria	RCT	96 patients with primary open angle glaucoma (mean age 56 yo)	Tertiary eye hospital
Sanguansak[59]	Two-Way Social Media Messaging in Postoperative Cataract Surgical Patients: Prospective Interventional Study	2017	Thailand	RCT	98 patients undergoing first eye cataract surgery	Hospital
Sun[60]	A cooperative management app for parents with myopic children wearing orthokeratology lenses: Mixed methods pilot study	2021	Taiwan	Mixed methods study	30 parents and their children with orthokeratology 7–12 yo	Ophthalmology clinic

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Table 2 (*continued*)

First author	Title	Year	Country	Study design	Population	Setting
Tavares[61]	Amblyopic patient adherence under patching treatment	2023	Brazil	RCT	34 patients up to 12 years of age with a diagnosis of amblyopia with $a > 2$ line difference in corrected VA	Paediatric ophthalmology clinic
Uttamapinan[62]	Effectiveness of the smartphone application in increasing compliance with occlusion therapy in children with amblyopia: a randomized controlled trial	2024	Thailand	RCT	Children aged 4–12 years with unilateral strabismic, anisometropic, deprivation, or mixed-type amblyopia. Total of 45 children enrolled in the study.	Ophthalmology clinic
Vagge[63]	A pilot study using electronic reminders for amblyopia treatment	2018	USA	RCT	24 parents of children 3–7 yo with amblyopia treatment	Paediatric ophthalmology clinic
Valente[64]	Development and usability evaluation of an application for patients with glaucoma.	2021	Brazil	Cross-sectional study	36 glaucoma patients (51 yo)	Ophthalmology clinic
Vinekar[65]	Improving Follow-up of Infants during Retinopathy of Prematurity Screening in Rural Areas	2016	India	Before and after quasi-experimental study	1510 parents of children with ROP	Neonatal intensive care units
Waisbourd[66]	The Wills Eye Glaucoma App: Interest of Patients and Their Caregivers in a Smartphone-based and Tablet-based Glaucoma Application	2016	USA	Cross-sectional study	50 glaucoma patients and their caregivers (mean age 60 yo)	Glaucoma clinic
Xiao[67]	Content Design and System Implementation of a Teleophthalmology System for Eye Disease Diagnosis and Treatment and Its Preliminary Practice in Guangdong, China	2017	China	RCT	Patients diagnosed with diabetes and require DR screening (no details in manuscript)	Hospitals
Yang[68]	Interventions to Promote Follow-up After Trabeculectomy Surgery in Rural Southern China: A Randomized Clinical Trial	2016	China	RCT	209 patients undergoing trabeculectomy (mean age 64 yo)	Hospitals
Yen[69]	Taipei's use of a multi-channel mass risk communication program to rapidly reverse an epidemic of highly communicable disease	2009	Taiwan	Mixed methods study	All residents of Taipei (2.2million)	Nationwide public announcement
Zangalli[70]	An Education- and Telephone-Based Intervention to Improve Follow-up to Vision Care in Patients With Diabetes: A Prospective, Single-Blinded, Randomized Trial.	2016	USA	RCT	468 patients >18 yo diagnosed with diabetes and require DR screening	Ophthalmology clinic

3.2. Summary of publications

Characteristics of the selected studies are presented in Table 2. As expected, >84 % of the total were published after 2015. Interestingly, only nine of these studies were conducted in low- and lower-middle income countries (LMICs). Study populations also varied widely, most targeting older adult patients with pre-existing conditions ($n = 34$) and a smaller number targeting children or their parents ($n = 14$). Most of the studies targeted mHealth interventions at people who have glaucoma ($n = 20$), followed by diabetic retinopathy ($n = 8$). The majority of studies were held in ophthalmology clinics or hospital departments ($n = 41$), and five were implemented in low vision rehabilitation centres. A small number took place in communities ($n = 3$) or school-based ($n = 3$). Three studies focussed on social media content analyses, evaluating the quality and reliability of information related to eye health conditions.

The most common study design used was a randomized controlled trial (RCT) ($n = 29$). Observational studies ($n = 12$) included cross-sectional ($n = 6$), prospective cohort ($n = 3$), and retrospective cohort ($n = 1$) studies, as well as a retrospective audit ($n = 1$). There were also quasi-experimental studies ($n = 9$), which included pre-post (before-and-after) designs, two of which were protocols only. Additionally, there were five mixed methods studies, three content analyses and one feasibility study.

As mentioned earlier, very few details were provided by authors on the settings for which the intervention was developed for or implemented in Therefore, our analysis focused mainly on the characteristics of interventions, mainly the delivery mode, the intended outcomes and its effectiveness.

3.3. Mode of mHealth intervention delivery

The results established a variety of delivery modes in which mHealth interventions in the field of eye care facilitate communication between health services and individual (Table 2).

Short message services (SMS) were the most common mode of delivering mHealth interventions, representing 18 of the 51 of the included studies. They were mostly delivered as appointment or treatment reminders.[19,23,26,38–41,46,50,56,58,61,67,68] A few studies used SMS to deliver results[35] and referral information after community screenings,[12,57] and another one employed mass regional SMS notifications in a multi-channel communication strategy.[69]

The 16 included studies reporting use of phone calls implemented these as automated phone calls,[19,29,45,47,51,54,70] interactive voice recognition technologies,[30,37] mobile phone calls,[34,55] phone helplines,[28,32,65] or voice messages.[49,50]

The use of applications on suitable hardware (smartphones or tablets) was another popular mode of delivery of mHealth intervention. Of the included studies, 13 applied several types of mobile applications, some general treatment reminder apps[52,63] and some specifically designed for eye care,[31,42,60,62,66,71] one of them designed as a virtual reality and augmented reality platform.[31] In addition, various messaging applications such as WeChat and WhatsApp were used to create

communication channels between practitioners and patients.[14,20,22,24,25,43,44,59] WeChat was also used by Fan et al. to read a QR code leading to a web-based questionnaire for patients.[27] Similarly, a glaucoma patient information video linked to a QR code was created, allowing patients to view and complete pre- and post-viewing questionnaires to assess their understanding of glaucoma.[53] In addition to targeted interventions, content analyses explored the role of various social media applications commonly accessed by mobile devices in disseminating health information related to eye conditions, such as glaucoma and myopia.[21,36,48]

Six interventions involved videoconferencing to deliver services to patients through different platforms such as Zoom, Microsoft Teams, Facetime or NearMe.[13,15–18,33]

3.4. Intended effects of mHealth communication interventions

The vast majority ($n = 52$) of the selected interventions were used to enhance communication between health professionals and patients (WHO's mHealth category 2[2]), with only three studies involving communication from patients to health professionals through phone helplines (category 1).[28,32,65] However, most of the category 2 interventions included the possibility to reach the clinician in some way (email, phone call or SMS).

The intended effect of the interventions were categorized into five broad outcomes based on the WHO classifications of mHealt:h2

i. Provide support for treatment compliance
ii. Improve appointment attendance
iii. Raise awareness on eye health
iv. Increase satisfaction from patients
v. Reach communities to increase utilization of eyecare services

3.4.1. Provide support for treatment compliance

Improving treatment compliance was the most frequently reported mHealth intervention outcome ($n = 23$), and included support for patients with self-administered medication, support for parents to increase compliance of their children to treatment, support for treatment plan adherence and to improve assistance in low vision rehabilitation services.

Twelve mHealth interventions were developed to provide additional support for patients to maintain their glaucoma medication treatment plans. In some cases, SMS or automated phone calls were sent to patients with glaucoma as reminders patients to take their glaucoma medication.[40,45,50] Some authors specifically targeted patients who had a history of barriers to implementing recommended treatment.[19,51] Additionally, an educational intervention was designed to provide support to a patients glaucoma treatment plan delivered by podcasts via Telegram/WhatsApp.[14]

Another approach to deliver medication reminders is via smartphone applications. Multiple studies utilised this approach in the treatment of glaucoma to deliver eye drop reminders, often in addition to educational material.[42,51,52,66,71] Few studies expanded this intervention mode by incorporating IOP monitoring[66,71] or alert sounds alongside images of the glaucoma medication to aid recognition.[42]

Alternative approaches were also implemented. Glanz et al.[30] created an automated, interactive communication intervention delivered via phone calls to improve patients interest and participation in their recommended treatment to glaucoma medication. Similarly, Newman-Casey suggested a multi-approach intervention integrating a web-based app, additional SMS/voice messages reminders when a medication dose is missed and in-person coaching sessions.[51] Lastly, Barbour-Hastie described a videoconference intervention to teach patients to remotely use a home tonometry device.[15] Only one study targeted cataract surgery medication, with SMS sent to patients to remind them of their postoperative treatment.[26]

Six interventions targeted parents of children requiring treatment to improve compliance.[25,49,60–63]

Morjaria et al. presented a complex education intervention that included automated voice message mHealth interventions to support children to adopt and maintain spectacle wear.[49] Similarly, an application integrating individualized health education counselling and reminders to parents was developed to increase compliance to orthokeratology treatments.[60] Three other studies reported the use of smartphone applications or SMS to deliver patching treatment reminders to parents/guardians to increase adherence in children with amblyopia.[61,63] Additionally, a pilot tele-counselling intervention provided support to parents of children with cerebral visual impairment to increase adherence to visual therapy.[25] Similarly, Bittner et al. delivered remote training for patients requiring telerehabilitation in the use of magnification devices via Zoom.[18] Parents were invited to communicate with the nurse over WhatsApp to share daily updates. Lastly, a WeChat-based continuity of care intervention supported diabetic retinopathy treatment plans with education, monitoring, and follow ups.[20]

Over the years, many low vision clinics have implemented telehealth to provide assistance for patients needing services. These models involved videoconference sessions to assist patients to utilize their low-vision devices at home.[13,16,17,33]

3.4.2. Improve appointment attendance

Improving appointment attendance is another commonly reported desired outcome of mHealth interventions ($n = 17$), and included pre-scheduled routine appointments, post-operative appointments, and referral attendance after community screenings.

Approaches to increase attendance of pre-scheduled appointments was primarily centred around appointment reminder interventions. Xiao et al.[67] designed and implemented a teleophthalmology system that included SMS reminders to all patients prior to their follow-up appointments. Few authors described SMS[23,39] or automated phone call interventions[47,54,70] for patients with diabetes to remind them of their scheduled appointment. Fudemberg et al.[29] sent automated telephone call appointment reminders to patients with glaucoma prior to their appointment. SMS reminders have also been utilised in an intervention for patients who were attending outpatient ophthalmology clinics for the first time.[38] Vinekar et al.[65] incorporated mobile phone helplines and mobile phone call reminders in a complex intervention package to increase appointment adherence to screenings for retinopathy of prematurity.

Improving post-operative attendance was an objective in four studies. Chang et al.[22] used the smartphone application WeChat with a QR code and a group chat to deliver post-operative appointment reminders and information to parents of children who had undergone cataract extraction. Similarly, automated appointment reminders were sent to parents of children with cataracts prior to their surgical appointment[46] and to patients following trabeculectomy surgery.[68] An alternative intervention to increase post-operative appointment attendance included delivering telephone voice reminders to families who did not attend a planned visit.[55] A novel approach involving QR codes leading to a post-operative questionnaire has been used to increase attendance to follow-up after strabismus surgery in China.[27] mHealth interventions with the aim to increase referral attendance after school- or community-based screenings also combine different approaches, including appointment reminders and informing parents/guardians of referral details through automated voice messages or SMS.[12,49,57] Some of these complex interventions also included the provision of eye health information.[49,57]

3.4.3. Raise awareness on eye health

Raising awareness on eye health was the main desired outcome in 10 studies aiming at different conditions.

Li et al.[43] delivered an mHealth intervention via WeChat, and a novel app involving an augmented reality game has also been tested by

Gunasekeran et al.[31] to increase awareness and improve participants' knowledge on glaucoma. As reported earlier, many other glaucoma interventions included some form of eye health education, especially through smartphones that included educational material and options to store eye-related medical data in applications to increase patient and caregiver knowledge of glaucoma.[51,66,71] Patel et al.[53] took and approach of using Q code-linked YouTube patient information videos to enhance glaucoma patients' understanding the eye condition.

Public service announcements delivered by SMS have been utilised in an mHealth intervention from Taipei to provide education and raise awareness of acute haemorrhagic conjunctivitis.[69] Telephone hotlines is another large-scale mHealth intervention utilised to increase patient knowledge as described by Finger et al.[28] The hotline provided specialist-led counselling to patients with retinal conditions to meet the increasing patient demand for information.

Other approaches to increase patient knowledge include SMS reminders to diabetic patients with information highlighting the need for regular eye examinations[23] or post-operative cataract education to patients via the LINE messaging app.[59] Smartphone applications or social media such as WeChat were also used to present health promotion messages to parents of myopic children.[44,60] Further, an SMS-based intervention was developed during the COVID-19 lockdown to raise awareness on infection symptoms to reduce outpatient attendance in ophthalmology clinics during that period.[41]

Several studies focussed on how social media platform content raises awareness of eye health conditions analysed through content analyses. Chahal et al.[21] examined lifestyle-related glaucoma information available on Google, Facebook, YouTube, and Reddit. Kayabaşı et al.[36] evaluated the quality and reliability of YouTube videos on myopia. Lastly, Ming et al.[48] analyzed TikTok videos to understand factors impacting the quality and audience engagement of myopia-related content.

3.4.4. *Increase satisfaction from patients*

Four studies utilised mHealth to increase satisfaction from patients following eyecare services, namely to decrease anxiety and increase post-operative satisfaction. A study by Chen et al.[24] reported the application of an mHealth intervention aimed at decreasing the anxiety of parents of children with cataract, or who may think their child has a cataract, through a mobile phone application (WeChat) combined with video links. Similarly, Digin et al. used individualised SMS reminders to decrease patients' anxiety after their cataract surgery.[26] In China, post-operative satisfaction was measured using an automated phone call as an mHealth intervention. This involved comparing the clinical characteristics at discharge to the self-reported post-operative outcomes reported by patients.[34] Similarly, an AI-driven clinical assistant was also effective at ensuring cataract surgery follow-ups in the UK.[37]

3.4.5. *Reach communities to increase utilisation of eyecare services*

The application of mHealth interventions to improve patient engagement with eye care services was another type of mHealth intervention, yet not as common ($n = 3$). National public service announcements were delivered by Hoffelt et al.[32] via the internet to encourage the people to contact a telephone hotline to determine their risk for glaucoma. Another intervention offered eye health screening to first-degree relatives of patients who have glaucoma via SMS.[58] SMS were also used by Katibeh et al.[35] to share results from a community mobile screening program in order to increase their utilisation of eyecare services.

3.5. *Outcome of mHealth interventions*

An intervention was considered effective when it yielded a positive result based on its desired outcome. Thirty simple and 26 complex interventions were reported. Considering the wide range of interventions, many of them combining numerous sub-intervenions, effectiveness was impossible to isolate and compare. Table 3 summarises the intervention type and the obtained outcomes of the included studies.

There were positive outcomes reported in 41 of the included studies, all types of interventions combined. However, only 21 of those studies had sufficient information (simple intervention, with a single variable) for the effectiveness of the individual mHealth intervention to be extracted, eleven of which were based on randomized controlled trials.[23,26,27,40,44,46,47,52,54,59] Main positive outcomes reported were increased appointment rates,[38] especially for diabetic examinations[23,47,54] or follow-up after surgeries[22,27,46,59] and increased treatment adherence for glaucoma medication.[19,40,42,52] Some mHealth interventions have also been effective to increase awareness for glaucoma[43] and myopia[44,60] and reduce postoperative anxiety.[26] Videoconferences technology was also effective and acceptable for training patients to use novel technologies for glaucoma monitoring[15] or low vision devices.[17,18] QR-linked YouTube patient-information videos significantly improved patient understanding of glaucoma.[53] Lastly, the use of SMS was also effective to reduce attendance to clinics during the COVID 19 lockdown.[41]

In 15 of the other studies reporting a positive outcome, the effectiveness of the individual communication-based mHealth intervention was not reported in isolation of the other intervention components.[12,13,20,24,25,31,35,55–57,62,65,68,70] Moreover, a few studies did not test effectiveness, but evaluated acceptability and interest for novel technologies, and obtained positive overall results.[16,34,37,66,69,71] Additionally, several studies were descriptions of systems for the delivery of an mHealth intervention that seemed to be successful but insufficient information was detailed in the study.[28,32,33,67]

Eight studies reported no change following the delivery of the intervention. Five of them were simple mHealth interventions,[29,39,58] including both studies on eye patching for amblyopia).[61,63] The remaining four studies applied complex interventions, and it could not be determined if the mHealth intervention was not effective, or if the results were due to adverse effects caused by the other components of the intervention.[30,45,49] These studies had no overarching characteristics except that they were part of a complex mHealth intervention. Additionally, two studies were protocols without any published results.[50,51]

Three studies were content analysis which examined the quality of eye health information across various social media platforms. Since these were not interventions, no conclusions can be drawn about the effectiveness of the content in influencing patient outcomes.[21,36,48]

4. Discussion

Telehealth is a rising practice amongst eye care professionals especially since the COVID-19.[72,73] With the ubiquity of cell phones across the world, utilization of mHealth is a promising emerging tool to communicate with patients and raise awareness for eye health. While it may lead to new forms of engagement and relationships with clients and communities,[74,65] the development of such technologies needs to be done in an efficient, cost-effective and equitable manner. This scoping review summarizes the current use of mobiles in interventions for communication between individuals and eye health services in a health promotion perspective.

Results highlight the extensive areas in eye health where mHealth is currently being applied, including the extensive modalities and intervention types that are in use at present. The studies were varied in regard to country, year the study was conducted, the mode of delivery of the mHealth intervention, and the domain in eye health where mHealth was applied. Unfortunately, the lack of standardisation in the selected papers made further analysis impossible. mHealth interventions are largely used in eye care to enhance communication between health professionals to patients, mostly for glaucoma and diabetic patients. In fact, applications of digital health are well known for those two conditions.[75,76] However, mHealth is now applied for many other eye health issues, such as cataract surgery follow-ups, community screenings,

Table 3
Overview of included study intervention types, effectiveness and study design.

Type of mHealth intervention		First author	Eye condition	mHealth intervention	Type of intervention	Outcome
Treatment adherence	Medication	Barbour-Hastie[15]	Glaucoma	Videoconference (NearMe) for remote teaching on home tonometry	simple	Successful training for home tonometry
		Boland[19]	Glaucoma	SMS reminders or automated phone calls for medication	simple	Increase in adherence rate
		Glanz[30]	Glaucoma	Individually-tailored messages to encourage adherence with medication taking, appointment keeping, and refills; provide information about glaucoma; and intervene on barriers to adherence.	complex (SMS + printed material)	No difference in adherence
		Lai[40]	Glaucoma	Daily SMS reminder at the scheduled time of eye drop administration	simple	Increased adherence to treatment
		Leshno[42]	Glaucoma	Glaucoma application with treatment reminders + beeping signal and visualization of the name and picture of the designated drug	simple	Increased adherence to treatment
		Lim[45]	Glaucoma	Monthly automated telephone calls reminding patients to take their glaucoma medications	complex (SMS + educational session with physician)	No difference in treatment adherence
		Newman-Casey[50]	Glaucoma	1. web based app with tailored glaucoma educational materials and teach eye drop instillation 2. Adherence monitor reminder : patients receive reminders when a medication dose is missed: an alarm (light or sound) and/or an automated phone call or text message Participants can also phone their coach if questions arise	complex (mobile reminders + coaching sessions)	NA (protocol)
		Newman-Casey[51]	Glaucoma	Reminders (audio and/or visual) and text message or automated phone call if a dose of medication is not taken within a pre-specified time frame	complex (SMS/automated phone calls + counselling with coach)	NA (protocol)
		Osahon[52]	Glaucoma	medication reminder mobile application	simple	Increased medication adherence
		Valente[64]	Glaucoma	Mobile app containing: quick videos on glaucoma - notifications for eye drops - results from previous examinations - IOP monitoring - questions (FAQ) with telecare option to send e-mails	simple	Acceptable app for patients
		Waisbourd[66]	Glaucoma	Application with educational videos, eye drop and appointment reminders, medical and ocular data storage, visual field tutorial, and intra-ocular pressure tracker	simple	Generated interest from patients (no quantitative results)
	Support for treatment plan (glaucoma)	Aazami[14]	Glaucoma	Educational intervention (booklet, group sessions, podcast, Q&A, follow-up calls)	Complex (multiple educational tools and follow-ups)	Significant improvement in visual function and quality of life, including vision-specific social function and colour vision in the intervention group compared to the control group
	Support for treatment (parents)	Tavares[61]	Amblyopia	SMS reminder for eye patching sent every three days	simple	No significant difference in adherence between the group that received text messages and the one that did not
		Vagge[63]	Amblyopia	Application with reminders to administer amblyopia treatments	simple	No significant change in compliance
		Sun[60]	Myopia (Orthokeratology)	Smartphone app-delivered with OK lens care, individualized health education, feedback of	simple	- Better care completion - 100 % follow up rate

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Table 3 (*continued*)

Type of mHealth intervention		First author	Eye condition	mHealth intervention	Type of intervention	Outcome
				tracking records, and reminder broadcasts through the app		
		Morjaria[49]	Community screenings (schools)	Automated Voice message to parents' mobile phone after receiving spectacles	complex (mHealth system screening + SMS)	No difference in spectacle wear rates
		Dhiman[25]	Cerebral visual impairment	Daily WhatsApp communication after follow-up phone calls with nurses	complex (part of a protocol for eye activities that included information booklet in PDF and videos for evaluation by ophthalmologist	Increase in adherence to exercises
		Uttamapinan[62]	Amblyopia	Amblyopia Treatment Chulalongkorn University (ATCU) smartphone application	Complex (educational content, patching calendar, mini-games, notifications)	Significantly improved compliance at 1-month in intervention group. No significant difference in compliance at 3 months, BCVA improved more in intervention group at both follow-ups.
	Support for treatment plan (diabetic retinopathy)	Cao[20]	Diabetic retinopathy	WeChat-based continuity of care	Complex (WeChat-based education + blood glucose monitoring + personalized feedback + ophthalmology follow-ups)	WeChat group showed significantly higher cognitive-behavioural ability, self-care skills, and diabetic retinopathy knowledge. Better physical and mental function, reduced visual acuity loss and incidence of diabetic retinopathy compared to routine care group
	Support for treatment plan (low vision)	Aravich[13]	Low vision	Videoconference for rehabilitation services	Complex (hybrid model, not only telehealth)	- patients' satisfaction - lower rate of missed appointments - increased family involvement
		Bittner[16]	Low vision	Videoconference for rehabilitation services	complex (3 different phases with various methods)	Telerehabilitation is acceptable to patients
		Bittner[17]	Low vision	Videoconference (Zoom) for rehabilitation services	simple	Improvement in reading abilities
		Bittner[18]	Low vision	Telerehabilitation with videoconferencing (Zoom) to provide remote training for magnification devices	simple	Reading ability improved significantly. Both telerehabilitation and in-office training showed similar improvements with no significant difference between groups
		Ihrig[33]	Low vision	videoconference (mobile phone or tablet)	simple	NA (system delivery)
Appointment attendance	Pre-scheduled appointments	Chen[23]	Diabetic retinopathy	SMS reminders prior to their scheduled appointments; contains information about diabetic retinopathy	simple	Improved attendance and knowledge about DR
		Fudemberg[29]	Glaucoma	Automated phone call 3 days prior to their appointment	simple	Same follow up adherence between control and intervention
		Kumar[39]	Diabetic retinopathy	SMS reminder before appointment	simple	No difference in attendance
		Mehranbod[47]	Diabetic retinopathy	Automated telephone reminders 1–7 days prior to the scheduled appointment	simple	Higher show rate at follow up
		Pizzi[54]	Diabetic retinopathy	Automated phone call before the scheduled appointment	simple	Higher scheduling DFE in intervention group
		Xiao[67]	Diabetic retinopathy	SMS reminders sent before visits	complex part of a wider teleophthalmology intervention	NA
		Zangalli[70]	Diabetic retinopathy	Automated phone call before scheduled appointment	complex (SMS + paper-based education)	Improved DFE adherence
	Post op follow-ups	Chang[22]	Paediatric cataract	Appointment reminders on WeChat + chat group for parents to share experience and communicate with professionals	simple	Increased attendance rates at follow ups (but not at initial appointments); no difference in compliance to treatment
		Fan[27]	Strabismus surgery	WeChat used to access a web-based follow-up questionnaire with QR code	simple	Better attendance in intervention group
		Lin[46]	Paediatric cataract	SMS reminders before appointment	simple	Increased attendance to follow up

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Table 3 (*continued*)

Type of mHealth intervention		First author	Eye condition	mHealth intervention	Type of intervention	Outcome
		Rai[55]	Paediatric cataract	Cell phone reminders (voice) to families who did not attend a planned visit	complex (Part of follow-up programme with counsellor, tracking system and cell phone reminders)	Improved post op rates
		Yang[68]	Glaucoma	SMS reminders before appointments	complex (SMS reminders and the offer of free postoperative medication)	Increased adherence to follow ups
	Referrals after screenings	Andersen[12]	Community screenings (schools)	SMS sent with referral information	complex (mHealth system for screening + SMS)	High attendance rate following screening
		Rono[56]	Community screenings (schools)	Personalised SMS to parents on the outcome of the eye screening and instructions for referral	complex (package of mHealth intervention, including health education and mobile screening)	Higher attendance at referral appointments
		Rono[57]	Community screenings	Personalised SMS with referral information	complex (mHealth system of screening +SMS)	Higher attendance at referral appointments
	First outpatients	Vinekar[65]	Retinopathy of prematurity	Phone helpline for parents to clarify their doubts, seek appointments and discuss other logistic difficulties	complex (part of a 12-month program)	Fewer loss at follow ups
		Koshy[38]	Community screenings	SMS reminders sent before first appointment	simple	Increased attendance rates
Raise awareness		Chahal[21]	Glaucoma	Social media content analysis on lifestyle measures for glaucoma (Google, Facebook, YouTube, Reddit)	Not applicable (content analysis)	Content on Google, YouTube, and Facebook had high-quality information. Reddit content had lower quality. The majority of accurate content was uploaded by healthcare professionals (HCPs).
		Finger[28]	Retinal diseases	Phone helpline staffed by ophthalmologists to counsel on retinal problems	simple	NA
		Gunasekeran[31]	Glaucoma	Augmented reality platform on app; Immersive game was designed to increase recruitment of the peripheral visual field and simulate glaucoma, along with educational messages about eye health	complex (VR and AR)	Raised awareness
		Kayabaşı[36]	Myopia	Social media content analysis on YouTube videos regarding myopia	Not applicable (content analysis)	Videos were of 'low to intermediate' quality. Videos uploaded by physicians had a higher quality and reliability compared to non-medical education channels
		Lai[41]	not disease specific - all eyecare was included	SMS notification sent to patients with(1) option of rebooking and drug refill via telephone hotline and (2) persuasion of patients with fever, flu symptoms or recent travel history to avoid ophthalmic clinic attendance.	simple	Reduced attendance during lockdown
		Li[44]	Myopia	Health education for parents sent by head teachers through WeChat	simple	Decrease incidence rates of myopia
		Li[43]	Glaucoma	WeChat account to share information on glaucoma	simple	Enhanced awareness
		Ming[48]	Myopia	Social media content analysis on TikTok regarding myopia information	Not applicable (content analysis)	Videos published by healthcare professionals and non-profit organisations were associated with high-quality but comparatively lower popularity. Videos addressing risk factors, management, and outcomes were most popular.
		Patel[53]	Glaucoma	QR code-linked YouTube patient information videos (PIVs)	simple	Significant improvement in patient understanding of glaucoma across six areas
		Sanguansak[59]	Cataract (post op)	Messages sent on LINE messaging app about hand and face hygiene, medication and	simple	Increased medical adherence and attendance to follow up at some visits

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Table 3 (*continued*)

Type of mHealth intervention		First author	Eye condition	mHealth intervention	Type of intervention	Outcome
				postop visit adherence, and links to patient education videos about postop care		
		Yen[69]	Acute haemorrhagic conjunctivitis	SMS notification to all residents of Taipei on the current status of the epidemic and recommended citizen-level control measures	complex (part of a multi-channel mass risk communications program)	High satisfaction of the public sensitization campaign
Communication	Decrease anxiety	Chen[24]	Paediatric cataract	Social media-based (WeChat) group activities to improve parents' knowledges	complex (multifaceted module including SMS + workshop with ophthalmologist)	Good knowledge retention and low dropout rates
		Digin[26]	Cataract (post op)	SMS reminder to patients undergoing cataract surgery about the need to take postoperative medications to reduce postoperative anxiety	simple	Lower post-op anxiety score
	Post-op satisfaction	Jiachu[34]	Cataract (post-op)	Cell phone calls 3-months post-op to determine satisfaction with vision and presence of discomfort	simple	Patients satisfied with follow up
		Khavandi[37]	Cataract (post op)	Automated interactive phone call by an AI-driven clinical assistant capable of delivering cataract surgery follow-up calls (Dora)	simple	Acceptable solution, easy-to-use
Eye care utilization		Hoffelt[32]	Glaucoma	Phone helpline to determine whether callers are at increased risk for glaucoma and eligible to receive a free glaucoma eye exam	simple	NA (description of system)
		Katibeh[35]	Diabetic retinopathy	SMS sent with results of screening	complex (screening + sms)	Eye care utilization improved significantly more in the mHealth arm
		Salihu[58]	Glaucoma	SMS reminder sent to all those identified for glaucoma screening	simple	No increase in uptake

health promotion and low vision rehabilitation. Some interventions even target children to improve adherence to amblyopia treatments, myopia control, compliance to spectacle wear or post-operative care. Modalities include mostly SMS, but also social media messaging and educational content delivery, smartphone apps, automated phone calls and videoconference. Some novel technologies are also being evaluated, such as chat groups, QR codes or augmented reality platforms. The literature demonstrates how multiple and varied mHealth interventions can be flexibly and aptly delivered to a multitude of eye health needs at the individual and group level.

Initially, another objective of this review was to compare the settings in which interventions were developed for and implemented in to understand fidelity of implementation. The majority of mHealth interventions were developed for ophthalmology clinics, either in eye centres or hospital departments. However, authors provided very few details on context and environment of implementation, therefore these research questions remain unanswered.

Evidence of the interventions' effectiveness was also summarized when they were evaluated. Most selected studies showed positive outcomes, highlighting the high potential of mHealth interventions in eyecare. While most of them were considered acceptable and interesting for patients, data sometimes lacked on its effectiveness. More research should therefore be made by developers to ensure that mHealth are effective and not just popular., Moreover, comparison of their effectiveness is challenging due to the wide variety of settings in the selected interventions. Nevertheless, we note that interventions for appointment attendance were generally more effective compared to treatment adherence such as glaucoma medication and amblyopia treatments. This highlights the complexity and the numerous factors that can impact compliance to eye care treatments.

Interestingly, similar interventions obtained different outcomes when implemented in different settings, enhancing how context and modalities of delivery can have a significant impact on effectiveness. While efficacy of text-messaging as health promotion interventions has been demonstrated in a few reviews,[77,78] results from this study show inconsistencies. For example, some automated phone calls interventions and SMS studies were ineffective as appointment reminders, but many others did increase follow-up rates with similar interventions. Unfortunately, very few details were provided by the authors on how the communication interventions were delivered to patients. For example, to whom should this be targeted, if it is a parent, which parent should it be sent to, or is there someone else in the household who is the decision maker? What time of the day should the message or the reminder alert on the app be set for? What sort of wording should be used in a message – should it be gentle and encouraging and non-judgmental, or should it be emotional and highlight the consequences of not completing a certain action such as not instilling glaucoma drops can lead to visual impairment? How and why an mHealth solution is used (or not) or accepted, goes beyond the technology itself; it is influenced by individuals and context-specific environmental factors.[79] Indeed, text messaging interventions tailored to demographics and psychosocial variables and including personalization are more efficacious.[77] Moreover, messages should be clear and direct, offering practical and relevant advice, in simple language, for those with lower health literacy and they should also be positively (gain/benefit) framed, focusing on emphasising the benefits of action. The algorithm of the mHealth initiative is also important - research suggests that messages should start at a higher frequency and decrease in frequency over time. Specifically, we refer to higher frequency as daily or multiple times per week, with a gradual reduction to weekly or less frequent messaging over time. The MyopiaEd initiative provides a good example of relevant steps to develop a large-scale health promoting SMS intervention.[80] There is now literature on the commonly used industry standard of once per week. However, data is still lacking on other modalities and interventions.

In fact, mHealth is frequently part of larger, complex interventions, which makes it impossible to isolate the effectiveness of the communication component. While it would be expected that complex interventions are more effective considering that they include many components and pathways to reach a specific health outcome, rates of positive outcomes were slightly higher with simple interventions in this study. Similarly, there was no significant difference in effectiveness between isolated text messaging interventions and interventions including other health promotion components in the meta-analysis by Head et al.[77] While complex interventions have greater potential to lead to behaviour change, lack of fidelity during implementation can impact outcomes.[49,51] Lack of participation from patients during developing may also impact these results.

What is clear from this review is that there certainly is an interest from eye care professionals to communicate with patients through mHealth. These interventions can be effective for multiple uses, particularly to increase attendance to appointments, treatment adherence or raise awareness. However, when it comes to eye health and how mHealth communication interventions are used, there are still a number of questions that remain unanswered, such as which mode of delivery or what type of interventions (simple or complex) is more effective. Behaviour change is complex and what motivates it, and which strategy is effective is not always straightforward to understand. While theory-based interventions are not always the most effective,[77] this study demonstrated that simple or multifaceted approaches have been reported to be effective in eyecare. Therefore, formative research before and during implementation of any mHealth solution is crucial to gain an understanding of the environment and context, and ensure fidelity of interventions in real life settings.[77]

Lastly, a large proportion of the research on mHealth for eye health to date was conducted in high income settings. Hence, it is important to conduct studies in low- and middle-income countries, especially, with the increasing mobile phone ownership and lack of human resources in remote areas.[81,82] However, there is another group to consider in this, those that are in high income countries but based in a low-income setting. There are those with chronic eye conditions specifically those at high risk. For example, dialysis patients may face challenges in owning a phone which could lead to their exclusion from review studies altogether. While few mHealth interventions from this study have been successfully implemented in low- and middle-income countries, it is important to conduct feasibility studies to allow for successful implementation of affordable and appropriate mHealth solutions in these countries. In fact, no economic evaluation or cost-effectiveness studies have been selected in this paper. Yet, lack of economic resources or infrastructures can be significant barriers to implementation of such technologies and should be taken in consideration when developing an mHealth intervention for LMICs.[74,78] Moreover, women in low- and middle-income countries are 8 % less likely than men to own a mobile phone, which translates to 165 million fewer women than men owning a mobile phone.[83] Lack of access for women in LMICs to obtain the technology required to deliver mHealth interventions may lead to inequitable access amongst those receiving the benefits. It is essential that stakeholders reflect on ethical considerations before implementing such interventions.

5. Limitations

This scoping review has some limitations. Firstly, the review did not extract or report on health system elements such who implemented the intervention and at what level of the health system. Additionally, there was no exploration of how the interventions described in the study are integrated into the health system. Detailed demographics on target populations were not charted, possibly overlooking age and gender inequalities. Moreover, the over-representation of publications from high income countries, and adult populations indicates a lack of representation of vulnerable groups such as children, low vision and low income patients, all of whom could benefit the most from mHealth interventions. Lastly, due to the nature of the scoping review, an assessment of the quality of studies was not conducted.

6. Conclusion

The use of mobile and digital health tools is increasing in all sectors of health care and this has further been accelerated globally by the Covid-19 pandemic. The eye health sector is no different, with innovative solutions for how patient communication and consultations are taking place. Given the global momentum in the acceptance of the use of mHealth interventions, we have the opportunity to ensure that mHealth tools are applicable and more importantly address the challenges. A wider opportunity is now available to use mHealth platforms to more rapidly test complex interventions or the individual components of them in a real-world setting that can lead to improved health outcomes. This will require careful consideration around the ethical governance of iterative improvement models that ensure health and eye health don't fall behind the rapidly shifting technological landscape.

75 word summary

Mobile health (mHealth) is increasingly used in eye care, yet its impact remains unclear. This scoping review synthesizes findings from 59 studies, mapping the diverse applications of mHealth across eye conditions and settings. While mHealth enhances adherence, appointment attendance, and patient-provider communication, the most effective intervention types remain uncertain. Addressing these gaps, particularly in diverse socio-economic contexts, is crucial to maximizing mHealth's potential in eye care.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

PM is an employee and AB is the CEO and founder of Peek Vision, a social enterprise that develops software to implement, optimise and evaluate eye health services in schools, communities and workplaces. These postions have no influence on the content of this manuscript.

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Supplementary materials

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