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An evaluation of the impact of mHealth interventions on patients' attendance to treatment for three common ophthalmic diseases that cause blindness: a systematic review

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Abstract

Background:

Ophthalmic diseases are those that affect the eye, including cataracts, glaucoma, age-related macular degeneration and diabetic retinopathy. These diseases can lead to blindness and vision loss, especially at advanced stages. Cataracts, glaucoma and diabetic retinopathy are the most common ophthalmic diseases that cause blindness. Patients encounter challenges with attendance to appointments for treatment because they may forget the date, time and/or place of the surgery. mHealth interventions are a means of addressing the challenge of patients missing appointments. This study reviews the use of mHealth reminders to improve patients' attendance to ophthalmic disease treatment.

Methods:

A systematic review was conducted to assess the literature from various databases including; PubMed, Scopus, (Africa-Wide Information, CINAHL, Computers & Applied Sciences Complete, Health Source: Nursing/Academic Edition by Ebscohost) and Web of Science. We searched different sources for grey literature including; Google.com, Open Grey, New York Academy of Medicine, WHO, Cochran library, and Cochrane Central Register of Controlled Trials. The interventions were limited to SMS and telephone calls. Studies were considered eligible if they were randomized control trials (RCT), prospective or retrospective cohort studies, cross-sectional studies, or if they reported on outcomes primarily related to patient attendance to ophthalmic disease appointments.

Results

Ten studies that met the eligibility criteria were included in the systematic review. The study setting included developed countries and low-and-middle-income countries (LMIC). Sixty percent of these studies were conducted in LMIC, while forty percent were conducted in developed countries. Eighty percent of the study participants were older than 55 years and the mean age of participants was 61.5 years. Both male and female participants were included, with approximately fifty nine percent of them being female.

Discussion

The assessment of the literature highlighted that mHealth reminders resulted in significant improvement in patient attendance to treatment for the three common ophthalmic diseases. The

mHealth platform was particularly relevant in LMIC, and SMS was the most successful intervention. Women were the major users of mHealth tools to gain access to services.

Conclusion:

This systematic review aimed to inform healthcare workers and decision makers in the health system on the use of mobile phone messaging as reminders to improve patient attendance to the three common ophthalmic diseases treatments that cause blindness. The evidence obtained from the systematic review will bring new opportunities for further research regarding the use of mHealth interventions as reminders for treatment adherence in general and ophthalmic diseases such as cataracts, glaucoma and diabetic retinopathy.

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List of Abbreviations

AMD	Age-related macular degeneration
CI	Confidence interval
CSC	Cataract surgical coverage
CSR	Cataract surgery rate
DR	Diabetic retinopathy
GPS	Global positioning system
ITS	Interrupted time-series
KDP	Kilimanjaro Diabetic Programme
LMIC	Low-and-Middle-Income Countries
MeSH	Medical subject heading
MM	Meftah Madi
RCT	Randomized Control Trials
non RCT	non-Randomized Control Trials
UCT	University of Cape Town
UK	United Kingdom
WHO	World Health Organization

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1. Chapter One: Introduction

1.1. Background

Ophthalmic diseases are prevalent worldwide, especially in elderly patients (Whitcher et al., 2001). Such diseases include cataracts, glaucoma, age-related macular degeneration (AMD) and diabetic retinopathy. These diseases lead to blindness and vision loss (Whitcher et al., 2001, Mitchell and Bradley, 2006). Cataract, glaucoma and diabetic retinopathy are the three most common eye diseases that cause blindness (Pelletier et al., 2016, Naidoo et al., 2014). In most advanced cases of eye disease, urgent surgery is required to avoid blindness (Boyd, 2014). Cataract is the most common ophthalmic disease affecting people globally (Brian and Taylor, 2001) and is considered the leading cause of blindness in the world (Bourne et al., 2013, Thavikulwat et al., 2015). According to the World Health Organization (WHO), the latest assessment in cataract blindness in 2010 was that cataract is responsible for 51% of world blindness, which represents approximately 20 million people (WHO, 2010). Cataract surgery is considered the only treatment for cataract disease.

In developing countries, cataract patients have difficulty gaining access to surgery and surgical facilities due to many factors. These factors including lack of awareness of the disease itself, lack of transport specifically for people who live in rural areas, and socio-economic conditions (Wearne, 2007). Vision loss associated with glaucoma is preventable with adherence to eye care medication and treatments (Quigley and Broman, 2006). Similarly, for diabetic retinopathy, a key factor for management is provision of and adherence to follow-up treatments (WHO, 2007). The reasons for the missed appointments include: forgetting the time of the appointment, misunderstanding the date, losing the address for the appointment, lack of communication, limited access to transport, cost, and culture (Malherbe, 2017, Cate et al., 2013, Mumba et al., 2007). Missing an appointment can lead to delays in treatment (Murray, 2000).

Many conventional methods have been used as reminders for general health diseases such as posted letters and appointment cards (Reekie and Devlin, 1998). However, interventions like mobile phone messaging has been shown in to improve attendance rates of patients to cataract surgery (Lin et al., 2012, Sanguansak et al., 2017). In addition, mobile phone messaging has improved patients' compliance to health care appointments for glaucoma (Pizzi et al., 2016).

Mobile phone messaging is a form of mobile health (mHealth). mHealth aims to address healthcare delivery by use of mobile telecommunication and multimedia technologies as an approach to fill the accessibility gap between patients and health professionals. mHealth has the potential to improve patient-provider communication, health promotion and disease management (Beratarrechea et al., 2014).

In developing countries, mHealth is used to address the problem of a limited healthcare workforce (Beratarrechea et al., 2014). WHO has suggested that mHealth can change the form of health service delivery worldwide (WHO, 2011). Recently, mobile phones and the internet are being used to offer various services to improve healthcare delivery; these services include voice and text communication (Beratarrechea et al., 2014). Mobile technologies provide access to healthcare professionals by facilitating immediate communication and faster decision-making by health workers since they can access information more easily through advanced mobile computing (Varshney, 2014). The use of smartphones by ophthalmologists is wide-spread globally (Bastawrous et al., 2012). In an investigation of mobile phone ownership, 99% of health professionals were found to own a mobile phone, with 81% of these being a smartphone (Beratarrechea et al., 2014).

The available literature on mHealth shows benefits in the use of mHealth for several diseases, but little is known on the use of mHealth for ophthalmic diseases such as cataract surgery. mHealth is shown as beneficial for diseases such as diabetes (Jin et al., 2004), HIV/AIDS (Fairley et al., 2003), and smoking cessation (Fairhurst and Sheikh, 2008). mHealth has shown impact on chronic diseases in LMIC (Beratarrechea et al., 2014). However, limited research has been conducted on the use of mHealth in cataract diseases. Therefore, this study aimed to evaluate the use of mHealth interventions as a reminder to improve patient attendance to ophthalmic disease treatments through a systematic review methodology. The systematic review focused on studies that have investigated mobile phone messaging as a way of encouraging patients to attend ophthalmic diseases treatment appointments. The evidence from this study would assist in devising strategies to improve attendance to appointments for ophthalmic disease treatments.

1.2. Aim and research question

The aim of the study was to evaluate the impact of mHealth interventions on patients' attendance to appointments for treatment of ophthalmic diseases that cause blindness.

The following research question was addressed: In patients with the three common ophthalmic diseases that cause blindness, do mHealth reminders have an effect on patient attendance to ophthalmic disease treatment appointments compared to conventional reminders?

The Patient Intervention Comparator and Outcome (PICO) were as follows:

P: The participants were patients with the three common ophthalmic diseases that cause blindness.

I: The intervention was mHealth intervention as a reminder.

C: The comparator was conventional reminders.

O: The outcome was patient's attendance to ophthalmic disease treatment appointments.

1.3. Dissertation outline

The dissertation is organized as follows, Chapter One reviews general background information about ophthalmic disease including cataract, glaucoma and diabetic retinopathy as the main three diseases led to blindness and poor representation of these disease to treatments adherence. also, presents the research question, aim and objectives of the study.

Chapter Two reviews the available literature on the topic of study. It contextualizes ophthalmic disease and outlines its prevalence from a global perspective. The review engages with the literature on mHealth as a tool that is used in offering health solutions. The final aspect is the evaluation of the relationship between mHealth and ophthalmic diseases.

Chapter Three describes the systematic review methods that were applied in the study. It explains the systematic review components including eligibility criteria, search strategy, data extraction, study selection, assessing risk of bias, data analysis and synthesis. It offers methods of dealing with missing data and assessing heterogeneity.

Chapter Four presents the results of the systematic review, including study selection, study characteristics, risk of bias in included studies and results of individual studies.

Chapter Five offers a discussion of the results and the limitations of the study. It also considers the impact of the results. In addition, it provides a conclusion and recommendations for further studies with regard to use of mHealth in ophthalmic diseases.

2. Chapter Two: Literature Review

This chapter reviews the available literature regarding cataracts and mHealth. It contextualizes ophthalmic diseases and outlines its prevalence from a global perspective as well as in developing countries. The chapter highlights some of the challenges that limit patient access to cataract surgery. Examples are provided of the benefits of the use of mHealth in the health care system and in the management of cataract, glaucoma and diabetic retinopathy.

2.1. Cataract

Cataracts are an opacification of the lens or its capsule (Lin and Michaelson, 2013). This prevents clear vision, and occurs as a result of advancement in age, natural occurrences such birth with cataract, traumatic experiences such as injuries, inflammation, or other eye diseases (WHO, 2010). There are many instances of minor lens opacities which do not substantively interfere with the vision of an individual, such as those that are able to absorb or deflect the light rays entering the eye, and consequently produce a distorted image on the retina (Hejtmancik, 2008). About 85% of cataracts are classified as senile or mature and a substantial proportion of these are associated with diabetes (Gupta et al., 2014). Diabetic patients are more likely to develop cataracts at an earlier age than patients who are not diabetic (Devgan, 2010).

Varying statistics from international, regional and country perspectives are instructive in assisting in our appreciation of cataracts. Historical numbers indicate that 47.8 per cent of persons globally are affected by cataract (Murthy et al., 2008). In 1990 it was estimated that 37 million people were blind worldwide, and 40 per cent of this number was attributed to cataracts (Thylefors et al., 1995, Allen and Vasavada, 2006). Contemporary projections indicate that since the population over the age of 60 years will stand at 120 million in 2020, the increase in the elderly population will lead to higher numbers with poor vision and blindness as a result of cataracts (Khairallah et al., 2015).

The WHO has estimated that over 20 million people already suffer from cataract blindness, and this number can be expected to grow with a rapidly aging population (WHO, 2017). Blindness from cataracts is considered to be one of the prevalent health challenges of the 21st-century (Brian and Taylor, 2001). Women are disproportionately affected by cataract insofar as they form the largest number of persons over 65 years who are affected (UN, 2015). In addition, the majority of the affected elderly people are living in Asia, Africa and America (WPPR, 2015).

Cataract has been reported to account for about 90% of the blindness in developing countries (Prokofyeva et al., 2013). In these countries cataract blindness has an association with disability and mortality, which is of economic and social concern (Frick and Foster, 2003). In developed countries, cataracts are responsible for 50% of the blindness (Lawani et al., 2007). The incidence of cataracts is associated with older age, low income, lower education and also with diseases such as hypertension and diabetes (Park et al., 2016). In South Africa, statistics indicate that cataract is the leading cause of blindness. Also, it is envisaged that cataract surgery has to be carried out on a minimum of two thousand people per million population per year for elimination of cataract blindness (Lecuona, 2011).

There are some similarities between cataract and other ophthalmic diseases such as diabetic retinopathy and glaucoma. For instance, all lead to blindness and require surgery for treatment (Pelletier et al., 2016). Early diagnosis and treatment are critical to prevent blindness in patients with diabetic retinopathy and glaucoma (Quillen, 1999, Pelletier et al., 2016). Patients may suffer from both cataract and glaucoma simultaneously; patients with glaucomic diseases who need surgery and have coexisting cataracts, may use the surgery as an opportunity to remove cataract. Those who need cataract surgery while their vision is affected by glaucoma, can also have both surgeries performed simultaneously (Grover, 2017).

Table 1 presents the three most common ophthalmic diseases that result in blindness (Quillen, 1999, Pelletier et al., 2016), and provides their causes, symptoms and treatment, thereby demonstrating the differences and similarities between the three diseases.

	Cataract	Diabetic Retinopathy	Glaucoma
Definition	Clouds on the lens of the eye which prevent sufficient light from reaching the retina (Boyd, 2014).	Damage in blood vessels of the retina due to increased levels of blood sugar; swelling can prevent blood from passing through other parts of the retina (Saudek, 2008).	Fluid build-up and high pressure affecting the optic nerve (Nordqvist, 2017).
Cause	Aging is the most common cause: the proteins in the lens start to breakdown (Boyd, 2014).	The main cause is increase blood glucose levels (Boyd, 2017).	Tumor, diabetes, inflammation and advanced cataract are causes (Nordqvist, 2017).
Symptoms	Sensitivity to light, double vision, blurry vision (Boyd, 2014).	Spots or floaters, blurred vision, fluctuating vision, and impaired colour vision (Boyd, 2017).	Redness of the eye, blurred vision, pain in the eye or forehead, and headache (Boyd, 2018).
Treatment	Traditional cataract surgery or laser assisted cataract surgery (Boyd, 2014).	Drugs such as anti-vascular endothelial growth factor injection or laser surgery (Boyd, 2017).	Eye drops to decrease eye pressure or laser surgery in advanced stages (Nordqvist, 2017)

Table 1: Most prevalent ophthalmic diseases leading to blindness(Quillen, 1999, Pelletier et al., 2016).

2.2. Cataract surgery

The World Health Organization has emphasized access to quality cataract surgery as a top priority (WHO, 2010). The urban areas of most developing countries have health facilities that provide cataract surgery services in areas of high population density, in stark contrast with remote areas where access to cataract surgery is limited (Brian and Taylor, 2001). In developing countries, a low number of children with cataracts attend health care facilities for surgery compared to the burden of disease in the community (Bronsard et al., 2008). Access to cataract surgery is affected by various factors. These include socio-economic barriers to cataract surgery, which are more common in remote areas and include a lack of transport, communication, undeveloped health care facilities as well as poverty (Wearne, 2007).

One of the challenges that adversely affect access to cataract surgery is missing appointments when the patients forget the time, date and address (Sawyer et al., 2002). Missing an appointment can lead to delays in treatment (Murray, 2000). Furthermore, lack of awareness of cataract surgery is a barrier (Bronsard et al., 2008). A lack of patient education by health

facilities affects the engagement of the patients to be booked for cataract surgery as well as post-operative follow-up (Chang et al., 2008). In addition to post-operative follow-up and monitoring, other challenges relate to the failure by patients to comply with medication (Brian and Taylor, 2001).

Poverty is a key factor that contributes to the failure to have surgery (Kessy and Lewallen, 2007). The low levels of cataracts in developed countries compared with the high levels of the same in developing countries is an indication of the effect of poverty (Resnikoff et al., 2004), and particularly affects the elderly in developing countries (Lewallen et al. (2009). Closely linked to poverty is the lack of infrastructure that is required to enable the surgery to take place. In Africa, the limited eye care services that are available are usually in cities. Also, transportation to such facilities from more rural areas becomes a challenge (Bowman et al., 2000).

In developing countries, the cost of cataract surgery is still the major limitation to reducing high rates of cataracts (Lee and Afshari, 2017). While the cost of cataract surgery may present a barrier to access, other attendant costs should be considered. These include the cost of transport to the hospital, loss of income by the patient for the days when they are not able to work, expenses when they are in hospital, and costs associated with having a caregiver after surgery and/or having a caregiver, family member, etc. to accompany the patient to surgery (Lewallen and Courtright, 2001).

Lack of knowledge coupled with the various societal stereotypes are instructive in understanding why cataract surgery does not take place in instances where patients have access to surgery. Lack of knowledge with regard to the availability of the surgical services as well as the fact that cataract can be cured is a great obstacle to having the surgery (Hubley and Gilbert, 2006). This lack of knowledge is usually fortified by the existence of cultural or societal beliefs that are used to explain the occurrence of cataract on an individual (Hubley and Gilbert, 2006). As a result, the society, community and individuals are prevented from appreciating the scientific methods that could be used to cure a disease (Balo et al., 2004). In South Africa, for instance, cultural and social barriers were found to prevent female patients from Limpopo in receiving cataract surgery. The reasons included; lower education levels, lack of social support, and patriarchal control of time and money among females compared with males (Ntsoane, 2016). In addition, in LMIC women are more affected by cataracts in comparison to their male counterparts. Women also have lower cataract surgical coverage than men (Lewallen et al., 2009).

Closely related to the beliefs, the lack of knowledge is also exacerbated by the lack of trust in the process of the surgery. Some people fear that the surgery may be unsuccessful and lead to adverse consequences like blindness (Rotchford et al., 2002). As such the lack of trust in the system keeps the benefits of the surgery from the patients who would otherwise need it.

2.3. mHealth

mHealth refers to the use of telecommunication devices to support the health system and clinical practice (Kahn et al., 2010). It engages technological advances coupled with medical expertise, presenting new possibilities in major healthcare areas such as diagnostics, telemedicine, research, reference libraries and interventions (Bastawrous et al., 2013). It is supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants and other wireless devices (WHO, 2011). mHealth platforms include all computer and medical devices, internet and mobile phone devices (Free et al., 2013).

mHealth aims to address healthcare delivery by use of mobile telecommunication and multimedia technologies as an approach to fill the accessibility gap between patients and health professionals. It has the potential to improve patient-provider communication, health promotion and disease management (Beratarrechea et al., 2014). Mobile technologies can provide access to healthcare professionals by facilitating immediate communication and can increase the level of decision-making by health workers through access to information through advanced mobile computing (Varshney, 2014). At its core, mHealth involves the use and capitalization on a mobile phone's core utility of voice and short messaging service (SMS) as well as more complex functionalities and applications including general packet radio service, third and fourth generation mobile telecommunications (3G and 4G systems), global positioning system (GPS), and Bluetooth technology (Thuemmler et al., 2018).

Mobile phone communication has been used as an essential approach to increase delivery of health services all over the world (Kaplan, 2006). In developing countries, mHealth has been used in an effort to address a limited healthcare workforce (Beratarrechea et al., 2014). Statistics show that while Africa bears 24% of the world's disease burden, only 3% of the world's health professionals are in Africa (Teke 2017). WHO has suggested that mHealth can change the form of health service delivery worldwide (WHO, 2011).

mHealth has recently been beneficial in the control of the Zika virus by pinpointing outbreaks and helping physicians detect the virus (Dudley et al., 2017), and in the fight against the Ebola virus (Dahiya and Kakkar, 2016). Examples of mHealth in the form of text message

intervention include smoking termination (Fairhurst and Sheikh, 2008), increasing attendance at primary care appointments (Gurol-Urganci et al., 2013), improving adherence to medication (Fairley et al., 2003), and follow-up of chronic diseases (Ferrer-Roca et al., 2004). Test messaging has also been used as a means to control infectious diseases and for health promotion (Obermayer et al., 2004). Lin et al. (2012) have found that SMS reminders have improved follow-up attendance for pediatric cataracts, thereby proving to be a useful tool in controlling infant cataracts in China.

Text messaging is considered the most common type of communication used between people (WHO, 2011). The SMS has been found cost effective and is efficient in reaching the patient regardless of the phone being switched off and in areas where phone calls are not allowed (Kaplan, 2006). Moreover, Balzer et al. (2014) found that SMS is a feasible tool for use as a reminder system.

2.4. mHealth and ophthalmic diseases

literature shows various examples of mHealth with ophthalmic diseases, for example, mHealth may aid in the use of cataract surgery. A two-way social media messaging app has been found to be useful in delivering post-operation information to cataract patients and is a feasible way for aiding early medication compliance. In addition, mHealth has been useful in assistances on post-operative follow-up for pediatric cataract patients (Lin et al., 2012, Sanguansak et al., 2017). A mobile phone app has been used to help doctors with decision support before cataract surgery (Wicklund, 2016). With regards to glaucoma mHealth has been shown to have a significant effect on improving adherence to glaucoma appointments and medications (Saeedi et al., 2015). While these studies show the positive effects of mHealth in improving the management of ophthalmic disease, a few cases where there has been no effect also exist (Koshy et al., 2008, Mtuya et al., 2016). However, of all the studies identified, few of them are RCTs. This lack of evidence in RCTs has therefore necessitated carrying out this study.

2.5. Summary

The literature has provided evidence that ophthalmic diseases treatment appointments are often missed due to forgetfulness, lack of communication, financial, cultural and societal barriers. mHealth has been used as a reminder in the health sector, for example in increasing attendance at primary health care appointments and improving adherence to medication.

3. Chapter Three: Methodology

This chapter describes the systematic review steps that were applied in the study, which was guided by the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA). The prism checklist is attached in Appendix A.

3.1. Eligibility criteria for include studies

3.1.1 Study design

Randomized control trials (RCTs), non-randomized control trials (non RCTs) such as prospective and retrospective cohort studies and cross-sectional studies were included.

3.1.2 Study participants

We included all studies that used participants who have cataract, glaucoma and diabetic retinopathy who may require surgery in order to avoid blindness associated with those diseases regardless of their age, gender, religion or race and location.

3.1.3 Type of intervention

mHealth interventions included in the study were SMS and telephone calls to encourage patients to attend appointments for surgery or treatment. We excluded mobile phone applications that require access to the internet, such as multimedia message service and emails. These applications might not be accessible to all users, compared to SMS and phone calls, especially in LMIC.

3.1.4 Outcomes

The primary outcome was patient's attendance to ophthalmic disease treatment appointments compared to conventional reminders. The secondary outcome was an evaluation of the cost of the reminders.

3.1.5 Study setting

There was no limit on the study setting and studies from all countries globally were included.

3.2. Search strategy

The search strategy was developed in consultation with a Health Sciences Information Specialist. We identified all relevant literature from the date of introduction of SMS text messaging on 3 December 1992 till 28 February 2018. Articles published in English and with

human targets were included (Deffree, 2015). A comprehensive search was conducted on PubMed, Scopus, (Africa-Wide Information, CINAHL, Computers & Applied Sciences Complete, Health Source: Nursing/Academic Edition by Ebscohost) and Web of Science. Specific search terms included free text and medical subject heading (MeSH). The search terms were adapted for different databases.

The search terms that described mHealth, ophthalmic disease and reminder system were used the search strategy for PubMed is represented in Table 2. The reference lists of relevant studies were assessed by the first author and full-text articles were obtained and reviewed for further information collection. Grey literature sources were searched for in Google.com, Open Grey and New York Academy of Medicine, WHO, Cochran library, Cochrane Central Register of Controlled Trials. Identified unpublished literature was assessed using the same eligibility criteria. The search terms used for databases and grey literatures sources are presented in Appendix B.

PubMed search strategy		
Search	Query	Number of items found
	((((((((((((((((("Cataract"[Mesh]) OR Cataract) OR "Cataract Extraction"[Mesh]) OR Cataract Extraction) OR cataract surgery) OR cataract removal) OR "Lenses, Intraocular"[Mesh]) OR Lenses, Intraocular) OR "Aphakia, Postcataract"[Mesh]) OR Aphakia, Postcataract) OR "Pseudophakia"[Mesh]) OR Pseudophakia OR "glaucoma"[Mesh]) OR glaucoma OR open angle OR diabetic retinopathy))))) AND ((((((((((((((((((((((((("Telemedicine"[Mesh]) OR Telemedicine) OR mHealth) OR mobile health) OR "Wireless Technology"[Mesh]) OR Wireless Technology) OR "Mobile Applications"[Mesh]) OR Mobile Applications) OR "Cell Phones"[Mesh]) OR Cell Phones) OR cellular phone) OR telephones) OR mobile telephone) OR mobile phones) OR "Smartphone"[Mesh]) OR Smartphone) OR "Text Messaging"[Mesh]) OR Text Messaging) OR text messages) OR textings) OR messaging) OR short message service) OR voice mail) OR telephone call) OR phone call) OR Whatsapp) OR "Reminder Systems"[Mesh]) OR Reminder Systems) OR Reminder))))) AND ((((((((((("Patient Compliance"[Mesh]) OR Patient Compliance[Title/Abstract]) OR "No-Show Patients"[Mesh]) OR No-Show Patients[Title/Abstract]) OR Patient Non-Attendance[Title/Abstract]) OR "Lost to Follow-Up"[Mesh]) OR Lost to Follow-Up[Title/Abstract]) OR Attendance[Title/Abstract]) OR adherence[Title/Abstract])) OR cost effectiveness[Title/Abstract])	14

Table 2: PubMed search strategy

3.3. Data extraction

Two researchers (MM and JF) extracted data from the eligible literature independently. Conflicts of view between the two researchers were resolved through discussion. When no agreement was reached, a third researcher intervened (TD). Key information extracted from the included studies were:

1. Author/s and year of the study.
2. Country of the study setting.
3. Type of facility/environment (e.g. eye clinic, pediatric hospital, community).
4. Association of an author.
5. Type of participants / study population / demographic characteristics (e.g. children, gender, age and race).
6. Type of mobile device users.
7. Nature of the mHealth intervention.
8. Type of study (i.e. study design).
9. Type of outcomes measured.
10. Findings / results.

Data was entered into Review Manager (RevMan) software, Version 5.1. by the authors (MM and JF) of this report. A second researcher verified the data entered for missing or incorrect information. Data extraction form is presented in Appendix C.

3.4. Study selection

The relevant studies extracted were saved into Endnote reference management software for further screening. Two researchers (MM and JF) screened the titles and abstracts of identified studies independently for eligibility. These researchers made the final assessment for inclusion using the full-text articles, while disagreements and conflicts were fixed by a third researcher (TD). Each author documented the reasons for exclusion of studies.

3.5. Assessing risk of bias

Risk of bias was assessed by two researchers (MM and JF) independently, and any disagreement was deliberated on and resolved in discussion with a third researcher (TD). This evaluation was based on criteria of the International Cochrane Collaboration (Likis et al., 2014) for RCTs i.e. randomization sequence generation, allocation concealment, blinding of participants, incomplete outcome data, selective outcome reporting and other sources of bias. Risk of bias in observational studies was assessed by using a tool for quality assessment of observational studies (Hoy et al., 2012). We stated our judgment of the risk of bias for each included study as low, high or unclear. A descriptive summary for the risk of bias for each domain in each included study is provided in figure 3 and 4.

3.6. Dealing with missing data

Relevant missing data were identified, and the articles compared with published trial reports. Any discrepancies were resolved by contacting the original authors and if there was no response from the authors, incomplete data was discussed.

3.7. Data analysis and synthesis

This systematic review was to determine the impact of use of mHealth intervention on patient attendance to cataract surgery. The methodology for data analysis was guided by the Cochrane Handbook of Systematic Reviews for Interventions (Deeks et al., 2011). Data were analyzed using Review Manager software (RevMan).

The results of each study were expressed as risk ratio with its corresponding 95% confidence interval (CI) for dichotomous data, or a mean difference with its 95% CI for continuous data.

The studies were gathered based on similar types of participants, interventions, study designs and outcomes for an overall estimate of effect. The data were pooled from studies of similar interventions, participants, outcomes and study designs in a meta-analysis using the random effects model if there is no significant statistical heterogeneity, methodological difference or high risk of bias. If variation between studies in the reported interventions, participants, study designs and outcome measures was encountered, we did not pool the results but summarized the results in a narrative format.

3.8. Assessment of heterogeneity

Clinical heterogeneity was measured by examining types of participants, interventions, and outcomes in each study. Those studies identified as being clinically homogenous were pooled. Heterogeneity between studies was evaluated using chi-square tests and I-squared statistics. We quantified any statistical heterogeneity between study results using the I^2 statistic. We regarded heterogeneity as considerable if the I^2 was greater than 50% (Higgins 2011).

3.9. Ethics approval.

There was on needs for ethics approval since the study did not involve human participants.

4. Chapter Four: Results

This chapter presents results of the systematic review.

Description of the studies.

4.1. Result of the search

Seventy studies were identified from the literatures searches. Ten studies were obtained from grey literature and the World Wide Web.

Fifty-one articles were reviewed after all duplicates were removed where sixteen studies were excluded. Thirty-five full-text articles were reviewed for eligibility and twenty-five articles were excluded with reasons. Only ten studies were included in the quantitative synthesis. The steps for selection of the studies that were included and excluded is represented in Figure 1.

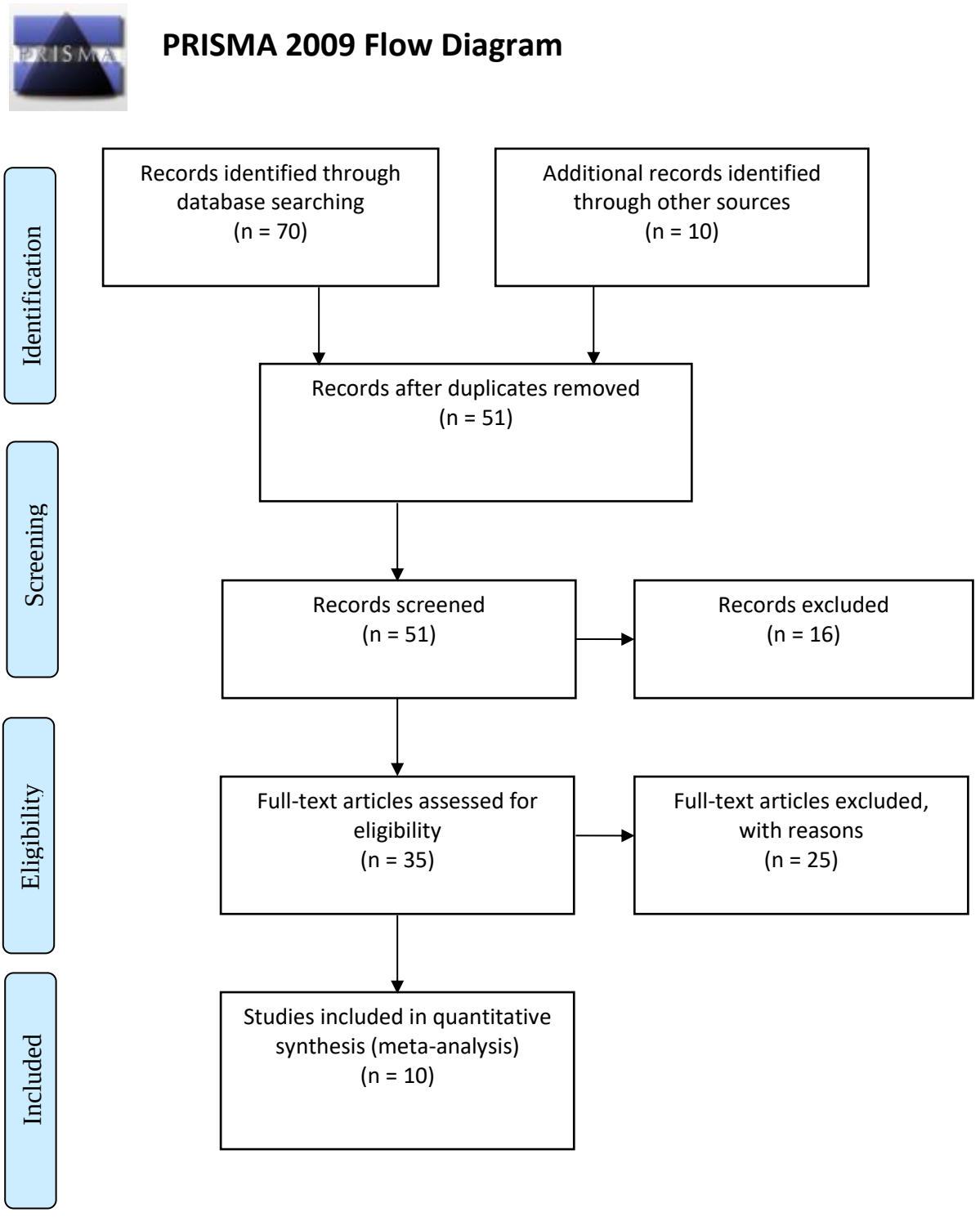

Figure 1: Visual representation of the study selection

4.2. Included studies

Study design and setting.

Ten studies were eligible and included in the review. Four of the ten studies were RCTs (Lin et al., 2012, Pizzi et al., 2016, Malherbe, 2017, Yang et al., 2016). The remaining six studies were non-RCTs with three a cohort studies (Huang et al., 2012, Meltzer et al., 2017, Fudemberg et al., 2016), two a cross sectional studies (Mtuya et al., 2016, Saeedi et al., 2015) and one non RCT study (Koshy et al 2008).

Four studies were conducted in China (Lin et al., 2012, Huang et al., 2012, Meltzer et al., 2017, Yang et al., 2016), three studies in the USA (Saeedi et al., 2015, Fudemberg et al., 2016, Pizzi et al., 2016), one in the UK (Koshy et al., 2008), one in Tanzania (Mtuya et al., 2016) and one in South Africa (Malherbe, 2017).

Four studies out of ten addressed cataracts surgery diseases (Lin et al., 2012, Huang et al., 2012, Meltzer et al., 2017, Malherbe, 2017). Another four studies addressed glaucoma diseases (Fudemberg et al., 2016, Saeedi et al., 2015, Pizzi et al., 2016, Yang et al., 2016). The remaining two studies addressed diabetic retinopathy (Mtuya et al., 2016), and ophthalmology outpatient appointments (Koshy et al., 2008).

4.3. Excluded studies

The main reason for exclusion of studies based on title and abstract is that they did not focus on cataract or associated conditions. Other excluded studies focused on interventions other than mHealth (Ludbrook et al., 2015, Prinja et al., 2015), asthma diseases (Gillissen et al., 2007, McDonald Heiner, 2007), sight loss diseases (Khan et al., 2015) esotropia diseases (Costello et al., 2001), oral supplementation (Chew et al., 2015), chronic diseases (Lin and Wu, 2014), drug delivery (Paganelli et al., 2010), medication noncompliance (Morrissey et al., 2007) and global public health problems (Rao, 2015).

The reasons for exclusion based on full-text review are presented in Appendix D. One of the main reasons was that the intervention did not use reminders and also did not measure any of the outcomes of interest (Gale et al., 2004, Gale et al., 2006, Lin et al., 2016, Drews-Botsch et al., 2016, Lambert et al., 2016, Norregaard, 2007, Hoffman and Pelosini, 2016, McGlynn et al., 2003, Chan et al., 2009, Cromelin et al., 2018, Joshi et al., 2013). Another reason for exclusion was that the studies did not focus on mobile phone messaging (Ramasamy et al., 2013, Nordmann et al., 2010, Boucher et al., 2008, Vengadesan et al., 2017, Owsley et al.,

2015, Thavikulwat et al., 2015, Singh et al., 2000). Other studies were excluded because of ineligible study design. Only three studies used systematic review design (Ramke et al., 2017, Delphino et al., 2016, Kishiki et al., 2016). Two studies focused on group study design (Kowing et al., 2010, Yan et al., 2012). One study was excluded based on did not meet intervention criteria (Sanguansak et al., 2017). Only one study was excluded based on language of publication (Audugé et al., 1998).

4.4. Study characteristics

4.4.1 Participants

In the ten included studies the total number of participants were 5399 [2183 male, 3216 females] of which 59% were female. Most of the participants who took part in the review were from developing countries, 72% [3895] were from settings in LMIC, 89% [3458] were from China (Lin et al., 2012, Huang et al., 2012, Yang et al., 2016, Meltzer et al., 2017). The remaining 21% of the participants were from other developing countries including Tanzania (Mtuya et al., 2016), South Africa (Malherbe, 2017). The participants were all patients with ophthalmic diseases including cataract, glaucoma and diabetic retinopathy, who required treatment or surgery in order to avoid loss of vision. Participants in those studies were receiving mHealth reminders for follow-up cataract surgery appointments or treatment and adherence to glaucoma and diabetic retinopathy medication. Participants ethnicity varied; the following ethnic groups was represented in the study sample, White, Black, Colored, African and Asian. The age categories of these participants are [child - 0 to 20 years, young 20 to 40 years, adults 40 to 60 years, old age over 60 years]. Only one study was found that included children under 18 years. In this study parents received reminder messages on behalf of the children (Lin et al., 2012). The mean age of all participants was [61.5 years]. Figure 2 on age distribution of the study participants per mHealth modality, shows the age groups of participants and mHealth interventions utilized. The figure shows that SMS intervention had the highest percentage compared to phone calls, while the age group of 60 to 80 years dominated the use of SMS interventions.

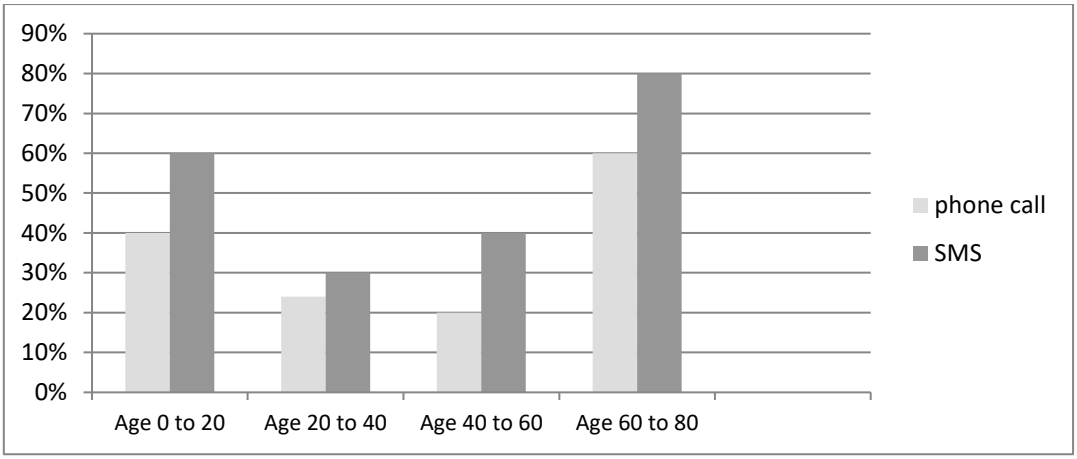

Figure 2: Age distribution of study participants per mHealth modality

The duration of studies was between 2 months and 2 years, with only one study conducted over a period of more than 2 years (Meltzer et al., 2017). Three studies were done in period of one year (Pizzi et al., 2016, Yang et al., 2016, Saeedi et al., 2015, Malherbe, 2017). The remaining studies took between 2 to 5 months (Koshy et al., 2008, Huang et al., 2012, Fudemberg et al., 2016, Mtuya et al., 2016).

The greatest sample size of participants was found in the cohort study by Meltzer, the sample size was 2316 participants (Meltzer et al., 2017). The remaining studies had a sample size between 80 and 1000 participants (Pizzi et al., 2016, Saeedi et al., 2015, Huang et al., 2012, Fudemberg et al., 2016, Lin et al., 2012, Yang et al., 2016, Sanguansak et al., 2017, Malherbe, 2017).

4.4.2 Interventions

The main mHealth intervention modality used by participants was SMS (Mtuya et al., 2016, Lin et al., 2012, Koshy et al., 2008, Saeedi et al., 2015, Yang et al., 2016, Malherbe, 2017). Four out of ten studies used telephone call reminders (Pizzi et al., 2016, Huang et al., 2012, Meltzer et al., 2017, Fudemberg et al., 2016).

4.4.3 Outcomes

Four out of the ten included studies reported on the primary outcome of improving adherence and follow up to glaucoma appointments (Fudemberg et al., 2016, Pizzi et al., 2016, Saeedi et al., 2015, Yang et al., 2016). Another four out of ten studies reported on the primary outcome of increased attendance to follow-up cataract surgery appointments (Lin et al., 2012, Meltzer et al., 2017, Huang et al., 2012, Malherbe, 2017). One study reported a primary outcome of

increased attendance to follow-up diabetic retinopathy appointments (Mtuya et al., 2016), one study reported improved attendance to ophthalmic outpatients appointments in general, with no specific diseases (Koshy et al., 2008).

Five out of the ten studies reported the cost of the intervention ,where one study conducted in China reported that the cost of reminders was low (US$0.02) per message (Yang et al., 2016). Another study conducted in USA reported that the cost of the intervention was US$11.32 per patient (Pizzi et al., 2016). One study conducted in South Africa reported the cost for three SMS reminder to be 54 cents (Malherbe, 2017). A study conducted in the UK reported that the cost of sending the reminder was 7.2 pence (Koshy et al., 2008). Onley one study conducted in China reported that the SMS reminder was free of charge (Lin et al., 2012). The remaining five studies out of the ten did not report on the cost of the intervention (Fudemberg et al., 2016, Huang et al., 2012, Mtuya et al., 2016, Meltzer et al., 2017, Saeedi et al., 2015). Summary on the characteristics of included studies are shown in Table 3 below.

Characteristics of included studies

Study ID	Study design, Country, Device	Sample size	Follow-up period	Age, gender	Interventions	Outcomes
Mtuya et al (2016)	A cross-sectional study. Country: Tanzania. Device: Mobile phone	203 participants Male 87 Female 116	Between April and June 2013.	50 to 80 years. Mean age 67.4 Male & female	Text messages were sent to inform patients about their screening, and mobile retinal image was used for eye examination	Increase attendance to follow-up appointments
Pizzi et al (2016)	Prospective randomized control. Country: USA. Device: telephone	256 participants Male 129 Female 127	1 September 2012 to 31 October 2013.	Over 65 years Male & female.	Telephone call reminders used to call patients 2-3 days prior to the appointment and customized letter sent 2 weeks before appointment	Improve adherence to glaucoma appointments
Saeedi et al (2015)	A cross-sectional study. Country: USA. Device: mobile phone	989 participants. Male 428 Female 561	Between February 2011 to January 2012.	3 age group Under 40 41 to 65. Over 65 years. [Mean age 68.0]	Text message and Email were sent to glaucoma patients as reminder for appointment and medication	Improving adherence to glaucoma appointments and ocular hypertension medications
Malherbe (2017)	Randomized control trials. Country: South Africa. Device: mobile phone	234 participants. Male 79 Female 136	Between June 2015 and June 2016.	Mean age: 67:49 control group, 69:46 intervention group.	Automated SMS reminder system dispatched an SMS reminder one month, four days and one day preoperatively between 10am and 12am	Attendance rate with and without an SMS reminder system.
Yang et al (2016)	Randomized control trials RCT Country: China. Device: mobile phone	209 participants. Female 209.	Between October 1, 2014 to November 31,2015.	Mean age 64.4 intervention group	Text message reminders were sent to patients 3 days before appointment	Improve follow-up at 1 month postoperatively

Fudemberg et al (2016)	Retrospective cohort study. Country: USA Device; telephone	259 participants Male 83 Female 68	Between 1 September 2013 and 30 November 2013	> 21 years of age Mean age 64.4 in CPEC clinic,66.3 in glaucoma clinic Male & female	Telephone reminders were sent to patients attending a primary eye care clinic.	Increase rate of adherence to follow-up appointments
Huang et al (2012)	Prospective cohort study. Country: China Device: telephone	518 participants Male 149 Female 277	Over two 4 days periods Between October 11-14,2009 and October 19-23,2009	Mean age 74.1 ± 8.8 years. Male & female	Telephone and advertisements were used to invite patients underwent cataract surgery to hospital-based study examination	Improving compliance with cataract surgery.
Koshy et al (2008)	Observational study Country: UK Device: mobile phone	9959 participants	Between April and September 2006	Information not available	SMS text messages were sent to patients with scheduled appointments at a hospital ophthalmology department in London.	Improve attendance at ophthalmology outpatients appointments
Lin et al (2012)	Randomized control trial RCT Country: China Device: mobile phone	258 participants Male 160 female 127	Information not available	< 18 years Male & female.	Automated SMS text message reminder was sent to parents of children before scheduled appointments	Increase number of follow-up appointments
Meltzer et al (2017)	Prospective cohort. Country: China Device: telephone	2473 participants Male 1068 Female 1405	From January 19,2010 to April 18,2012	Mean age 68.4 Male & female	Telephone and transportation interventions were used to increase follow-up at least 40 days after cataract surgery	Increase follow-up at least 40 days after surgery and presence of complications

Table 3: Characteristics of included studies

4.5. Risk of bias in included studies

The risk of bias in four RCTs was assessed using a cochrane risk of bias tools. The risk of bias in these four studies is described in Figure 3.

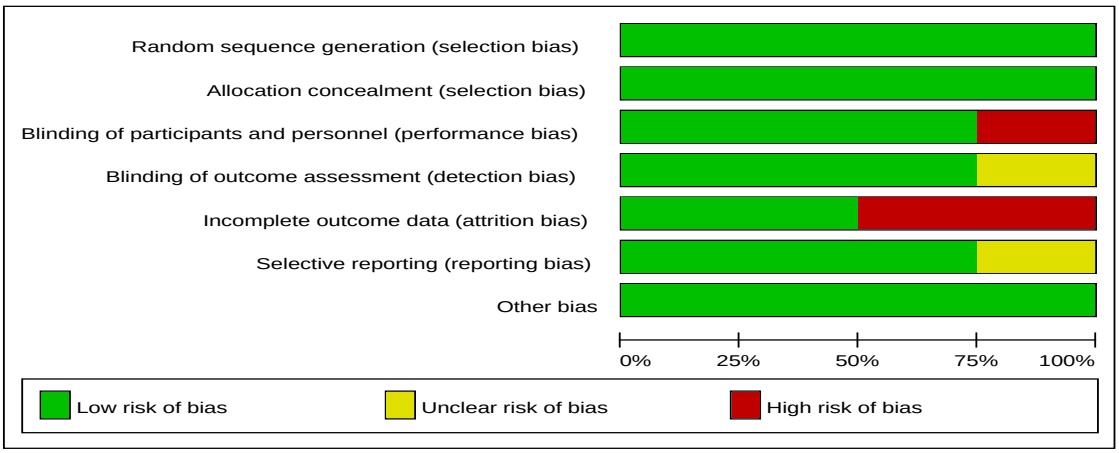

Figure 3: Risk of bias graph: review authors' judgements about each risk of bias item

4.5.1 Allocation (selection bias)

The random sequence generation was low in four randomized control studies, and all studies were described the randomization of allocation regarding of mHealth intervention reminder on attendance to ophthalmic diseases appointments. Where two studies applied random number generator program (Lin et al., 2012, Malherbe, 2017). The remaining two studies applied certain aspects of sequence generation methods such as simple randomization program (Yang et al., 2016). and recommended follow-up program (Pizzi et al., 2016).

Allocation concealment was low risk in all randomized control studies (Lin et al., 2012, Malherbe, 2017, Pizzi et al., 2016, Yang et al., 2016).

4.5.2 Blinding

Blinding of participants (performance bias) were low risk in three studies (Pizzi et al., 2016, Malherbe, 2017, Lin et al., 2012). Only one study participants were not blinded (Yang et al., 2016).

Blinding of outcomes (detection bias) were low in three studies (Yang et al., 2016, Malherbe, 2017, Pizzi et al., 2016). Risk of bias was unclear in one study(Lin et al., 2012).

4.5.3 Incomplete outcome data (attrition bias)

Risk of attrition bias was low in two studies (Malherbe, 2017, Yang et al., 2016), while in remaining two studies risk of attrition bias was high. One RCT study on pediatric cataract treatment (Lin et al., 2012) had many participants that were lost during follow-up which made it impossible to determine whether there was a significant improvement on the outcomes. Also there was incomplete outcome data in one study (Pizzi et al., 2016) where approximately 30 % of patients were cancelled without rescheduling or simply do not show up for an appointment and were lost to follow-up.

4.5.4 Selective reporting

The risk of selective reporting was low in three studies (Malherbe, 2017, Lin et al., 2012, Yang et al., 2016), and unclear in one study. Study by Pizzi et al reported in the method of the study that one particular outcomes were not reported in the results (Pizzi et al., 2016).

4.5.5 Other sources of bias

There were no other possible sources of bias since none of the studies indicates there is evidence of possible sources of bias.

4.5.6 Risk of bias in observational study

Assessment of risk of bias in the remining six observational studies was assessed using the quality assessment tool by Hoy et al. 2012 that, is particularly used for observational studies design (Hoy et al., 2012). This tool shows the categorizes of risk as high risk for those studies with an overall score of >8 points, moderate risk as 6-8 and low risk 0-5 points, as seen in Figure 4.

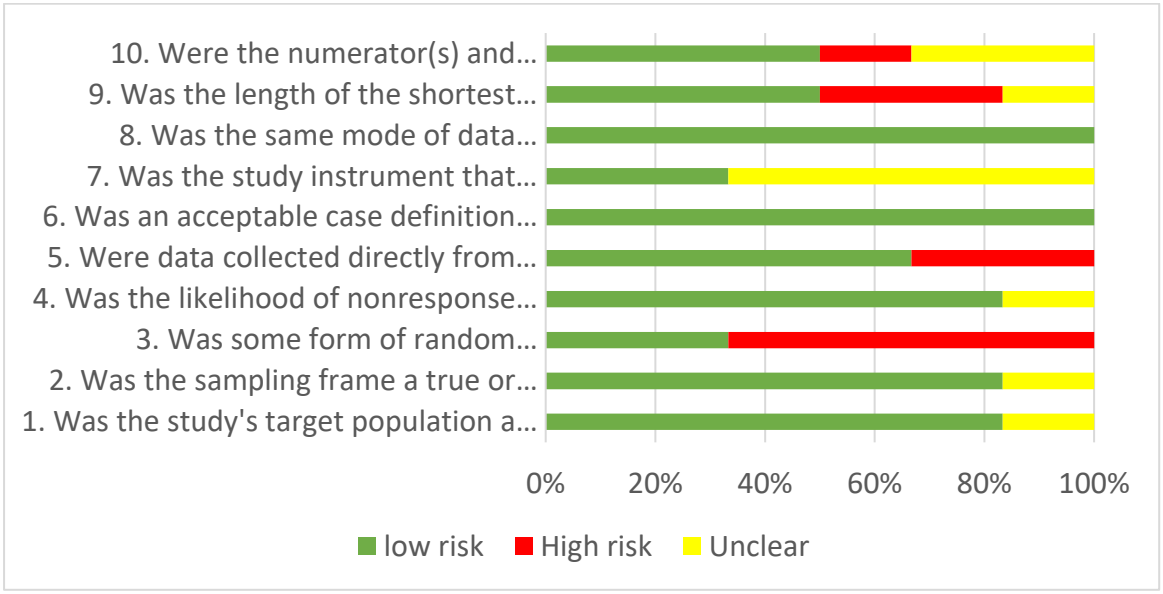

Figure 4: Risk of bias graph for observantional studies

The assessment of the risk of bias in observational studies was low in five (Fudemberg et al., 2016, Huang et al., 2012, Meltzer et al., 2017, Mtuya et al., 2016, Saeedi et al., 2015), and was unclear in only one study (Koshy et al., 2008).

4.6. Results of individual studies

Effect of the interventions.

4.6.1 Effect of SMS reminder compared to conventional reminder.

Analysis of two RCT studies (Lin et al., 2012, Malherbe, 2017), shows that patients who had cataracts showed improvement in appointment attendance (RR 1.26; 0.89, 1.78) compared to cataract patients that had used conventional methods as seen in Figure 5.

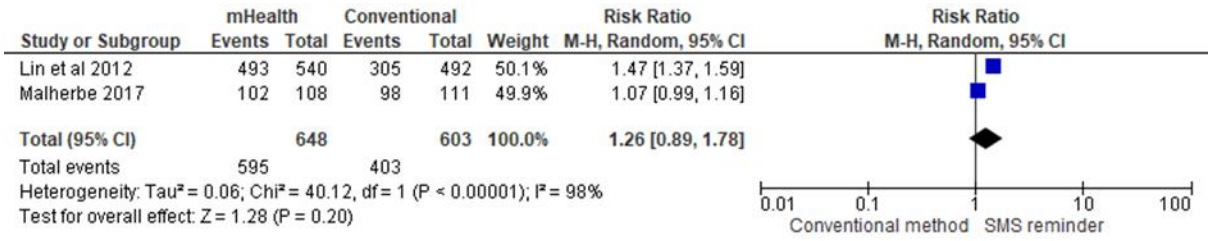

Figure 5; Analysis of 2 RCTs that shows the effect of SMS reminder in cataract diseases

One a cross sectional study shows that SMS reminder has difference on SMS reminder group compared to conventional methods. According to the study SMS has useful impact when used as reminder for patients with glaucoma disease as seen in Figure 6.

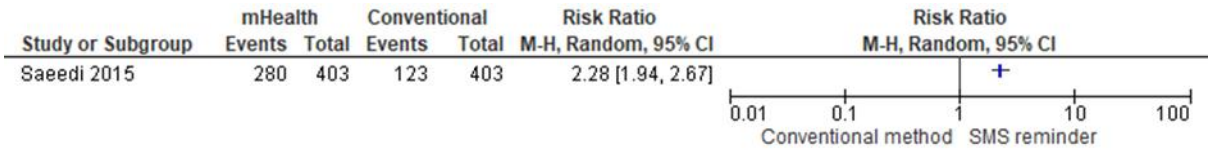

Figure 6: Analysis of a cross sectional study shows the effect of SMS reminder with glaucoma diseases.

Analysis of non RCT study (Koshy et al., 2008), shows that the SMS reminder has no improvement on the SMS reminder group compared to conventional methods when used as reminder in ophthalmalgia outpatients' appointments as seen in Figure 7.

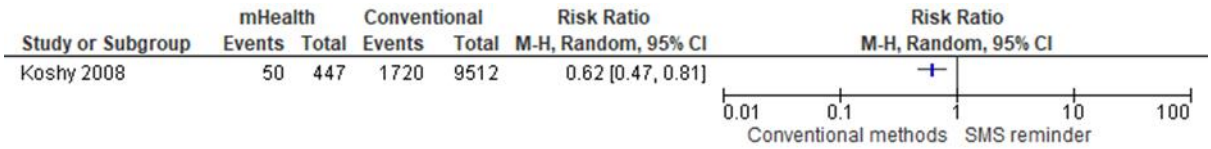

Figure 7: Analysis of non RCT study shows the effect of SMS reminder with ophthalmology outpatients appointments.

Analysis of one a cross sectional study (Mtuya et al., 2016), shows that the SMS reminder had no improvements on the appointments of diabetic retinopathy compared to conventional methods as seen in Figure 8.

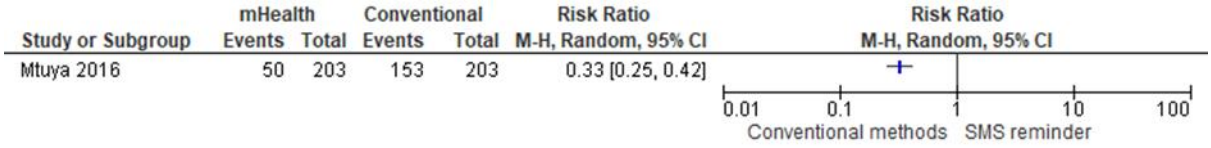

Figure 8: Analysis of a cross sectional study shows the effect of SMS reminder with diabetic retinopathy.

4.6.2 Effect of phone call reminder compared to conventional reminder.

Analysis of two cohort studies (Huang et al., 2012, Meltzer et al., 2017), shows that the phone call reminder had no improvement in the attendance of cataract disease patients compared to conventional methods as seen in Figure 9.

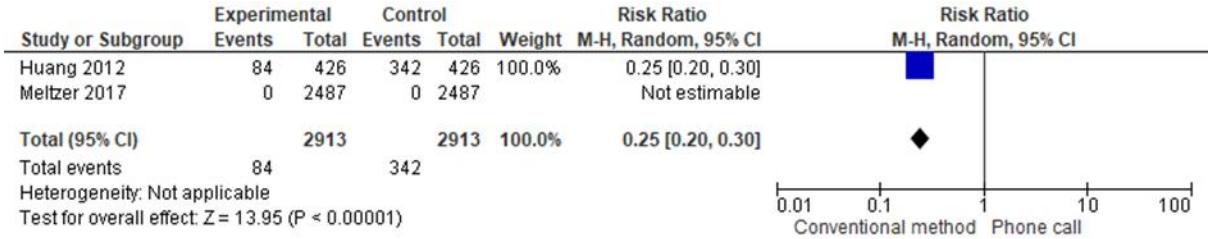

Figure 9: Analysis of two cohort studies shows the effect of phone call reminder with cataract diseases.

Analysis of one RCT study (Pizzi et al., 2016), shows that the phone call reminder has very slight improvement among glaucoma patient as a method of appointment reminder compared to conventional methods as seen in Figure 10.

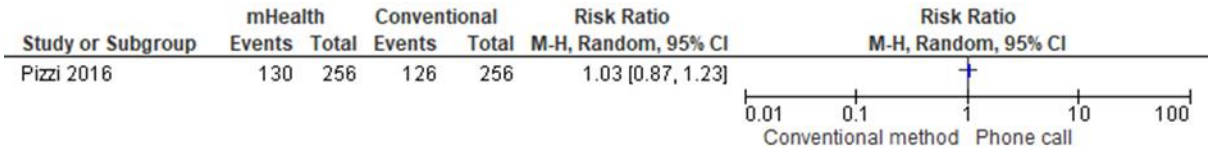

Figure 10: Analysis of one RCT study shows the effect of phone call reminder with glaucoma diseases.

5. Chapter Five: Discussion, Conclusion and Recommendations

The systematic review aimed to determine the impact of mobile phone messaging as a reminder to improve patient attendance to cataract surgery. This section discusses the results in the context of the aims and objectives of the study and provides a summary of the limitations of the study. Conclusions are drawn, and recommendations are made for further study.

5.1. Discussion

The systematic review aimed to determine the impact of mobile phone messaging as a reminder to improve patient attendance to cataract surgery. This section discusses the results in the context of the aims and objectives of the study and provides a summary of the limitations of the study. Conclusions are drawn, and recommendations are made for further study.

A total of seventy studies was retrieved from our initial search. Once duplicates were removed and articles screened according to the eligibility criteria only ten articles remained. The ten articles varied substantially in relation to study design, settings and sample size. The literature and results from this review indicate that there is a lack of peer-reviewed studies that use mHealth as a reminder for cataract surgery. Furthermore, only four studies were included that met the gold standard of study designs which is RCTs (Lin et al., 2012, Yang et al., 2016, Pizzi et al., 2016, Malherbe, 2017). These four RCT studies addressed the use of mHealth intervention with cataracts and glaucoma diseases. Two studies were conducted in China (Lin et al., 2012, Yang et al., 2016) , the remaining two were in the USA (Pizzi et al., 2016) and South Africa (Malherbe, 2017). This confirms the assertion by Lin et al. (2012) that there are only a few studies in which mHealth was used for the management of cataracts.

Participants of the study were all patients who had experienced ophthalmic diseases including cataracts, glaucoma and diabetic retinopathy as those particular disease has considered the most ophthalmic disease leading to blindness (Quillen, 1999, Pelletier et al., 2016). With regard to the location, 72% of the participants were from LMIC (Huang et al., 2012, Lin et al., 2012, Yang et al., 2016, Meltzer et al., 2017, Sanguansak et al., 2017, Mtuya et al., 2016) while 89% of these participants were from China (Lin et al., 2012, Huang et al., 2012, Yang et al., 2016, Meltzer et al., 2017). This confirms the prevalence of cataract diseases in these countries and the incidence of blindness associated with cataract.

With regard to gender of participants, among the total number of participant of 5399, [2183 male, 3216 females], females were 59% higher than males. eight studies in the review demonstrated a higher female participation rate. The literature also reported that, in many

developing countries the prevalence of ophthalmic disease such as cataract is higher in women compared to men (Thomas et al., 2016).

With regards to the age of participants, 80% of the participants between 60 to 70 years of age utilized mHealth intervention the most (Lin et al., 2012, Yang et al., 2016, Pizzi et al., 2016, Malherbe, 2017, Fudemberg et al., 2016, Huang et al., 2012, Meltzer et al., 2017, Mtuya et al., 2016, Saeedi et al., 2015) . This clearly demonstrates that most people over 65years of age have been affected by ophthalmic disease such as cataract, glaucoma and diabetic retinopathy in over the world. Literatures states that over 50% of American people have been diagnosed with cataract disease by the age of 70 years (Friedman, 2012). The evidence highlights that when targeting a particular group then age would be a key factor given the success among the 60 – 70 years age group.

With regard to mHealth reminder modalities, the results show that 60% of mHealth studies used SMS (Mtuya et al., 2016, Lin et al., 2012, Koshy et al., 2008, Saeedi et al., 2015, Yang et al., 2016, Malherbe, 2017). This statement confirms that text messaging is often used when evaluating the use of mHealth intervention in increases attendance or adherence to appointments or medications with diseases such as cataracts, glaucoma and diabetic retinopathy (Lin et al., 2012, Saeedi et al., 2015, Mtuya et al., 2016). The use of SMS as reminder is regarded as the most beneficial tool; this is attributed to the cost effectiveness of the intervention compared to other mobile phone applications that require internet connectivity (Kaplan, 2006). Also, SMS have been reported to be more accessible to mobile phones users since they are able to use this modality (i.e. SMS) even when no voice calls are allowed or permitted (Balzer et al., 2014).

The main outcome of interest in the systematic review study was improving patients' attendance to ophthalmic diseases treatments compared to conventional reminders. Results from the study show that there was a significant difference in attendance rate for studies that used SMS reminders compared to telephone reminder studies (Lin et al., 2012, Koshy et al., 2008, Yang et al., 2016, Saeedi et al., 2015, Mtuya et al., 2016, Malherbe, 2017). This gives a clear indication on the usability of SMS reminder on improving attendance to ophthalmic diseases appointments and adherence to medications. Literature also demonstrated that SMS has been found to be a feasible tool for use as a reminder system (Balzer et al., 2014). It has been reported that SMS reminders improve attendance rates for pediatric cataract treatments (Lin et al., 2012). Also, SMS has been reported to had improve adherence to glaucoma appointments (Saeedi et al., 2015).

The cost of the intervention has been reported in five studies that the cost was low, four of these studies was SMS reminder used (Koshy et al., 2008, Lin et al., 2012, Malherbe, 2017, Yang et al., 2016), although evaluation of the cost of interventions in this systematic review was the secondary outcomes. However, literature demonstrate that the SMS reminder has been found superior due to low operation costs compared with other mHealth modalities, on the other hand mobile phone call reminder has been found costly and time consuming (Malherbe, 2017).

One of the limitations in the study was that only four RCT studies were included in the systematic review and this adversely affects the reliability of the evidence regarding to the effect of the interventions (Lin et al., 2012, Pizzi et al., 2016, Yang et al., 2016, Malherbe, 2017). In addition, one of the included studies addressed ophthalmology in general, focusing on outpatient appointments without specifying the particular disease. Also, there was missing data regarding the characteristics of participants such as age and gender (Koshy et al., 2008).

5.2. Conclusions and recommendations

The review has shown that mHealth interventions have a positive effect on patient attendance to follow-up appointments for ophthalmic disease including cataracts, glaucoma and diabetic retinopathy. This has been evident in the use of SMS as the most successful modality of mHealth reminders in comparison to other modalities such as phone.

Many of the participants included in the review were from LMIC. In LMIC's the prevalence of preventable blindness or blindness related to cataracts, glaucoma, and diabetic retinopathy is high. Also, eighty percent of the participants were older than 55 years and sixty percent were female.

Given the potential that the study has shown for mHealth in the management of ophthalmic diseases, it is recommended that further research is given priority, especially in LMIC and on groups severely affected by ophthalmic diseases, such as women over the age of 55. Future studies should be conducted to determine the effectiveness of mHealth reminders applied before surgery for patients experiencing ophthalmic disease symptoms.

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Appendix A: PRISM checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	1
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	3
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	iv
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	11
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	12
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	12
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	14
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	13
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	13
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	25
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	28
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	28

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	23
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	16
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	18
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	23
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	26
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	26
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	23
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	29
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	31
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	31
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit: **www.prisma-statement.org**.

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Appendix B: Search terms

Cataract: Search Terms.

#1 Search Pseudophakia. Items found 2585

#2 Search Aphakia, Postcataract. Items found 1815

#3 Search "Aphakia, Postcataract"[Mesh]. Items found 1810

#4 Search "Lenses, Intraocular"[Mesh]. items found 3984

#5 Search Lenses, Intraocular. items found 16020

#6 Search cataract removal. items found 2563

#7 Search cataract surgery. items found 44063

#8 Search Cataract Extraction. items found 33435

#9 Search "Cataract Extraction"[Mesh]. items found 31317

#10 Search cataract. Items found 66506

#11 Search "Cataract"[Mesh]. Items found 26842

12 "Cataract"[Mesh]) OR cataract) OR "Cataract Extraction"[Mesh]) OR Cataract Extraction) OR cataract surgery) OR cataract removal) OR "Lenses, Intraocular"[Mesh]) OR Lenses, Intraocular) OR "Aphakia, Postcataract"[Mesh]) OR Aphakia, Postcataract) OR Pseudophakia. Items found 74510

mhealth: Search Terms.

#1 Reminder Systems. Items found 3649

#2 "Reminder Systems"[Mesh]. Items found 3017

#3 Whatsapp. Items found 141

#4 Phone call. Items found 1806

#5 telephone call. Items found 3215

#6 Voice mail. Items found 355

#7 short message service. Items found 3107

#8 messaging. Items found. Items found 4843

#9 texting. Items found 2999

#10 text messages. items found 3641

#11Text Messaging. Items found 2743

#12 "Text Messaging"[Mesh]. Items found 1818

#13 Smartphone. Items found 5240

#14 "Smartphone"[Mesh]. Items found 1652

#15 mobile phones. Items found 11309

#16 mobile telephone. Items found 10643

#17 telephones. Items found 63602

#18 cellular phone. Items found 10168

#19 "Cell Phone"[Mesh]. Items found 8453

#20 Cell Phones. Items found 10196

#21 "Mobile Applications"[Mesh]. Items found 2727

#22 Mobile Applications. items found 6688

#23 Wireless Technology. Items found 5541

#24 "Wireless Technology"[Mesh]. Items found 2659

#25 mobile health. items found. 45705

#26 mHealth. Items found 27720

#27 "Telemedicine"[Mesh]. Items found 22157

#28 telemedicine. Items found 26026

29 ("Telemedicine"[Mesh]) OR telemedicine) OR mHealth) OR mobile health) OR "Wireless Technology"[Mesh]) OR Wireless Technology) OR "Mobile Applications"[Mesh]) OR Mobile Applications) OR "Cell Phone"[Mesh]) OR Cell Phones) OR cellular phone) OR telephones) OR mobile telephone) OR mobile phones) OR "Smartphone"[Mesh]) OR Smartphone) OR "Text Messaging"[Mesh]) OR Text Messaging) OR text messages) OR texting) OR messaging) OR short message service) OR Voice mail) OR telephone call) OR Phone call) OR Whatsapp) OR "Reminder Systems"[Mesh]) OR Reminder Systems. Items found 121851 .

Attendance Search Terms

#1 Cost effectiveness[Title/Abstract]. Items found 50322

#2 Adherence[Title/Abstract]. Items found 95870

#3 Attendance[Title/Abstract]. Items found 21634

#4 Lost to Follow-Up[Title/Abstract]. Items found 14459

#5 "Lost to Follow-Up"[Mesh]. Items found 933

#6 Patient non-attendance[Title/Abstract]. items found 28

#7 No-Show Patients[Title/Abstract]. Items found 21

#8 "No-Show Patients"[Mesh]. Items found 68

#9 Patient Compliance[Title/Abstract]. Items found. 8374

#10 "Patient Compliance"[Mesh]. Items found 67259

#11 "Patient Compliance"[Mesh]) OR Patient Compliance[Title/Abstract]) OR "No-Show Patients"[Mesh]) OR No-Show Patients[Title/Abstract]) OR Patient non-attendance[Title/Abstract]) OR "Lost to Follow-Up"[Mesh]) OR Lost to Follow-Up[Title/Abstract]) OR Attendance[Title/Abstract]) OR Adherence[Title/Abstract]) OR Cost effectiveness[Title/Abstract]. items found 228365.

PubMed Search Terms: items found 17

((((((((((((((("Cataract"[Mesh]) OR Cataract) OR "Cataract Extraction"[Mesh]) OR Cataract Extraction) OR cataract surgery) OR cataract removal) OR "Lenses, Intraocular"[Mesh]) OR Lenses, Intraocular) OR "Aphakia, Postcataract"[Mesh]) OR Aphakia, Postcataract) OR "Pseudophakia"[Mesh]) OR Pseudophakia)))))

AND

((((((((((((((((((((((((((("Telemedicine"[Mesh]) OR Telemedicine) OR mHealth) OR mobile health) OR "Wireless Technology"[Mesh]) OR Wireless Technology) OR "Mobile Applications"[Mesh]) OR Mobile Applications) OR "Cell Phones"[Mesh]) OR Cell Phones) OR cellular phone) OR telephones) OR mobile telephone) OR mobile phones) OR "Smartphone"[Mesh]) OR Smartphone) OR "Text Messaging"[Mesh]) OR Text Messaging) OR text messages) OR textings) OR messaging) OR short message service) OR voice mail)

OR telephone call) OR phone call) OR Whatsapp) OR "Reminder Systems"[Mesh]) OR Reminder Systems) OR Reminder)))))

AND

((((((((((("Patient Compliance"[Mesh]) OR Patient Compliance[Title/Abstract]) OR "No-Show Patients"[Mesh]) OR No-Show Patients[Title/Abstract]) OR Patient Non-Attendance[Title/Abstract]) OR "Lost to Follow-Up"[Mesh]) OR Lost to Follow-Up[Title/Abstract]) OR Attendance[Title/Abstract]) OR adherence[Title/Abstract])) OR cost effectiveness[Title/Abstract])

Web of Science Search Terms: items found 25

TOPIC: (: (Cataract OR Cataract Extraction OR cataract surgery OR cataract removal OR Lenses Intraocular OR Aphakia Postcataract OR Pseudophakia))

AND

TOPIC: ((Telemedicine OR mHealth OR mobile health OR Wireless Technology OR Mobile Applications OR Cell Phone OR cellular phone OR telephones OR mobile telephone OR mobile phones OR Smartphone OR Text Messaging OR text messages OR texting OR messaging OR short message service OR voice mail OR telephone call OR phone call OR Whatsapp OR Reminder Systems OR Reminder)).

AND

TOPIC: (: (Patient Compliance OR No-Show Patients OR Patient Non-Attendance OR Lost to Follow-Up OR Attendance OR adherence OR cost effectiveness)).

Ebscohost Search Terms: items found 2

Boolean/Phrase:(Cataract OR Cataract Extraction OR cataract surgery OR cataract removal OR Lenses Intraocular OR Aphakia Postcataract OR Pseudophakia)

AND

Boolean/Phrase (Telemedicine OR mHealth OR mobile health OR Wireless Technology OR Mobile Applications OR Cell Phone OR cellular phone OR telephones OR mobile telephone OR mobile phones OR Smartphones OR Text Messaging OR text messages OR texting OR messaging OR short message service OR voice mail OR telephone call OR phone call OR WhatsApp OR Reminder Systems OR reminder)

AND

Boolean/Phrase:(Patient Compliance OR No-Show Patients OR Patient Non Attendance OR Lost to Follow-Up OR Attendance OR adherence OR cost effectiveness)

Scopus Search Terms

TITLE-ABS-KEY (Cataract OR “Cataract Extraction” OR “cataract surgery” OR “cataract removal” OR “Lenses Intraocular” OR “Aphakia Postcataract” OR Pseudophakia).

AND

TITLE-ABS-KEY (Telemedicine OR mHealth OR “mobile health” OR “Wireless Technology” OR “Mobile Applications” OR “Cell Phone” OR “cellular phone” OR telephones OR “mobile telephone” OR “mobile phones” OR “Smartphones” OR “Text Messaging” OR “text messages” OR texting OR messaging OR “short message service” OR “voice mail” OR “telephone call” OR “phone call” OR WhatsApp OR “Reminder Systems” OR reminder).

AND

TITLE-ABS-KEY (“Patient Compliance” OR “No-Show Patients” OR “Patient Non-Attendance” OR “Lost to Follow-Up” OR Attendance OR adherence OR “cost effectiveness”)

Grey literature Search Terms:

Google.com:

mobile phone, messaging, reminder, cataract surgery. Items found 3

Open Grey:

mobile phone, messaging, reminder, cataract surgery. Items found 0.

New York Academy of Medicine:

mobile phone, messaging, reminder, cataract surgery. Items found 0.

World Health Organization WHO:

mobile phone, messaging, reminder, cataract surgery. Items found 0.

Cochran Library:

mobile phone, messaging, reminder, cataract surgery. Items found 1

Cochrane Central Register of Controlled Trials:

mobile phone, messaging, reminder, cataract surgery. Items found 0

Appendix C: Data extraction form

- Reference (First author / Year / Journal citation)

- Location:
  - Region
  - Country:
  - Classification:

- Sample size:
  - Intervention population sample (#)
  - Control population sample (#)

- Duration of study:
  - In months, divide by pre- and post-

- Study design type:
  - Randomized Controlled Clinical Trial
  - Quasi-experimental
  - Time-series
  - Other (write-in)

- Intervention:
  - mHealth

- Modality of mHealth
- SMS
- APP
- Telephone call
- USSD

- Main outcome measures:
  - Cataract Surgery Attendance
  - Decrease in blindness due to removal of cataracts

- Results:

- Notes

Appendix D: Excluded studies

No	Study	intervention	Reason for excluded
1	RP Gale et al.,2004	Telephone questionnaire	The intervention was not used as a reminder, study did not measure our outcomes of interest.
2	RP Gale et al.,2006	Telephone questionnaire	The intervention was not used as a reminder, study did not measure our outcomes of interest.
3	Lin et al 2016	Telephone interview	The intervention was not used as a reminder, study did not measure our outcomes of interest.
4	C. Drews-Botsch et al. 2016	Telephone interviews	The intervention was not used as a reminder, study did not measure our outcomes of interest.
5	SR Lambert et al 2016	Telephone interview	The intervention was not used as a reminder, study did not measure our outcomes of interest.
6	Norregaard et al 2007	Telephone interview	The intervention was not used as a reminder, study did not measure our outcomes of interest.
7	Hoffman et al 2016	Telephone interview	The intervention was not used as a reminder, study did not measure our outcomes of interest.
8	Ramasamy et al 2013	direct ophthalmoscopy	The study did not address mobile phone messaging.
9	Kowing et al., 2010	Telephone call reminder system	The study design was a focus group study.
10	Audugé et al 1998	Information not available	The study was not published in English.
11	Nordmann et al., 2010	A computerized device (Travalert®	The study did not address mobile phone messaging.
12	Boucher et al.,2008	mobile screening imaging	The study did not address mobile phone messaging.
13	Vengadesan et al (2017)	No intervention	The study did not address mobile phone messaging.
14	Owsley et al., 2015	nonmydriatic camera	The study did not address mobile phone messaging.
15	Yan et al., 2012	telephone or short message to remind	The study design was a focus group study.
16	Thavikulwat et al 2015	No intervention	The study did not address mobile phone messaging.
17	McGlynn et al 2003	Telephone interview	The intervention was not used as a reminder, study did not measure our outcomes of interest.
18	Chan et al 2009	Telephone interview	The intervention was not used as a reminder, study did not measure our outcomes of interest.
19	Cromelin et al (2018)	Telephone interview	The intervention was not used as a reminder, study did not measure our outcomes of interest.
20	Joshi et al 2013	telephone questionnaire	The intervention was not used as a reminder, study did not measure our outcomes of interest.

21	Remke J et al 2017	Telephone call	Systematic review study.
22	Delphino et al 2016	Phone Monitoring	Systematic review study.
23	E Kishiki et al 2016	Cell phone reminder	Systematic review study.
24	AJ Singh et al., 2000	No intervention	The study did not address mobile phone messaging.
25	Sanguansak et al, 2017	Multimedia message	did not meet mHealth interventions criteria