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Telemedicine integration into the eye health ecosystem in scaling of effective refractive error coverage in Kenya

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This study explored the potential of telemedicine integration into the eye health ecosystem with an aim of scaling effective refractive error coverage in Kenya. This exploratory study was conducted telephonically and through online interviews with key opinion leaders, ophthalmologists, optometrists, ophthalmic clinical officers, optical technicians and beneficiaries of the optical technician's services in rural areas. A telemedicine workflow was developed and validated based on the comments from the key opinion leaders using the Delphi technique. Quantitative and qualitative data were analysed using SPSS and NVivo Software respectively. All of the key opinion leaders agreed that telemedicine is relevant in the eye health ecosystem and recognition of primary vision technicians is critical for effective telemedicine integration. The reasons for the need of telemedicine integration were categorized into; good relationship, organized refractive error service delivery, convenience and availability and cost reduction. The possible factors influencing integration of telemedicine identified were categorized into cost, unwillingness, dominance, perception, lack of technical team, policies and network coverage. The limited human resources in the eye health ecosystem in developing countries cannot effectively deliver refractive error services to the growing population. Hence, integration of telemedicine and establishment of policies recognizing telemedicine are desirable to strengthen task shifting and scale effective refractive error coverage.

Keywords Task shifting, Telemedicine, Scaling, Integration, Eye health, Refractive error

Abbreviations

RE	Refractive error
URE	Uncorrected refractive error
WHO	World health organization

Uncorrected refractive error (URE) remains the leading cause of visual impairment globally[1] with its impact highly felt in developing countries such as Kenya. In Kenya, there are approximately 1091 eye care professionals with only 560 clinical refractionists attending to approximately 47 million Kenyans[2], which is below the World Health Organization (WHO) recommendation of one clinician to a population of 250,000[3]. The distribution of the limited human resources within urban areas limits the population residing within remote areas from accessing refractive error (RE) services. Hence, adoption of approaches such as telemedicine, which is the provision of health care remotely via information and communications technology may enable the scaling of services to remote areas is desirable[4]. In Kenya, the scope of practice for ophthalmologists entails provision of medical and surgical management of eye conditions or management with optical devices, optometrists provides comprehensive vision and optical care, management of restricted range of eye rehabilitation while the optical technicians dispense optical prescriptions from either ophthalmologists or optometrists[5]. However, given that the human resources for eye health in Kenya remains limited, task shifting which is the redistribution of tasks among health workforce team members with an aim of scaling human resource in a cost-effective way is desirable for Kenya. However, given that most public health sectors in Kenya lack RE services[6] with the optical industry dominated by the private sectors, the services remain expensive. Therefore, to achieve universal health coverage, integration

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of technological approaches such as telemedicine is desirable to strengthen task shifting. Therefore, this study assessed the relevance of telemedicine in addressing URE in Kenya.

Currently in Kenya, training one eye care professional whose scope of practise entails refraction cost approximately US$ 1680—US$ 20,450 while training an optical technician cost approximately US$ 700[7,8]. Given the high cost of undertaking conventional training of eye care professionals, RE services are only available in few tertiary hospitals in Kenya with majority of primary and secondary healthcare facilities lacking such services. As a result, this study intends to assess the feasibility to integrate telemedicine into the eye health ecosystem in Kenya to allow for establishment of satellite community vision centres managed by optical technicians under supervision by an optometrist. However, with the limited literature on the effectiveness of telemedicine in addressing URE, the potential of telemedicine remains unknown in addressing URE hence warranting this study.

The BE HEALTHY BE MOBILE (BHBM) initiative of the WHO has been shown to scale awareness on myopia and increase patients visits to eye care facilities[9]. This implies that technology has the potential to scale awareness creation and enhance demand for services across the geographical locations. However, this does place an extra burden on the eye care system in terms of creating access to optometrists or other cadres providing RE services. Achieving an effective RE coverage will require that everyone access RE services regardless of their geographical location and economic status. However, in Kenya, the underserved population in rural areas could greatly be affected by URE given that RE services are not readily available[6]. As a result, establishment of optical units within rural areas and task shifting for clinical refractionists could be desirable to address the challenges around accessibility and availability of RE services. However, with the limited resources available, such initiatives may not be holistic[10]. Therefore, addressing the burden of URE in a cost-effective way will require utilization of innovative approaches such as the integration of telemedicine within the eye health ecosystem to strengthen the task shifting and scale effective RE coverage across the geographical locations. Telemedicine may allow the limited number of optometrists in urban areas to scale RE service delivery to remote areas by supervising optical technicians.

Methods

This study was conducted in four phases. During the first phase, an online survey was sent to ophthalmologists, optometrists, ophthalmic clinical officers and optical technicians. A telephonic interview was also conducted with patients who had sought RE services from the optical technicians operating vision centres in rural areas. This study was conducted from June 2022 to March 2023. The recruitment of participants for this phase entailed a contact with the ophthalmological society of Kenya, optometrists association of Kenya, ophthalmic clinical council and the social enterprise engaged in undertaking skills development in Kenya. For the professionals associations, the representatives were contacted with details about the study. Thereafter, they were requested to notify the members about the study and to provide the contact details including emails and phone numbers for the members. The social enterprise undertaking skills development for optical technicians in Kenya was also contacted with the details about the study and provided the contact details for the primary vision technicians. The identified primary vision technicians were also asked to provide the list of beneficiaries they have provided refractive error services to.

The beneficiaries were contacted telephonically and those who consented were included in the study. For the beneficiaries of refractive error services, the survey was administered through telephonic calls. After the contact details for the potential participants were provided, the researchers contacted the individuals through email with details about the study and an informed consent was sent to the individuals. A reminder was sent to the individuals after every seven days for the consent. Thereafter, the survey was sent to the participants who signed the informed consent. The aspects around the survey included; whether they are aware of the concept of telemedicine, the relevance of telemedicine integration into the eye health ecosystem in Kenya, whether eye care professionals are comfortable supervising optical technicians, if optical technicians are comfortable being supervised by optometrists and whether telemedicine should entail a conversation between the eye care professional and the patient directly or whether it should be between the eye care professional and optical technicians. The other aspect of the survey had questions designed for patients derived from optical technicians operating refraction points in rural areas. The patients were considered for inclusion as they reside within rural areas and majorly seek optical technician's services within rural areas. The survey with the patients seeking RE services from the optical technicians was undertaken to ascertain whether they were comfortable being attended to by the optical technicians under supervision by an eye care professional located in urban area. No compensation was rewarded to the participants. However, the results from this study are anticipated to scale quality RE services in low-resource setups.

During phase two, an interview was conducted with ten key opinion leaders across the country from the private, public and social enterprises sectors on the aspect around telemedicine integration into the eye health ecosystem in Kenya. The inclusion criteria for the key opinion leaders were based on the past involvement of the individuals with the Ministry of Health in developing the national strategic plans for eye health in Kenya[11]. The recruitment of the key opinion leaders was conducted through a formal letter sent to the Ministry of Health to provide the list of stakeholders involved in the development of the national strategic plan for eye health in Kenya. Thereafter, the list was provided and the individuals were contacted with the details about the study and a request to consent to participate in the study. Within our expert panel, it was determined that three Delphi rounds using email for correspondence would be sufficient to achieve consensus and stability[12,]. The emails were anonymous and they were sent to an individual opinion leader without them knowing each other. The experts' selection was is to increase the qualitative strength of recommendations or consensus[13]. After three rounds of Delphi participation, 10 key opinion leaders were retained and based on our experience with previous Delphi studies; we planned for 40% attrition in each round. To ensure that we achieve the minimum number, we estimated that

35 invitees would be required in the first round of the Delphi. We adopted two approaches to convene the key opinion leaders engaged in eye care delivery in Kenya.

The set of key opinion leaders recruited to the Delphi included a representative from the ophthalmic service unit Kenya, ophthalmologist representing the ophthalmological society of Kenya, optometrist representing the optometrists association of Kenya, Information and Communication Technology expert from an international SE, optometrist in-charge of training of the optical technicians, policy expert representative from the Kenya Society of the Blind, the head of partnership wider NGOs Africa from an international SE, ophthalmologists operating regional SE and a representative of the ophthalmic clinical officers. Rather than approaching the ophthalmic service unit Kenya alone, we chose a group of stakeholders in eye health working towards achieving universal health coverage to contribute to the development of the framework. Secondly, the key opinion leaders in our initial set of 35 contacts were invited to recommend colleagues who, in their opinion, might be interested in participating in this Delphi on the basis of their work or expertise. However, no additional invitees by the 35 contact accepted to participate in the study hence only the 35 were included. Throughout the Delphi process, key opinion leaders were blinded to the identity of others by sending independent email to the invitees, except for individuals who referred us to subsequent key opinion leaders. Survey content was never associated with a key opinion leader identifier; only the researchers could associate key opinion leaders with responses. All the included questions from the survey concerned the respondents' area of professional expertise (Supplementary 1). An email reminder was sent to key opinion leaders on a weekly basis to increase the response rate.

A representative from the ophthalmic service unit Kenya was included given that this is the department at the Ministry of Health responsible for eye care services in Kenya. The representatives of the eye health cadres associations in Kenya were included as it is the members who will be tasked in ensuring the success of the telemedicine approach. Notwithstanding, given that the Kenya Society for the Blind in partnership with Non-Governmental organization such as the Christian Blind Mission and ONESIGHT EssilorLuxottica Foundation has rolled a telemedicine approach to address URE in some sections of the country[14], including representatives from this sectors was considered appropriate as they would provide their view based on what they are currently undertaking to aid in designing of a nationwide telemedicine approach within the eye health ecosystem in Kenya. The inclusion of optometrists to supervise the optical technicians through telemedicine was adopted for the development of the proposed telemedicine workflow based on the current approach used by the Kenya Society for the Blind to deliver RE services.

Again the inclusion of social enterprises training representatives was deemed suitable as they are at the forefront in the training of optical technicians who remain crucial for the success of telemedicine within the eye health ecosystem in Kenya. In addition, given that currently in Kenya, optical technicians undertakes refraction and deliver RE services in remote areas, we made an assumption that telemedicine integration may potentially strengthen the quality of RE service delivery. The interview was conducted telephonically and guided through a semi-structured questionnaire focusing on the key opinion leader's views on the need for telemedicine integration into the eye health ecosystem and the need for a telereferral in Kenya. After the interview, the key opinion leaders were given a brief overview of telemedicine and a proposed approach for its integration into the eye health ecosystem to strengthen the task shifting for RE service delivery. The brief overview on telemedicine for the key opinion leaders was to ensure unbiased perspectives were obtained from opinion leaders before proceeding with subsequent data collection.

During Phase three, a workflow for telemedicine in RE service delivery was developed in drawing on the current models used by various social enterprises in Kenya such as the OneSight EssilorLuxottica Foundation. Based on the key constructs derived from phase one and phase two, a workflow framework was developed. Once drafted, the proposed workflow for telemedicine for RE service delivery was evaluated by the key opinion leaders, using a Delphi technique[15]. A systematic and meaningful synthesis of responses was ensured through drafting and refining the questions asked of the key opinion leaders in every round. The questionnaire was piloted among members of our authorship team who were not directly involved in designing the Delphi.

We communicated with the key opinion leaders in English and used Google Forms to conduct our surveys. A pre-specified definition of consensus was developed based on two criteria[15]. First, the key opinion leader was eligible to have achieved consensus around a given survey item if at least 70% of respondents agreed with that item. When using a five-point Likert scale, we defined "disagreement" as a score of two or less. The five-point Likert scale comprised of 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree and 5 = strongly disagree. This criterion ensured that a strong majority of the respondents agreed with any included survey item. Second, an item was said to have achieved consensus only if none of the respondent who stated "disagree" or "strongly disagree raised concerns that were considered fundamentally incompatible and could not coexist together with the survey items in terms of principles and functionality. A simple summation was adopted to provide an overall score for the respondents.

This criterion aligns with approaches from formal consensus decision-making, where a structured discussion is used to understand and resolve the merits and drawbacks of a given proposal[16]. This approach recognizes that essential insights can be tendered by a minority of decision-makers, and attends to the substance of minority opinions. Procedurally, these minority opinions were gathered by requiring that key opinion leaders offer free-text comments if they disapproved of a survey item. We analysed these free-text responses and incorporated that feedback into subsequent rounds of the Delphi and into the final telemedicine workflow. As the analysis advanced, an emphasis on and reiteration of certain issues above others became more apparent. These elements coalesced into the final categories and themes.

Round I was designed to elicit broad and general concepts from the key opinion leaders using open-ended questions with free text:

1. What is, in your opinion, the purpose of telemedicine?

2. What are the characteristics of refractive error that make it amenable to telemedicine?

3. What are the advantages of supervision from highly qualified health workers to individuals with fewer qualifications and shorter training through telemedicine?

Following Round I, the researchers combined and analysed the key opinion leader's responses in taxonomy according to common themes and categories (Supplementary 2). We attempted to make the items on each list mutually exclusive and comprehensive. We synthesized these findings in a survey to elicit participants' level of agreement with each of the themes and categories on a five-point Likert scale for Round II. This survey also offered free-text response options for key opinion leaders to add additional comments or categories as required.

Our study initially used the term "telemedicine" in isolation, rather than the broader concepts of both task shifting and telemedicine. In Round I, key opinion leaders raised conceptual distinctions between task shifting and telemedicine. Recognizing that this had emerged organically from the Delphi process, we added questions to refine the distinction between task shifting and telemedicine and integrated this distinction into our conceptual model.

Once we received all responses from Round II, the data was again reviewed by the researchers. Concepts below 50% were eliminated and those above 50% were retained on the basis of the key opinion leader's scores and collapsed into more general categories, including a definition of telemedicine, the purpose of telemedicine, opportunities arising from telemedicine programmes, and conditions required for the implementation of telemedicine. These results were sent back to the key opinion leaders as a survey for Round III. Key opinion leaders were asked to review the final list of items, state whether they agreed or disagreed with each item, and voice concerns or comments in free text. Following Round III, the researchers integrated the experts' consensus responses into a reasonable and manageable set of concepts and sub-concepts to form the framework[15].

During phase four, the workflow framework developed in phase three and discussed by the key opinion leaders was presented to ophthalmologists, optometrists, ophthalmic clinical officers, optical technicians. The reason for presentation was to seek the eye care professionals and optical technicians input on the workflow and to assess whether they are comfortable with the proposed approach. The patients will not be included in this phase, however, after the framework is rolled out, strengths, weaknesses and opportunities analysis will be undertaken based on the patients view for modification of the developed framework. The statistical data analysis for quantitative data was conducted in the Statistical Package for the Social Sciences version 29.0.0, 2022. For qualitative data, thematic analysis was carried out by categorizing the codes into categories using NVivo Software, Version 11 and themes based on the semantic meaning of the codes. It was an iterative process consisting of both deductive and inductive processes[17]. Initial codes and categories were generated from the interview guides (deductive process). New categories that consist of similar codes were added as required to capture the participants' comments in details (inductive process). During this inductive process, the themes were identified by repetitions (the more the concept appears in the text, the more likely it is to be a theme), similarities and differences[18]. This study was approved by the Biomedical Research Ethics Committee South Africa; under ref: BREC/00004105/2022 and Maseno University Ethics Review Committee ref: MUERC/1051/22. A permit was issued by the National Commission for Science and Technology ref: NACOSTI/P/22/16128. Written informed consent to participate in the study was obtained from all the participants. All methods were performed in accordance with the relevant guidelines and regulations. The study adhered to the tenets of Helsinki Declaration.

Results

Phase one

During this phase, a survey was sent to 494 participants with a response rate of 93.3%. The participants who responded to the survey included ophthalmologists 18% (n = 83), optometrists 35.6% (n = 164), ophthalmic clinical officers 22.1% (n = 102), optical technicians 24.3% (n = 112). All of the optical technicians had secondary level of education while the other eye care cadres had a diploma, bachelors and master level of education. Based on gender, males constituted 67% of the participants with majority being between 30–40 years. The second category of the respondents included 100% (n = 674) patients benefitting from RE services from optical technicians who operate rural vision centres. A total of 96% (n = 647) patients responded to the telephonic call. A total of (n = 220; 34%) of the patients benefitting from RE services from optical technicians had secondary level of education with the remaining 66% (n = 427) had primary level of education. Table 1 details the eye care professionals and optical technician's perspective on telemedicine.

All of the ophthalmologists (n = 56; 67.5%) and the ophthalmic clinical officers (n = 93; 91.2%) who disagreed with the concept of telemedicine between eye care professionals and patients directly reported that resources are still required to ensure the success of such approach. Again, they reported that awareness creation and the roles of eye care professionals should be re-defined for the success of the approach if it is to be adopted.

"I think resources are required and proper awareness creation among the general public if a doctor-patient consultation through telemedicine is to be adopted"- Ophthalmologist

"The current situation in Kenya in which a proper framework has not been developed to allow for patient-doctor consultation hence a more holistic approach like what is suggested on eye care professional-primary vision technician is achievable and realistic"-Ophthalmic clinical officer

Majority of the optometrists (n = 161; 98.2%) reported that RE diagnosis and management entails some processes that requires a patient and the eye care professional attention. Hence, eye care professional-patient

Eye care professional category	Responses	
1. Are you aware of the concept of telemedicine	Yes	No
Ophthalmologists	76 (91.6%)	7 (8.4%)
Optometrists	152 (92.7%)	12 (7.3%)
Ophthalmic clinical officers	91 (89.2%)	11 (10.8%)
Optical technicians	93 (88.1%)	19 (16.9%)
2. Do you think integration of telemedicine into the eye health ecosystem in Kenya is relevant	Yes	No
Ophthalmologists	81 (97.6%)	2 (2.4%)
Optometrists	141 (86%)	23 (14%)
Ophthalmic clinical officers	96 (94.1%)	6 (5.9%)
Optical technicians	103 (92%)	9 (8%)
3. Are you comfortable supervising optical technicians if integrated into the eye health ecosystem in Kenya	Yes	No
Ophthalmologists	62 (74.7%)	21 (25.3%)
Optometrists	110 (67.1%)	54 (32.9%)
Ophthalmic clinical officers	83 (81.3%)	19 (18.7%)
4. Are optical technicians comfortable being supervised by eye care professionals such as optometrists through telemedicine	Yes	No
Optical technicians	112 (100%)	0 (0%)
5. Should telemedicine entail a conversation between the eye care professional and the patient directly	Yes	No
Ophthalmologists	27 (32.5%)	56 (67.5%)
Optometrists	3 (1.8%)	161 (98.2%)
Ophthalmic clinical officers	9 (8.8%)	93 (91.2%)
Optical technicians	4 (3.6%)	108 (96.4%)
6. Should telemedicine entail a conversation between the eye care professional and optical technicians	Yes	No
Ophthalmologists	51 (61.4%)	32 (38.6%)
Optometrists	117 (71.3%)	47 (28.7%)
Ophthalmic clinical officers	85 (83.3%)	17 (16.7%)
Optical technicians	103 (92%)	9 (8%)
7. Are you comfortable and satisfied with the services provided by the optical technician within the rural area vision centre?	Yes	No
Beneficiaries of refractive error services	540 (83.5%)	107 (16.5%)
8. Do you think supervising the optical technicians remotely will improve the quality of services?	Yes	No
Beneficiaries of refractive error services	647 (100%)	0 (0%)

Table 1. Eye care professionals and optical technician's perspective on telemedicine.

consultation through telemedicine may not be realistic unless it is a review case just to confirm how the patient is going around with the spectacles provided initially or other ocular conditions such as allergies.

> "Even if telemedicine would be that good, it is unrealistic to engage in a consultation without physically examining the patient"-Optometrist

Majority of the patients who have benefitted from RE services from optical technicians (n = 612; 94.6%) reported that supervision of the optical technicians will ensure quality service delivery hence reducing the time spent in travelling to other facilities to seek the services.

> "I will say that supervision of the current community members with skills development will ensure that they deliver quality eye care services which are satisfactory to the community members"-Patient

Phase two

All of the key opinion leaders (n = 10; 100%) were aware of the concept of telemedicine and agreed that telemedicine is relevant in the eye health ecosystem in Kenya. Most of the key opinion leaders (n = 6; 60%) agreed that telemedicine has the potential of addressing the human resource challenge in developing countries such as Kenya. The key opinion leaders argued that integrating telemedicine into the eye health ecosystem could potentially strengthen task shifting and scale quality RE service delivery across the economic pyramid. The remaining (n = 4; 40%) of the key opinion leaders argued that telemedicine is more relevant in the eye health ecosystem in addressing the human resource challenge if only satellite vision centres can be established in remote areas without RE services under supervision of a competitively recruited community members.

> "For me I think telemedicine can address the human resource challenge in eye health in Kenya given that it will allow the community health volunteers with basic training in refraction to manage cases that they could but because of lack of guidance, they are sent to optometrists for refraction"-Opinion leader#03
> "In my opinion, I would say the underserved population in Kenya find it hard to access refractive error services and if telemedicine can be adopted then they would be able to access such services through even the primary vision technicians"-Opinion leader#07

"This aspect of telemedicine in my view is suitable in addressing the human resource challenge. However, it will be ideal if some community members are trained on the basics of dispensing and be deployed within remote areas without eye care professionals to undertake refraction under guidance by a qualified eye care professional in urban areas through telemedicine"-Opinion leader#08

Only two (20%) opinion leaders believed that the current network coverage in Kenya is sufficient for telemedicine application in RE service delivery in Kenya. The key opinion leaders argued that telemedicine requires a well-structured stable internet connection that should specifically be designed for telemedicine. However, 80% of the key opinion leaders argued that even though the internet coverage in Kenya is good even within the remote areas, the mechanisms that would be adopted for payment of the internet should be prioritized for the success of telemedicine integration into the eye health ecosystem in Kenya.

"The network coverage in Kenya is generally good and I think if telemedicine is adopted then it can be successful in refractive error service delivery-Opinion leader#07
One of the things that we cannot run away from is embracing technology in eye health and with the current network coverage in Kenya, telemedicine is possible and I think if adopted can scale refractive error service delivery even to the underserved regions in Kenya"-Opinion leader#03
"It is true that the internet coverage in Kenya is stable but we must device a mechanism on how the purchase of internet will be undertaken if telemedicine is integrated into the eye health ecosystem"-Opinion leader#09

Notwithstanding, all of the key opinion leaders (n = 10; 100%) agreed that introducing telemedicine is important and should be integrated across all sectors in eye health. There was total consensus by all of the key opinion leaders that social enterprises should empower the community health volunteers on issues around telemedicine as they are already recognized by the government.

"Quality of refractive error management is very important and social enterprises should also engage the community health volunteers in such trainings as they are already recognized by the government"-Opinion leader #10
"The influence that community health volunteers have in their areas of jurisdiction makes them well placed to be trained so as to address refractive error burden and if they combine force with others then we can make a difference"-Opinion leader #01

All of the key opinion leaders (n = 10; 100%) agreed that telemedicine integration into existing eye health ecosystem across all sectors would contribute significantly to RE service delivery. The key opinion leaders acknowledged that the status of eye health in Kenya might not achieve vision 2030 if technology is not embraced.

"The government of Kenya is focused in achieving the vision 2030 and this implies that telemedicine should be integrated into the eye health ecosystem to scale refractive error service delivery"-Opinion leader#03
"Training eye care professionals in Kenya is expensive and the burden of refractive error continues to pose a challenge. As a result, technology is highly desirable to address this challenge in a cost effective way in Kenya"-Opinion leader#01
"The number of eye care professionals in Kenya cannot effectively attend to the growing population and this implies that technology is necessary and the eye health ecosystem should be integrated with technology"-Opinion leader#03

All of the key opinion leaders (n = 10; 100%) noted that telemedicine will address issues around quality of RE service delivery and strengthen the task shifting approach since the community health volunteers and other primary vision technicians will have the opportunity to deliver RE services under guidance by optometrists.

"Technology is very important and being that there are inadequate human personnel to attend to the growing population, technology will address issues such as detection of refractive error"-Opinion leader #06
"If there can be a good technology then refractive error service delivery can be enhanced as issues around communication will be addressed"-Opinion leader #10

Potential of telemedicine in scaling effective refractive error coverage

Almost three quarters of the key opinion leaders (n = 7; 70%) agreed that telemedicine has the potential of scaling effective RE coverage in Kenya. The key opinion leader's reasons were categorized into four themes as shown in Table 2.

Theme no	Major themes	Number of coded segments
Theme 1	Good relationship between eye care professionals, primary vision technicians and patients	5
Theme 2	Reduces the cost around refractive error service delivery	6
Theme 3	Enhances convenience and availability	2
Theme 4	Enhance an organized refractive error service delivery	5

Table 2. The potential of telemedicine in refractive error service delivery in Kenya.

Theme 1: Good relationship between eye care providers and patients. Majority of the key opinion leaders (n = 7; 70%) noted that through the application of telemedicine within the eye health ecosystem, the aspect of professional discourse which arises among eye care professionals and primary vision technicians could potentially be addressed. They argued that if primary vision technicians can consult eye care professionals before or during dispensing of spectacles then the aspect of questioning the potential of primary vision technicians in RE service delivery will be eliminated.

> "Many eye care professionals do feel that primary vision technicians can sometime make mistakes but due to lack of a mechanism of communication, telemedicine will eliminate such mistakes"-Opinion leader#06
> "The main problem we do have is a situation where one cadre of eye care professional feels that they are well placed to undertake a task as opposed to the other cadre and through technology where communication will be present, such situation will be eliminated"-Opinion leader#03
> "I feel application of telemedicine in eye health will improve the contact between eye care providers and even the refractive error patients"-Opinion leader#01

Theme 2: Reduces the cost around refractive error service delivery. Almost half of the key opinion leaders (n = 4; 40%) denoted that application of telemedicine has the potential of reducing the cost incurred by patients in seeking RE service. The key opinion leaders reported that with the current situation in Kenya in which limited eye units exists within the public health sectors, long queues is a major concern for most patients seeking RE services within the public health sectors offering comprehensive RE services including spectacles.

> "In my view, telemedicine is necessary in the eye health ecosystem in Kenya given that we have very few eye hospitals and the population in need of eye services are many, hence many patients crowd in the few hospitals and this can be addressed through technology"-Opinion leader#03
> "Being that many people are unable to afford refractive error services in Kenya with very few eye units, telemedicine may help the underserved also access and afford services from their rural areas"-Opinion leader#07

Theme 3: Enhances convenience and availability. Two key opinion leaders argued that telemedicine could enhance convenience when it comes to RE service delivery. The key opinion leaders reported that the inadequate human resource in the eye health ecosystem in Kenya cannot effectively deliver RE services to the underserved population within rural areas thus warranting the need for telemedicine integration into the eye health ecosystem to cost effectively extend services to such areas.

> "One of the challenges with refractive error service delivery is convenience and many eye care providers and even the patients are inconvenienced by the fact that they have to travel to seek services from the eye care professionals and the eye care professionals are overburdened as they undertake many tasks. Hence telemedicine will ensure that only patients with refractive error are attended to"-Opinion leader#03
> "I will say that many people are not able to access and afford refractive error services because there are no professionals to create awareness and attend to the population in need, hence through technology, many people will be able to get services due to availability of eye care professionals even if virtually to address their concerns"-Opinion leader#07

Theme 4: Enhance an organized refractive error service delivery. Only two of the key opinion leaders reported that integration of telemedicine into the eye health ecosystem may enhance an organized RE service delivery approach. The key opinion leaders denoted that the facility-based delivery approach of RE service delivery would only be ideal if human resource and refraction points were adequate, warranting the need of telemedicine integration into the eye health ecosystem in Kenya to scale service delivery beyond a facility.

> "The current approach of refractive error service delivery is facility based and it is marred with challenges, hence I think through telemedicine, cases of referral will be reduced and refractive error patients will be able to access services at their homes and even during screening events"-Opinion leader#07
> "The reason as to why I say telemedicine is good for refractive error management is because it will ensure that eye care professionals attend to patients not necessarily in the clinics and services offered through consultation will be equivalent to what could have been done at the clinic hence saving time for the patients"-Opinion leader#06

Possible factors that could potentially influence the integration of telemedicine into the eye health ecosystem in Kenya

All of the key opinion leaders (n = 10; 100%) argued that telemedicine being a new concept; various challenges are anticipated warranting the need of a strong partnership among the stakeholders in eye health and establishment of policies recognizing telemedicine in the eye health for its success within the eye health ecosystem in Kenya. All comments from the key opinion leaders were categorized into eight themes as shown in Table 3.

Theme 1: Unwillingness of eye care professionals to work in remote areas. Three quarters of the key opinion leaders (n = 8; 80%) believed that integration of telemedicine within the eye health ecosystem might be difficult given that many eye care professionals are more into facility-based delivery approach. This could be attributed to the minimal attention directed towards technology when compared to the facility-based approach.

Theme no	Major themes	Number of coded segments
Theme 1	Unwillingness of the eye care professionals to work in remote areas	8
Theme 2	Feeling of dominance in the optical industry by a specific sector	6
Theme 3	Weak relationship between existing eye care professionals and primary vision technicians	4
Theme 4	Perception by eye care professionals that telemedicine might replace them	3
Theme 5	Cost required in establishing a running telemedicine system	7
Theme 6	Lack of a technical team	9
Theme 7	Lack of policies recognizing telemedicine in eye health	9
Theme 8	Lack of proper network for smooth operation of the telemedicine	5

Table 3. Possible factors that could potentially influence the integration of telemedicine into the eye health ecosystem in Kenya.

> "To be sincere, telemedicine can face challenges since a high proportion of eye care professionals are working in urban areas and may not consider rural areas as an option since there is a notion that many in the rural areas cannot afford spectacles"-Opinion leader#03

Theme 2: Feeling of dominance in the optical industry by a specific sector. All of the key opinion leaders (n = 10; 100%) had reservations about the acceptance of the integration of telemedicine within the eye health ecosystem given that the optical industry is dominated by the private sector with practitioners in this sector possibly finding it difficult to come to terms with this approach. They argued further that it might be difficult for the private sectors to embrace the concept with the perception that their profit margins may reduce as many patients who would consider travelling to a site in the private sector may now have the option of receiving the same services at the community vision centres. However, the key opinion leaders denoted that telemedicine is mainly intended to scale accessibility and availability of RE services across all geographical locations without necessarily having to interfere with the entrepreneurship perspective in the optical industry. As a result, the key opinion leaders suggested for establishment of policies outlining what telemedicine entails in the eye health ecosystem and RE service delivery.

> "Now that the private sector dominates the optical industry in Kenya, it will be difficult to integrate telemedicine unless all the patients will be referred to them for spectacles"-Opinion leader#07
> "The most holistic way to roll out telemedicine in the eye health ecosystem in Kenya is through establishment of policies outlining what exactly telemedicine is intended to do and why it should be embraced so that the dominant private sectors in the optical industry could advocate for its strengthening"-Opinion leader#05

Theme 3: Weak relationship between existing eye care professionals and primary vision technicians. All of the key opinion leaders (n = 10; 100%) were of the view that integrating telemedicine in the eye health ecosystem in Kenya may be difficult given that a weak relationship exists between eye care professionals and the primary vision technicians. However, they further argued that for telemedicine to be successful within the eye health ecosystem, primary vision technicians and the community health volunteers with skills development on eye health is ideal since they operate within their communities.

> "In as much as telemedicine is necessary in scaling refractive error, primary vision technicians must be included within the chain as they have access to community members who are unable to access refractive error services in urban areas. However, with the weak relationship, integration might be very difficult"-Opinion leader#05

Theme 4: Perception by eye care professionals that telemedicine might replace them. Almost half of the key opinion leaders (n = 4; 40%) argued that awareness on telemedicine is still very low among eye care professionals and generally in Kenya, as a result, there could be a feeling among eye care professionals that telemedicine can replace them. The key opinion leaders argued that being that the telemedicine concept has not been used in Kenya within the eye health ecosystem, many eye care professionals may have a concern that telemedicine is intended to replace them.

> "Although I am not sure if this could be the case, but I have the feeling that many eye care professionals can have the fear that telemedicine will replace them from undertaking refraction hence depriving them from where they earn a livelihood"-Opinion leader#07

Theme 5: Cost required in establishing a running telemedicine system. There was agreement amongst all the key opinion leaders that telemedicine is very expensive and this may influence its integration into the eye health ecosystem in Kenya. The key opinion leaders argued that an initial cost is required which may not be readily available given that resources are limited. Notwithstanding, the key opinion leaders reported that the most

suitable way to address this barrier is through establishment of policies to recognize telemedicine with a strong partnership among all stakeholders in the eye health ecosystem in Kenya.

> "I think telemedicine is very expensive and in Kenya, it may take longer to be embraced given that a system has to be developed, but I do not know if this can be the case"-Opinion leader#10
> "Without a proper recognition of telemedicine in the eye health ecosystem through strong policies and partnership, it will be difficult to address the barriers around telemedicine integration into the eye health ecosystem in Kenya"-Opinion leader#02

Theme 6: Lack of a technical team. All of the key opinion leaders believed that lack of a technical team could potentially influence the integration and success of telemedicine in the eye health ecosystem in Kenya. They therefore expressed that for a successful integration of telemedicine in the eye health ecosystem in Kenya, training of technical teams to streamline telemedicine with the current hospital management system is necessary.

> "Currently many eye care professionals are used to the hospital management system and integrating telemedicine into the existing system will require training of a technical team that might be expensive"-Opinion leader#08

Theme 7: Lack of policies recognizing telemedicine in eye health. All of the key opinion leaders (100%) reported that lack of policies regarding telemedicine in Kenya is a major concern that may influence its integration into the eye health ecosystem. The key opinion leaders argued that a strong partnership is desirable to facilitate establishment of policies for the smooth integration of telemedicine.

> "I have looked at telemedicine even during Covid-19 and one of the things I will say is it can work in the eye health ecosystem but policy recognizing the concept is necessary for smooth operation"-Opinion leader#03

Theme 8: Lack of proper network for smooth operation of the telemedicine. All of the key opinion leaders were of the view that network coverage in remote areas could be a factor that may influence the integration of telemedicine into the eye health ecosystem. They therefore argued that without stable internet connection especially in remote or rural areas, telemedicine might not be possible since the intention for integration of telemedicine is to ensure that the underserved population within remote areas access RE services just like their peers within urban areas.

> "I will say that since telemedicine requires internet for smooth operation, it may be difficult to integrate the concept as some remote areas in Kenya lack strong internet and the strong internet is majorly present in urban areas hence creating a barrier for the integration"-Opinion leader#03

Phase three

Proposed telemedicine workflow for refractive error service delivery in Kenya

This workflow developed for telemedicine integration into the eye health ecosystem in Kenya was developed based on various constructs and considerations derived from Phase One. Firstly, the workflow was anchored on the significance of the primary vision technicians and other healthcare professionals with skills development within the eye health ecosystem in Kenya. The consideration of these cadres was based on the assumption that they can potentially act as the link between the communities and the eye care professionals working in urban areas. Again another assumption was made that considering the primary vision technicians could facilitate a structured referral in which patients move from primary vision technicians to other eye care professionals only for cases beyond their scope with an intention of addressing the cost incurred by patients in seeking RE services. Secondly, establishment of vision centres/refraction points within the rural areas was intended to act as the telemedicine centres that will be linked to the established eye units within urban areas. Thirdly, the public sectors without eye units should be equipped with basic refraction equipment such as visual acuity chart, trial box, trial frame and near chart for utilization by healthcare workers with skills development on eye health. Basic frames display and reading glasses should be available within the facilities. Cost-effective spectacles should be availed to the facilities by social enterprises. Notwithstanding, the social enterprises should adopt a cross-subsidization approach to ensure that underserved community members can benefit from the RE services. Fourthly, we made a projection that for the proposed workflow to be successful in the eye health ecosystem, a task shifting approach should be recognized. Again, we proposed that the primary vision technicians should undertake refraction within the community vision centres; healthcare professionals with skills development on eye health to undertake refraction within the public and private facilities they are attached to; and optometrists and ophthalmologists to undertake refraction within the vision centres integrated in the public and private sector health facilities. Finally, this workflow is intended to reduce the number of unnecessary referrals and to ensure that primary vision technicians operating within rural areas can receive more patients and remain sustainable. Notwithstanding, telemedicine workflow should be integrated within the existing hospital information system to help in reporting URE cases. Considering the distribution of healthcare facilities in Kenya is based on a ratio of 1:50,000[11], we proposed for one optometrists to supervise a maximum of five optical technicians operating within rural areas. We anticipated that this will scale the number of RE patients examined compared to what a single optometrist could examine in a day. The input of key opinion leaders were sought on the proposed workflow designed for the integration of telemedicine into eye health ecosystem in Kenya as shown in Fig. 1.

Majority of key opinion leaders (n = 7; 70%) supported the aspect of telereferral within the proposed telemedicine workflow. The key opinion leaders argued that if proper skills development is undertaken by social

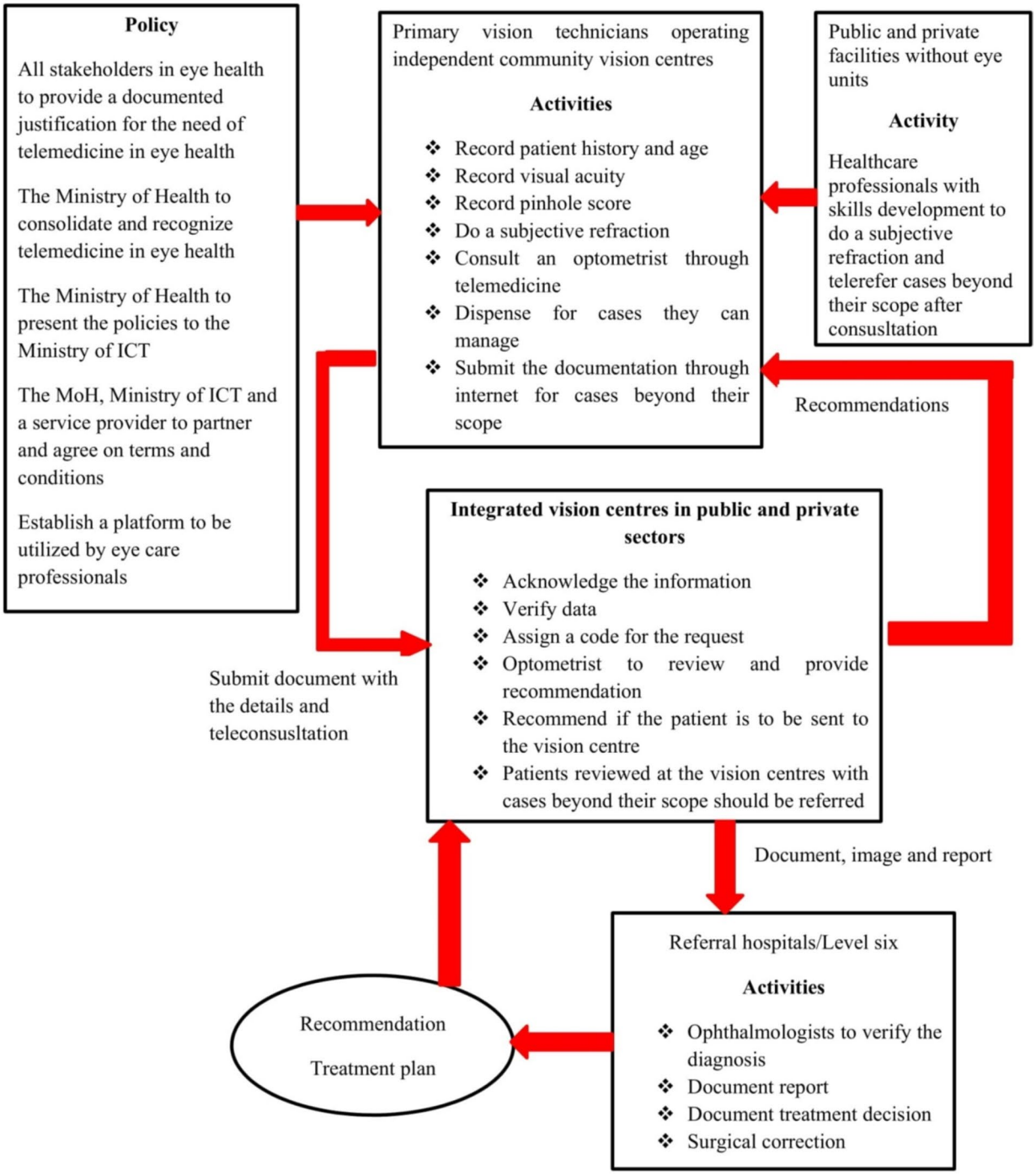

Figure 1. Proposed telemedicine workflow.

enterprises and other stakeholders in eye health through integration into existing institutions offering eye health courses then telemedicine would be scaled. The key opinion leaders also stated that referral has been a present problem in the eye health ecosystem in Kenya since patients are referred manually without a well-structured framework for follow-ups. Hence, this proposed workflow will ensure that referred patients are attended. This is attributed to the fact that the proposed referral chain is intended to ensure a symbiotic relationship. Thus, the referral aspect will be useful for eye health ecosystem in general.

> "Referral is very crucial and if technology will be incorporated across all sectors delivering eye health then refractive error will be addressed effectively"-Opinion leader #04
> "The eye health ecosystem ranging from private, social enterprises and even the public sector cannot address refractive error effectively without a strengthened referral chain"-Opinion leader #07

All of the key opinion leaders (100%) reported that inclusion of the policy perspective is relevant for the success of telemedicine in the eye health ecosystem in Kenya. The key opinion leaders argued that inter-

departmental and cross-sectorial collaboration within ministries is suitable and should be prioritized since the Ministry of Health alone may not achieve effective telemedicine integration into the eye health ecosystem.
"For me I feel the workflow is very good and the policy aspects will ensure that aspect is integrated and is accepted across the eye health ecosystem in Kenya"-Opinion leader#05
"If you look at the current situation in Kenya on telemedicine in the general health, the success is not that promising as the Ministry of Health has not engaged other sectors and ministries such as the ICT who are destined to play a major role if telemedicine is to be integrated into the health sector"-Opinion leader#01
"By establishing a platform, I would say this would address issues around privacy of the patients as this aspect will be integrated into the existing hospital information system"-Opinion leader#4

All of the key opinion leaders (100%) reported that the consideration of integrating vision centres across the public and private health sectors could potentially ensure a strengthened cross-sectorial partnership hence eliminating aspects such as conflict of interest that could possibly arises. The key opinion leaders acknowledged that the current situation in Kenya in which most public health sectors do not have RE services warrants for integration of such services across the public and private sectors to scale availability and accessibility of RE services.

"Accessibility and availability of refractive error services has been a major problem within the eye health ecosystem hence through integration of vision centres within all levels of healthcare delivery channels across public and private health sectors, refractive error service delivery will be scaled through supervision of optical technicians by optometrists using telemedicine"-Opinion leader#08

All of the key opinion leaders (100%) agreed that adopting the proposed telemedicine workflow will ensure that each eye care provider regardless of their scope of training will benefit and the primary vision technicians operating vision centres within rural areas will remain sustainable, as they will be receiving referrals. Notwithstanding, the key opinion leaders recommended utilization and integration of cost-effective technologies such as the portable autorefractometers within the primary vision centres to ensure that optometrists can guide the optical technicians on the best correction to dispense.

"You know currently in Kenya, many primary vision technicians find it extremely hard to operate smoothly and remain sustainable given the fact that they establish vision centres within rural areas and they do not have a clear description of what they should do hence their relationship with other eye care professionals remains weak, hence through this approach they will be have to get support from other eye care professionals"-Opinion leader#07
"I will say this proposed approach has the capacity to ensure a stable relationship between all eye care providers and those within the rural areas will receive refractive error patients just like their counterparts within the urban areas"-Opinion leader#05

Phase four

Majority of the ophthalmologists (n = 74; 89.2%) reported that the workflow proposed is holistic in the sense that it prioritizes the primary vision technicians to be engaged in RE service delivery as opposed to the current situation in which the role of this cadre remains undefined. They reported that the proposed workflow is suitable for Kenya given that most optical units are located within urban areas and through application of this approach, the underserved community members in remote areas could benefit from services of eye care professionals in urban areas.

"I will say that this workflow is more suitable for Kenya as it gives weight to the role of primary vision technicians and recognizes that telemedicine approach in which patients consult directly with eye care professionals remains expensive and may require resources which are not readily available"-Ophthalmologist

All of the optometrists (100%) reported that the proposed workflow is important and will potentially scale quality service delivery through individuals with skills development such as the primary vision technicians.

"The commonest concern we have with optical technicians is that they engage in refraction when their scope of practise does not allow them to do so in Kenya. As a result I think this approach will ensure that optical technicians are supervised and dispense the right prescription"-Optometrist

Most of the ophthalmic clinical officers (n = 97; 95.1%) reported that the proposed telemedicine workflow is comprehensive and targets regions which remains underserved when it comes to RE services. Again they reported that through integration of the primary vision technicians into RE service delivery under supervision, RE services would potentially be scaled.

"I think these are the kind of approaches that should be adopted in Kenya within the eye health ecosystem as most of the time the primary vision technicians remains unrecognized and to achieve universal health coverage, they remain crucial"-Ophthalmic clinical officer

All of the primary vision technicians (100%) reported that the proposed workflow will create a good relationship between them and other eye care professionals hence quality RE service delivery. They also reported that the proposed telemedicine workflow will ensure that patents gain confidence in their activities hence increase in patient's visits to their vision centres and sustainability.

"Now that this workflow prioritize our role in refractive error service delivery, I think we will have good relationship with other eye care professionals and we will definitely increase our income and sustainability since more patients would probably visit our vision centres"-Primary vision technician

Discussion

The burden of URE demands for adoption of different approaches inclined towards scaling service delivery, human resources, education/awareness and addressing the cost barriers. Although telemedicine has been shown as a synergizing approach in scaling healthcare service delivery, its application within the eye health ecosystem in Kenya remains unexplored. Hence, this study developed a telemedicine workflow that could be adopted to scale RE services in Kenya.

According to Naidoo & Govender[19], a team approach is worthy of attention in scaling RE service delivery as it creates a collaborative environment benefitting RE patients. This implies that eye care professionals should embrace a team approach with primary vision technicians for effective telemedicine integration. Given that the underserved populations residing within the rural areas are unable to access RE services[6], adoption of innovative approaches are desirable to scale RE services to such population. This study has shown that most representatives from the professional associations for eye health, social enterprises, Kenya Society for the Blind and the ophthalmic service unit Kenya are aware of the concept of telemedicine and agree that it is relevant in the Kenyan eye health ecosystem. This warrants the need for efforts directed towards task shifting to ensure a justifiable basis for rolling out telemedicine in the eye health ecosystem in Kenya. Although the eye health ecosystem in Kenya predominantly depend on eye care professionals with conventional training, which is the ideal, task shifting and training of primary vision technicians is desirable to supplement the efforts of the limited human resources with conventional training. As a result, telemedicine integration is desirable to scale RE service delivery in a cost-effective way in a resource-constrained country such as Kenya through task shifting strengthened with telemedicine. With good network coverage in developing countries such as Kenya[20], our study has shown that telemedicine is possible in the eye health ecosystem and can potentially scale effective RE service delivery if a task shifting and a team approach is adopted. Therefore, for telemedicine to be successful within the eye health ecosystem in developing country such as Kenya, task shifting should be prioritized.

Telemedicine is a concept that has been adopted in different parts of the world due to its efficiency in healthcare services delivery[21]. Although in developing countries such as Kenya, telemedicine remains an emerging concept, its potential in scaling effective RE coverage may warrant the worth for its integration into the eye health ecosystem in Kenya. Our study finding has highlighted that telemedicine may scale effective RE coverage due to its potential in enhancing good relationship between eye care professionals, primary vision technicians, and patients. Although professional discordance among eye care professionals in Kenya has been shown to impact negatively on RE service delivery[22], the discordance needs to be addressed. The relationship aspect among eye care professionals and primary vision technicians should be prioritized to ensure smooth RE service delivery. It has also been noted from the findings that telemedicine has the potential of reducing the cost around RE service delivery, enhancing convenience and availability, as well as enhancing an organized RE service delivery. In Kenya for instance, during the Covid-19 pandemic, The Kenya Medical Practitioners and Dentist Union issued approval for virtual medical services[11], an indication that telemedicine concept is receiving recognition in Kenya. Therefore, utilization of telemedicine should not be limited to emergencies but should be adopted as a routine approach to scale healthcare services delivery. This study has shown that patients residing within rural areas acknowledge the importance of telemedicine as a probable mode for supervision of optical technicians. This will not only ensure that patients in remote areas are satisfied by the services provided by optical technicians but will also ensure scaling of services to underserved areas. To ensure full potential of telemedicine within the eye health ecosystem, the Ministry of Health[5] in partnership with other stakeholders in eye health ecosystem should advocate for recognition of telemedicine integration into the eye health ecosystem and establishment of policies outlining how privacy of the patients would be enhanced within the approach. Therefore, telemedicine should be integrated within the existing hospital information system to ensure that cases of URE are reported.

The eye care professionals are well placed to advocate for telemedicine integration into the eye health ecosystem. However, with the dominant facility based delivery approach of RE services in Kenya[23], awareness creation is worthy of attention among eye care professionals on the significance of technology in scaling effective RE coverage. Evidence shows that strategic decisions about establishing remote consultation services, allocation decisions for appointment type (phone, video, e-, face-to-face), and clinical decisions when consulting remotely are fraught with contradictions and tensions[24]. This is similar to our study in which factors such as unwillingness of the eye care professionals to work in remote areas, feeling of dominance in the private sector optical industry, cost required in establishing a running telemedicine system, lack of policies recognizing telemedicine in eye health, lack of a technical team and lack of proper network may influence the integration of telemedicine into the eye health ecosystem in Kenya. Based on the key opinion leaders views from our study, most eye care professionals are based in urban areas which is similar to a study by Morjaria et al.[6], This is a clear indication that the populations residing in rural areas are unable to access RE services making innovative cost-effective approaches desirable. To address this gap in a cost-effective way, the Ministry of Health in partnership with other stakeholders in eye health should be at the forefront in advocating for establishment of vision centres within the private, public health sectors and satellite vision centres in rural areas integrated with telemedicine. However, to achieve this, skills development should be prioritized so that the healthcare professionals without prior training on eye health could benefit from competency based skills development and engage in RE service delivery within the established vision centres. Primary vision technicians and community health volunteers with skills development should be considered to act as the link between the community members and the optometrists located within the urban areas and effectively undertake refraction through telemedicine.

Working towards the achievement of the 2030 IN SIGHT agenda requires that issues around accessibility, affordability and availability should comprehensively be addressed come 2030[26]. Although telemedicine is intended to strengthen the task shifting approach for a quality and effective RE coverage, it is also linked with challenges such as unstable internet networks[27]. However, the cost of addressing the aforementioned challenge is relatively cheaper when compared to training of an eye care professional in Kenya[4]. As a result, more conservative and innovative approaches should be adopted given the limited resources available in developing countries such as Kenya. Therefore, efforts of all eye care professionals regardless of their duration of training should be acknowledged and integrated into the eye health ecosystem to ensure an achievement of the 2030 IN SIGHT in Kenya. Our study has denoted the significance of primary vision technicians for effective telemedicine integration into the eye health ecosystem in Kenya. With the current inadequate human resource and the expensive and time-consuming training approaches, telemedicine should be integrated, conventional training of human resources remains critical. Therefore, recognizing the potential of all cadres within the eye health ecosystem in Kenya and working towards addressing the possible challenges that could potentially influence the integration of telemedicine into the eye health ecosystem should be addressed.

A study on mobile usage at the base of economic pyramid in Kenya showed that over 60% owned mobile phones which justifies the assertion that majority of Kenyans embraces[28]. However, most applications more focused on M-PESA which is a mobile phone money transfer service used to deposit, withdraw, transfer money and pay for goods and services[29], there is minimal applications on health information. This justifies that internet coverage in Kenya is good and could potentially support telemedicine if integrated within the eye health ecosystem. Notwithstanding, the proposed telemedicine workflow (Fig. 1) tend to enhance sustainability of the satellite vision centres operated by primary vision technicians through referrals from healthcare sectors without established eye units. Through such referrals and sales of spectacles, the optical technicians would potentially generate some revenue to purchase the internet used for smooth telemedicine operations. However, the eye care professionals supervising the optical technicians through telemedicine should be compensated through revenue generated by the service provider for the internet. Stable internet could potentially ensure a faster delivery approach hence addressing the long queue challenge and cost effective delivery approach.

In conclusion, this study denotes that telemedicine has the potential to strengthen task-shifting approach and scale effective RE coverage in a resource constrained country such as Kenya with limited human resources. However, for the full potential of telemedicine to be realized, a task shifting approach should be adopted and policies should be established to recognize telemedicine in the eye health ecosystem. Notwithstanding, refraction points should be established, and integrated with telemedicine, to ensure that all the primary vision technicians with skills development are attached to a satellite vision centre to undertake refraction under supervision by an optometrist through telemedicine. Finally, development of a strengthened referral pathway should involve a consensus among all stakeholders.

This study had limitations such as not showing how task shifting should be undertaken for the existing human resource in eye health ecosystem in Kenya. Therefore, future studies are desirable focused on the aforementioned, including a cost–benefit analysis, cost-utility analysis or cost-effectiveness analysis to determine the cost of integrating telemedicine and the possible return from such investment. Again, this study acknowledges the nomination process introduces selection bias relating to identification of panel members as a limitation of this study. An assumption was made that skills development for competitively recruited community members and healthcare workers without prior training in eye health as primary vision technicians could be worthy of attention in scaling effective RE coverage through telemedicine. In addition, an assumption was made that optometrists should supervise primary vision technicians through telemedicine for comprehensive RE service delivery. Finally, even though this study identified the advantages of remote supervision of primary vision technicians with optometrists, future evidence should be generated to identify potential disadvantages of such supervision when it comes to RE service delivery.

Data availability

Data is available from corresponding author.

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Author contributions

SM: conceptualization; formal analysis; writing—original draft; writing—review and editing; visualization. KN: conceptualization; review and editing; visualization; supervision. RH: conceptualization; review and editing; visualization; supervision.

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The authors declare no competing interests.

Additional information

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