Universal Eye Health and its relation to Digital Health: A Systematic Analysis

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List of Abbreviations

UEH	Universal Eye Health	**CSR**	Cataract surgical rate
UHC	Universal Health coverage	**CSO**	Cataract Surgical Outcome
MSVI	Moderate or severe Visual Impairment	**eCSC**	Effective Cataract surgical coverage
WHO	World Health Organization	**BCVA**	Best Corrected visual acuity
SDG	Sustainable Development Goals	**eLearning**	Electronic or online Learning
MDG	Millennium Development Goals	**DSS**	Decision Support System
DR	Diabetic Retinopathy	**mHealth**	Mobile Health
LMICs	Low- and middle-income countries	**BOOST**	Better Operative Outcomes Software Technology
WHA	World Health Assembly	**PEEK**	Portable Eye Examination Kit
EHRs/EMR	Electronic Health Records/ Electronic Medical Records	**ETDRS**	Early treatment Diabetic Retinopathy Study
AI	Artificial Intelligence	**CNN**	Convolutional Neural Network
PICO	Patient, Intervention, Comparison, Outcome	**NHI**	National Health Insurance Program
PRISMA	Preferred Reporting Items for Systematic reviews and Meta-Analyses	**GOe**	Global observatory of eHealth
DL/ML	Deep Learning/ Machine Learning	**NTRA**	National Telecommunications Regulatory Authority
ARMD	Age-Related Macular Degeneration	**COVID-19**	Corona Virus Disease 19
IPCEC	Integrated People Centered Eye Care	**ICT or IT plan**	Information Communication technology plan

List of Abbreviations

IAPB	International Agency for Prevention of Blindness	**USA/ UK**	United States of America/ United Kingdom
ICO	International Council of Ophthalmology	**MLOP**	Middle level Ophthalmic Personnel
ITU	International Telecommunication Union	**AMD EMR**	Age macular degeneration Electronic Medical Record
APTOS	Asia Pacific Tele-Ophthalmology Society	**E & M** **R & D**	Evaluation and Monitoring Research and development
EMR	Eastern Mediterranean Region of WHO	**FGA14H**	Focus group on Artificial Intelligence for Health
AFR	African region of WHO	**FOP**	Fundus on Phone
SEAR	South East Asian Region of WHO	**RAAB**	Rapid Assessment of Avoidable Blindness
EUR	European Region of WHO	**SMS**	Short Message Service
UN	United Nations	**MOH**	Ministry of Health
HiAP	Health in all policies	**HIRA**	Health insurance Review assessment
NCDs	Non communicable diseases	**MEDS**	Ministry of food and drug safety
NGOs	Non-governmental organizations	**GBP**	British pound sterling
ICD	International Classification of the diseases	**GDHP**	Global Digital Health Partnership
UNICEF	United Nations Children’s Fund	**WPR**	Western Pacific Region
SS Africa	Sub Saharan Africa	**KOICA**	Korea International Cooperation Agency
HIS	Health Information System	**ODA**	Official Development Assistance

Abstract

Background Despite the vigorous efforts of different Global public health sectors regarding eye health. It became now available, but not yet to everyone. From here appeared the urge of the development of Universal Eye Health (UEH) to ensure reducing social inequality in eye health services delivery and improving eye services' coverage. Digital Health has also become an important frontier in health care services delivery nowadays. This research aims to study the availability and accessibility of UEH and the role of Digital Health as an additive factor in improving it.

Methods This is an observational retrospective study. 2 methods where used for in-depth study of current situation of digital eye health in LMICs; Country profiles of the studied countries from different WHO regions and systematic analysis. Literatures have been searched at three search engines: PubMed, Google Scholar, and Cochrane Library. An overview of review articles was conducted using patient, intervention, comparison, and outcome (PICO) framework. Search keywords were; "Digital health", "Smart health", "eye health", "Cataract", and etc. Our 37 publications were identified as suitable regarding the three expected categories of outcomes.

Results Digital health was found to be an important factor in the attainment of UEH in the studied countries. Three categories of outcomes representing the effect of digital health were found in the systematic analysis which helped in improving the eye health system: quality of life of patients with ocular diseases, quality of eye health services and access to the eye health services. Implication of these results on digital eye health in Egypt was identified as well.

Conclusion Digital health was found to be an important additive factor in the attainment and expansion of UEH in many of the studied countries. Portable screening devices, Fundus photography, and retinal diagnostics AI innovations and Teleophthalmology have become the black horse of the eye field nowadays but still used in a limited range in many countries in need of such technologies. Using EHRs in research and gathering data for cataract surgical indicators still also used in a very narrow scope which needed to broaden. As it is strongly needed to monitor UEH indicators to be able to have a real assessment of the countries' progress in their national eye plans and improve access and quality of eye services and of patient life, especially in LMICs.

Keywords: Universal Eye Health, Cataract, Diabetic Retinopathy, Retinal Diagnostics, and Digital health.

CHAPTER I

1.1 Background

1.1.1 Introduction

All countries have a responsibility to keep their people safe, especially the most vulnerable [1]. From that perspective Universal health coverage (UHC) has been developed to ensuring that all people have access to the needed health services of sufficient quality and without any financial hardship. The World Health Organization (WHO) recognized it as a critical element in reducing social inequality, to achieve the goals of Sustainable Development Goals (SDG) by 2030 [2].

Despite intense efforts of Global public health sectors regarding Universal eye health (UEH), It is now available but not yet to everyone. from here, appeared the urge to WHO action plan 'Towards Universal Eye Health: A Global Action Plan 2014–2019'. Its target was to reduce the prevalence of avoidable visual impairment in 2019 by 25% and to integrate eye health into all sectors. [3] Global initiatives fighting diseases affecting eye health included also VISION 2020, which aims is to eliminate the leading causes of all preventable blindness as a public health issue by the end of the year 2020 [4]. They finally included; The World Report on Vision, which is the latest most enormous global effort regarding eye health, which aims to galvanize action to address world eye healthcare challenges. Building on WHO existing Framework on integrated people-centered health services (IPCEC), by making integrated people-centered eye care is the care model of choice. According to this Report; The global estimated causes of preventable visual impairment are; unaddressed refractive errors and presbyopia, Cataract, Glaucoma, corneal opacities, Diabetic retinopathy (DR), Trachoma [5].

The World Health Assembly has guided the development of national eye-care plans for the past 15 years. Many low- and middle-income countries (LMICs) use these national eye-care plans to guide efforts to strengthen eye-care services. In 2003, resolution (WHA56.26) urged the Member States to establish national eye-care plans. Subsequent resolutions (WHA59.25 in 2006; 62.1 in 2009; 66.4 in 2013) consistently recognized the importance of evidence to inform eye-care plans, explicitly monitoring and evaluating data and documentation of acceptable practices and effective models of care. Furthermore, the resolutions recognized the need to build capacity for epidemiological and health systems research within LMICs. Global action plan 2014–2019 in 2013 (resolution WHA66.4) also reaffirmed the importance of using a range of evidence, including epidemiological, monitoring, and operational research data. This evidence was incorporated in a sample of 28 national eye-care plans generated since the Universal eye Action plan 2014-2019. Most countries (26.93%) cited estimates of the prevalence of blindness, and 18 countries (64%) had set targets for the cataract surgical rate in their plan [6] [7].

There are some many challenges and barriers face UEH action plan and World Report on Vision application. For instance, healthcare delivery geographical access, healthcare provider-related, culture and language, and health system barriers [8]. Despite, the global prevalence of blindness still very high: 32.4 million individuals are blind; 2.2 billion have a vision impairment; However, the good news is that 80% of these cases of blindness are avoidable (at least 1 billion people have a moderate or severe visual impairment (MSVI) that could be prevented or is yet to be addressed) [5]. Success stories, including control of trachoma and onchocerciasis showed that global partnerships, public-private partnerships, and philanthropy are responsible for these programs' success [9].

Digital Health recently has gained the attention of healthcare industries, clinicians, and patients [10]. Using Teleophthalmology, Artificial intelligence (AI), and deep learning in retinal imaging diagnostics and mHealth and other subdivisions of Digital Health in ocular medicine is an evolving technology that holds promise for mass screening of retinal diseases such as DR with minimal involvement of human beings. Healthcare affordability, quality, and accessibility can be amplified using this technology [11]. Cataract indicators and monitoring processes have evolved alongside cataract services over the past 30 years and will continue to do so in the future as the leading indicators of UEH. To be useful, indicators require good quality data and careful interpretation by clinicians and program managers in order to identify which aspects of cataract services are most in need to be strengthened. This could be achieved easily via eLearning of the ophthalmologists and Electronic Health Records (EHRs) [12].

Our hypothesis; is to discuss whether Digital Eye Health a vital additive factor in the attainment and expansion of availability and accessibility of Universal eye health (UEH) or not? To understand more about the global eye health, we took some countries eye health profiles as eye health care models (as a randomized sample from WHO regions). These countries should be whether apply digital health in eye health already or they start their initial steps towards its application. This is aim to tackle the gaps, challenges and success stories in their health care systems regarding factors affecting Eye health services delivery. We searched that intending to improve the quality and coverage of universal eye care in the world. We also conducted a systemic analysis regarding Digital health's role in expanding coverage of eye health, Universal eye health (UEH) services. Literatures have been searched at 3 databases: PubMed, Google Scholar, and Cochrane. under patient, intervention, comparison, and outcome (PICO Framework) and guided by the Preferred Reporting Items for Systematic Reviews Meta-Analyses (PRISMA) guidelines.

1.1.2 Objectives of work

1. Tackling Eye health care situation in the world through the scope of Universal eye health
2. Identifying the effect of using Digital Health approaches in improving Universal Eye services delivery availability, accessibility, and coverage now and in the future.

1.1.3 Aim of Work

To study the link between the current situation of Universal eye health globally and the use of digital health through studying it from different views: Egypt, Kenya and India as a random sample of LMICs, Republic of Korea as a well-developed country in this field, and finally the most successful examples of digital eye health from different countries of different WHO regions.

1.2 Methodology

Research procedure

This observational retrospective study was done by collecting secondary data from online articles via two methods; Country profiles and overview of the review articles for in-depth search of the current situation of global eye health situation and its relation to the digital health. For country profiles section, we took some countries eye health profiles as eye health care models whether they apply digital eye health already or they start their initial steps towards its application to show the gaps, challenges and successes of Eye services delivery and systems (as a randomized sample from 5 WHO regions). The studied countries should have National eye plans under the World Health Assembly on UEH or National eye program and apply some Digital eye health field as well. The studied countries are Egypt, Kenya, and India as LMICs, high income country as Republic of Korea and one successful example in digital eye health from other countries as; Thailand, Saudi Arabia., UK and some organizations as International Telecommunication Union (ITU) of United Nations**,** International council of Ophthalmology (ICO), Asia Pacific Tele-Ophthalmology Society (APTOS).

For Systematic overview section, the literature has been searched at three search engines: PubMed, Google Scholar, and Cochrane Library. A systematic review was conducted and guided by the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines.

Date and period of study

Table 1. Research timeline

Data collection	September 2020
Data analysis and management	September- October 2020
Finalizing, Printing	November 2020
Final submission	23 th of November
Final discussion (Last defense)	4 th of December 2020

Type and site of study Qualitative retrospective systematic review study which has been conducted in Yonsei University Medical Library.

Research strategy

Hypothesis Is Digital Eye Health a vital additive factor in attainment and expansion of Universal eye health (UEH) or not?

PubMed, Google Scholar, and Cochrane library databases were searched for relevant articles. All articles gathered through this initial screening process were evaluated for inclusion criteria in the sample pool.; Only review articles with relevant titles or abstracts published between January 2006-June 2020, in the English language, were considered for the first screening process. In Google scholar, the primary search was restricted to title only to shortlist the vast number of irrelevant articles. Whereas, for Pubmed and Cochrane Library, the search has been done for both title and abstract. Those 3 search engines have been chosen due to the availability of many articles about digital health in the eye health field from both a medical and a Public health scope. In this way, we expected that we would find the most relevant clinical outcomes for this study.

We conducted an initial systematic search for published literature using combinations of keywords; We based the search string on three classes of the patient, intervention, comparison, and outcome (PICO framework). All search terms under one heading are linked by a Boolean (OR), and each group is linked by a Boolean (AND).

Table 2. Search combinations of the methodology

Search Combinations
<Digital health> <Smart health> <mHealth> <eye health> <Cataract> <Diabetic retinopathy> <Glaucoma> <ARMD> <Review articles of Digital health and eye health> <Review articles of Smart health and eye health><Review articles of mHealth and eye health><Review articles of mHealth and cataract><Digital health or smart health and eye health><Digital health or mhealth and eye health>

We found 145 articles from Pubmed, 620 from Google scholar and 224 articles from Cochrane with total 989 articles for the initial screening. And ended up with 37 articles for the final screening.

Data Collection and Synthesis

Sample selection

Case studies where collected by the main researcher using secondary data from online articles, WHO reports and global eye initiatives and organizations' reports. While, the Systematic analysis was carried out by two researchers to classify the outcomes reported in the articles' titles and abstracts according to our initial screening inclusion criteria:

1. Review articles.
2. Published between January 2006-June 2020.
3. Relevant articles to our search field with one of the search keywords for each group of terms were mentioned in the articles' title or abstract.
4. In the English language.
5. Not Duplicated in the same database or within the three databases.

Table 3. Terms used for selecting articles in the inital screening

Digital health in eye health
Digital health in cataract surgery
Digital health effect on improving universal eye health coverage, availability and accessibility
Digital health improving quality of eye health or quality of patient's life
Electronic Health Records in eye health or ophthalmology
eLearning in eye health or ophthalmology
Teleophthalmology or Artificial intelligence in eye health or ophthalmology
Deep learning in eye health or ophthalmology
Smart phones in ophthalmology
Retinal imaging or diagnostics and digital health

Exclusion criteria for the secondary screening: The subsequent full-text analysis of the retrieved publications, performed independently by one researcher for the secondary exclusion of irrelevant articles due to the following reasons:

1. Full texts not available or not free of cost.
2. No clear explanation of methodology analysis of the article.
3. Our search terms and keywords were present in the paper, but there were no references to the construct (i.e., unspecific use of the terms).
4. No extensive analysis or reporting on the effects of one of Digital health applications' outcomes on eye health care, or there were no appropriate measures to assess it.

Data management and analysis

For case studies, the compared countries were analyzed using tables, figures and essay for in-depth analysis of UEH indicators and digital health impact on it in these countries. While for the systematic overview, our three database queries resulted in 989 sources. After removing duplicates, 971 studies were left for a more detailed examination. The titles and abstracts of the 971 articles were doubled checked by two researchers for compliance with the inclusion criteria described in the Methods section. This leads to the identification of 103 articles that met our first screening inclusion criteria. Assessment of the remaining papers' full texts resulted in the second screening step based on our secondary exclusion criteria. In the end, 37 publications were identified as suitable.

Figure 1. Systematic review flow chart depicting the literature selection process

Initial search

Articles are searched from Pubmed, Google Scholar, Cochrane Library for the last 15 years.

145 articles from Pubmed engine, 620 from Google scholar and 224 articles from Cochrane were initially examined.

First Screening

Articles which were excluded after revising the titles and abstracts in Pubmed (N=81) and Cochrane (N=213)

Articles which were excluded after revising the titles in Google Scholar (N= 592)

Total excluded (N=886)

Eligibility

We analyzed the articles to further specify and define of search terms, string following PICO:

P: Global eye health care system

I: Digital Health applications (Electronic Health Records, eLearning, mHealth apps, Social media, AI techniques in eye health and Teleophthalmology)

C: Not applicable. **O:** effect on Universal eye health and global eye health system

Final Included articles

Articles included in this final systematic review (N=37)

66 articles excluded: 27 irrelevant contents, 17 no clear methodology, 22 not full/free text

Table 4. Classification of search outcomes

1	Improving the quality of life of eye patients	1.Making eye services more available, accessible, affordable and acceptable to each person in the population via removing the barriers for receiving eye health services as; geographical barrier, cost of services, inequity in service distribution and eye patient satisfaction. 2.Assessment of quality of patients' life after receiving the digital health application in eye health. Via using; Smart phones and mobile apps, digital devices, home screening and digital low vision aids.
2	Digital health effect on universal eye health indicator (Cataract surgical indicators and improving quality of eye health services)	Effect on Cataract surgical services as; cataract surgical rate, coverage, outlay and outcome through EHRs, eLearning and hospital digital applications.
3	Digital health effect on universal eye health indicator (Diabetic retinopathy and glaucoma prevalence)	Improvement in diabetic retinopathy screening and reduction in the prevalence of DR via retinal digital diagnostics by Teleophthalmology and Artificial intelligence (Deep Learning).

Table 5. Criteria that cover each of the three categories of outcomes

1. Available types and uses of eye health services, Apps or devices
2. Accuracy and reliability of the category (Standards/guidelines and ethical issues)
3. Barriers to the eye health services or Apps use
4. Countries/regions or organizations which apply these services if found in literature
5. Outcomes and future of services /Patient satisfaction/Improve quality of patient's life

Chapter II
UEH and Digital Health

2.1 Sustainability of Universal Eye Health

Universal Health Coverage (UHC) is defined by WHO as; ensuring that all people have access to their needed health services (preventive, promotive, treatment, rehabilitation, and palliation) of sufficient quality while also ensuring that the use of these services does not cause any financial hardship [13].

Universal health coverage has become a major goal for health sectors in many countries and a priority of WHO. The early start of UHC was in 1978. The Alma-Ata Declaration developed a bold plan for global health action, identifying primary health care as the base for achieving health for all. Several years later, the Ottawa Charter for Health Promotion, responding to growing health challenges within industrialized societies, recognizing the determinants of health as an integrated and part of health for all. United Nations (UN) agencies, national governments, and civil society organizations assured these declarations, confessing the access to health care and health determinants as basic human rights. As a result of this recognition, nation's emerging obligation to establish health policies for those determinants and ensure universally accessible primary health care was endorsed [14]. UHC 2030 is the new extension of UHC, a multi-stakeholder partnership advocating for increasing political commitment to UHC and facilitating accountability and sharing data. It frames; 1. Leaving no one behind 2. Transparency and accountability 3. Evidence-based national health strategies 4. Making health systems everybody's business 5. International cooperation [15].

In most of the world, UHC is sought through a combination of public and private-sector health care systems. In most LMICs, health systems are evolving to increasingly rely on the private sector because the public sector lacks the infrastructure, staff, and technology to meet all health care needs. In low-income countries, nearly 50 % of health care financing is out-of-pocket. With the expected increase in the overall fraction of care provided through the private sector, these expenditures can be financially catastrophic for the informal workforce [16].

Health and health equity value in their own right. The Helsinki Statement on Health in all policies (HiAP), Finland, June 2013. It was built upon a rich heritage by the Alma Ata Declaration, the Ottawa Charter, and Adelaide conference in 1988. These identified intersectoral action and healthy public policy as central elements for promoting of health and health equity and the realization of health as a human right. These principles have been reinforced in the 2011 Rio Political Declaration on Social Determinants of Health [17].

Universal Eye Health (UEH) is defined by WHO as a part of Universal Health Coverage (UHC)–as– "ensuring that all people have access to needed preventive, curative and rehabilitative eye health services, with good quality to be effective, while also ensuring that people do not suffer financial impoverishment when paying for these services" [18]. For that, the World Health Assembly has guided the development of many global initiatives and national eye-care plans in the last 15 years (Since 2006). Many LMICs use these Eye-care plans to guide efforts to strengthen eye-care services by providing the opportunity for a country's stakeholders to communicate about their activities and for the health ministries to guide coordinating these activities. In pursuit of universal eye health, countries need to consider what data are needed and which of it is available, and the mechanisms to promote such data collection, interpretation, and use to achieve adequate health policies and practices regarding universal eye health.

Universal eye health: a global action plan 2014–2019 in 2013 (resolution WHA66.4) reaffirmed the importance of using a range of evidence, including epidemiological, monitoring, and operational research data. This evidence was incorporated in a sample of 28 national eye-care plans generated since the Universal Actin plan 2014-2019. Most countries (26.93%) cited estimates of the prevalence of blindness, and 18 countries (64%) had set targets for the cataract surgical rate in their plan. Other evidence was rarely cited for setting measurable targets. This limited use of evidence reflects a lack of availability and highlights incomplete use of existing evidence. For example, despite sex-disaggregated data and cataract surgical coverage being available from surveys in 20 countries (71%), these data were reported in only nine countries' eye health plans (32%). Only 3 countries established sex-disaggregated indicators, and only one country had set a target for cataract surgical coverage for future monitoring. Countries almost universally recognized the need to strengthen health information systems, and almost one-third planned to undertake operational or intervention research. Realistic strategies need to be identified and supported to translate these intentions into action.

Accurate, reliable, and timely data are required for priority setting, planning, and delivering good quality health care to all. This data is necessary for countries to plan and effectively manage their eye health programs. The data also need to be used, which requires acknowledging their value in achieving agreed targets and outcomes. In pursuit of universal eye health, countries need to consider what data are available and the mechanisms to promote data collection, interpretation, and use.

This data needed to be collected through evidence via digitalizing the Eye Health system in the world countries through Electronic health records (EHRs) which provide accurate, reliable, and timely data regarding the progress achieved in Eye health services, especially the sex cataract surgical indicators. Also, help to monitor the progress in National eye plans and programs.

These EHRs need adequate education and training for the use of such technology. Management might be even more important in settings where maximal use of the few resources available is a practical necessity. Professional healthcare management, consisting of either clinicians or non-clinicians with management training, needs to focus on hospital performance, process optimization, cost savings, and quality, and provide administrative support. Hospital leadership should consist of clinical leaders and professional managers.

Reliable supply chains are crucial. Consumable shortages are often due to inadequate information and poor management. These issues can be countered with management standards of supply chain management, but the application of these standards would need upfront investments to ensure future savings. Too many surgical units run as close to or below the minimum necessary units of resources, making them ultimately unreliable. With investments in warehousing and information management, health-care managers can focus on optimization of efficient, bidirectional information flow, based on usage patterns with built-in redundancy [19].

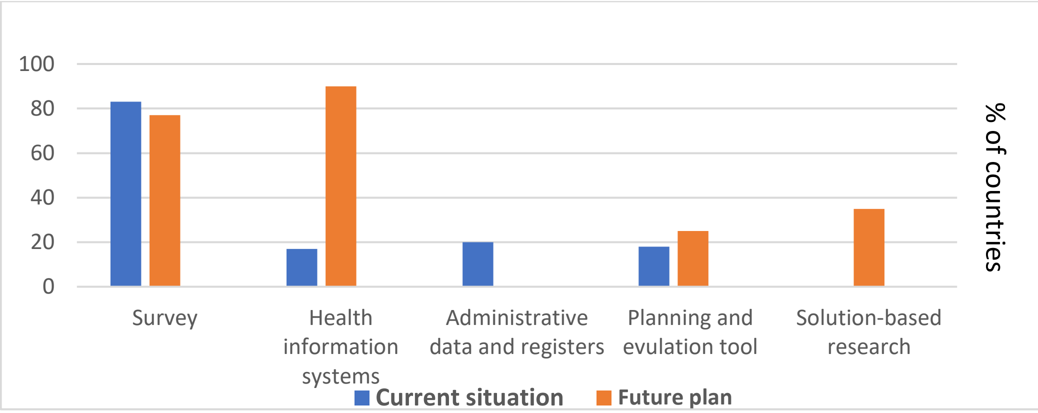


Figure 2. Sources of evidence in Eye-care plans from low/middle income countries

Source: Ramke et al. (2018) [19]

Eyecare is particularly relevant to SDG3.8 on health and well-being. Eye care needs to be an integral part of UHC to address the challenges. When considering it through the lens of UHC, it is;

(i) Provide quality eye care services according to population needs (i.e., both met and unmet).

(ii) Ensure that the cost of priority eye care interventions is included in service packages covered by pre-paid pooled financing.

(iii) Move towards Integrated People-Centered Eye Care (IPCEC) [20].

Access and barriers to eye care services [20]

The use of eye care services is uneven and is determined by the availability, accessibility, affordability, and acceptability of such services. Use of eye care services generally greater in high-income than in LMICs. Cataract surgery coverage rates – an indicator of eye care within populations –show marked variations by income level: surveys conducted in Viet Nam, Yemen, and Malawi reported rates <40%, while rates >80% were reported in Uruguay, Argentina, and Australia. Exception for Iran reported cataract surgery coverage rates of > 90%.

1) **Availability** Shortage and maldistribution of trained human resources are of the most significant challenges. A 2019 study of the ophthalmology workforce covering 94% of the global population reported that, while the number of practicing ophthalmologists,

optometrists, and allied personnel increases in most countries, there is inequitable distribution and a significant shortfall in the current and projected number of ophthalmologists in many LMICs. Also, a shortage of medical ophthalmic equipment is present; results of an ophthalmic equipment survey of 173 health care settings (56% tertiary hospitals) located predominantly in regions of Africa (70.5%) and South-East Asia (13.3%) revealed that more than 60% of services did not have a photocoagulation laser as a primary intervention for vision-threatening diabetic retinopathy (DR).

2) **Accessibility** Many barriers as gender, socioeconomic status, lack of knowledge, and perceived cost of eye care can prevent patients from accessing services. Population-based surveys conducted in LMICs reported that women are significantly less likely to undergo cataract surgery than men. While in high-income countries, Australia and Canada found that men used eye care services less frequently than women. In Nigeria, a national survey showed that almost half of the participants who had undergone a cataract procedure had been couched, and almost three-quarters of these eyes were blind.

3) **Affordability** Direct costs as transportation cost and health insurance coverage play an important role. 50% of people in LMICs live more than one hour from central city (compared with 10% in high-income countries). Further evidence of the impact of direct eye care costs is found in studies that have reported consistently that patients without health insurance have notably lower rates of use of eye care services than those with insurance, especially for those who cannot afford private-for-profit sector fees. A recent review of health system dynamics in Trinidad and Tobago revealed that private sector optometrists and ophthalmologists provide 80% of all eye care. In comparison, less than 20% of the adult population were reported to have health insurance that covers care provided by the private sector.

4) **Acceptability** Previous literature has reported that the acceptance of wearing spectacles is often influenced by factors such as cosmesis, the belief that spectacles identify the wearer as having a disability, or that vision worsens with continued spectacle wear. A study among children in China reported that a low acceptance of free or low-cost spectacles was related to parental beliefs that the spectacles were of poor-quality A distrust of service quality, along with fear of the procedure, have also been cited consistently as barriers to the uptake of cataract surgery in many countries.

Global Initiatives since 2006

Global initiatives that had been launched in the field of UEH by WHO and its international partners since 2006 which include; Vision 2020: The Right to Sight-Action Plan 2006-2011, in 1999 (elimination of the leading causes of all preventable blindness as a public health issue by the end of the year 2020). Action plan for the prevention of avoidable blindness 2009-2013 in 2008 both of them drew a framework of expected global action in the Ophthalmology field. Then came global imitative of Towards Universal Eye Health: A Global Action Plan 2014–2019, in 2012, With the aim of reduction of 25% in the prevalence of avoidable visual impairment by 2019 (compared in 2010) as an implementation tool for the two previous initiatives. International Agency for the Prevention of Blindness (IAPB) has also chosen to highlight the UEH action plan in its World Sight Day Report 2013. Finally, The World report on vision, in 2019 appeared as the most considerable global efforts regarding eye health to galvanize action to address world eye healthcare challenges (by making the integrated people-centered eye care is the care model of choice) which were launched in 2019 to promote the universal coverage of eye services, and advocate efforts to address Non-communicable (NCDs) and neglected tropical diseases affecting eye health [21].

A. VISION 2020: The Right to Sight-Action Plan 2006-2011 [22]

The global initiative is known as ‘VISION 2020: the right to sigh-Action Plan 2006-2011’ was launched in 1999 and is now an established partnership between the World Health Organization (WHO) and the International Agency for Prevention of Blindness (IAPB) to eliminate the leading causes of avoidable blindness by the year 2020. This occurred via facilitating the planning, development, and implementation of sustainable national eye-care programs based on three core pillars: Disease control, Human resources development, Infrastructure and technology

The vision of VISION 2020 is a world in which no one is needlessly blind. Its aims to eliminate the leading causes of avoidable blindness by 2020 and prevent the projected doubling of avoidable visual impairment between 1990 and 2020. By integrating an equitable, sustainable, comprehensive eye-care system into every national health system, the initiative strengthened national healthcare systems and facilitated national capacity-building. Impressive successes in the prevention of blindness (for example, in Gambia, India, Morocco, Nepal, Philippines, Sri Lanka, and Thailand) testify to local VISION 2020 partners' commitment and demonstrate the impact and potential of this global initiative.

Objectives of Vision 2020

1. Raise the profile in critical audiences of the causes of avoidable blindness and the solutions.
2. Advocate for and secure the necessary resources to increase prevention and treatment.
3. Facilitate the implementation of national VISION 2020 programs in all countries.

Strategies for the period 2006–2008

(1) National programs development
(2) Financial sustainability
(3) Partnerships between national governments and VISION 2020
(4) Public relations
(5) Advocacy
(6) Resources mobilization

Widen the corporate membership of IAPB and establish a corporate group to avoid conflicts of interest. Support the 'Optometry Giving Sight' fund-raising initiative.

Blindness, visual impairment and disabilities Situation in 2006

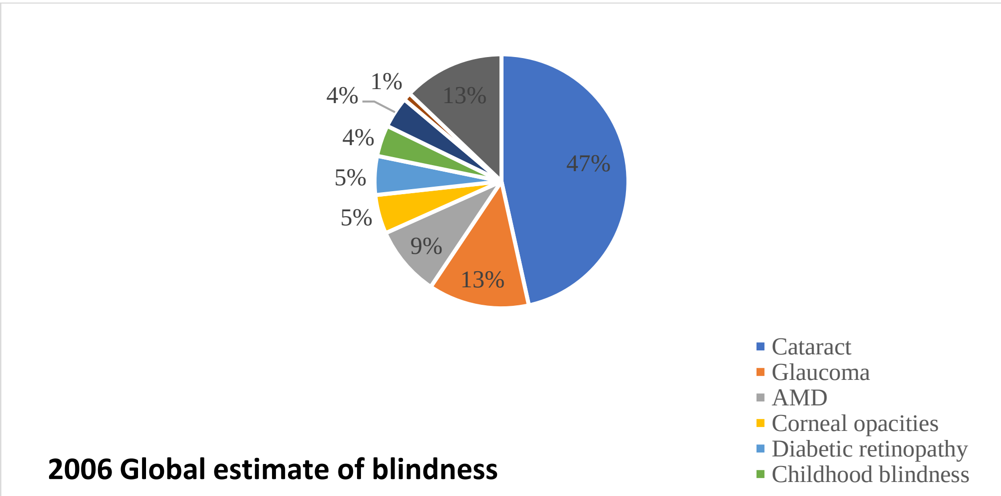


Figure 3. WHO 2006 Global estimate of blindness causes excluding refractive errors

Source: Vision 2020 [22]

Situation, Strategies, Achievements and Targets of Eye diseases in 2006

Table 6. Estimated number of visually impaired or blind people according to the causes of blindness in 2006

Causes blindness	Cataract	Trachoma	DR	ARMD	Glaucoma
	18 million bilaterally blind Western Pacific Region >50 % of in poorer regions.	80 million with 10.6 million with entropion trichiasis and 5.9 million irreversibly Visually impaired from corneal scarring	1.8 million (4.8%of all blindness) ranging from close to 0 % in Sub Saharan Africa to 3-7 % in South East Asia, Western Pacific to 15-17% Americas and Europe	3 million (8.7% of all blindness) ranging from close to 0 % in Sub Saharan Africa to 50% in industrialized countries and expected to be doubled in this year 2020	4.5 million blinds from glaucoma and expected increase of glaucoma cases in to 60.5 in 2010 and 80 million in this year 2020

Source: Vision 2020 [22]

Cataract

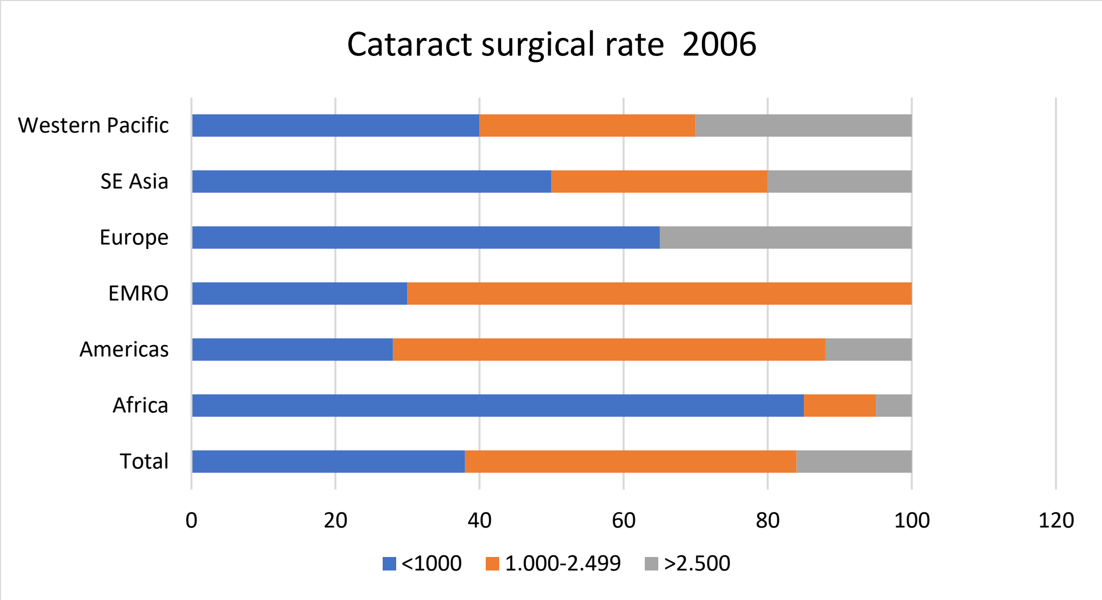


Figure 4. Cataract surgical rate by WHO regions in 2006

Source: Vision 2020 [22]

Achievements: *Cataract is included in most national plans for the prevention of blindness.

Cost-effective surgical techniques have been developed, tested, and improved continuously (e.g., small-incision cataract surgery and use of good-quality, low-cost intraocular lenses).

Refractive Errors

Achievements: *Uncorrected refractive errors increasingly addressed in national plans for the prevention of blindness.

*Low-cost, good-quality spectacles are becoming available.

*In 2003, a WHO working group reviewed the current classification of visual impairment and blindness and made recommendations for the revised version of the International Classification of Diseases (ICD).

Childhood Blindness

In low-income countries, high proportions of children are blind from preventable causes, which require community-based interventions.

Achievements:

*Vitamin A deficiency: United Nations Children's Fund (UNICEF) has estimated that global efforts prevented between 1998 and 2000 about 1 million child deaths, and the Vitamin A Global Initiative led by UNICEF set the target of eliminating vitamin A deficiency by 2010.

*Measles immunization coverage: continues to improve. In 2004, there were 454.000 deaths from measles, a reduction of 48% from 1999. The Measles Initiative, focusing on 47 countries, mainly in sub-Saharan Africa, where 98% of deaths occur, to reduce deaths from measles by 90% by 2010 from 2000. The WHO Region of the Americas has eliminated measles, and three other regions have set elimination targets. will also reduce measles-related corneal ulceration and scarring.

*Retinopathy of prematurity: Programs for detecting and treating severe retinopathy in premature expanding throughout Latin America and Eastern Europe, China, and India.

*Child eye-care centers: Training in pediatric ophthalmology is becoming more prevalent.

*Consumables for children: Low-vision devices for children

Onchocercariasis

*At the closure of the Onchocerciasis Control Programme in 2002, 40 million people in 11 countries had been saved from infection, and eye lesions, 600.000 cases of blindness had been prevented.

*All 13 foci in Latin America had reached a therapeutic coverage of at least 85% by 2006.

*****Since the African Programme for Onchocerciasis Control was launched in 1995, 40 million people in 16 countries have been treated annually, covering 117.000 communities.

Trachoma

Endemic in 55 countries, including Egypt, Cambodia, and Gambia. The estimated number of affected people has fallen from 360 million in 1985 to about 80 million today. Trachoma affects the poorest and most remote rural areas of Africa, Asia, Central, and South America, and the Middle East. The majority of gender burden are women.

Achievements: At the national level, political support for trachoma control has increased continually since 1997, the year WHO Alliance for the Global Elimination of Blinding Trachoma (GET 2020) was created and activated at the global level.

Diabetic Retinopathy

About 50% of persons with diabetes are unaware that they have the condition, although about 2 million deaths every year are attributable to complications of diabetes. After 15 years, about 2% of persons with diabetes become blind, and about 10% develop severe visual loss. After 20 years, more than 75% of patients will have some form of diabetic retinopathy. Overall, the direct health-care costs of diabetes range from 2.5% to 15% of annual healthcare budgets.The costs of lost production can be as much as five times the direct health-care cost according to estimates derived from 25 Latin American countries.

Achievements: Some low- and middle-income countries are developing models for screening and treatment of diabetic retinopathy.

Glaucoma

**Achievements: ***Research into various aspects of glaucoma is being conducted internationally.

*New anti-glaucoma drugs have been developed, and new treatment options are being evaluated.

*Screening tests for angle-closure glaucoma are being developed and evaluated.

HUMAN RESOURCE DEVELOPMENT

Aim; to have an appropriately trained, available, multidisciplinary workforce that will focus on the coverage, quality, and sustainability of eye health services.

Objectives; Train community healthcare workers for preventive education, simple treatment, early detection and referral to health facilities, skill mix. Train mid-level eye-care personnel for instrument maintenance and repair, low-vision care, and simple refraction.

Table 7. Human Resource development according to the global initative Vision 2020

Action	Ophthalmologist	Optometriss	Community eye care	Mid-level eye care personnel	Equipment technicians
Target and Indicator	-Achieve a ratio of one ophthalmologist per 250.000 pop. -In SS Africa, ratio of 1:400.000 / 2010 and 1:250.000 / 2020. -In Asia, ratio of 1:100.000 / 2010 and 1:50. 000 / 2020.	-Achieve an appropriate ratio of optometrists per population. -Proportion of optometrists integrated into primary care programmes.	-Proportion of residency programmes in a country that integrated community ophthalmology module. -Number of eye-care personnel who trained in community ophthalmology.	-In SS Africa, achieve a ratio of one ophthalmic medical assistant, officer or nurse per 200.000 pop. /2010 and a ratio of 1:100.000 /2020. -In Asia, achieve a ratio of 1:50 000 / 2010.	-25% of secondary centres with functioning trained personnel /2010 and 50% /2020. -60% of tertiary centres with functioning trained personnel by 2010 and 100% by 2020.

Source: Vision 2020 [22]

TECHNOLOGY

Aim to ensure an optimal supply of appropriate, high-quality, affordable equipment, instruments, consumables, and resource materials essential for delivering of eye-care services.

Current situation In many parts of the world, there are still shortages of usable diagnostic and therapeutic equipment and supplies necessary for practitioners to apply modern techniques to combat blindness. Despite improved access to information technology globally, some eye-care personnel, for instance, in rural Africa, do not have easy access to the internet or the information necessary to make the best buy. Much of the information is available only in English. Nevertheless, there have been many improvements since VISION 2020. A standard list with guidelines on the equipment necessary for a district eye-care program is now available on websites and in print and is regularly updated. Training in equipment maintenance, confined mainly to India and West Africa, has also been undertaken elsewhere, including East Africa and Pakistan. Training material in electronic and print forms is now available [22].

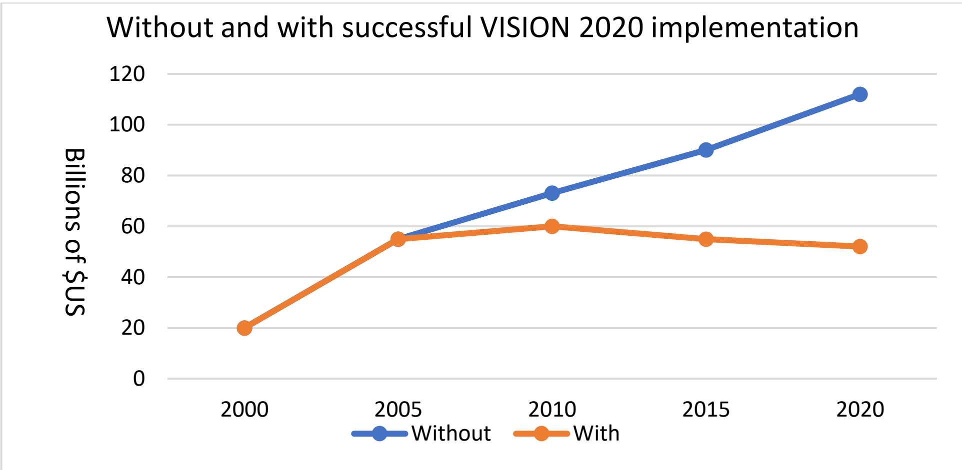


Figure 5. Projected cost of reduced productivity by visual impairment caused by eye diseases, 2000–2020 versus without VISION 2020 implementation

Source: Vision 2020 [22]

B. Action plan for the prevention of avoidable blindness and visual impairment 2009-2013 [23]

5 Main Objectives

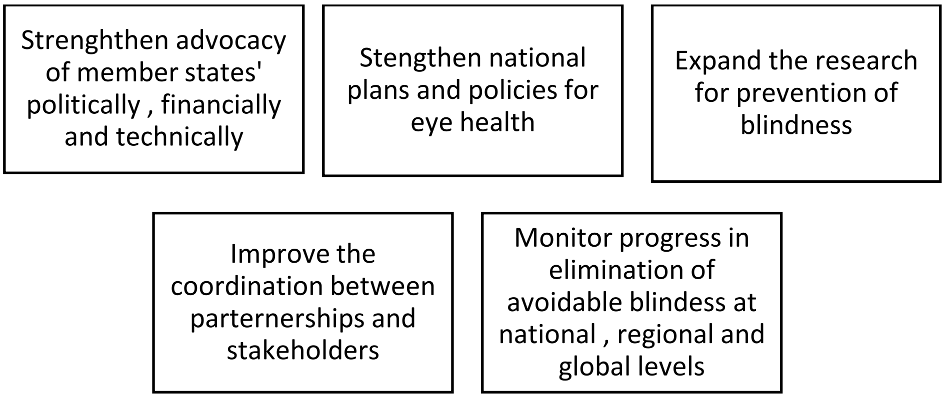


Figure 6. The five main objectives of action plan 2009-2013
Source: Action plan for the prevention of avoidable blindness 2009-2013 [23]

At the Sixty-first World Health Assembly in 2008, Member States requested that an action plan be developed to address the eye-health agenda and complement the existing Action plan for the global strategy for the prevention and control of noncommunicable diseases, endorsed in resolution WHA61.14. WHO Secretariat developed a draft action plan to prevent avoidable blindness and visual impairment using an open consultative process. The draft action plan was endorsed at the 124th session of the Executive Board in January 2009. Subsequently, the 62 World Health Assembly adopted resolution WHA62.1 The Action plan supports the implementation of WHO is Eleventh General Program of Work 2006-2015 and the Medium-term strategic plan 2008-2013. The plan draws on experience in the control of avoidable visual impairment in various socio-economic settings. In 2009, WHO estimates showed that 314 million worldwide live with visual impairment. Of these, 45 million are blind, of whom 90% live-in low-income countries. The major causes of blindness were cataract (39%), uncorrected refractive errors (18%), glaucoma (10%), age-related macular degeneration (7%), corneal opacity (4%), diabetic retinopathy (4%), trachoma (3%), eye conditions in children (3%), and onchocerciasis (0.7%). Five objectives are defined within the Action plan.

Table 8. Overview of actions and purpose of Action plan of Avoidable Blindness (2009-2013)

Objectives	Member states	WHO secretariat
1.Adovacy of political, financial commitment	National coordination at MOH/other institutions, consider budgetary, integrate eye health at all health delivery level and in health promotion agendas, Observe World Sight day.	Conduct political analyses to support high level decision makers, Work on social determinants of health and make policy makers aware of relation between blindness and poverty (2009-11).
2.Strengthen national plans	Develop national guidelines for blindness prevention or adopting WHO one, review existing policies, incorporate blindness prevention in poverty reduction plans, Develop eye health workforce from paramedics and community workers through training.	Review experience of public health strategies for control of blindness, Direct technical support of national blindness prevention committee, develop standardized approach of collection of data including health insurance, strengthen WHO offices capacity (2009-11).
3.Expand research	Promote research by national institutions on social determinants of health, assess economic cost of blindness, Include epidemiological, and workforce in national eye plans.	Collate data on risk factors as smoking, radiation, coordinate agenda of eye health in LMICs, assessing impact of public health policies on eye health (2009-11).
4.coordination of stakeholders nationally /internationally	Actively support existing national/inter. Alliances, including NCD, neglected tropical diseases control, Promote public-private partnerships nationally.	Convene WHO monitoring committee pursuant to resolution WHA56.26, Strengthen role of WHO collaborating centers by linking their workplans (2009-10).
5.Monitor progress	Provide regular updated disaggregated data, establish surveillance system using existing WHO tools: Cataract and trachoma.	Review and update list of indicators for M &E, Document from successful countries about their good practices in 2005 (2009-11).

Source: Action plan for the prevention of avoidable blindness 2009-2013 [23]

Situation Analysis in 2009

Epidemiological surveys have been conducted in 65 countries. However, the absence of surveys in the remaining countries had greatly hampered detailed planning, monitoring:

1. By the end of 2008, 118 Member States had reported the establishment of a national committee. However, not all national committees are functional; in many cases, such committees have not successfully initiated effective action.
2. Experience has shown that, in LMICs, a comprehensive national plan containing targets and indicators that specified, time-linked, and measurable leads to substantially improved provision of eye healthcare services. Most LMICs (104 Member States by the end of 2008) have reported the development of national eye health and blindness prevention plans, but reporting on and assessing their implementation and impact was insufficient.
3. **Achievements and resource mobilization;** In the previous decade, WHO urged for a unified prevention of blindness through the global initiative; Vision 2020. Achievements in controlling onchocerciasis and trachoma were based, respectively, on implementation of WHO's community-directed treatment strategy with ivermectin and the SAFE strategy for trachoma control. Such a unified approach convinced major donors that long-term commitment is required as the Merck donation program for ivermectin to control onchocerciasis. As well, the distribution of azithromycin under a donation program by Pfizer to control trachoma, African Program for Onchocerciasis Control, the Onchocerciasis Elimination Program for the Americas, the WHO Alliance for the Global Elimination of Blinding Trachoma, and VISION 2020: the Right to Sight.
4. **Human resources and infrastructure;** despite efforts to strengthen human resources for eye health, a crucial shortage of eye-care personnel persists in many low-income countries. Many countries in the African Region, for instance, have less than one ophthalmologist per million inhabitants as Gambia. Although recent technological developments in eye care have resulted in advanced diagnostics and treatment, the cost of adequately equipping a secondary and tertiary eye-care center is prohibitive for many low-income countries. [23].

C. Universal Eye Health: A global action plan 2014-2019 [24]

WHO estimates that in 2010 there were 285 million people visually impaired, with 39 million blind people. Cataract (33%) and refractive errors (42%) are considered priorities. If refractive services and cataract surgeries to the people in need are implemented consistently across the world, two-thirds of the visually impaired people could recover good vision. There is ample evidence that comprehensive eye care services are needed to become an integral part of primary health care and health systems development. In 2010, 82% of those blind and 65% with moderate- severe blindness were older than 50 years of age. In meeting the action plan target, the expectation is that most significant gains will reduce the prevalence of avoidable visual impairment in that portion of the population over the age of 50 years. In 2019, it was estimated that 84% of all visual impairment was among those aged 50 or more. It becomes increasingly critical to incorporate the blindness prevention and rehabilitation agenda into more expensive health policies as post-MDGs actions.

Universal Eye Health: A global action plan 2014-2019; aimed to reduce avoidable visual impairment as a global public health problem and secure access to rehabilitation services for the visually impaired. Following the request of Member States at the 66 World Health Assembly in 2011 adopting resolution WHA66.4 entitled Towards universal eye health: a global action plan 2014–2019. Eye health needs to be included in broader NCDs and communicable disease frameworks and substantially contribute to global initiatives addressing aging, marginalized, and vulnerable. Setting a global target for the action plan, Members have agreed to reduce avoidable visual impairment by 25% by 2019 from the baseline established by WHO in 2010.

WHA 66.4

(Resolution of 66 world health assembly on May 24, 2013)

1.Recalling WHA56.26, WHA62.1 and WHA59.25 on elimination of avoidable blindness.

1.Recalling WHA56.26, WHA62.1, and WHA59.25 on the elimination of avoidable blindness.

2.Recognizing that the global action plan 2014–2019 builds upon the action plan to prevent avoidable blindness for the period 2009–2013.

3. Recognizing linkages between areas of action plan 2014–2019 and efforts to address NCDs and neglected tropical diseases; Endorsed the action plan 2014–2019 on universal eye health.

There are three National indicators at the goal and purpose levels to measure progress at the national level: (i) Prevalence and causes of visual impairment; crucial for resources allocation, planning, and developing synergies with other programs (25% reduction in 2019 than 2010). (ii) A number of eye care personnel; Ophthalmologists, optometrists, and allied ophthalmic personnel (determining the availability of the eye health workforce. Gaps can be identified in human resource and plans adjusted accordingly).; and (iii) Cataract surgical service delivery; (rate and coverage), an important measure that provides information on the degree to which cataract surgical services are meeting needs. For sustainable Universal eye health coverage and eye health integration in all health sectors, it is expected to implement broader development initiatives as a draft action plan for the prevention and control of NCDs 2013–2020.

Table 9. Vision, goal and purpose of global action plan 2014-2019

Vision	Goal	Purpose
World free of visually impaired persons, where people with unavoidable visual loss can achieve full potential through universal access to eye services.	Reduce avoidable visual impairment as a global public health problem and secure access to rehabilitative services for the visually impaired.	Improve access to comprehensive eye health care services that is integrated into health systems.
	Measurable indicators Reduction of avoidable blindness by 25% by 2019 / baseline in 2010.	**Measurable indicators** 1) Number of eye health workers/100.000. 2) Cataract surgical rate.

Source: global action plan 2014-2019 [24]

Table 10. Action plan principles and approaches

Universal access and equity	Human rights	Evidence-based practice	Life course approach	Empowerment of blind people
All people should have equitable access to health care regardless of age, gender or social status.	Interventions for treatment, must be compliant with international human rights conventions.	Interventions for treatment, prevention and promotion need to be based on scientific evidence and good practice.	Eye health and related plans need to take account of health and social needs at all stages of the life course.	People who are blind or with low vision can participate fully in social, economic, political, cultural aspects of life.

Source: global action plan 2014-2019 [24]

Table 11. Objectives and actions of global action plan 2014-2019 [24]

Objective 1	**Objective 2**	**Objective 3**
Increase political and financial commitment of member states for eye health care	National eye health plans and programs for enhancing universal eye health are established in line with WHO's framework for action for strengthening health systems	Multisectoral engagement and partnerships strengthening for eye health improvement
Indicators -Number of member states that published prevalence surveys and eye care service assessment of member states in the last 5 years until 2019. Observation of World Sight Day.	**Indicators** Number of Member States reporting the implementation of plans and programs for eye health, or have prevention of blindness committee, or have eye care sections in their national lists of essential medicines, diagnostics and **health technologies**, or reporting integration of eye health into national health plans and budgets, or reporting a national plan that includes human resources for eye care, or reporting evidence of research of eye health programs.	**Indicators** -WHO Alliance for the Global Elimination of Trachoma by the Year 2020, African Program for Onchocerciasis Control, and Onchocerciasis Elimination Program for the Americas. -Number of Members that have eye health incorporated into relevant poverty-reduction strategies. - Number of Members that refer to a multisectoral approach or reporting eye health as a part of intersectoral collaboration in their national eye health plans.

Source: global action plan 2014-2019 [24]

D. World report on Vision 2019 [20]

Thanks to continuous concerted action taken over the past 30 years, progress has been made in many areas. Depending on 1999 Vision 2020: The Right to Sight, intensified global advocacy efforts and strengthened national prevention of blindness programs, and supported the development of national eye care plans has been developed. This initiative was maintained by four WHA resolutions: WHA56.26 (2003); WHA59.25 (2006); WHA62.1 (2009), and WHA66.11 (2013). Also, by a report presented at the Seventieth WHA in May 2017 detailed the considerable progress made in implementing the 2014–2019 global action plan (resolution WHA66.4), which ended up with Universal eye health: global action plan 2014-2019 in 2013 and finally sustained by publishing the World report on Vision in 2019.

The World report on vision sets out concrete proposals to address challenges in eye care. The key proposal is to make integrated people-centered eye care (IPEC), embedded in health systems and based on intense primary health care, the care model of choice and scale it up widely. People who need eye care must be able to receive high-quality interventions without suffering financial hardship. Including eye care in national health plans and essential care packages is an integral part of every country’s journey towards universal health coverage. Making eye care integral to UHC will contribute to reaching Sustainable Development Goal (SDGs) 3.8. To facilitate the choices that countries must make when implementing UHC, WHO is developing an online data repository detailing WHO recommended part of it is regarding eye care, which will contribute to progressing the agenda of it as part of UHC forward.

Aims of the report

To raise awareness of the global magnitude and impact of eye conditions and vision impairment and the need to address gaps in data, particularly met and unmet eye care needs;

1. To draw attention to effective strategies to respond to eye care needs.
2. To take stock of progress and identify the main challenges facing the field of eye care.
3. To emphasize the need for making eye care an integral part of UHC.
4. To make a case for IPEC as the way forward.
5. To make recommendations to be implemented by all countries to improve eye care.

Scope of the report

This report makes the case that IPEC is the care model of choice and can help meet the challenges.

Global magnitude of eye conditions and vision impairment between 2012-2019

1. Globally, at least 2.2 billion people have a vision impairment. At least 1 billion (almost half) of these cases with moderate to severe distance vision impairment could have been prevented or has yet to be addressed.
2. Accurate estimates of the total number of people globally with vision impairment cannot be calculated based on currently available data as it is lack. This is because population-based surveys do not typically report vision impairment in those who wear spectacles or contact lenses to compensate for the vision impairment from a refractive error.
3. The burden of most eye conditions is not borne equally with inadequate access to eye care.
4. Eyecare is a good investment. Preventing vision impairment will improve productivity.
5. Since a person can have more than one eye condition, the real figures cannot merely be summed to derive a global estimate as the number and prevalence of people with at least one eye condition are not available.
6. 188.5 million people globally living with mild distance vision impairment.
7. The estimated global number of people with vision impairment and those with vision impairment that could have been prevented or has yet to be addressed; Unaddressed refractive errors 123.7 million, cataract 66.2 million, glaucoma 6.9 million, corneal opacities 4.2 million, Diabetic retinopathy 3 million, trachoma 2 million, unaddressed presbyopia 826 million.

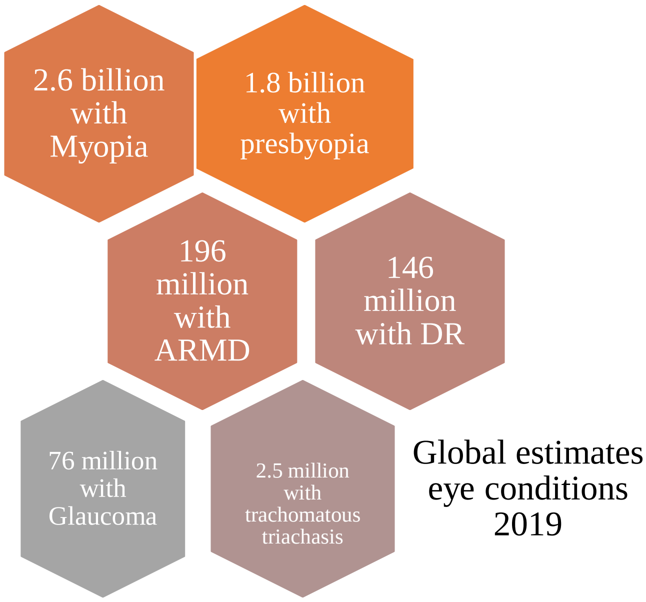


Figure 7. Global estimates of number of people affected by selected eye conditions that can cause vision impairment and blindness in 2019 by world report on vision

Source: global action plan 2014-2019 [24]

The costs of addressing the coverage gap

To achieve global health targets set for 2030, LMICs will need to invest in an additional 23 million health workers and build more than 415.000 new health facilities. The coverage gap costs for unaddressed refractive errors4 and cataract5 globally are estimated to be $14.3 billion US dollars. By breaking down the costs, cataract surgery alone needs US$ 6.9 billion while refractive error surgery and services need US$ 7.4 billion. It is estimated that 11.9 million people globally have a moderate or severe vision impairment or blindness due to glaucoma, DR, and trachoma that could have been prevented. The estimated costs of preventing vision impairment in these 11.9 million would have been US$5.8 billion.

Future Expectations

Population Aging By 2030, the number of people worldwide aged over 60 years is estimated to increase from 962 million (2017) to 1.4 billion, while numbers of over 80 years will increase from 137 million (2017) to 20 The number of people with the age-related eye condition glaucoma has been projected to increase 1.3 times between 2020 (76 million) and 2030 (95.4 million); and those with ARMD, 1.2 times between 2020 (195.6 million) and 2030 (243.3 million). The number with presbyopia increases from 1.8 billion in 2015 to 2.1 billion in 2030.

Lifestyle Reduced time spent outdoors, increased near work, and increased urbanization will lead to an increase in the number of people with myopia will increase from 1.95 billion in 2010 to 3.36 billion in 2030. There was also an increase in the number of people with diabetes across all countries during the past thirty years with the number of people with DR is estimated to increase from 146 million in 2014 to 180.6 million in 2030.

Integrated people-centered eye care (IPCEC)

Integrated People-Centered Care (IPCC), which is the new concept of UHC, is defined as services that confirm the people receive a continuum of health; promotive, preventive, treatment, or rehabilitative, to address the full spectrum their needs. It can now to contribute towards achieving SDG 3: "Ensure healthy lives and promote well-being for all at all ages" is became the main framework of the World report on Vision [25].

The implementation of integrated people-centered eyecare requires these four strategies;

1. Empowering and engaging people and communities;

Health literacy is an essential component of empowering individuals and their families; it is crucial for many eyecare service effectiveness. The eye care sector needs to increase its efforts to provide sound and practical education. Strategies for engagement can occur at the individual or specific population group level. One example of effective community empowerment in eye care is ivermectin as a preventive intervention for onchocerciasis. With result showed; Over 142 million people received treatment by the end of 2017. In the same year, 14 countries reported having achieved 100% geographical coverage, and over 17 million disability-adjusted life years (DALYs). Outreach eye care services have been shown effective in increasing service coverage in hard-to-reach communities. To simplify access to care for underserved populations, rapid technological change also has potential. Telehealth is employed effectively in the field of eye care. Telehealth supports people in rural and remote settings who are otherwise underserved.

2. Reorienting the model of care;

It involves ensuring that efficient health-care services are designed and provided utilizing innovative models of care that prioritize primary and community care services and the co-production of health. Building a vital Primary Health Care with integrated eyecare is essential since eye care involves delivering interventions aimed at the individual through primary care (e.g., DR screening) and population-based interventions, such as the provision of vitamin A supplementation. Successful eyecare interventions are being delivered through other health services such as retinopathy of prematurity (ROP) screening in Argentina in 2007 after the national legislation mandated formal integration of these services.

3. Coordinating services within and across sectors;

Three strategic approaches: coordinating individuals, health programs and providers, and across sectors. All are fundamental to achieving IPEC. The coordination of services focuses on improving care delivery by aligning and harmonizing processes and information systems (ICT).

4. Creating an enabling environment

Via Leadership and governance and health Information and surveillance system are fundamental. For example, they are Integrating vertical programs into the health system and developing of well-integrated health information system in Oman. Also, establishing Data sources censuses, individual records, social registries, service and records, health record, and population surveys is critical.

Successes and remaining challenges in eye care

Substantial progress has been made in addressing specific eye conditions and vision impairment. The number of children and adults with eye infections and blindness due to vitamin A deficiency, onchocerciasis, and trachoma has decreased in all regions during the past 30 years. With the successes of the preventive interventions for active trachoma, the number of people worldwide who need operations for trachomatous trichiasis has decreased substantially during the past decade: from 8.2 million in 2007 to 2.5 million in 2019.

Cataract is the leading cause of blindness globally and has been a primary focus of many programs to meeting the Vision 2020 objectives. As a result, many LMICs have seen substantial increases in rates of cataract surgery. For example, India was successfully increased its cataract surgery rate by almost nine-fold between 1981 and 2012. These endeavors have resulted in modest reductions in the global proportion of vision impairment and blindness attributable to cataract between 1990 and 2015.

Scientific and technological advances

1) Advances in surgical techniques for cataract, coupled with improvements in intraocular lens design and the increased availability of low-cost, high-quality intraocular lenses, has led to significant improvements (in terms of the quality of the visual outcome of patients, safety and surgical volume) in cataract surgical service delivery.
2) Scientific advances in treatment for people with human immunodeficiency virus has rendered its related ocular infections largely prevented, although immune recovery uveitis has emerged as a complication.
3) The adoption of telehealth solutions has effectively improved access to a range of eye care services, particularly for those living in rural and remote areas of many countries.
4) The use of mobile-based software applications for vision assessment and cataract surgery benchmarking and artificial intelligence (AI) technologies a range of eye conditions, including DR, offer further hope for enhancing access and quality of health care to the most neglected communities.
5) Technology advances have changed vision rehabilitation. The development of smartphones, voice recognition, and accessibility features in computer operating systems have dramatically enhanced access to information and communication for individuals with vision impairment and blindness.
6) Digital audiobooks are widely available in increasing numbers for those with print-reading disability. Individuals with vision impairment can navigate using GPS or use electronic canes to detect nearby obstacles.

Challenges moving forward

1) Changing population demographics; Challenges remain in ensuring that quality services are planned and provided according to population needs.
2) Data challenges; During the past two decades, these have undoubtedly made major contributions to understanding the epidemiology of vision impairment and blindness. Despite these achievements, robust survey data are lacking in approximately half the world's countries. Data gaps particularly pronounced in central and southern sub-Saharan Africa,

eastern and central Europe, central Asia, and the Caribbean. Of those countries that have conducted surveys, many of their findings remain unpublished, and approximately only 15% have national-level data. To date, the vast majority of survey methodologies have been undertaken for population subgroups aged 50 years and over since an estimated 80% of vision impairment occurs in this age group.

3) Integration; Eye care is not typically included in strategic health plans.
4) Inequalities in access to eye care services; Most eye care delivery focuses on the providing curative interventions at the secondary and tertiary levels of the health system and is often restricted to urban and more extensive regional settings.
5) Health information systems (HIS); HIS often do not include relevant data on eye conditions, their determinants, and health systems data related to eye care [20].

2.2 Digital health effect on Cataract indicators and retinal diagnostics

We need to start from scratch in some developing and LMICs for ePolicies implementation with to reach 3 targets; Electronic health records (EHRs) implementation or expansion (system), eLearning (provider = Ophthalmologists and paramedics), mobile health apps (receiver = patients) for cataract surgical services and retinal diagnostics use EHRs, Apps, teleophthalmology and Artificial intelligence techniques for retinal diseases screening. To improve the cataract surgical services and reducte its prevalence as major causes of blindness (especially Diabetic retinopathy) as the main Indicators of UEH. This will help save the ophthalmologists time to do more cataract surgeries and other eye health care services and improve their technical skills via;

(1) Improve availability and accessibility and affordability through;
  a. The increasing number of cataract surgeries
  b. Minimizing waiting lists
  c. Reducing indirect costs
(2) To be useful, indicators require good quality data and careful interpretation by clinicians and program managers to identify which aspects of cataract and retinal care services are most in need of being strengthened and improving the quality of service and monitoring its adequacy and equity.

Digital Health

Digital health connects and empowers people to manage health and wellness, augmented by accessible provider teams working within flexible, integrated, interoperable, and digitally-enabled health care environments that strategically leverage digital tools, technologies, and services to transform health care delivery [26]. WHO defined eHealth as the cost-effective and secure use of information and communication technologies to support the health and health-related fields, including healthcare, health surveillance and health education, knowledge, and research? eHealth differs from Digital health in that it has been described by WHO as the use of information and communication technology for health. In contrast, digital health is described more broadly as an umbrella term for areas including eHealth itself plus many other digital fields [27].

Since 2009 the Global Observatory for eHealth (GOe) has created and updated an online directory of eHealth-related national policies and strategies from the Member States. It includes national eHealth policies or strategies and plans, and national telehealth policies have also been added to broaden the coverage. This resource is designed to support eHealth strategies by governments through easy access to existing policy and strategy documents worldwide. Besides, it gives an indication of which countries have existing national strategies, assuring the accountability in the various aspects relating to the use of information and communication technologies (ICT) for health are all part of an eHealth governance function at the national level. This third global survey of the WHO GOe investigated how eHealth can support UHC and UEH in the Member States. A total of 125 countries participated in the survey in 2015, which shows a clear reflection of the growing interest in this area. WHO site for eHealth was last updated in March 2016 [28].

Digital health/mHealth has a broad scope and includes the use of many fields; [29][30]

1. Artificial Intelligence (AI)
2. Telehealth/Telemedicine
3. Wearable devices and remote sensing
4. Health Information and Communication Technology (ICT), bioinformatics tools (-omics)
5. eLearning
6. Medical social media platforms and the Internet of things
7. Big data analytics and predictive modeling and blockchain
8. Digitalized health record platforms (EHRs)
9. Patient-physician-patient portals, DIY diagnostics, compliance, and treatments
10. Decision support systems.

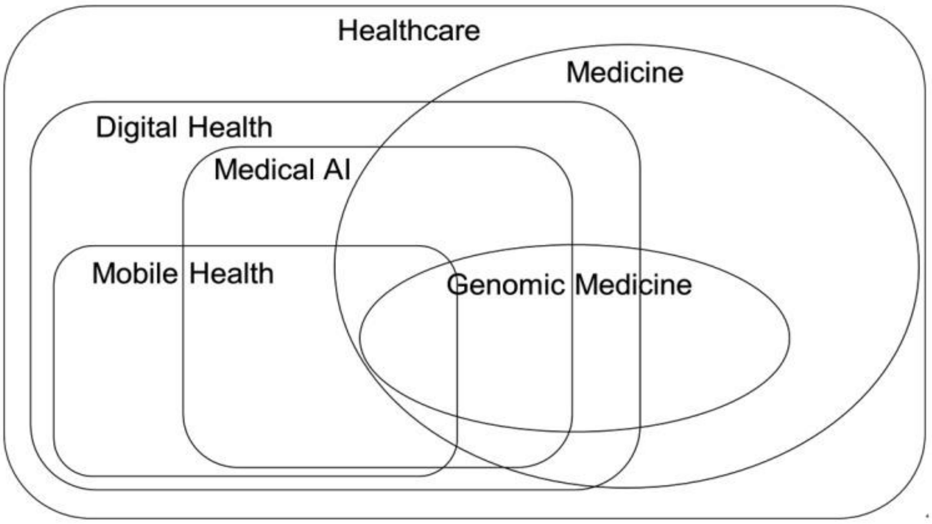


Figure 8. Relationship between digital health and other terms
Source: Shin (2019) [31]

In Vision 2020, infrastructure and technology are from the three main pillars of planning, development, and implementation of sustainable national eye-care programs. Despite improved access to information technology globally, some eye-care personnel, for instance, in rural Africa, do not have easy access to the internet or the information necessary to make the best buy. One of the main objective of Vision 2020 is to make use of new information technology to improve management efficiency and information exchange [22].

One of the Universal action plan 2014-2019 principles is evidence-based practice via interventions for treatment, prevention, and promotion, which is needed to be based on scientific evidence and good practice. Moreover, its second objective is the establishment of national eye health plans and programs for enhancing universal eye health, having a prevention of blindness committee, or having eye care sections in their national lists of essential medicines, diagnostics, and health technologies, or reporting integration of eye health into national health plans [24].

World report on Vision mentioned many achievements in Eye health-related to digital health including;

- Advances in surgical techniques for cataract, coupled with improvements in intraocular lens design and the increased availability of low-cost, high-quality intraocular lenses.
- The adoption of telehealth solutions improving access to a range of eye care services.
- The use of mobile-based software applications for vision assessment and cataract surgery benchmarking and artificial intelligence (AI) technologies to detect a range of eye conditions, including DR.
- Technology advances have changed vision rehabilitation as the development of smartphones, voice recognition, and accessibility features in computer operating systems.
- Digital audiobooks are widely available for those with print-reading disability [20].

Cataract surgerical indicators and how to tackle by digital health applications

Providing cataract surgical services at a rate adequate to eliminate the backlog of cataract, at a price that is affordable for all people, both rural and urban, in an equitable manner, and with a high success rate in terms of visual outcome and improved quality of life was the priority objective of Vision 2020. Also, including cataract in most national plans for the prevention of blindness, increasing cataract surgical rates in many countries and using cost-effective surgical techniques in cataract surgeries are also some of Vision 2020 targets. Furthermore, in Action plan for the prevention of avoidable blindness and visual impairment 2009-2013, planned scope mentioned that according to evidence indicators of this period 2009-2013, the magnitude of avoidable blindness caused by communicable diseases like trachoma and measles is decreasing. In contrast, NCD age-related eye conditions as cataract are increasing. And it recommended the urge for a coordinated intersectoral approach for NCD conditions (as Cataract) [22][23].

In Universal Eye Health: A global action plan 2014-2019, the plan mentioned that Cataract (33%) and refractive errors (42%) are considered priorities, and if cataract surgeries and refractive services to the people in need are implemented consistently across the world, two-thirds of the visually impaired people could recover good vision. Cataract surgical service delivery; (rate and coverage) was considered an important measure that provides information on the degree to which cataract surgical services are meeting needs for sustainable Universal eye health coverage and as one of the three National indicators at the goal and purpose levels to measure the progress of countries at the national level [24].

World report on Vision mentioned that in 2019, there are still 66.2 million cataract patients worldwide. To achieve global health targets set for 2030, LMICs will need to invest in an additional 23 million health workers and build more than 41.5000 new health facilities. The costs of the coverage gap for cataract and unaddressed refractive errors globally are estimated to be $14.3 billion US dollars. By breaking down the costs, cataract surgery alone needs US$ 6.9 billion. By 2030, the number of people worldwide aged over 60 years is estimated to increase from 962 million (2017) to 1.4 billion, while the numbers of those aged over 80 years will increase from 137 million (2017) to 202 million. Which for sure threatens that the number of people with age-related (senile) cataract will be projected to increase many folds by that time [20].

Cataract is defined by the World Health Organization (WHO) as a clouding of the lens of the eye that prevents clear vision. An Age-related cataract occurs as a result of denaturation of lens proteins and is currently thought to be irreversible. These changes often occur in both eyes, although the effects can be asymmetrical. Surgical removal of the opaque lens is the only treatment option currently available for cataract an artificial intraocular lens (IOL) is usually implanted to replace the removed lens' focusing power. Cataract is one of the main leading causes of blindness worldwide and the primary cause in LMICs. It is one of the most common surgical interventions in many high-income countries and some middle-income countries. However, good quality services are not universally accessible, particularly in LMICs. Low quality understandably reduces the willingness of people with operable cataract to undergo surgery. Therefore, it is critical to improve the quality of care to reduce vision loss from cataract subsequently. Interventions have been undertaken to improve cataract surgical services; however, the effectiveness of these interventions on promoting equity is unknown.

Factors such as genetic predisposition, exposure to sunlight, smoking, diabetes, being female, and ethnicity may play a role in higher cataract rates. However, in LMICs high prevalence of cataract blindness may be due to the uptake of services and the quality of available services, possibly more than biological factors. A systematic review of studies of barriers to surgical care published in 2011 of which 54% were based on ophthalmology services, found that the key barriers identified were physical access (distance, poor roads, lack of transport), lack of resources and expertise, direct and indirect costs, and fear of surgery. In 2012, Blanchet study undertook a review of systematic reviews to inform universal coverage of cataract services and identified similar barriers to those listed in the systematic reviews.

Health inequity is defined as differences in health outcomes between population subgroups that are avoidable, unfair, and unjust. Health inequality refers to measurable differences in health between individuals and groups. Health inequity cannot be objectively measured, as normative judgements: of what makes a difference unfair and unjust are required. Cataract blindness is inequitably distributed between countries. The estimate of global age-standardized adult (50 years and above) prevalence of cataract blindness in 2015 was 0.78%, but this varies significantly in different world regions. It was lowest in high-income countries of Asia Pacific, Australasia (0.09%) and Western Europe (0.09%), and up to 30 times higher in West (2.35%) and East Sub-Saharan Africa (1.97%). Inequity within countries is also apparent. Associations have been documented between a higher prevalence of blindness (regardless of cause) and being female, living in a rural area, having low socioeconomic status, being less educated, and belonging to an ethnic minority. In 2015, it was estimated that globally women were 1.21 times more likely to have cataract visual impairment than men [32][33].

The UEH Action Plan includes cataract surgical coverage (CSC) as an access coverage indicator for cataract services. The WHO identified CSC as a promising UHC indicator in its inaugural UHC monitoring report, recognizing its value beyond monitoring coverage of eye services, as a means of measuring access to services for the elderly more generally. Despite CSC strengths, it still does not provide a good indication of the quality of cataract services and so by itself is insufficient to track progress towards UEH. Fortunately, it is possible from data collected in the population-based visual impairment surveys to calculate an indicator that combines CSC with a measure of cataract surgery quality, which is the cataract surgical outcome, which measures the visual outcome in the operated eyes. Also, Effective Cataract Surgical Coverage (eCSC) could be used as a candidate UHC tracer indicator [34]. In the recent World Report on Vision, WHO outlined how quality eye care services contribute directly to achieving universal health coverage (UHC). CSR, CSC, CSO, and eCSC have the characteristics of effective service coverage indicators, as preferred by the WHO/World Bank, as it combines information on the proportion of the population covered and the surgical intervention outcome [35].

Cataract surgical outcome has not been available to everyone equally. A systematic review and meta-analysis of 23 studies from LMICs found that men were 1.7 times more likely to have had cataract surgery than women. They estimated that severe visual impairment (less than 6/60 in the better eye) in LMICs could be reduced by 11% if women received cataract surgery as frequently as men. This review also analyzed the cataract surgical outcomes in LMICs, including cataract surgical coverage (CSC) and useful CSC, from 20 countries showing women tended to 5 worse than men in terms of access and quality of cataract services.

When addressing cataract blindness, there are sex indicators of cataract surgeries; however, the quantity of surgeries usually becomes a priority, and the focus on increasing the number of cataract operations is a must. Cataract surgical rate (CSR) is the first cataract indicator commonly reported. CSR equals the number of cataract operations per million population per year. The CSR can be as high as 10,000 in some developed countries and less than 1,000 in some countries with a younger population or inadequate eye care services. A target CSR can be established based on the desired output of the available cataract surgeons in the area or the estimated incidence of operable cataract [12]. CSR needed in each country (the target CSR) is determined by the number of eyes that will develop cataract in one year (the incidence). Incidence is affected by the age structure of a population. Older populations have a higher incidence of cataract than younger populations. If the number of new cases (the incidence) is higher than the cataract surgical rate, then the backlog (the number of eyes that require cataract surgery) will also be high [36].

Another important indicator is the Cataract surgical coverage (CSC). CSC is the proportion of people with bilateral cataract who have been operated upon in one or both eyes. Results are given separately to show coverage among people with best-corrected visual acuity (BCVA) of <3/60, <6/60, or <6/18 and expressed as a percentage as 'CSC3/60 85%' means that 85% of people with BCVA of 3/60 have had surgery in one or both eyes. While, Effective cataract surgical coverage (eCSC) is the proportion of people with bilateral cataract and BCVA of <3/60, <6/60, or < 6/18 who have received cataract surgery in one or both eyes and have postoperative presenting VA of 6/18 or better in at least one operated eye. Other important indicators are Cataract surgical outcome (CSO), which is the proportion of operated eyes with a good visual outcome (6/18 or better) after cataract surgery, written as CSO_{good} is often reported, and the causes of poor outcome are given [12].

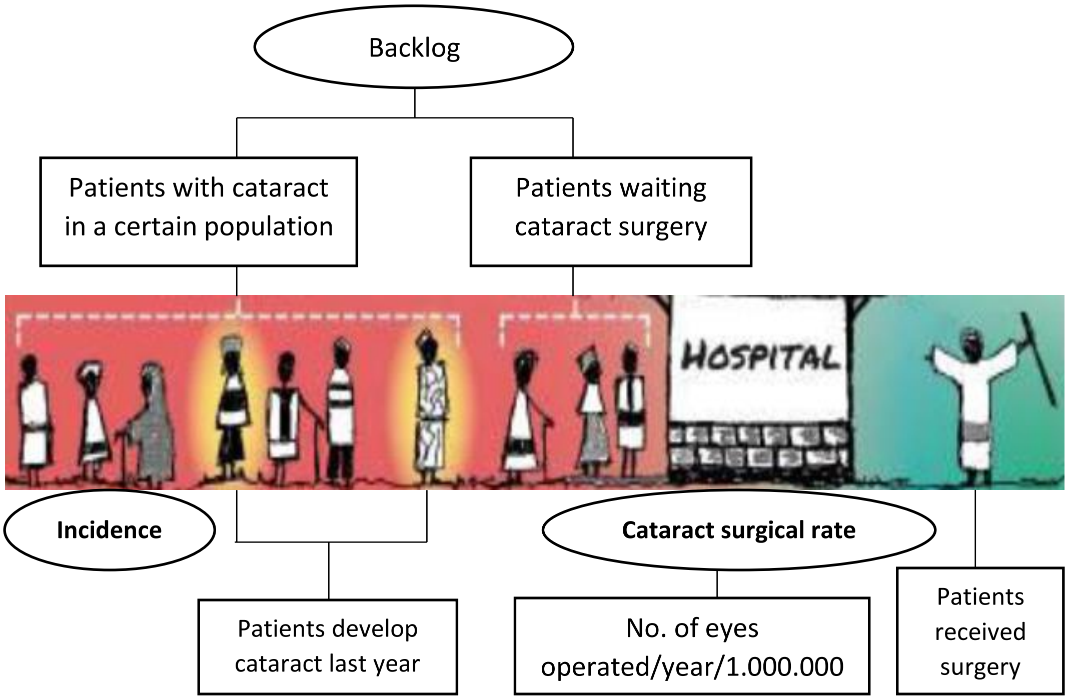


Figure 9. Understanding incidence, backlog and cataract surgical rate

Source: Community eye health (2017) [36]

To eliminate unnecessary blindness from cataract we need ongoing services which year by year will deal with the new cases. Therefore Vision 2020 is about "sustainable services" rather than one-Off campaigns targeting "backlog." Sustainability implies the ongoing availability of adequate resources (people and funding). Throughout the world, eye care and, particularly, the cost of managing cataract is becoming a significant part of health costs. Someone has to pay either the government, health insurance companies, patient, or donor. The cost of a cataract procedure comprises various components, including the cost of consumables, salaries, overheads, and a proportion of the cost of the infrastructure, instruments, and equipment. There are also significant indirect costs incurred by the patient for transport, time lost from work, food, etc. In an effort to achieve sustainability, the cost of cataract surgery should be kept as low as possible without affecting the outcome of the surgery. Currently, "Western" cataract surgery is too expensive for most of the world, and probably also for Western countries.

Worldwide, 10 million cataract operations are done each year, but there is a need to do at least 30 million per year for the indefinite future. The economy of scale should bring lower costs. A first step is to minimize the cost of consumables through bulk purchase of “value for money” sutures, IOLs, and medicines. The second step is to increase productivity so that the relative cost of salaries and overheads per cataract procedure is reduced. Through efficient use of only essential consumables and good productivity, the cost in developing countries can be kept to less than £50 (58.8 $US) per operation. However, this cost is still too high for many patients, and therefore, some form of subsidy may be required. Various cost recovery systems have been developed to generate income from paying patients (India), sale of spectacles (Africa), and other less essential eye services (Latin America) [37].

Calculation of the number of cases of catastrophic expenditure resulting from accessing surgical care (81.2 million annual cases) does not take into account patients who cannot access surgical care in the first place. The proportion of the population incurring financial catastrophe from accessing surgery is higher in LMICs than in high-income countries, probably because of an inability of the poorest people to reach appropriate services. The historical scale-up rate (5.1% per year) was established using surgical volume data and a GNI per-person time series to estimate the level of surgical care countries expected to achieve by 2030 given their income. Between 2015 and 2030, surgical conditions will be responsible for a cumulative loss to the global economy of $20.7 trillion or 1.3% of projected economic output. To reach unmet targets of Millennium Development Goals (MDGs) 4 and 5, the need for integration of surgical services into comprehensive platforms of health-care delivery is straightforward. Improvement of surgical capacity at the district hospital level was identified as one of the 30 top mechanisms for advancing global welfare at the 2009 Copenhagen Consensus [38].

Beyond using postoperative visual acuity to assess effectiveness, the quality of cataract services includes many clinical and non-clinical dimensions. For example:

- Timeliness: cataract commonly occurs bilaterally. In many settings, the current recommendation is to operate on one eye at a time and allow enough time for the operated eye to heal before operating on the second eye. However, delay in surgery for the second eye has been linked to an increased risk of falls and road traffic accidents.

- People-centeredness: it may be common for patients to visit hospitals several times before the surgery for different preoperative assessments, even though some of these could be done in one visit. Reducing the number of hospital visits to get surgery would improve quality from the patient perspective.

- Equity: there is no physiological reason why outcomes should be lower in women than men, but women tend to have lower access and poorer postoperative vision outcomes than men. A further example of inequity is seen in the difference in effective cataract surgical coverage among indigenous (51.6%) and non-indigenous Australians (88.5%).

- Quality and efficiency (productivity): there is a link between the quantity of surgery a surgeon performs and its quality. It has also been demonstrated that cheaper service delivery options, such as outreach camps, can be less cost-effective compared with surgery delivered in static clinics due to worse outcomes [39].

Cataract services include the range of activities on the pathway from detecting people with operable cataract to these people undergoing surgery and receiving postoperative care. As such, cataract services are both community and facility-based. So, regardless of the setting, it should involve a broad range of healthcare providers from the community level (village health workers as case finders) through primary (optometrist) and secondary services (surgical team). Besides, consideration of all of the health system building blocks is relevant to strengthen cataract services. Quality of care of cataract services is one of the objectives embodied by the concept of UEH, together with equity in access and financial protection. [39].

Human resources are the backbone of health-care delivery systems. At present, Significant shortages worldwide in the surgical workforce compounded by maldistribution of the existing workforce both within and between countries result in gross inequity. LMICs are disproportionately affected by low surgical workforce density. Within these countries, people living in rural areas, those with a low income, and those who are marginalized are the most affected by these shortages. Despite these challenges, surgical providers endeavor to provide care for people who need it.

In 2006, the WHO’s World Health Report identified a crucial threshold of 228 skilled health professionals per 100. 000 population below which countries were unable to reach essential health targets and were deemed to be in a health workforce crisis. Only 12% of the specialist surgical workforce practice in Africa and Southeast Asia, where a third of the world's population lives. 44% of the world's population lives in countries with a specialist surgical workforce density lower than 20 per 100.000 population. Only 28% lives in countries with a specialist surgical workforce density higher than 40 per 100.000 population. Based on UN World Population Prospects to 2030, we estimate an additional 2.28 million specialist surgical providers are needed worldwide to reach that same density by 2030, even without accounting for brain drainage. To meet this target, the present global surgical workforce would need to double [38]. In the Universal eye health: a global action plan 2014– 2019, the WHO recommended that the Ministries of Health (MOHs) annually report the number of eye care professionals to measure also the progress of Universal eye health as number of Ophthalmologists and allied ophthalmic personnel represents one of Universal eye health important indicator [6][40].

The ICO carried out a survey study in 2015. The estimated global number of ophthalmologists was 232.866. The number of ophthalmologists by country ranged from 0 in some small Pacific Island countries (Cook Islands, Micronesia, Nauru, Niue, and Tuvalu) to 36.342 in China. Approximately 17% of the global population in 132 countries have access to less than 5% of the global ophthalmologist population. Two-thirds of the global ophthalmologist population were located in 13 countries (China, USA, India, Japan, Brazil, Russia, Germany, Italy, Egypt, France, Mexico, Spain, and Poland) [36] [40].

Table 12. Global distribution of the ophthalmologist density per million per population

Number of countries	Number of ophthalmologists/1.000.000 in these countries
Global mean of Ophthalmologists	31.7 (<1 to 182) Ophthalmologists/1.000.000
14 countries	< 1 Ophthalmologist/1.000.000
31 countries	1-3 Ophthalmologist/1.000.000
47 countries	4-24 Ophthalmologist/1.000.000
88 countries	25-99 Ophthalmologist/1.000.000
13 countries	>100 ophthalmologists/1.000.000

Source: Resnikoff et al. (2020) [40]

The number of operations can be used to set and monitor output targets and compare the efficiency of cataract services and surgeons in different hospitals or geographic areas;

- Average weekly output per cataract surgeon: the total number of cataract operations divided by the total number of cataract surgeons in the same area, divided by the number of weeks in a working year.

- Annual output per cataract surgeon: the total number of cataract operations per individual cataract surgeon within 12-months [12].

(1) Electronic Health Records (EHRs)

Electronic Medical Record (EMR) is a systematized collection of patient health information electronically stored in digital formats. Another definition was offered on Improving the Patient Record. However, instead they used the term Computer-based patient record as an electronic patient record that resides in a system specifically designed to support users by providing access to complete and accurate data, alerts, reminders, clinical decision support systems, links to medical knowledge, and other aids. This term tries to offer a full picture of the whole process: collecting, entering, and analyzing the data [41].

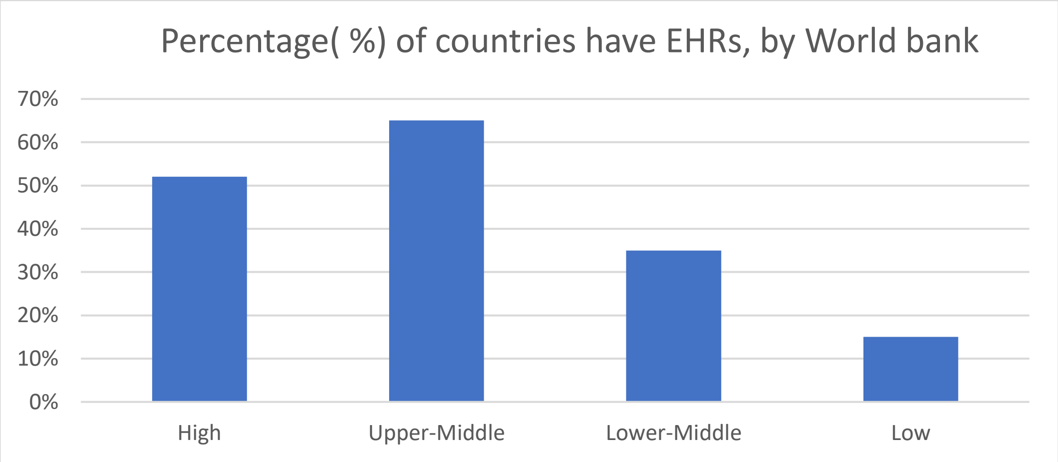


Figure 10. National EHRs systems according to countries income

Source: WHO Global Health Observatory (2020) [42]

There has been a steady growth in adopting national electronic health record (EHR) systems over the past 15 years – and a 46% global increase in the past five years. More than 50% of upper-middle- and high-income countries have adopted national EHR systems. Adoption rates are much lower in the lower-middle (35%) and low-income countries (15%). The most frequently cited barriers to implementing EHRs are the lack of funding, infrastructure, capacity, and legal frameworks. Widespread adoption of electronic health records (EHRs) has resulted in the collection of massive amounts of clinical data. In ophthalmology, in particular, the volume range of data captured in EHR systems has been proliferating. Nevertheless, making effective secondary use of this EHR data for improving patient care and facilitating clinical decision-making has remained challenging due to the complexity and heterogeneity of these data.AI techniques present a promising way to analyze these multimodal data sets [43].

Primary care providers can now view records and document screening and referral of cataract patients according to their eye condition. As the EMR provides access to information and resources, it helps the ophthalmic surgeons decide a suitable time for operations according to each patient situation and priority in the waiting list. The EHR notes including more complete documentation of examination elements than the paper notes including general health and investigations of the patients. They improve interconnectivity between ophthalmic surgeons and other departments (examination and investigations) which is needed in the preparation of cataract surgery, saving much time, effort and finance for the patients. They are also used in the follow up of the patients after surgery which is implemented in many governmental hospitals of Saudi Arabia [44].

Computerized software tools are also subsequently developed to monitor cataract surgical outcomes on a routine basis. The following information is recorded for each operation:

- Visual acuity before surgery
- Surgical technique used
- Whether the outcome is good, borderline or low, both after surgery and at follow-up
- The type of complication, and cause of poor outcome, if any

The proportion of good, borderline or low outcomes and the proportion of complications can be calculated. In the software tools, filters can be applied to the dates, surgeon, clinic, and other parameters to make more detailed analysis possible. The software is intended to provide insight into where and how modifications in the service can further improve visual outcomes. The system is not intended to compare individual eye surgeons or clinics, but to monitor improvement in outcome over time for the same surgeon or clinic. Unfortunately, many ophthalmologists have been reluctant to use the monitoring tools available, and we must identify and overcome the barriers to incorporating the monitoring of outcomes into routine practice [12].

Some questions have to be asked when considering if EMR is suitable for a National Health System: first, the Viability, Reliability, and Integrity of the EMR. Secondly, the proper type of Ophthalmic EMC (Web-based EMR/ Client-Server EMR) should be taken into consideration. Another question that arises is if EMRs can be subspecialized in Ophthalmology such as Glaucoma, Retina, and others. This offers the possibility of completing a database that can be used for studies and audits and improve the Health System. Using EMR can also offer accurate data to estimate the prevalence of some specific conditions and rare diseases.

When talking about Viability, Reliability, and Integrity of the EMR, first it has to be decided if it is part of a hospital informational system, with both functions: clinical and administrative or medical information system, just collecting, storing, and making available the data essential for the patient care. The aim of this type of system is not to facilitate financial information, but instead focus on improving patient care. As a system, the viability of the EMR depends on the Operational effectiveness - having those resources needed for accurate patients' records, Financial effectiveness - trying to maximize the income and reduce the loss of resources, Compliance - ensuring the function of the system based on laws and regulations. The quality of the system is often missed or ignored in medical practices. The Reliability of the system can measure the quality of EMR.A reliable EMR should provide the right information to the right user at the right moment. The EMR should offer both the physician and patient the information desired [41][42].

EHRs are currently promoted through governmental incentives to improve the quality, efficiency, and cost of ophthalmic care. However, a minority of ophthalmologists and surgical centers have adopted EHR. One concern is that EHRs may disrupt operating room workflow and increase documentation time. Many countries now became very well developed in EHR implementation as Rwanda, Kenya, Tanzania, Uganda, Thailand, Malaysia, Singapore, and Australia [43][44][45].

(2) eLearning

eLearning is defined as any educational intervention mediated electronically via the Internet, which has steadily increased among health professionals worldwide. Several studies have attempted to measure the effects of e-learning in medical practice, which has often been associated with positive effects compared with traditional learning (without access to e-learning). The biomedical literature contains numerous examples of terms synonymous with the definition of e-learning: web-based learning or training, online learning or education, computer-assisted or -aided instruction or computer-based instruction, Internet-based learning, multimedia learning, technology-enhanced learning, and virtual learning. Applying the latest information technologies to education takes advantage of increasing Internet access (via optical fibers, WIFI 3G/4G mobile phone technology).

The delivery advantages of an e-learning program are; lower costs, widespread distribution, increased accessibility to information, frequent content updates, and personalized instruction in terms of content and pace of learning. Moreover, the interactivity and ability to link educational programs with past experiences and specific needs fit the adult learning paradigm, and. The most important is increasing health personnel capabilities of dealing with technology facilities their experience in working with ICT and EHRs and different booming out technologies. eLearning in healthcare is divided into preservice learning of medical students in medical and paramedical schools also, In-service learning and training of health professionals in hospitals and clinics [46].

With so much data coming into the ophthalmic field through these digital routes, the specific roles within the health care environment will have to change. eLearning is needed for HCWs to properly understand and evaluate the data, especially the EHR usage. As Health care personnel is not only in need of medical background but preferably an IT background to be able to understand and interpret the data for example, if data coming from an app is due to a software glitch or from EHR, an employee with an IT background may be able to recognize what is happening, whereas an employee with just a medical background may not. If they do not recognize that the data, they are reading is artifactual, they could make incorrect diagnoses and management intervention [47].

Different educational approaches that can be successfully supported with eLearning as presented;

1. Sharing of information; by phone, video-conferences or webinars.

2. Experiential learning through simulation; webinars could be held for sharing ophthalmic medical and surgical experiences for cataract surgeries via the internet
3. Supporting collaboration; by phone, video-conferences and to provide support for challenging cases or discuss the need for referral
4. Providing performance support and decision making [48].
5. A collaborative approach between tertiary centers, hospitals, and rural hospitals for technical support has been fostered by the Christian Medical College in Vellore, India, which has a longstanding practice of encouraging its surgical graduates to practice in rural communities. These surgeons are paired with colleagues at the tertiary center, who are available by phone to provide eLearning, electronic training, and technical support for challenging cases or discuss the need for referral [38].

(3) Mobile Health and Social media apps

The Global Observatory for eHealth defined mHealth or mobile health as medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants, and other wireless devices. Decision support systems (DSS) are increasingly demanded because diagnosis is one of the main activities that physicians accomplish every day. This fact seems critical when primary care physicians deal with uncommon problems belonging to specialized areas as eye conditions without need to referral. Also, it may help public users to know more about their eye health. mHealth and telemedicine via smartphones could be used to communicate, follow up, seek feedback on services and send health announcements and instructions before and after cataract surgeries to the patients and also to Seek feedback from patients on cataract services. This could save much time, efforts for the ophthalmology surgeons and patients, reduce indirect costs of frequent visits and improve the quality of cataract services [6][49].

Mobile health (mHealth) tools have been implemented in various global health contexts. The data collected through devices and smartphone apps will have a tremendous impact on the field of ophthalmology. More than 1 million data points of the refractive error have been collected in patients between the ages of 5 and 7 years through one project in India. It is possible that over the next 5 years, this project team could look at those data points and correlate them with nutrition, sunlight exposure, or any other number of behavioral factors, and possibly develop an algorithm to help patients modify their behavior to change health outcomes [47]. In Kenya, Tanzania, and elsewhere, mobile money services have been used to reimburse transportation costs for patients who need surgery but do not have bank accounts. Unfortunately, too many practical applications do not last beyond the initial pilot project because of poor planning for scale-up, insufficient local buy-in, and minimum budgeting for monitoring and assessment. International efforts, led by a consortium on surgical m-Health, bring together the public and private sectors, funders and NGOs to promote the development of value-additive applications and coordinate well-designed assessments of effect [38].

Social media apps are currently essential tools as Facebook medical pages, WhatApp group and smartphones Play store medical apps. They are used to promote health messages as a part of health promotion campaigns, help to manage patient appointments, seeking feedback to health facilities or health professionals on cataract services, make health announcements. They could be used as well to Learn about health issues, help decide what health services to use, Participate in community-based health forums. (Application will be mentioned in Egypt part of country profile section) [50].

Researchers are currently testing several mobile device applications and wearable devices for eye care that may provide useful policy and planning information. Two notable examples are the BOOST application (Better Operative Outcomes Software Technology) for monitoring outcomes of cataract surgery and the Peek application (Portable Eye Examination Kit) for vision screening and referral [19]. BOOST is a freely-downloadable app. which will lead users in LMICs through the data collection in hospitals in Africa, Asia, Latin America, and the Pacific. As they showed strong demand for easy-to-use software which would allow users to measure and benchmark their surgical results against other practitioners locally and globally in a cloud-based database. This app. while also providing straightforward advice on methods to improve outcomes. Based on this feedback, BOOST steps the user through two rounds of data collection: First, uncorrected (without glasses) visual acuity the day after surgery is measured and entered in the system. This allows outcome quality (proportion of patients with good [>= 6/18] and bad [<= 6/60] visual acuity) to be benchmarked, initially against the facilities in the system database, and subsequently against other users of BOOST worldwide. Secondly, users choose from among three reasons for poor vision outcomes (refractive problems, surgical misadventure and presence of ocular co-morbidity) returning at least 6 weeks after surgery with presenting vision <= 6/60. The app then automatically suggests changes in pre- and post-clinical care designed to remediate the most common cause of low vision identified for a user [49].

Retinal diagnostics

The digital revolution in ophthalmology is without doubt, destined to transform how we deliver health care. Artificial intelligence (AI) and Teleophthalmology are seen as the main drivers of digital health innovation, and current data holds enormous potential for improved diagnostics, personalized treatments, and early disease prevention. Retinal diseases such as; diabetic retinopathy (DR) and age-related macular degeneration (ARMD) are ideal for embracing digital analytics. For instance, they are the leading causes of blindness in many developing and developed countries and require repeat standardized investigations and analysis for treatment determinations. Improvement in the diagnostic pathway would be of enormous benefit to the lives of many patients worldwide. Lifelong routine retinal evaluation of DR combined with appropriate treatment has reduced the risk of severe loss of vision to less than 2% per person and 4% per eye [51][52].

Teleophthalmology American Telemedicine Association defines Telemedicine as; "the use of medical information exchanged from one site to another via electronic communications to improve a patient's health status". Due to the increasing need for more accessible, financially affordable, and effective healthcare services, telemedicine has emerged as an alternative method for assessing the specialized evidence-based approaches. Teleophthalmology for DR screening could be done cost-effectively, especially in underserved and remote populations. Considering that the estimated number of diabetics projected to reach 642 million by the year 2040 and the incidence of ocular complications secondary to diabetes are also expected to increase substantially.

Historically, current screening strategies for detecting DR have low compliance, but technological development can enhance care access. Establishing mechanisms to overcome geographic and financial barriers to access is vital for preventing visual disability. The burden of implying immediate and cost-effective screening for patients with DR via distant imaging of the retina has become one of the most widely used telemedicine applications in Ophthalmology [53].

Telescreening in Comparison with face-to-face clinical exam is inevitable. Many photographic methods have been evaluated that allow images of the retina to be captured either by ophthalmologists or by paramedical staff and then sent to be interpreted by expert readers. The gold standard method is the Early Treatment Diabetic Retinopathy Study (ETDRS) mydriatic standard field 35 mm stereoscopic color photograph. Digital fundus photography and nonmydriatic photography are more practical alternatives, having the advantage of faster and easier acquisition and transmission and storage of retinal images [54].

Teleophthalmology covers many medical activities, including diagnosis, treatment, prevention, research, distant learning, and continuing education. Specialists can give consultations with flexible timetables and locations, even from their homes. Furthermore, teleophthalmology makes significant savings in time and travel expenses. As a result, the acceptance by the examined population is remarkable. In addition to the tele-eye care application, advantages of digital imaging systems include short examination time, electronic medical images, and the ability of non-ophthalmologists to screen for diseases. Teleophthalmology provides secondary specialist advice in the diagnosis and management of difficult cases. It also supports real-time surgical telementoring by which complex eye-care procedures are taught [55].

Artificial intelligence (AI) Using Artificial Intelligence in ophthalmology is an evolving technology that holds promise for mass screening and perhaps even help establish an accurate diagnosis. AI has emerged as a significant frontier in computer science research. Healthcare affordability, quality, and accessibility can be amplified using this technology. It is a general term that means accomplishing a task mainly by a computer or robot, with the least human being participation. The application of AI in ophthalmology mainly concentrates on the diseases with a high incidence with good sensitivity, such as Proliferative DR with sensitivity ranged from 75-91.7%, non-proliferative DR 75- 94.7%, for ARMD 75-100%, retinopathy of prematurity (ROP) > 95%, glaucoma 63.7-93.1%, and for cataract it achieved > 70% similarity against clinical grading. The AI devices mainly fall into two major categories; the Machine Learning (ML) and Deep Learning (DL) techniques and the natural language processing methods. There are mainly two DL models; convolutional neural network (CNN) and massive-training artificial neural network (MTANN) [11][56].

DL provides techniques or algorithms that can automatically build complex relationship model by processing the input available data and generalizing a performance standard. Moreover, it can be briefly described as enabling computers to make successful predictions or judgments by repeatedly learning existing representative materials. The algorithm is crucial in standardizing the retinal image’s input, given that different retinal cameras may have different characteristics (e.g., a black border surrounding the retinal image, circular vs. rectangular image and, etc.). The standardization of the input images (contrast adjustment and auto-cropping of the image borders) may help optimize the training and testing of a DL algorithm. Furthermore, most of them need to be labeled its features in advance by relative authoritative experts. Besides, some other data are used to verify the established algorithm. To report the diagnostic performance of an AI system, the gold standard or reference standard (also known as ground truth) plays a pivotal role. In ophthalmology, the reference standard/s are usually ophthalmologists, reading center graders, non-physician professional trained technicians, or optometrists. In terms of examination methods, it could be done as clinic-based examination or image-based examination [56][57].

Mobile Health apps Peek application (Portable Eye Examination Kit) is a hardware and software solutions that allows the smartphone to visualize the retina. An adaptor clip was designed with Rhinoceros 3D McNeel to create a miniature prismatic solution, re-routing light from the native flash to coincide with the optical path. Peek provides a greater field and low-cost alternative to conventional direct ophthalmoscopy, comprising a smartphone adaptor. The technology takes advantage of the smartphones' intrinsic auto-focusing features to provide a high-resolution view of the retina through an un-dilated pupil. The adaptor couples the native mobile LED flash to the camera, allowing clinicians an access view of the retina using the smartphone. This low-cost technology has been designed to improve access to ophthalmic diagnostics in resource-poor settings. Randomized controlled trials are underway to assess the impact of technology as in Kenya. It could be a handy tool for vision screening and monitoring the retina post-operatively after cataract surgeries [58].

EMRs in retinal diagnostics The EMRs technology gives health providers information in formats that were not possible with paper charts. EMR improves attainment of chronic disease management and screening targets. The studies demonstrated also improved quality measures. Primary care providers can now view records and do and document screening and referral of retinal patients. It also can provide treatment goals or alerts to remind providers when individual interventions are due or out of date. Studies showed quantitative and qualitative differences like paper versus EHR documentation of ophthalmic findings, especially in retinal diseases such as DR, ARMD, and glaucoma [44].

Chapter III

Digital Health implications on UEH

3.1 Case Studies: Country Profiles

Randomly selected sample from 3 WHO regions are included in this chapter (Section I); (Eastern Mediterranean Region "EMR" represented by Egypt; African Region" AFR" represented by Kenya; Southeast Asian Region "SAER" represented by India; then hen having a hint for the current situation of Digital health-related to UEH in South Korea in Section II. Finally, some successful examples from different countries and international organizations were mentioned in section III as; Thailand, The United Kingdom (UK), Saudi Arabia, Asia Pacific Tele-Ophthalmology Society (APTOS), International Telecommunication Union, International council of Ophthalmology.

Section I:

The Main countries designated for research

(1) Background about the current health status and the current situation of Universal eye health (UEH) national action plan or program and Universal health coverage (UHC) of the main 3 countries of research;

3.1.1 Egypt (EMR Representative)

Egypt plays a vital role in the Middle East in geopolitics from its strategic position as a transcontinental nation. However, the country could have significant influence, not only in terms of its economic and geographical position but also because any political changes within its borders will undoubtedly affect those nearby [59]. Egypt also holds a pivotal role through its relationship with the EU and as an ally of the United States. Egypt has one of the largest populations in the EMRO region. WHO EMRO regional office located in its capital Cairo. Two-thirds of the global ophthalmologist population are located in 13 countries (China, USA, India, Japan, Brazil, Russia, Germany, Italy, Egypt, France, Mexico, Spain, and Poland) [40].

A new universal health coverage law had been received parliamentary approval in December 2017 in Egypt. Health care will be provided for everyone, even 30% of those who cannot afford to pay. Enrollment is obligatory, with fees set according to income with additional funding sources to include taxes on tobacco and polluting industries, including cement. It will bring together all groups of society under one insurance umbrella. The New Universal Health Insurance Law puts Egypt on the road towards progressive realization of Universal Health Coverage. All forms of health insurance, whether governmental or private, will be canceled. The treatment system under State expense will end with its application in every governorate. Egyptian medics and activists had looked forward to universal health care for about 20 years. Thanks to the perseverance of civil society advocates who have pushed to hold governments accountable, this law comes to light. The system started gradual application from 2018-2032. Egyptians will pay between 1300 Egyptian pounds (EGP) (£54) and 4000 Egyptian pounds (£167) a year, while those under the minimum wage will be exempt. The scheme's total costs varied according to official reports, up to 600 billion Egyptian pounds by the year 2032 (£25 billion) [60][61].

An estimated 51.0 % of the population has some type of health insurance [62]. 42 million people, out of a total Egyptian population, do not benefit from any health insurance services. The year 2019 witnessed the implementation of this new universal health insurance system. More than 1.5 citizens have been registered in the new health insurance organization since its launch, in its first phase in the governorates of Port Said, Ismailia, Suez, South Sinai, Luxor, Aswan [63].

Egypt has its national eye plan 2014-2019 after the World Health Assembly Resolution on universal eye health, May 2013 and under the Global Initiative of "Universal Eye Health: A global action plan 2014-2019". Over the last period, Egypt has spearheaded several health initiatives with special focus on sight issues [64].

3.1.2 Kenya (AFR Representative)

Kenyan Government expenditure on healthcare is about 7% of GDP in 2018. With the support of various stakeholders, Kenya's government has, over the years since independence in 1963, initiated policy reforms and strategies earmarked towards universal health coverage. Some of these are outlined in various policy documents, including Kenya Health Policy Framework (1994-2010), Health Sector Strategic Plans, Vision 2030 (operationalized through the medium-term expenditure framework of (2008-2012), the Constitution 2010, and finally, the Health Bill of 2015. In December 2018, President Uhuru Kenyatta declared UHC to be a national priority in Kenya as part of his 'Big

Four Agenda' for national sustainable development. Under this initiative, the Government of Kenya has committed to making strategic investments in health to ensure that all Kenya residents can access the essential health services they require by 2022. UHC coverage now in Kenya stands at about 58%. In 2013 user fees were abolished at the primary health care facilities to encourage uptake of services. However, out of pocket still account for around 26.1% of health spending nationally [65][66].

Kenya could be used as a successful case study, as the current strategic national plan for eye health and blindness prevention (2012–2018) had been ended, and the country had begun to develop its seventh eye-care plan (2019–2023). The eye health sector receives government support at the national level, and Kenya's eye-care plans are annexed to the national health sector strategic plan. The ophthalmic services unit at the health ministry develops annual operational plans and budgets based on the national eye-care plan. The next eye-care plan in Kenya can draw on a broad range of evidence sources. The global priority indicators will be included with an explicit statement that they will only be measured should appropriate surveys be undertaken. The plan will provide a list of priority districts to help direct support from donors, researchers, and development partners should fund for future surveys. A priority in the plan will be to strengthen the eye health information systems and evaluate policies at the facility, subnational and national levels using routinely generated data in the health information systems. Kenya provides valuable insights into what can be done at the country level to improve data collection and use in UEH national eye plans according to WHO [19]

Table 13. Potential sources of evidence for Kenya's next eye-care plan [19]

Surveys	Surveys in Eight regions; 2004-2017, Rapid Assessment of Blindness survey; 2013, Cohort studies; Nakuru, 2013/2014.
Health information systems	Eye facility monthly reports within the national District Health Information System 2 data platform (2012–2017).
Administrative data	Human resources; Nairobi University; College of Ophthalmology of Nurses Council register; health ministry ophthalmic unit records.
Planning and evaluation tools	Evaluation report eye health plan, 2012–2018, Eye care service assessment tool, 2017.28, Eye health system assessment, 2015.
Guidelines	Completed: retinoblastoma, DR; forthcoming: ROP, glaucoma.
Others	Cataract surgical postoperative outcomes from 6 eye departments, DR service at Kenyatta hospital, trachoma analysis report, 2013.

Source: Ramke et al. (2018)

3.1.3 India (SEAR Representative)

India's total population is 1,380,004,385 people in mid of 2020, according to Worldometer, which represents around 71 % of Southeast Asian countries' total population [9]. Regional Office for Southeast Asia region is in New Delhi. Governmental current expenditure on health per GDP= 3.6%. In 2007, VISION 2020 INDIA developed India's 11th five-year draft plan for blindness prevention. A committee which was constituted of a high-level expert group in UHC in 2011 has been developed, with a mandate to developing a framework for providing easily accessible and affordable health care to all defined under the universal health coverage. India's commitment towards achieving UHC is clearly reflected in policies and institutional mechanisms. India also has launched Ayushman Bharat. It encompasses two complementary schemes, Health and Wellness Centers and the National Health Protection Scheme. Health and Wellness Centers are envisioned as a foundation of the health system to provide comprehensive primary care, free essential drugs, and diagnostic services. In contrast, National Health Protection Scheme is envisaged to provide financial risk protection to poor and vulnerable families arising out of secondary and tertiary care hospitalization to the tune of five lakh rupees/family/year [68].

India designed the blindness prevention program in 1976. It was the first country to recognize blindness and visual impairment as an essential health priority. For a long time, this program had been cataract-centric with little focus on a universal eye care system despite that cataract surgical services needs unmet till now. India has performed well in improving the cataract surgical rate (5,136/million population in 2016) and cataract surgical coverage, though it is not uniformly distributed across the country. VISION 2020: The Right to Sight India, in close collaboration with the Ministry of Health and Family Welfare, Government of India, WHO India office, International Agency for the Prevention of Blindness (IAPB), and other key stakeholders, has organized a national consultation on 29-30 October 2015 for developing a country action plan for implementation and adaptation of Universal Eye Health: A WHO global action plan 2014-2019 as was endorsed in 66 World Health Assembly (66.4 Resolution). Then Odisha launched its universal eye health program on World Sight Day, October 12, 2017. Named, Sunetra (Healthy Eyes), the government pledged INR 6,820 million (US$ 100 million approximately) for the program spread over 5 years. The bold message was "Eye Care for All by 2022 [69][70]. The number of lives covered under health insurance in India FY 2014-2019. In 2019, over 472 million Indians covered under health insurance schemes (Statista, 2019), [71].

2. **Table 14.** Important Socio-demographic indicators related to UEH /UHC for 2019

Indicator	Egypt	Kenya	India
Population	100.388	52.574.000	1,380,004,385
Surface area (Km2)	1.002.000	591.958	3.287.263
GNI/Capita	$US 2,690 (3.93% decline from 2018).	$US 1.750 (9.38% increase from 2018)	$US 2,130 (5.97 % increase from 2018).
% Urbanization	42.7%	27.51%	34.50%
Population below poverty	32.5 % [a]	21.92 %	36.1% [b]
Life expectancy at birth (females/ males, years)	73.0 / 68.7	65.2 / 60.6	69.0 / 66.7
Population age distribution (0-14/60+ years old, %):	33.8 / 8.1	39.2 / 4.0	26.6 / 9.9
Current Health expenditure (% of GDP)	4.6%	7%	3.6 %
Number of Physicians (per 1.000 pop.)	0.8	0.2	0.8

Source: UN data, Statista.com, Macrotrends.net, Worldometer.info, [a] Egypt independent (2019) [72], [b] Wikipedia [73].

Egypt: Governmental and university hospitals 1000-4000 EGP (63-254 $US) and private hospitals 2500-15000 EGP (158-952 $US); Kenya: Governmental and university hospitals 22000 Kenyan Shillings (200 $US) and private hospitals 32000 Kenyan Shillings (300$US); India: Governmental/university hospitals 20000 Rs. (INR) (272 $US), private hospitals up to 65000 Rs. (INR) (817 $US).

(3) <u>**UEH Indicators**</u>

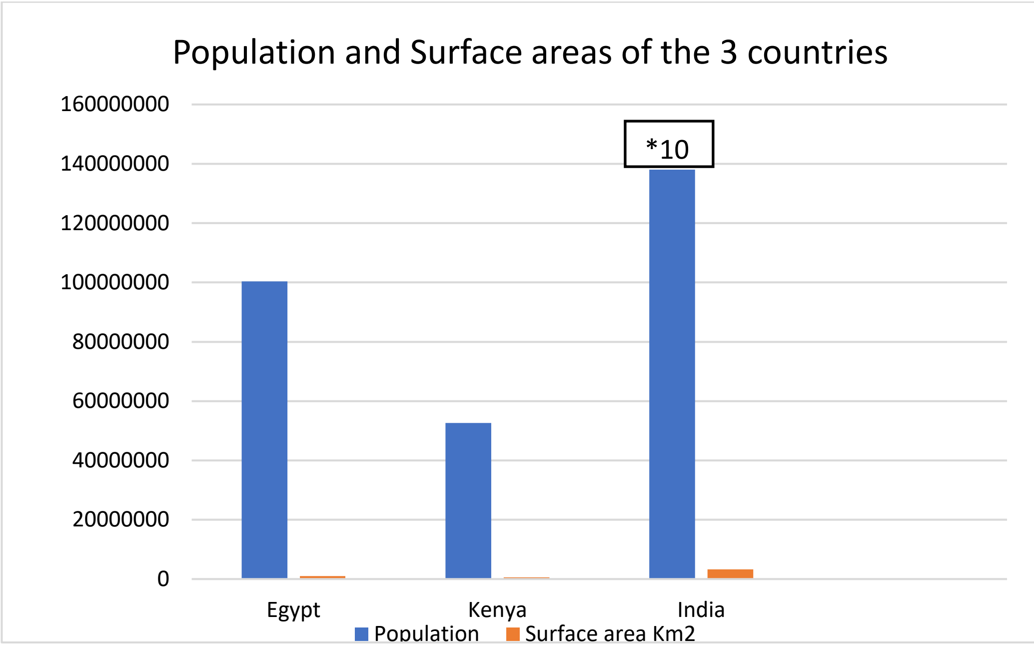


Figure 11. Population and surface area of the three compared countries

Source: UN Data country profiles [Egypt, Kenya, India] and Worldometer.net

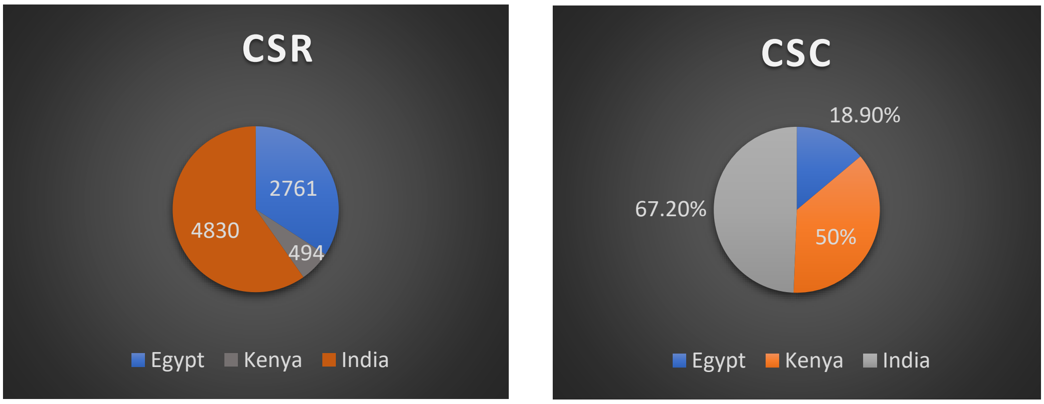


Figure 12. A. Cataract surgical rate, and **B.** Cataract surgical coverage of the three countries

Source: IAPB Global action plan indicators (2020), Elbieh et al. (2018), Khanna et al (2017), Kenya: uneven distribution of eye specialists [74][75][76][77]

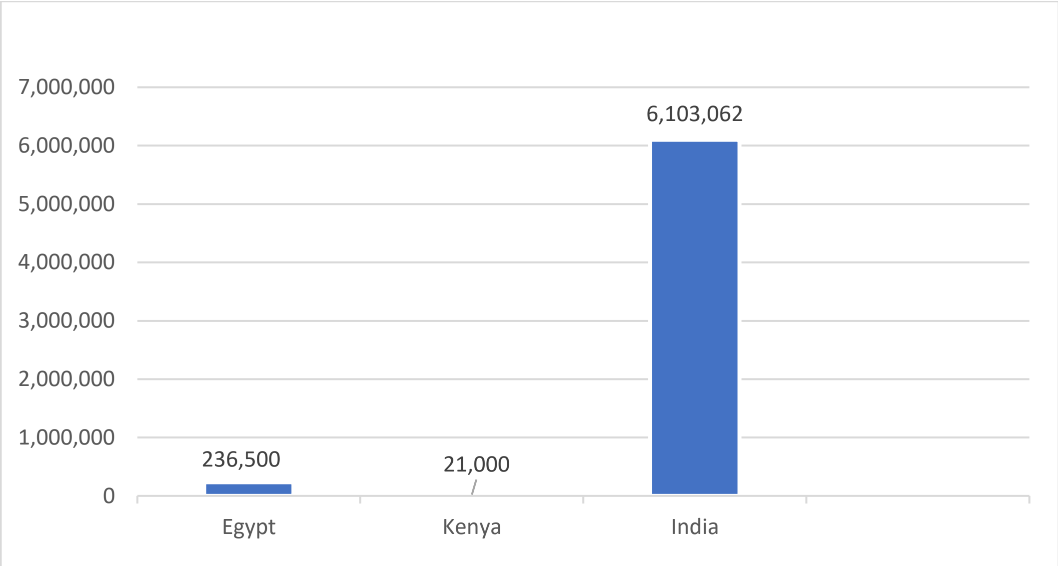


Figure 13. Number of cataract surgeries in the 3 countries in 2014

Source: IAPB Global action plan indicators (2020) [74]

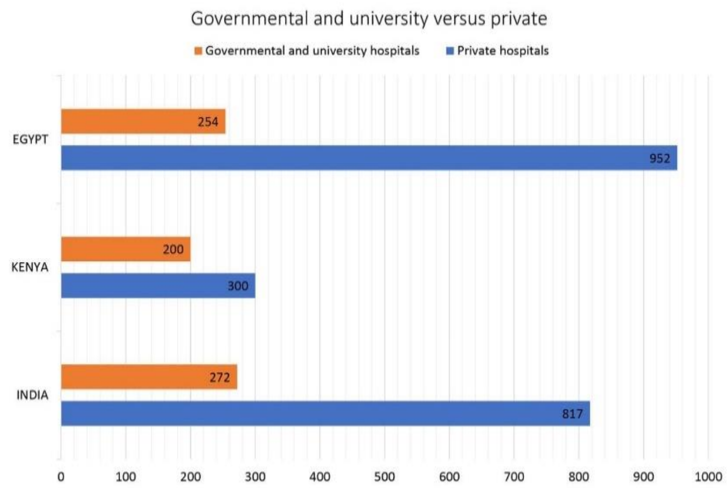


Figure 14. Cataract Surgical Outlay

Source: Ebieh et a (2018), Dr. Agrawal's eye hospital **[75][78]**

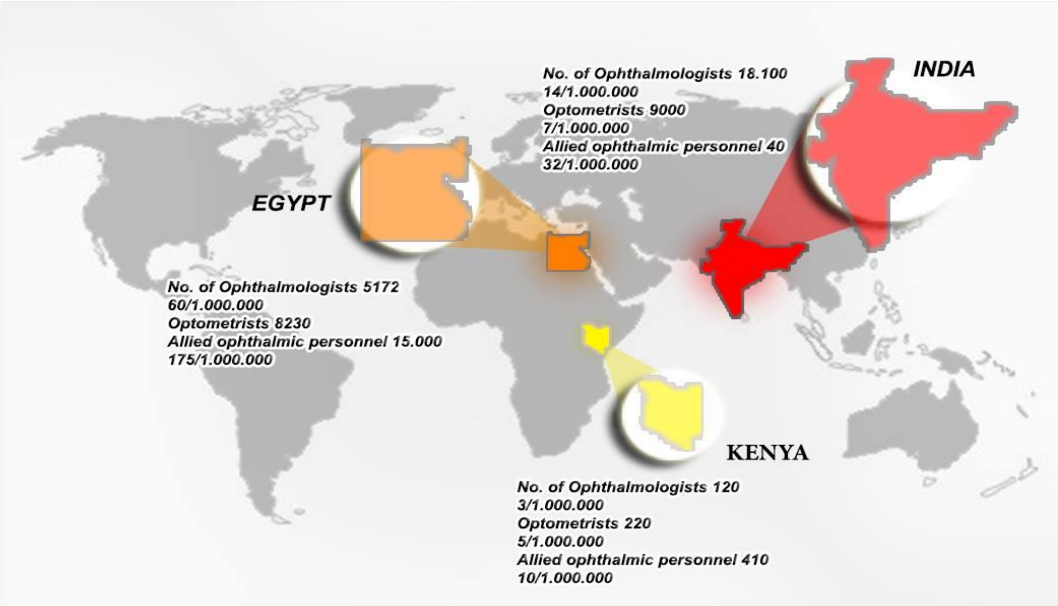


Figure 15. Map of number of ophthalmologists, optometrists and allied ophthalmic personnel in the three countries

Source: IAPB Global action plan indicators (2020), ICO (2012) [74][79]

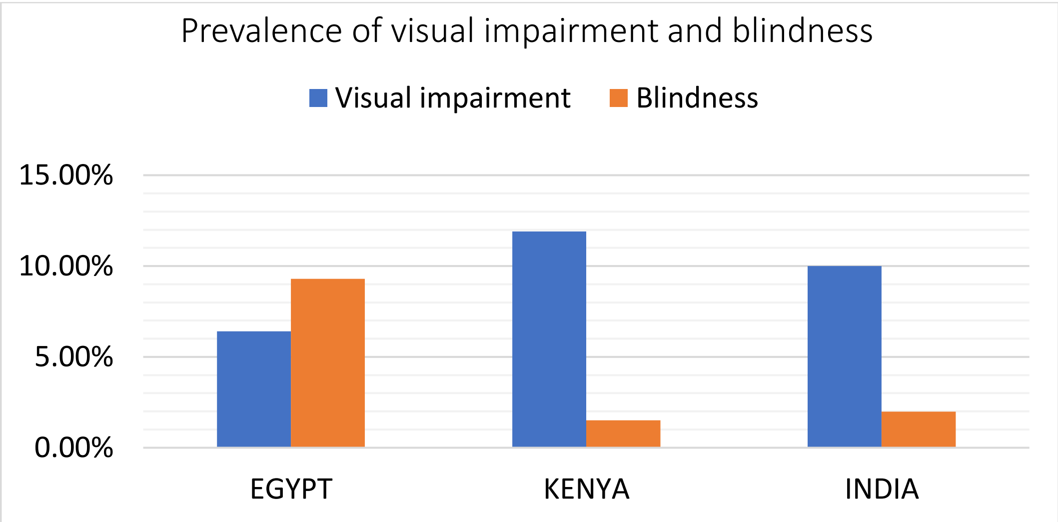


Figure 16. Prevalence of visual impairment and blindness in the three countries [80][81][82]

Source: Mousa et al. (2014), Turin (2010), Zheng at al. (2011)

Table 15. Causes of blindness in the three compared countries

Indicators	Egypt	Kenya	India
Causes of visual impairment and blindness	cataract (60%), uncorrected refractive errors (16%) and corneal opacities (12%) IAPB Global action plan indicators [a].	Senile cataract, trachoma, glaucoma, vitamin A deficiency among children, refractive errors and diabetic retinopathy complications. Others as injuries among industrial workers or during farming [b].	Cataract (66.2%), DR, ARMD, glaucoma, corneal opacity, and myopic maculopathy. (62 million visual impairment /8 million blind) [c].

Source: [a] Mousa et al. (2014), [b] WHO: Kenya atlas (2016), [c] Paranjpe et al (2017) [80][83][84]

Access to timely essential surgeries and Equity in cataract surgeries

In Egypt; the prevalence of cataract is 22.9% (higher in women, 26.5% than men 17.2%). Age, sex, family size, illiteracy, unemployment and living conditions are the major risk factors for cataract vision loss in Egypt. Women main barriers of cataract surgery services include; socioeconomic factors, such as literacy, socioeconomic status, cost of cataract surgery includes transportation to the hospital; loss of work for the patient or the guardian accompanying the patient, Also, poor rural women often have less disposable income, or control of finances, than men, cataract surgery requires transportation to hospital. This reduces the use of cataract services by women because they are less likely than men to travel outside of their village for services, cultural traditions and fear of surgery and surgery outcome is also important factor. women who have cataract surgery are three times less likely to have an intraocular lens implant compared to men [74] [75] [80]. Cataract surgeries could be undergone free of charge depending on social insurance in some governmental general or specialized governate hospitals as the Egyptian general secretariat hospitals/Insurance coverage vary whether partial or complete depends on type of insurances like company or factory special insurance or complete coverage under National Health insurance (NHI) with free of charge in governmental insurance hospitals except for services like special patient request to improve the quality of Intraocular lenses.

On the other hand, in Kenya, the two most significant barriers to entry in the Kenyan health system are the cost of care, and the availability of suitable care within a reasonable distance (i.e., geographic barriers). physical health] infrastructure in some regions of the country has a coverage of one facility per 50-200 km. Also, Rumors of blinding eye surgery are not uncommonly mentioned by patients who refuse surgery with low education levels, particularly in rural areas. Finally, uneven distribution of health workers between urban and rural areas [34]. Patient under National health insurance can undergo the operation free of charge in the governmental hospitals. While in India, Untreated cataract remains the biggest cause of blindness in India (66.2%) in middle aged men and women (between 50-90 years) besides causing severe visual impairment (80.7%), and moderate visual impairment (70.2%). But financial constraints (22.1%), need for surgery not felt (18.4%) and fear of surgery (16.1%) remains the three common reasons for people not to go for the commonplace eye surgery. Gender difference and preference to uptake health services towards males could be due to gender-defined social roles, which could be confounded by factors like literacy, socioeconomic status as domestic responsibilities and that the woman is not the main earning member of the house as well as urban-rural differences leads to less access to eye care services. Despite increased efforts by the government and NGOs, patients still don't access these services. The main barriers reported by patients were financial/lack of need for eye care [70][82].

(3) Digital Health

(A) mHealth Framework Country's year of participation in WHO global survey on eHealth eHealth policies**,** eHealth expenditures and legal and ethical framework has been mentioned in **Table 17.** and **Table 18.** of the appendices section [85][87][88][89].

(B) mHealth current Applications

<u>Egypt</u>

1. ICT plan is approached by the Egyptian MOH since 2012 with the support of WHO, which have 5 pillars; Health Insurance for all citizens, enable quality service delivery improvement, sustainable funding, public-private partnership, consumer protection. MOH's IT Vision spans across information, application, infrastructure, and people management. The MOH IT plan

includes also; the Pharmaceutical Registration System is an administrative application which automates the registration process of pharmaceuticals, including drugs (human and veterinary). It also includes Telemedicine initial steps; 10 VANs are scanning all the country for cancer breast, and equipped with video conference equipment and satellite connection for telemedicine and teleconsultation [89].

2. Teleophthalmology initiatives are conducted in the country as in World Sight Day, Egypt's "Healthy Eyes Initiative" launched an infographic about its "remarkable achievements. About 180.000 Egyptians underwent checkups in 17 governorates under the "Healthy Eyes Initiative" for different causes of blindness, including cataract. Over 14.000 eye operations were conducted under the initiative. This initiative aimed mainly to spread awareness among people, especially in the villages, about protecting themselves from the causes of blindness or low vision while highlighting the importance of early checkup to ensure receiving needed treatment in proper time. The initiative also aimed to protect at least 4.7 million Egyptians from vision problems within three years and declare Egypt free from blindness caused by this year 2020 in line with the WHO plan. The initiative was launched by Sonaa El Kheir Foundation.
3. This is not the sole initiative in Egypt to combat blindness and poor vision because another Presidential campaign has also launched called "Noor Al Hayat" to help low people undergo eye checkup. Noor Al Hayat aims at examining 10 million students at the primary education stage and 2 million of the neediest people in addition to providing a million medical glasses, carrying out 250.000 eye surgeries, reintegrating and empowering the visually impaired people. The initiative is bankrolled by "Tahya Misr Fund". Noor Al Hayat and Healthy Eyes initiatives came to be consistent with World Sight Day's theme. "Let's pledge to make Vision First!", which marked to find solutions to ensure that everyone, everywhere has access to sight. The two Egyptian initiatives were part of several overtures for moving ahead toward the Sustainable Development Goals, especially SDG 3 on health and well-being.
4. eLearning in health sciences at the tertiary level is used in teaching health sciences and in training health professionals.
5. Barriers to eLearning underdeveloped infrastructure and Perceived costs too high.
6. eLearning target groups preservice students and in-service professionals in medicine, including ophthalmology and nursing, and preservice students for both Public health and pharmaceutical sciences.

7. EHRS is not widely approached in Egypt except in some private ophthalmic hospitals. However, there is a new governmental direction already started to digitalize its hospital records as already applied in family medicine records in the Egyptian PHC units.
8. Social media and mHealth mobile applications for medical consultations in different fields of medicine, including Ophthalmology, are wide as Egypt based-startups Chefaa, Vezeeta and D-Kimia are among the leading health-tech startups revolutionizing the industry on various levels; with a National policy on its use by the governmental organization (ICT Police department, Ministry of Interior). Established in 2017, Chefaa, an Egypt-based health-tech startup, manages chronic patient's monthly prescriptions and all pharmacy needs using AI and GPS technology. A domain expert team manages its cutting-edge technologies. The current situation of COVID-19, It witnessed an increase by 300%, driven by chronic patients needing to secure their monthly prescriptions amid the lockdown, especially that chronic patients are among the risk groups, so it can help cases like glaucoma patients to have convenient access to their monthly prescript eye drops. Social media and mobile apps are also used for many usages to promote health messages for health campaigns and make health announcements. It also helps manage patient appointments, seek feedback on services as Vezeeta mobile app, which aims to empower consumers to make more informed healthcare decisions. The app allows users to book online appointments, teleconsultations, doctors' home visits and can also be used for online ordering and delivery of medications. Many social media pages and groups are available for online ophthalmic and other medical care consultations [89].
9. It has digitalized Universal Health Insurance system, which started its real work in 2019 as mentioned in the background.
10. The Egyptian government is driving digitalization in the country across sectors. More recently, developed a national AI strategy to be integrated into the different sectors such as healthcare, education [86].
11. A clear up to data Database (website) for eye health services coverage in Egypt is needed to be implemented very soon by the MOH to clarify the progress in Egypt national eye plan 2014-2019 and provide evidence of its indicators, which could not be achieved without digitalizing and implementing a policy of data collection from whole the Egyptian public, private, insurance and university eye hospitals, and departments. As in a country as vast as Egypt, vast amounts of medical data are being generated every day in hospitals, healthcare units, pharmacies, and

labs, in addition to some data generated by healthcare consumers. However, the common problem lies in making good use of the data available.

<u>Kenya</u> [90]

1. Tele-radiology local informal program is now working.
2. Supply chain management information systems on duty.
3. Human resources for health information systems are available.
4. Social media is used by the government to promote health messages as a part of health promotion campaigns and make general health announcements and by the public to learn about health issues, help them to decide what health services to use, provides feedback to health facilities and health professionals, help to run community-based health campaigns, participate in community-based health forums.
5. mHealth: Accessing/providing health services; Toll-free emergency, health call centers, appointment reminders (Pilot), Mobile telehealth, management of disasters and emergencies, treatment adherence. Accessing/providing health information; community mobilization, access to information, databases and tools, Patient records, mLearning, decision support systems. Collecting health information; patient monitoring and surveys.
6. Implementing an Open-Source Electronic Health Record System in Kenyan Health Care Facilities; EHRs in many provinces under United Kingdom support. The Kenyan government, working with international partners and local organizations, has developed an eHealth strategy, specified standards, and guidelines for electronic health record adoption in public hospitals. It had implemented two major health information technology projects: District Health Information Software Version, for collating national health care indicators and a rollout of the Kenya EMR and International Quality Care Health Management Information Systems. Following these projects, a modified version of the Open Medical electronic health record system was specified and developed to fulfill the clinical and administrative requirements of health care facilities operated by devolved counties in Kenya. This open medical EHRs are used to automate the process of collating health care indicators and entering them into the District Health Information Software Version 2 system using Kenya EMR and HMIS Software [91].

India

* eLearning in health sciences at the tertiary level used in teaching health sciences (pre-service) and in training health professionals (in-service) in medical, nursing and public health fields [92].

* Many mHealth and telemedicine initiatives are conducted in the country, the Best example for applying digital health in Universal eye health is; [93][94]

Aravind Hospitals and Foundation (Aravind Hospital Digital health welfare care)

The foundation was established in 1976. Aravind's non-profit network – consisting of five hospitals, a research institute, an intraocular lens factory, and an eye bank. It expanded now to serve over 3.3 million outpatient visits a year. It is currently the largest and most productive eye health care service group in the world. As a result of openly sharing its model, the Aravind model has been replicated in over 300 eye hospitals in 30 countries, with a number of those hospitals becoming regional replicators of this model as well.

Healthcare systems around the world are usually challenged by balancing between quality and affordability. Aravind Eye Care has overcome this challenge and revolutionized India's eyecare system by providing high-quality vision care at lower costs. Its business model focuses on achieving leveraging different economic scales, cross-subsidization, and vertical integration. Changing its business model was another critical way to scale its services by reducing their costs by optimizing their resources. As a result of openly sharing its model, the Aravind model has been replicated in > 300 eye hospitals in 30 countries, with a number of those hospitals becoming regional replicators its model of care. Core principles that drive Aravind Eye to this day: Turn no patients away, give the highest level of care, be self-sustainable, and do not operate on external funds.

Aravind Eye care model

1.Cataract surgeries indicators; optimized their fixed costs; such as the doctors and operating theatre so that they could begin performing almost 4 times as many cataract surgeries in a day as is the normal (from 15 surgeries/day to > 50-60 /day). This was done by introducing a just-in-time approach where a doctor is provided with two tables for operating instead of one, several other devices to perform non-surgical tasks, and creating a new role to called the middle-level ophthalmic personnel (MLOP) to support the doctor, so that ophthalmic surgeons could focus on surgeries instead of needing to spend time on tasks such as records keeping, suggesting lens options, or moving patients around in the theatre. When a doctor is operating on one patient, the nurse performs non-surgical tasks on the other patient. As soon as the doctor finishes with the first patient, he/she can move the surgical set up to the other patient and start the next procedure. By creating special training for this support system, even the role did not require a nursing degree, thereby lowering the cost of each support personnel by 1/5 (from 50,000 to 10,000 rupees). Aravind is focused on maximizing the utilization of its infrastructure and increasing productivity. It ensures that doctors are focused only on the critical tasks of diagnosis/surgery.

Table 18. Aravind hospital as a model of eye care in India

Indicators	India/Aravind	Average global/India
Prevalence of blindness	12 million	37 million
No. of optometrists	9.000 (real no. in India)	40.000 (Needed no. in India)
No. of surgeries	350.000-400.000 surgeries in Aravind with 60% for subsidized	CSO < ½ of cataract surgeries complications Compared to UK hospitals
No. of surgeries/surgeon/year	2000	National average 400
Cataract surgery outlay	16 $US for subsidized and up to 1000 $US Full price for affordable	US price: 3000 $US

Source: Abhilasha (2015), Rahman et al. [93][94]

2.Rural outreach camps and teleophthalmology; One of the first innovations was to design services for anyone who cannot access the existing eye care hospitals. They began by visiting rural areas to set up outreach camps that would offer services such as patient screening. This leads only to bring in 7% of patients who needed care. So, they set up permanent primary eye care centers with the ability for ophthalmologists to perform remote examination and screening via cameras - increasing reach to 40% within one year of adoption and 70% by the second year.

3.Differential Pricing for equitable treatment; is by having a dual pricing model, where the wealthier, 50% of the patients, pay for the cost of 50% of the patients who cannot afford the surgeries otherwise. The hospital provides no differentiation in the medical service quality except that the patient who pays gets a classier outpatient experience, higher quality of lenses used, and the quality of post-surgery amenities provided as a private room. At the same time, a subsidized patient is provided basic hard lenses and room on a sharing basis.

4.Training medical cadre; the Aravind training institute is a model of vertical integration that allows the Aravind foundation to have a pipeline of well-trained doctors and nurses. Nurses and technicians are comprising 60% of its workforce and its operating model. Every year Aravind identifies women from local communities and provides them advanced training to become nurses. Aravind also offers a two-year post-graduation specialization in ophthalmology and recruits over 45 doctors annually from the institute. This robust monitoring system and a focus on research ensure that these doctors and nurses continue to innovate and well-performing [93][94].

Section II:

3.1.4 Current situation of Digital Health related to UEH in the Republic of Korea

In comparison to the main 3 studied countries, we will find the situation in South Korea as follows;

Background

Southern Korean Peninsula current population is 51,269,185 people at mid-year 2020 according to UN data **(Worldometer 2020)**. According to the NHI, the country's health insurance service covered 63.8 % of all medical expenses in late 2019, compared with 62.7 % in 2017. Universal health insurance coverage was applied in South Korea since 1977 and achieved in 1989 as NHI has been expanded to the whole nation. In 1998, the health insurance system was reformed and integrated the fragmented medical insurance society for the self-employed, such as fishermen and farmers, and then in 2000, the NHI system was unified. After that, Health Insurance and Review Assessment (HIRA) as an independent agency distinct from the insurers and providers have been developed. Under the UHC system, having fee-for-services covering all citizens in South Korea, HIRA contains comprehensive information of all healthcare services for around 50 million beneficiaries. HIRA’s large repository of data in the healthcare sector, has enormous potentials in several ways: enhancing the efficiency of the healthcare delivery system without compromising the quality of care, adding supporting evidence for a given intervention, and providing the information needed to prevent adverse events [95][96][97].

Table 19. Korean UEH indicators

No. of Ophthalmologists/Million **Total number of Ophthalmologists** [98]	40/1.000.000 2.026
Prevalence of visual impairment/blindness [99]	4.1/0.2 %
Access to eye services [99]	Inaccessibility; increasing age, living in rural area, unemployment, being without spouse or private health insurance.

Source: ICO (2012), Rim et al. (2014)

N.B. Other South Korean UEH indicators are not available online.

Digital Health

A) **mHealth framework** [100]

South Korea is part of the WHO 2009 global survey on eHealth. In this survey, Korea revealed;

1.National eGovernment and eHealth policy were partly implemented from 2007

2.National ICT procurement policy for the health sector is also partly implemented from 2007.

3.National telemedicine policy partly implemented.

4.Public funding on ICT equipment, pilot projects and medical/IT skill training and scholarships.

5.eLearning in medicine, public health and nursing (pre-service and in-service).

B) **Legal and ethical frameworks for eHealth** [100]

-Legislation on health-related data to ensure the privacy of personally identifiable data.

-Legislation for sharing health-related data between health care staff through EHRs within the same and between different health care facilities.

-Government-sponsored initiatives about Internet safety and literacy and security tools for facilities used by children.

-Quality assurance approaches to health-related internet content with voluntary compliance by content providers or web site owners

C) **mHealth current applications** [10][101][102]

1.According to the Ministry of Food and Drug Safety (MFDS) 'Smart Healthcare Medical Devices: Technology and Standards Report 2018', the digital healthcare market in Korea was estimated at

GBP 2.4 billion in 2015 and to reach (British pound sterling) GBP 4.4 billion by this year 2020. with the healthcare data market alone expected to be worth GBP 170 million by 2023.

2. EMRs systems in Korea were 93.6% in hospitals and 91.6% in clinics in 2017. This comprehensive EMRs coverage is associated with Korea's near-universal digitization of patient data, digital storage of clinical images, electronic hospital administration databases and the expanding use of remote sensor technology. Large-scale research and investments in the healthcare Big data field are underway as Asan Health Innovation Big Data Center, National Bio Bank, The Precision Medicine Hospital Information System Project, and the Precision Medicine-Based Cancer Diagnosis Project.

3. The Ministry of Science and ICT has projected that Korea's AI healthcare market will grow by approximately 70.4% annually, from just GBP 1.23 million in 2015 to GBP 17.65 million by this year 2020. expected to grow by 40% annually to reach GBP 3.1billion in 2024. Yonsei University Developing AI-based disease prediction service based on big data, Seoul National University Developing an AI-based hospital information system, Seoul Asan Hospital Opening a business group for AI-based analysis of medical images, and St. Mary's Hospital Developing AI-based radiation cancer treatment technology with Stanford University. Moreover, JLK Inspection, by combining DL technologies and image processing techniques, is developing the AIHuB, a medical diagnostics platform that will allow physicians to diagnose different diseases.

4. According to a 2018 Pew Research Center report, Korea ranks first worldwide in terms of smartphone ownership (94% of adults own a smartphone and use the internet) and the fourth-fastest-growing market in the Asia Pacific region for wearable medical devices. Currently dominated by health activity monitoring applications from significant smartphone companies, the market is expected to grow in vital signs monitoring and diagnostics products in the near future with GBP 136.7 million.

5.The major three obstacles in the face of digital health in South Korea are:

A) Telemedicine between doctors and patients is still prohibited by Korean law. Besides, almost full coverage and accessibility of all medical, including ocular services are achieved, so digitalization is highly applied within the medical institutions and hospitals but not within them or among the nation and patients prefer face to face ocular consultation, as there is already access to the service, more than teleophthalmology. Government plans to expand the usage of telemedicine in Korea have faced persistent opposition from medical professionals. Activists' fear that telemedicine would lower the quality of medical services and hinders small local clinics' operations. 50,000 medical industry workers are estimated to be put out of work by the legalization of telemedicine

Solution: Based on the rapid technological advancement of medical AI, current digital health is shifting focus in Korea, from hospital information systems to medical AI. More than 20 medical AI solutions with 6 approved by Korean MFDS are targeting computer-aided diagnosis of medical radiology images as AI in Teleophthalmology.

B) Issues of regulations and reimbursement: the problem is that most of the regulations do not align with digital health since they currently target traditional medical technologies, not digital health.

Solution: Global Digital Health Partnership (GDHP) has been formed. GDHP is a collaborative effort of 21 government agencies and the WHO regarding digital health in each country. Korea is one of the leading countries in digital health regulation. Korean MFDS issuing the first medical AI software regulation guidelines in 2017 and currently working on a more detailed one.

C) Korea has a single unified national insurance system. Unfortunately, reimbursement decisions by Korean government agencies take approximately one year. If a new digital health solution is categorized as existing technology, then no additional fee applies to newly developed digital health technology. Despite many experts' requests, HIRA does not have a plan to promote digital health technology using a reimbursement strategy.

Solutions should be suggested in the future to help to solve this hurdle for digital health companies.

6. In May 2018, the Regional Program Manager of IAPB Western Pacific Region (WPR) visited South Korea to facilitate the organization's collaboration and cooperation with its partners in the country and has attended a special session on innovation and technology which was organized by project BOM (also known as the Ophthalmology Department of Yonsei University College of Medicine) and attended by leading social venture firms in the country dedicated to eye health and disability such as LabSD, Ovitsz and others. These social ventures were supported by the Korea International Cooperation Agency (KOICA), responsible for the country's Official Development Assistance (ODA) through its Creative Technology Solution Program as;

1) LabSD's EYELIKE Platform; allows health professionals with minimum training to conduct international standard screenings for the diagnosis of eye diseases such as DR, AMD, and glaucoma with considerably reduced time and cost, while sharing the information with the entire referral system via AI and fundus camera.

2) Ovitz P-10; cost-effective, portable Wavefront autorefractor, P-10, that can be easily used to measure refractive error, more quickly, precisely, and accurately both in the office and in the field. Ovitz aims to offer comfortable and timely access to an affordable visual acuity test.

3) Braillist; developed a device that supports vision impaired persons to use smartphones more independently and conveniently and improve patient's quality of life.

4) DOT, braille cell that is 1/20 size and 1/10 cost compared to existing piezo-electric cells that have long been considered as the standards in the braille device market. It will give students the chance to be free from carrying around bulky and heavy braille books to the school and increase access to learning materials in resource-limited conditions [10][101][102].

Section III

3.1.5 Successful examples in digital eye health application field from other countries and international organizations

(1) Thailand (Deep Learning vs. Human Graders for Classifying Severity Levels of Diabetic Retinopathy in a Real-World Nationwide Screening Program) [103] [104]

There are 1,500 ophthalmologists in Thailand, including 200 retinal specialists, who provide ophthalmic care for approximately 4.5 million patients with diabetes. Half of the ophthalmologists and retinal specialists' practice in Bangkok, the capital of the country, while a majority of patients with diabetes live in areas 100 kilometers or more from provincial hospitals, far away from where ophthalmologists typically practice. The latest Thailand National Survey of Blindness showed that 34% of patients with diabetes had low vision or blindness in either eye. DR was and continues to be the most common retinal disease that causes bilateral low vision in Thailand. Artificial intelligence program in Thailand has been used to screen for diabetic eye disease, which causes permanent blindness. The eye screening program in Thailand follows a similar Google program in India and highlights a push by big tech companies to show the social benefits of new AI technologies. Google's Thailand diabetes program was announced in partnership with a Thai state-run Rajavithi Hospital. This followed a joint-study which found the AI program to have an accuracy rate of 95% when it comes to disease detection, compared with 74% from opticians or eye doctors. The program analyses patients' eye screen results to assess if they are at risk of vision loss, which will enable them to have preemptive treatment. The Thai government has made diabetic eye screening one of the country's national health indicators since 2015.

(3) **The United Kingdom (Electronic Health records in Ophthalmology)** [105][106]

In the UK, EHRs system or database has been used in selected hospitals for a long time. As with any new development, there are early and late adopters, as well as non-adopters. Several years ago, it was suggested in the Royal College of Ophthalmologists' Commissioning Guidelines for Contemporary ARMD Services that 'data capture and management personnel were important for internal and external audits, as well as resource management'. Other recommendations on electronic records followed. It is now widely used in monitoring the treatment of neovascular AMD (AMD) and called AMD EMRs.

(3) Saudi Arabia (Electronic Health records in Ophthalmology) [107][108]

Electronic Medical Record (EMR) systems are being implemented increasingly worldwide. Saudi Arabia is one of the developing countries that commenced implementing such systems in 1988. A number of Saudi Arabian hospitals, either governmental or private, have implemented EMR systems successfully. EHR is now used in the Ophthalmology field in Saudi Arabia to document eye imaging, eye Examination recording, orders and results Associated with Ophthalmology-specific processes, clinical reminders, tracking and complaint-specific documentation, E&M Coding Assistance for Care Givers, follow-up instructions and procedures and E-Prescription. It has many benefits for using in Saudi Arabia as importing data, information sharing, locating alluding doctors, team up on treatment, ensuring progression of care and community-oriented clinical records. Socioeconomics, medical history, clinical discoveries, history and full shading pictures with other eye mind suppliers, locally or within the nation Over, MDI shared care community, maintain control, socioeconomics, medical history, clinical discoveries, history and full shading pictures with other eye mind suppliers, locally or within the nation Over, MDI shared care community, maintain control, compare different demonstrative pictures. HIPAA consistent condition, compare different demonstrative pictures and HIPAA consistent condition through a high level of security and securely trade data. It is used in all Ophthalmology subspecialties as cataract surgeries, cornea, glaucoma, medical retina Pediatric Ophthalmology/Strabismus, Refractive Surgery, Uveitis/Immunology Oculoplastic and orbital Surgery, Ophthalmic Pathology, oncology and neurotheology.

(4) ITU (International Telecommunication Union) of united nations AI-Opta [109][110]

ITU is the United Nations specialized agency for information and communication technologies (ICTs)**.** Founded in 1865 to facilitate international connectivity in communications networks. Artificial Intelligence (AI) innovation will be central to achieving the United Nations' Sustainable Development Goals (SDGs) by capitalizing on the unprecedented quantities of data now being generated on health and other related issues. ITU will provide a neutral platform for government, industry and academia to build a shared understanding of the capabilities of emerging AI technologies and consequent needs for technical standardization and policy guidance.

Members of the medical and AI communities with a vested interest in AI for Ophthalmology become engaged in the group dedicated to establishing a standardized benchmarking platform for AI for Ophthalmology (retinal imaging diagnostics) within the ITU and WHO Focus Group on “Artificial Intelligence for Health” (FG-AI4H).This topic group is devoted to using AI for the detection and diagnostics of ophthalmological conditions as Diabetic Retinopathy (DR), Age-related Macular Degeneration (ARMD), Glaucoma, Pathological Myopia and Red Eye. These conditions require regular screening by an eye care professional to prevent vision impairment and blindness. However, given the large numbers of people affected worldwide, there is are not enough specialists globally to screen everyone at risk. The shortfall is particularly acute in developing countries, including India, and many countries in Asia and Africa. Also, many affected people live in remote areas with little or no access to clinics and screening facilities. This makes these conditions a global healthcare challenge that needs urgent resolution. Recent advances in AI algorithms for image recognition and medical diagnostics are effective in detecting these conditions at accuracy levels comparable to human specialists. Therefore, a standard way of benchmarking the performance of various AI applications to detect and diagnose these conditions is essential. It will help select and evaluate appropriate solutions to address the global healthcare challenge posed by these diseases.

The primary output of a topic group is one document that describes how to perform the benchmarking for this topic. The process will continue over several meetings until the topic description document is ready for performing the first benchmarking). For a rigorous evaluation, undisclosed data sets must be available and high quality and compliant with ethical and legal standards. The data must also originate from a variety of sources so that it can be determined whether an AI algorithm can generalize across different conditions, locations, or settings (e.g., across different people, hospitals, or measurement devices). The properties of the data serving as input to the AI and of the output expected from the AI, as well as the benchmarking metrics, are agreed upon and specified by the topic group.

Finally, the AI-to-be-evaluated will be benchmarked with the undisclosed test data on FG-AI4H computing infrastructure. Here, the AI will process single samples of the undisclosed test data set and predict output variables, which will be compared with the "ground truth". The results of the benchmarking results will be provided to the AI developers and will appear on a (potentially anonymized) leader board.

(5) International Council of Ophthalmology (ICO) eLearning training [111]

ICO established an eLearning platform via its Committee on Technologies for Teaching and Learning Continuing Professional Development, which explores new and emerging technologies for ophthalmic education and provides technical guidance for Continuing Education and training online courses of ophthalmologists worldwide.

(6) Asia Pacific Teleophthalmology Society (APTOS) [112]

Founded by a group of Teleophthalmology specialists in the Asia-Pacific region in May 2016, the APTOS aims to bring together clinicians, researchers, technicians, institutes and organizations to form an alliance that promotes communication, exchange and collaboration in Teleophthalmology. It also provides a platform on which eye care or Telemedical professionals can share knowledge and collaborate to deliver efficient, accessible and quality UEH care throughout the region. Through its annual symposium, APTOS brings together highly expert specialists for lively discussions about applying technological advances in tele-ophthalmology. It also supports individual countries in the Asia-Pacific region to explore the best mechanisms for local teleophthalmology development. APTOS 2020 has been held in Seoul, Republic of Korea, in December 2020.

3.2 Systematic Review

In this chapter we identified the three categories included in the categorization model of the expected results settled in the methodology section in **table.** We classified the 37 finally chosen articles into three key questions which are described as follows;

3.2.1 Key Question 1: Digital health effect on improving the quality of life of eye patients (by patient's home screening, electronic low vision aids, Smartphones and electronic devices, Mobile Apps and social media)

The narratives on the category (quality of life of eye patients) most explicitly mentioned in 11 articles found in our search, as follows; types and efficacy of electronic low vision aids as computerization of the magnifiers and adding low electronic vision aids to tablets and head-mounted displays were mentioned in 3 articles 113, 114, 115. Studies in article 113 found it has the potential to deliver real benefits to a large number of patients, especially if a multidisciplinary approach to implement it. In contrast, articles 114 and 115, did not find sufficient evidence of the efficacy of telerehabilitation and electronic reading aids. Furthermore, for smartphones and mobile Apps, article 116, categories and types of Android mobile Apps are also mentioned as target audiences. In article 117, the use of smartphones for patient assessment, educational–visual aids, administrative and health care educational tools, as well as their use as reference tools are explained. Smartphone sensors as single field fundus camera are a cost-effective window to remote health care services via using raw data from them and send it to the remote healthcare facilities for investigation. Further, using AI technology for monitoring the eye health and activities of daily living is mentioned in articles 118, 119. Decision support systems for ophthalmology mostly focus on diabetic retinopathy. Many researchers boost the possibility of combining it with EHRS and cloud storage to multiply their efficiency 120.

Home self-testing for the screening of amblyopia and visual acuity is mentioned in articles 119, 121. There is also a need for effective linking self-tests of visual acuity with health care, which could involve remotely delivered care, especially in post-cataract surgical care in LMICs 121. The barriers for using eye services and mobile Apps as; physical ability and perceptual barriers for the elderly and pitfalls as not updated apps and lack of restrictions from not target audiences and works reported in the literature are based-on nonrandomized, non-blinded studies on a limited number of subjects have been illustrated in many articles as 116, 118, 122. Accuracy, reliability, security issues, need for guidelines/ legislation and professional involvement of ophthalmologists in developing the ophthalmic medical Apps and devices mostly mentioned in all our searched literature, especially in articles 116, 118, 119, 121, 123. 4 articles explained the ability to use smartphones and devices and electronic low vision aids as a cost-effective method in remote, underserved areas which is explained in articles 113, 118, 121, 123. All searched literature assured the importance of smart devices to improve the quality of eye patient life and patient and ophthalmic personnel satisfaction, preferences 119, 121.

3.2.2 Key Question 2: Digital health effect on universal eye health indicator as Cataract surgical indicators and improving quality of eye health services (by EHRs, eLearning, telecommunication in hospitals)

EHRs is nowadays very popular in the Ophthalmology field in many countries as the USA, UK, Saudi Arabia and Sweden. It has multiples uses, such as Patient-Reported Outcome Measures (postoperative patient satisfaction), administrative databases epidemiologic features and outcomes of diseases, measurement of healthcare quality (Cataract surgery and corneal transplantation are fields in which clinical quality registries have been incredibly beneficial in improving quality of care by using outcome data), monitoring of adverse events and training of junior ophthalmologists as IRIS Registry. It could also be used as a good source in medical research is mentioned in article 124.

On the other hand, using SMS reminders, emails and Smartphone applications-based interventions can efficiently be used to monitor cataracts, glaucoma and DR patients. It could also be used to evaluate the surgical patient symptoms postoperatively, which could be applied to post-operative cataract surgical care, improve patient adherence to prescribed protocols, clinic attendance, and have the potential to reduce healthcare services costs 33. One of the studies 125 proposed it as a very effective monitoring tool in LMICs on groups severely affected by these 3 ophthalmic diseases as women older than 55 years. Additionally, researchers reported many benefits from using SMS as reminders, including easy use, inexpensiveness, and rapid automated message delivery. In contrast, Minimal risks were reported and many patients found the reminders to be satisfactory. 126, 127. Moreover, mobile technology between health care workers, in 128, Health professionals often use their mobile phones to share clinical information, including the transmission of images. This review found that mobile technologies may reduce the time between presentation and management of the health condition when primary care providers or resident physicians use them to consult with specialists and reduce referrals. However, barriers and concerns like; privacy, the security of patients' data, technological issues and less confidence regarding diagnosis and management sometimes hinder healthcare's further use. There is little evidence in the literature about healthcare providers' satisfaction with the intervention, although healthcare providers reported that mobile technologies allowed for rapid care delivery.

eLearning in medical and paramedical schools and online professional ophthalmic training (In-service training) are used nowadays in the eye field. The integration of online lectures into undergraduate medical education is well-received by students and improves learning outcomes and Knowledge. multiple studies demonstrated that knowledge was equivalent (or better) between students learning through online lectures than traditional learning. There are ophthalmology apps which are used by ophthalmologists as educational networking as; the American Academy of Ophthalmology Apps, Eyetube. Also, there are Ophthalmic tool apps as; Ophthalmic Instruments, Eye Handbook, Ullman Indirect and visual aids apps as; Be My Eyes. Finally, social media apps as; Twitter which could be used for acquiring continuously updated information quickly and accurately, communicating with peers all over world, and solving problems in ophthalmic practice 129, 130.

3.2.3 Key Question 3: Digital health effect on universal eye health indicator Diabetic retinopathy and glaucoma prevalence (by Artificial intelligence use in digital retinal diagnostics and Teleophthalmology)

Many articles explaining AI in ophthalmology and teleophthalmology were found in the three search engines. Nevertheless, the most highly specific reviews were 5 articles for AI and 13 articles for Teleophthalmology. For AI use in Ophthalmology, 3 articles were talking about Deep learning (DL) and Machine learning (ML) use in the detection and treatment of DR, ARMD and ROP. Also, in finding algorithm for the visual field for glaucoma diagnosis and prognosis 131, 132, 133, especially where there is a limitation of availability of retina specialists and trained human graders in many countries Automated retinal imaging technologies have the potential to reduce the barriers to access to eye health care system and eye health screening, thus it may help to minimize avoidable blindness across the world. ML can effectively learn from increasingly complicated images with a high degree of generalization, using a relatively small data repository. It also has advantages in terms of information integration, data processing, and diagnostic speed. However, many concerns are mentioned in papers regarding validity, accuracy, reliability, sensitivity, specificity, and correct retinal disease staging of algorithms and black-boxes. As AI becomes more sophisticated, there may be many ethical challenges ahead, including transparency, bias, legal and regulatory issue, data protection and intellectual property, cybersecurity and decision making. Two new retinal imaging techniques were illustrated in review 134, which are the Crowdsourcing and Automated Retinal Image Analysis (ARIA), which have been applied to reduce costs in the screening of DR. The difference between the Crowdsourcing accuracy of grading is affected when the level of DR severity is added while ARIA is not affected. Technological booms allow smartphone-based attachments and integrated lens adaptors to transform the smartphone into a fundus camera. Some versions use apps designed for screening of ocular fundus abnormalities based on AI –driven algorithms such as; Iexaminer, Ocular CellScope, Portable Eye Examination Kit, D-Eye System. This advantageous technique could create a greater community outreach by decentralizing eye healthcare delivery, especially that it can be handled by semiskilled personnel. In third-world countries where residents in rural areas have limited access to proper eye healthcare, it is considered as a cost-effective, practical tool for screening the retina and facilitating referral to an eye specialist on time 135.

For Teleophthalmology, the vast majority of searched literature was about it as the next black horse of digital Ophthalmology. Uses and types are mentioned in articles 136, 137; Retinal tele-evaluation, Ophthalmology emergency teleconsultation, Neuro-ophthalmology, glaucoma, uveitis teleophthalmology, Teleophthalmology in general ophthalmology and ocular adnexa., use teleophthalmology in health education, epidemiology, research, and logistics. Tele-ophthalmology integrates ophthalmic technology with EHRs by taking advantage of telecommunications (landline phones, video conferencing and emails). This integrated platform provides access to specialized experts, where retinal specialists can exam individuals living in remote and underserved areas. Accuracy and Reliability of single-field fundus photography for Diagnosing DR are very high, for the sensitivity of digital imaging for detecting DR is (62.5% to 98.2%) and specificity (76.6% to 98.7%) compared with Early Treatment Diabetic Retinopathy Study (ETDRS) and for Clinically Significant Macular Edema (CSME) is 100% (95% CI, 90–100%), and the specificity was 97% (95% CI, 95–98%) 137, 138, 139. Tele-glaucoma as well is more specific and less sensitive than in-person examination. The pooled estimates of sensitivity were 0.832 (95% CI 0.770, 0.881) and specificity was 0.790 (95% CI 0.668, 0.876) in study 140. New technologies, such as sensors and wireless devices, present promising tools that enable continuous monitoring of IOP for glaucoma monitoring. Utilizing wearable sensors, eye health information can be transmitted from home to remote sites. Combined with new technologies (Bluetooth, USB port, ZigBee, WIFI) or via telemetry. Moorfields Eye Hospital's collaboration with Google DeepMind aims to create a general-purpose AI algorithm that can look at Optical Coherence Tomography (OCT) scans and diagnose age-related macular degeneration and diabetic retinopathy. Big data showed amazing service delivery models to pool large databases together to identify trends and predict future risks to vision. It is also showed an equivalent outcome to that of the standard outpatient model for the studied Visual Field test for glaucoma monitoring. Parameter 141. ROP for at-risk infants and ARMD for elderly teleophthalmology screening is an emerging technique in the ophthalmic field. However, such screening programs for ARMD are not widely virtually nonexistent as from ophthalmic personnel point of view, there is a need to reduce referrals. Home monitoring of ARMD and e-consultation is recommended by Mayo clinic and non-doctor-led virtual ARMD clinics have been piloted in the United Kingdom 142, 143, 144.

Teleophthalmology is not meant to substitute face-to-face eye examination; it is meant to facilitate and provide appropriate and timely access to eye healthcare services in the underserved areas 136, 142. Many national screening programs have digital fundus photography as their basis. In the past years, several techniques and adapters have been developed that allow digital fundus photography to be performed using smartphones as DR and diabetic maculopathy are considered the leading causes of blindness in the working-age population. Implementable screening workflows are required if an evidence-base is strong enough to affect policy change, so national DR screening would become possible in LMICs settings where cost and availability of trained eye care personnel are currently key barriers to implementation 145, 146. Also, barriers are uneven distribution of the countries because there are limited countries with both capacities, such as infrastructure and needs for teleophthalmology. India and Kenya take more than half of the implementing sites and focus of teleophthalmology on DR only and neglect of other diseases should be solved equitably 146.

Many countries have a successful experience in teleophthalmology as the UK has the most successful teleophthalmology program for DR screening 138. Thailand also became one of the leading countries regarding teleophthalmology researches after establishing teleophthalmology system between Bangkok and health centers in remote rural areas 146. Singapore Integrated DR

Program (SiDRP) is a very successful program. The USA has the two largest DR screening programs; Joslin Vision Network and the Department of Veteran Affairs model. In India, with much of the population in rural areas, smartphone-based imaging devices such as Remidio fundus on phone (FOP) camera have been used in teleophthalmology screening. Efficient DR screening strategies have been explored and implemented, in line with the national Healthy China 2030 strategy, to support the "prevention first" principle and the telemedicine-enabled program of Lifeline Express has carried out free DR screening nationwide at 29 DR screening centers 144. Only less than a quarter of countries in the Asia-Pacific region have national DR screening guidelines. Of these countries only; Australia, New Zealand, China, India, and Malaysia, have guidelines written specifically on the care of DR, whereas the remaining 5 countries (Japan, Singapore, Hong Kong, the Philippines, and Sri Lanka) incorporated their DR screening guidelines within diabetes guidelines. Rapid Assessment of avoidable blindness (RAAB) could be used as a suitable epidemiological data tool. Some of the Patient-identified barriers to screening were forgetting appointments, feeling that physicians were not well-trained, and transportation costs. Also, Country-specific barriers such as high costs, traveling time, inconvenience from screening or treatment, and lack of medical reimbursements, lack of patient awareness and poor health literacy are other barriers for teleophthalmology widespread besides technical and security issues 147. However, patient's satisfaction with teleophthalmology is very high 138, 148. Most of the searched and selected articles mentioned teleophthalmology as a cost-effective and patient-friendly technique. The sustainability of this program is supported by multidisciplinary approaches and via solving its accuracy, reliability and legal problems, for example in 137, 138, 142, 145, etc. Especially, in the COVID-19 Pandemic era the use of smartphones, SMS and video-calling, secure mobile applications and social media tools are indispensable. Subsequently, more sophisticated eye examinations via telemedicine could be developed 144.

A snapshot of the articles' category of outcomes and its keywords is mentioned in **Table 20.** As well as, a classification of articles according to their outcome variable included in this systematic review is mentioned in **Table 21. 22.23.** in the appendices section which are summarizing; Paper (the name of first author and year of publication of the article), country or WHO region or implementing organization, Intervention (type of digital health services), and category of outcome affection on eye health and finally the outcome of each study.

3.2.4 Implications of Digital health applications on UEH (UHC) in Egypt

The Egyptian MOH continues to embark on the development and modification of its ambitious IT Master plan 2012-2017 under the supervision of WHO and improving the digitalization in the country across sectors as a national AI strategy to be integrated into the different sectors such as healthcare, education. Furthermore, Digitalizing and Universally Health Insurance system coverage. Also, Teleophthalmology shows a promising future in Egypt but needs to foster efforts to increase the number of campaigns from two; Healthy Eyes Initiative and Noor Al Hayat, to more either governmental or non-governmental to improve the coverage accessibility to the rural and informal areas in far Egypt. All these steps will surely expand the universal eye health coverage and quality in Egypt on the governmental level. This was supported by achieving significant progress in building the Information Society, by providing legal framework committing to intellectual property rights agreements; and creating the National Telecommunications Regulatory Authority (NTRA).

At a population level, there were 91.32 million mobile subscribers in 2012. For the internet, there are 29.53 million internet users, while the internet penetration rate was 36.31% in 2012. mHealth mobile applications as Chefaa, Vezeeta and D-Kimia showed widespread usage in the last 5 years. Moreover, using social media medical pages and groups on Facebook, WhatsApp or other platforms are widely used and starts to gain popularity among Egyptian citizens in last years. However, it needs further regulations regarding the medical information and e-consultation done through it by the governmental authorities. Portable medical devices and low vision electronic aids are still not affordable to a wide range of the Egyptian population and need more governmental and nongovernmental to subsidize the vulnerable and impoverished ocular patients to improve their quality of life. For Ophthalmology care workers in Egypt, wide use and trust of smartphones (social media groups, and SMS) for sharing information, experience, diagnostic images and patient reminders and communication is tremendously rising in the last two decades. EHRs did not gain health worker's trust in Egypt till now and face with many challenges like; Insufficient infrastructure, unavailability of good internet connectivity in some places outside large cities, High costs, lack of skills, knowledge and recourses.

Chapter IV

Discussion

Universal eye health and digital health are two new shining stars in the Ophthalmology field nowadays. The history of UEH started around 15 years ago with the birth of the first well-organized global effort in eye health which is “Vision 2020: The Right to Sight” in 2006. While, diagnosis and treatment of disease has been the focus of AI since the 1970s and EHRs were adopted in 1990s [149]. Despite both fields are showing inspiring future but still not widely approved by either the patients or the Ophthalmologists themselves. UEH is available, but not yet to everyone [3]. Also, Digital eye health started to be used in many countries and showed many successful stories but not all countries applied it. So, what about linking both of these promising two fields together? Will it be in the sake of Ophthalmology and Public health society or digital health could hinder the application of UEH especially in LMICs with low health sector resources. This is the hypothesis of this research to find the relation between UEH and Digital Health and to identify whether this relation is with positive or negative impact on UEH widespread via Digital health impact on the quality of life of patients with ocular diseases, the quality and accessibility of eye services.

This research has tackled this relationship via two methods for thorough and in-depth results. First method is via searching the country profiles of many countries all over the world whether LMICs as Egypt, Kenya and India, high income countries as Republic of Korea or successful examples from different countries already applied digital eye health from different WHO regions. Second method was overviewing the literature for review articles related to our topic. In which we found a reasonable amount of review articles exploring the effects of Digital health interventions in the eye health field, in the three used search engines. Then most relevant 37 articles were finally selected.

The findings from countries profile showed that applying digital health in eye health care in LMICs as Teleophthalmology, smart phone apps and digitalized universal health insurance showed success and are expected to show more success in the future to improve access and quality of life of patients in Egypt. Moreover, adoption of EHRs in Kenya, has been underway for several years, particularly in comprehensive care clinics, and eye hospitals and they are used increasingly to improve purchasing systems, support administrative functions and for better documentation of patients' data. Considerable support from government, international partners as UK and regional health informatics organizations will be required in the future to enable hospitals to move to full EHRs adoption for better quality of eye health services [150]. Applying Teleophthalmology in Aravind model of care (outreach camps) in India is the ideal example of positive impact of digital health in expanding UEH.

HIRA organization in South Korea is considered as well as a great example of using big data informatics and digital health apps in monitoring the quality of services and patient's satisfaction through continuous M &E of all the health sectors process in the whole health organization of the Republic. Korean are considered the first worldwide smart phones and internet users worldwide which could to directed more in the future towards efficient e-consultation and medical apps use. Medical AI market is not only promising in Korea but also worldwide as well other fields of digital health which showed huge jump from 2015 till now [151]. Many successful digital eye health fields were also adopted as EHRs in UK and Saudi Arabia, Teleophthalmology in Singapore and Thailand, AI by ITU, and finally eLearning by ICO.

Moreover, the systematic review indicated for the first group of results that using electronic devices and smartphone sensors and Apps in eye health is a huge step towards improving the accessibility and availability of eye medical care [113] [118]. Furthermore, using smartphones as reminders for patients and a way of communication between health care personnel was found to be very useful in most of studies. Smart phone reminders help patients for more adherence and engagement to the follow up appointments for different ophthalmic diseases as cataract, DR and glaucoma. SMS was found to be the most effective modality of mhealth as patient reminder [125]. Health professionals nowadays depend mostly on their mobile phones for sharing their experience, transmission of images and for diagnosis of difficult cases [128]. Using home self-screening mobile Apps and e-consultation via social media showed major improvement in the quality of life of patients and for access to eye services especially in situations like current COVID-19 pandemic [121]. However, some studies found that digital vision aids are not much better than traditional aids [115].

Accuracy, reliability, absence of strict guidelines and ophthalmology professional involvement in the developing of ophthalmic medical Apps and devices were the most discussed and controversial issues among all the reviewed articles [123]. Also, credibility, validity, and security of patients' data and the threats posed by common cyberattacks, the physical coupling of sensors and actuators make them vulnerable to attacks mounted from the physical channel, such as signal manipulation. To protect not only data but system inferences and decisions. This metadata must be securely bound to the data with a combination of cryptographic hashes and signatures to ensure that neither the data nor metadata has been tampered with [153].

Our review also points out in the second group of results to the impact of EHRs various functions in the assessment of Patient reported outcome measures (postoperative patient satisfaction) and measurement of healthcare quality (following the Cataract surgeries in which the quality clinical registries is particularly beneficial in improving quality of care via monitoring the outcome data) and for junior ophthalmologists training as well [124]. Unfortunately, wide use of EHRs in eye field still needs a long path as large number of Ophthalmologists found them time consuming and many patients are still conservative regarding their security issues. The absence of broader use of EHRs and comprehensive, sustainable and well-funded surveillance system which has validated measures, verifiable data, and interoperable databases leads to scarcity of eye health data [152]. Also, Lack of clear guideline of digital health usage in eye health with absence of good monitoring of national eye plans in most of the countries, all of these factors obstruct the application of digital eye health.

Furthermore, in many papers, eLearning in medical and paramedical schools and professional online training courses, Apps and websites for ophthalmologists were founded to improve professional learning outcomes. It is also observed that knowledge was equivalent (or better) between online lectures compared to traditional learning. Further, eLearning has a high degree of ophthalmologists' satisfaction [129]. eLearning is needed for HCWs to properly understand and evaluate the data, especially the EHR usage. As Health care personnel is not only in need of medical background but preferably an IT background to be able to understand and interpret the data [47].

The vast majority of articles which were tackled in our research were about AI in ophthalmology and teleophthalmology (18 articles from total 37) which represented the third part of this research results. For AI use in Ophthalmology, articles mostly discussed the revolution of DL and ML in the detection and treatment of DR, ARMD and ROP. However, many concerns were mentioned in articles regarding its accuracy, reliability. Some articles also mentioned the degree of its sensitivity and specificity in grading the retinal diseases [131][132][133]. Teleophthalmology well-noticed importance and distribution observed by many reviews, clinical trials, pilot projects and also on the practical field which were mentioned as one of the most cost-effective and patient-friendly tools of improving access to the eye services in underserved areas in LMICs [137].

In our studied literature, many countries have been mentioned as successful examples of applying DR screening program of UK, USA, Singapore, Thailand, India, China, Kenya [144] [147]. Despite, most of the focus of Teleophthalmology now is going towards DR screening, there is a promising future of applying AI and other Teleophthalmology innovations in screening other retinal diseases as ROP, ARMD and in Tele-glaucoma [140][142][143]. For that, public health and ophthalmology health promotion efforts still needed to be more widely conducted to aware patients who have those diseases about this new technology and also to provide adequate training of medical doctors and paramedics on how to apply it. As it is expected to fill the huge access gap of eye services for the sake of patients with mentioned retinal diseases in underserved areas and to reduce the prevalence of blindness from such eye conditions.

Funding is considered the biggest problem facing the real application of digital health in LMICs with low GDP for health. The focus area in the policy development in which the digital healthcare initiative is intended to function is the sustainable funding that will support long-term growth, where alignment with broader healthcare policy is essential [154]. While in high income countries as South Korea, governmental plans to expand the usage of teleophthalmology usually faced by a persistent opposition from the medical professionals. As the activists' fear that telemedicine would lower the quality of services and hinders small local clinics' operations [102].

Finally, this study observed that the need to broaden teleophthalmology services in LMICs especially Egypt, becomes an urge to fill the gaps in the accessibility and availability of eye health services and ophthalmic personnel shortage. Further, more integration of the eye health sector into the national health systems via the establishment of EHRs and robust eye health database to cover the severe scarcity in eye health data should also be tackled urgently by the global Public health and Ophthalmology societies. These two steps have become cornerstone for monitoring the national eye plans and real progress towards UEH according to the scope of Vision 2020, Towards Universal eye health: Global action plan 2014-2019 and World report on vision. Such data includes information about UEH indicators as cataract surgical rate and coverage and prevalence of DR and glaucoma. So, our reply to this research question, is to accept the hypothesis that Digital health is a vital additive factor in UEH and expected to have a more major role in UEH improvement in the future.

4.1 Academic and political contribution

This research is keen on searching the link between Digital health and UEH through in-depth systematic overview and country profiles search of literature. Our results showed that the Digital health played an important role in improving access and quality of services of eye health and also in modifying the quality of life of patients with ocular diseases in the past. We also expect that it will play a major role in expanding UEH in the future in the same manner but more efforts needed to be done by the Public health society for further international collaboration, data sharing and also funding from developed countries for more future application of digital health in LMICs.

The political contribution of this study is regarding the recommendation of establishment of universally approved guideline of Digital health and clear eye health database in LMICs to help to monitor the integration of national eye plans in general health plans and also integrating Teleophthalmology, and EHRs in eye health plans. As well as monitoring UEH indicators as cataract surgical indicators and prevalence of blindness causes.

4.2 Ethical considerations

Ethical exemption was obtained from IRB of Yonsei University on the date 14/08/2020. The research will not involve any human interventions or personal information.

4.3 Bias and limitations

This systematic retrospective review study had some limitations as it is conducted depending on secondary data collected from review articles available online in the Yonsei Medical School library which; (i) Although it is conducted via comprehensive literature search on three databases using a variety of pertinent search terms, certain studies may have been missed due to lacks or bias in indexing and/ or filters of these search databases. (ii) Depending on review articles only, Lack of clear abstract or methodology of some articles or its dependence on a systematic analysis of experimental or clinical trials not observational in-depth analysis (Significantly that some of the digital health applications still under trial in many countries) may tighten the area of search and prevent us from answering some critical or fundamental questions regarding the role of digital health effect in the eye health field. (iii) Some information may be underestimated or not fully cover our whole area of research. It is documented from LMICs that have no exact database for Eye health and Digital Health services. (iv) Data collected in reviews from December 2019 till June 2020 were done under the pressure of COVID-19 Pandemic, which may affect the quality of them is another limitation. (v) Lastly, the time available for the data collection was limited as well.

Chapter V

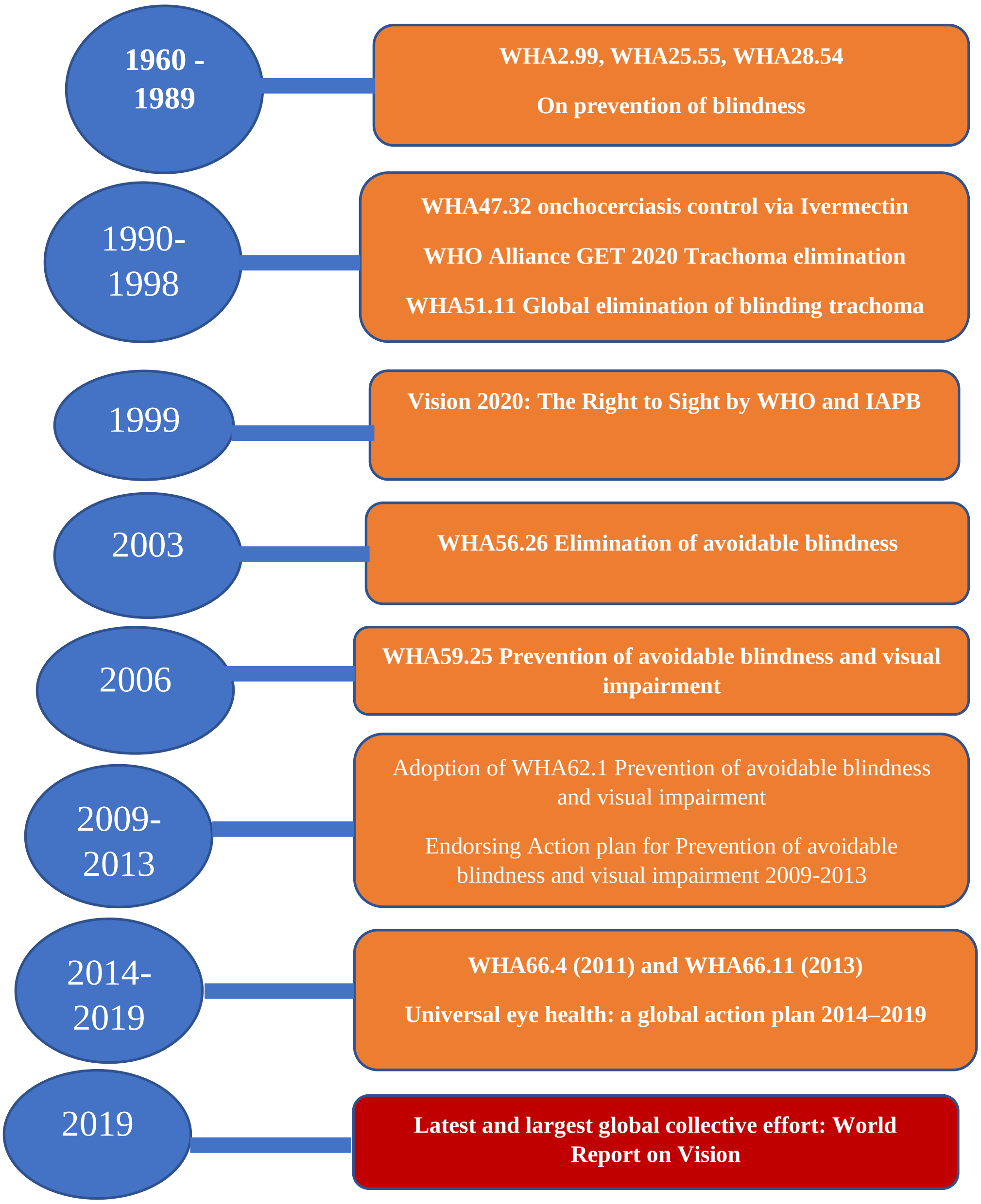
Conclusion

Digital health was found to be an important additive factor in the attainment and expansion of UEH in many of the studied countries. It can improve UEH coverage through the following three points. Firstly, through the quality of life of patients with ocular as home self-monitoring devices and mobile Apps, Do It Yourself (DIY), were found to be user-friendly and cost-effective tools that are much needed now in the COVID-19 pandemic. Furthermore, the growing tremendous dependence on the use of the smartphones, portable medical devices, wearable technologies have been driving a technical revolution in the ophthalmic field as a part of the virtual medical practice era. Secondly, through improving quality of eye services via using EHRs in research and gathering data. Despite that using EHRs for collecting information for cataract surgical indicators still used now in narrow scope, which needed to be broadened to improve the quantity and quality of data as there is scarcity of reliable data related to indicators measuring the progress in Universal eye health. It is actually needed not only to link EHRs to the cataract indicators but also to link it to the other UEH indicators such as prevalence of DR and glaucoma to be able to assess countries' progress in their national eye plans especially in LMICs. eLearning of ophthalmologists, whether pre-service or in-service, was found very effective in improving their medical knowledge and skills. Using mobile phones for sharing images, videos and experiences between Ophthalmologists and SMS reminders for patients is widely accepted and used nowadays. Finally, there is a general agreement that portable screening devices and automated image analysis can facilitate the access to eye services via early detection and timely management of the DR screening process. Also, it helps in screening other ocular diseases as glaucoma, ARMD, and ROP. Moreover, Fundus photography and retinal diagnostics AI innovations, as part of various teleophthalmology techniques worldwide, have shown promise as point-of-care diagnostic devices. Teleophthalmology became, as we mentioned before in the results, the black horse of the eye field nowadays. Egypt is in the correct way to establish its position in Digital eye health. It only needs strong collaboration with countries which achieve an advance in Digital health as South Korea, Singapore, Thailand, USA and UK to share their experience with it in this new field to achieve universal digital eye health in the near future.

Recommendations

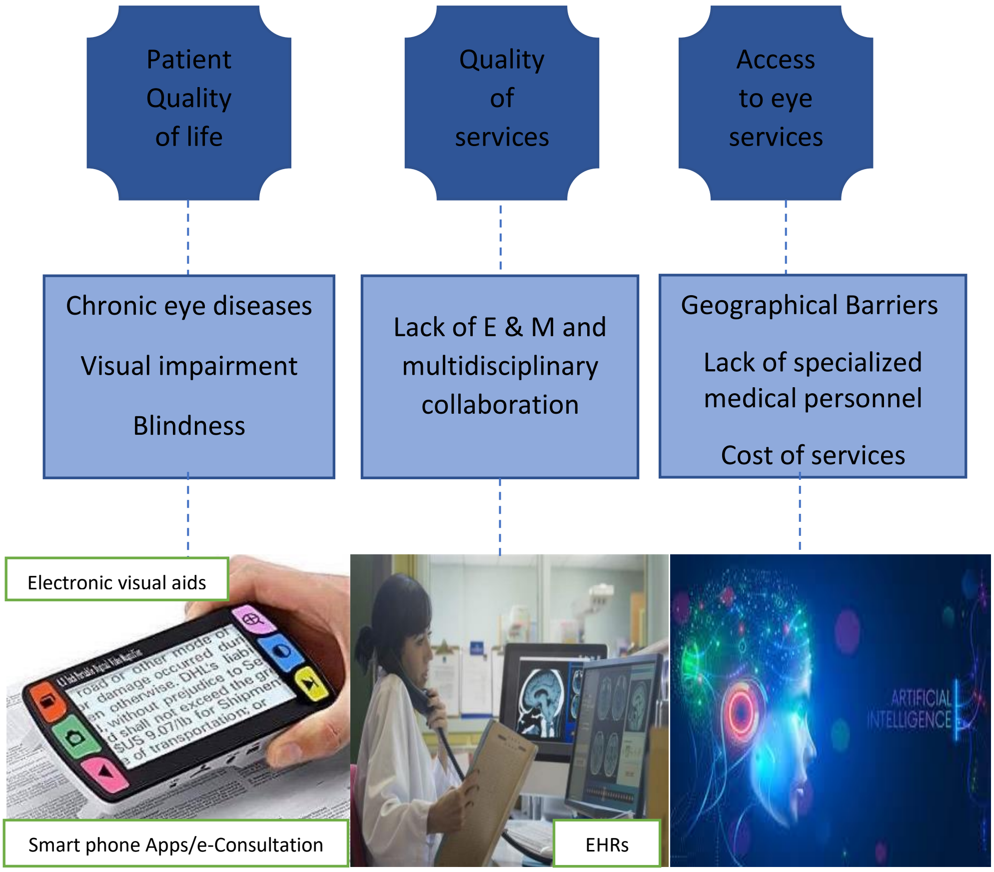
1. Establishing universally admitted guideline for reliability and security of digital eye data.
2. Establishing a national eye health database for UEH indicators as cataract surgical indicators and prevalence of eye diseases in each of LMICs with WHO and international partners supports to improve the monitoring of national eye plans, and linking EHRs to these databases.
3. Integrating teleophthalmology programs for cataract, DR screening in the national eye plans of LMICs by reallocating resources as the major causes of blindness.
4. Integrated people-centered eye care: patient engagement and education (online and offline) programs to reduce health illiteracy and improving patients' participation in the screening programs and regular eye monitoring for early detection of eye diseases.
5. Integrating eye health in national health plans in the developing countries is strongly recommended.
6. For Egypt, EHRs and teleophthalmology well-established programs are needed to be added to the Egyptian national eye plans, and developing a long-term collaborative protocol for sharing experience and data regarding digital eye health with advanced digital health countries are strongly recommended.

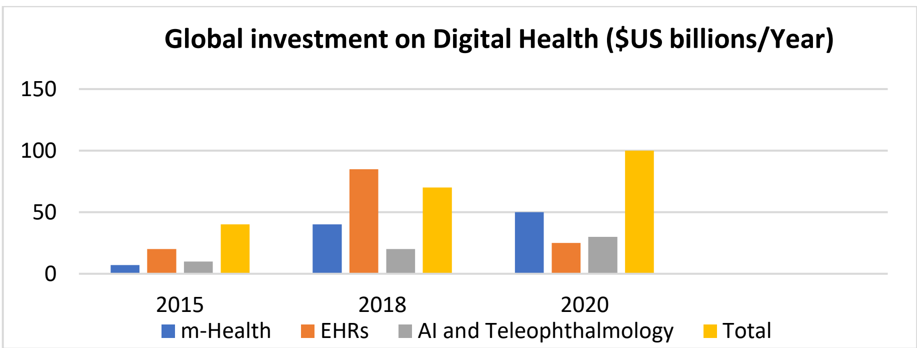
Appendix 1. Global efforts on prevention of blindness and Universal Eye Health (1960-2019)



Source: Action plan for the prevention of avoidable blindness 2009-2013 [23]

Appendix 2. Digital health effect on availability and accessibility of Universal eye health





Source: Cover US (2019) [151]

Table 16. Country's year of participation in WHO global survey on eHealth and eHealth policies

Digital health Indicators	Egypt [a]	Kenya [b]	India [C]
Year of participation in the WHO global survey on eHealth	Egypt participated in in the 2009 global survey on eHealth.	Kenya participated in in the 2015 global survey on eHealth.	India participated in the 2009 survey on eHealth and in 2013 survey based on the CoIA countries.
eHealth policies	**1.**National eGovernment and eHealth policy were partly implemented from 2006 **2.**National ICT procurement policy for health sector is also partly implemented. **3.**The Egyptian MOH has Informatin Communication Technology "ICT"plan for Healthcare from 2012 [d] . **4.**No national telemedicine policy is available until now. .	**1.**National Eye plan 2012-2018 and extended for 7 years. **2.**National eHealth policy or strategy from 2011. **3.**National health information system (HIS) policy or strategy. **4.**Health professionals In-service training in eHealth.	**1.**National eGovernment and eHealth policy, implemented 2006. **2.**National ICT health procurement policy, in 2006. **3.**ICT training for students at tertiary institutions. Also, health institutions offer in-service continuing education in medicine, Public health. **4.**National telemedicine policy, partly implemented with Formal evaluation and of telemedicine (2006).

Source: [a] WHO Global observatory for eHealth 2009 and [b] 2015, [c] WHO SEAR: India eHealth, [d] Torky (2012) [85][87][88][89]

Table 17. eHealth expenditures, legal and ethical framework

Digital Health Indicators	Egypt [a]	Kenya [b]	India [c]
eHealth expenditures and their funding source	Egypt is aiming to have 7.7 % of its GDP derived through Artificial Intelligence (AI) by 2030 [86]. Both major two Teleophthalmology initiatives; Noor El Hayat and Healthy Eyes are governmental funded. Egypt also fund ICT equipment, software, pilot IT health projects and scholarships for HCWs through GDP for health and donors ODA and public-private partnership funding.	Kenyan Government expenditure on healthcare is about 7% of GDP in 2018. Donors ODA and non-public funding are available for digital health application in Kenya.	Indian governmental expenditure on health per GDP is very low 3.6% according to UN data. Despite that the global observatory mentioned that there are public, private and public-private partnerships funding on ICT equipment, pilot projects, skills training related to the health sector. Also, Donors (ODA) funds are available for the development of health sector.

Source: [a] WHO Global observatory for eHealth 2009 and [b] 2015, [c] WHO SEAR: India eHealth, [85][87][88]

Table 17. eHealth expenditures, legal and ethical framework

Digital Health Indicators	Egypt [a]	Kenya [b]	India [c]
Legal and ethical frameworks for eHealth **Legal and ethical frameworks for eHealth**	**A. Legislation on patients' data** Health policy is available to protect personal data in EMRs. **B. Legislation for sharing health-related data between HCWs** through EMR within the same health care facility and between different health facilities within country. **C, Internet safety** Government sponsored initiatives about Internet safety and literacy **D. Quality assurance to health- Internet content** compliance of web site owners to internet regulations and continuous monitoring by NTRA	**A. Legislation on patients' data** Health policy is available to protect personal data in EMRs. **B. Internet safety** *****Governs civil registration and vital statistics. *****Governs national identification management systems.	**A. Legislation on patients' data** Health policy is available to protect personal data in EMRs. **B. Internet safety** *****Governs civil registration and vital statistics. *****Governs national identification management systems.

Source: [a] WHO Global observatory for eHealth 2009 and [b] 2015, [c] WHO SEAR: India eHealth [85][87][88]

Table 20. Category of outcomes and its keywords

Category of outcomes and its keywords	Keywords no. of times mentioned and citations
(1) Quality of life (n=11, 29.7 %)	
1. Electronic low vision aids	**3** (113,114,115)
2. Smart phone Apps	**5** (116,117,118,119,120)
3. Home Self-monitoring Apps	**2** (119,121)
4. Barriers of using digital health approaches	**3** (116,118,122)
5. Accuracy, reliability and security of mobile Apps	**5** (116,118,120,121,123)
6. Smart devices use as cost effective/user-friendly tools.	**4** (113,118,121,123)
7. Direct mention of importance of digital health Apps to improve quality of patients' life and satisfaction	**2** (119,121)
(2) Quality of services (n= 8, 62.6%)	
1. EHRs	**4** (117,120,124,137)
2. SMS as patients' reminders and its benefit/risk ratio	**3** (33,126,127)
3. Telecommunication between HCWs	**1** (128)
4. eLearning (ophthalmologists) pre-and in-service	**2** (129,130)
(3) Access to the eye services (n= 18, 48.6 %); 5 articles about AI (13.5 %) and 13 about Teleophthalmology (37.8%)	
1. Deep and Machine Learning use in Ophthalmology	**3** (131,132,133)
2. Teleophthalmology is not substitute to face to face eye exam but appropriate timely access to eye care	**2** (136,142)
3. Many countries have included digital fundus photography in national and workflow screening	**2** (145,146)
4. Barriers of application of AI based fundus photography, screening and teleophthalmology	**2** (146,148)
5. Patient satisfaction about Teleophthalmology	**2** (138,148)
6. Using Teleophthalmology as cost effective and user-friendly access tools for screening of DR and others	**5** (135,137,138,142,145)
7. A lot of countries started applying Teleophthalmology screening program of DR and other retinal diseases	**3** (138,144,146)

Table 21. Classification of articles that fall under outcome variable (Quality of life)

Paper First Author/Year	Country/ Region	Intervention	Outcomes of the study
Moshtael et al., 2015 [113]	UK	low vision aids	Electronic vision aids have potential for progress by work multidisciplinary.
Bittner et al, 2020 [114]	USA	Telerehabilitation	Studies indicated the potential benefit and feasibility but not the efficacy of telerehabilitation for low vision.
Virgili et al., 2018 [115]	Italy	low vision aids	Insufficient evidence that a specific type of electronic devices allows faster reading speeds than others however training usually improve it.
Karthikeyan et al., 2019 [116]	India	Smart phones Apps	-Described the Categories of smart phone ophthalmic Apps and target audiences. -Barriers and accuracy and reliability
Zvornicanin et al., 2014 [117]	Bosnia and Herzegovina	Smart phones	Described the uses of the smart phone ophthalmic Apps and its ability to be used to fill the EHRs.
Majumder et al.,2014 [118]	Canada	Smart phones sensors	-Monitoring eye health by the smartphone sensors can be sent over the internet to a remote healthcare facility for detailed investigation and its barriers of useage.

Table 21. Classification of articles that fall under outcome variable (Quality of life)

Paper First Author/Year	Country/ Region	Intervention	Outcomes of the study
Paudel, 2018 [119]	Nepal	Smart phones Apps	-Smart phones Apps for VA assessment in Amblyopia. -Accuracy and reliability concerns.
De la Torre-Díez et al., 2015 [120]	Spain	Decision support system smart phones	Main focus of systems now is on posterior eye pole especially DR early diagnosis with possibility to connect it to EHRs/cloud.
Yeung et al., 2019 [121]	UK	Self-testing Apps	-eHealth vision tools have potential to meet a growing vision impairment in LMICs. -Accuracy/ reliability of most has not been established.
Wildenbos et al.,2018 [122]	Netherlands	Aging barriers	Effective and satisfactory use of mHealth by elderly is complicated by physical and perceptual barriers.
Shahbaz et al.,2020 [123]	Italy	Smartphone laws	The importance of establishment of global teleophthalmology society from both technology, ophthalmology fields and ethical principles.

Table 22. Classification of articles that fall under outcome variable (Quality of eye services)

Paper First Author/Year	Country/ Region	Intervention	Outcomes of the study
Tan et al., 2019 [124]	Australia	EHRs	Multiple uses of EHRs.
Ramke et al.,2017 [33]	NewZealand	Digital health improving cataract surgical services	SMS reminders could be used to evaluate surgical patient symptoms postoperatively as in post-operative cataract care in LMICs.
Madi, 2018 [125]	South Africa	mHealth impact on 3 ophthalmic diseases	SMS reminders could be used as a cost-effective monitor tool in cataract, glaucoma and DR.
Schwebel et al.,2018 [126]	USA	SMS Reminders	Benefit/risk ratio of using SMS as reminders of patients.
Lu et al.,2018 [127]	USA	SMS and smartphone Apps Reminders of surgical patients	By utilizing patient's own technological resources, m-health engages the patient in their own healthcare.
Gonçalves-Bradley et al., 2020 [128]	UK	Mobile technologies and health providers	Health professionals often use mobile phones to share clinical information.
Tang et al., 2020 [129]	Canada	Medical eLearning	eLearning for Ophthalmologists preservice and in-service was founded to increase their knowledge and skills and they show satisfaction of it.
Yang et al., 2020 [130]	China	Smart phone Apps for Ophthalmologists	Types of online medical and surgical educational Apps for the Ophthalmologists

Table 23. Classification of articles that fall under outcome variable (Access to eye services)

Paper First Author/Year	Country/ Region	Intervention	Outcomes of the study
Balyen et al., 2019 [131]	Turkey, UK	AI, ML, DL	-Usage in diagnosis/ treatment of DR, ARMD, ROP. -Accuracy, reliability, sensitivity and specificity (S&S) concerns.
Tong et al., 2020 [132]	China	ML in Ophthalmology	-Usage in diagnosis/ treatment of DR, ARMD, ROP. -Accuracy, reliability, and (S&S) concerns.
Ting et al., 2018 [133]	Singapore	AI, DL	-Usage in diagnosis/ treatment of DR, ARMD, ROP. -Accuracy, reliability, and (S&S) concerns
Mudie et al., 2017 [134]	USA	Automated retinal analysis	Demonstrated two new retinal imaging techniques; Crowdsourcing and Automated Retinal image Analysis (ARIA).
Panwar et al, 2016 [135]	Singapore, UK, India	Fundus photography in 21 th century	Demonstrated some apps designed for screening of fundus abnormalities based on AI–driven algorithms as a cost-effective tool.
Grisolia et al., 2017 [136]	USA, Brazil, China	Teleophthalmology	-Mentioned the uses and types of Teleophthalmology. -Use of Teleophthalmology as timely access to the eye services not substitute to face to face eye exam.
DeBuc, 2016 [137]	USA	Retinal imaging	-Mentioned the uses and types of Teleophthalmology. -Accuracy, reliability, and (S&S) concerns.

Table 23. Classification of articles that fall under outcome variable (Access to eye services)

Paper First Author/Year	Country/ Region	Intervention	Outcomes of the study
Salongcay et al.,2018 [138]	Philippines, USA	*Teleophthalmology and DR*	-Black horse in screening DR in rural areas -Accuracy, reliability, and (S&S) concerns. -Cost-effective user-friendly tool of DR screening. -Mentioned high patient satisfaction regarding Teleophthalmology.
Whited et al.,2006 [139]	USA	Teleophthalmology DR	-Accuracy, reliability, and (S&S) concerns.
Thomas et al.,2014 [140]	Canada	Tele-glaucoma	Tele-glaucoma use and (S&S).
Ignacio et al., 2018 [141]	Spain, UK	Glaucoma screening	-Sensors and wireless devices, present as promising tools that enable continuous monitoring of IOP for glaucoma monitoring and transmit it from home to remote sites. -Big data showed amazing model of service delivery to identify trends and predict future risks to vision.
Chan-Ling et al.,2018 [142]	Australia, USA, NewZealand	ROP screening	-Use of teleophthalmology in ROP diagnosis in remote areas. -Use of Teleophthalmology as timely access cost-effective and user friendly to the eye services not substitute to face to face eye exam.

Table 23. Classification of articles that fall under outcome variable (Access to eye services)

Paper First Author/Year	Country/ Region	Intervention	Outcomes of the study
Kanagasingam et al.,2014 [143]	Australia, USA	Retinal imaging in ARMD	-Use of teleophthalmology in ARMD diagnosis in remote areas
Li et al., 2020 [144]	UK, China, South Korea, USA, Japan, Hong Kong, Singapore	Teleophthalmology, AI review; global perspective	Use of teleophthalmology in diagnosis of DR, ARMD, and glaucoma in different countries.
Bolster et al., 2015 [145]	UK	DR screening workflow (access to eye services)	-Use of teleophthalmology in workflow screening programs of eye care. -Illustrated Teleophthalmology as cost-effective user-friendly tool in retinal (DR) screening.
Yoon et al., 2019 [146]	South Korea	Teleophthalmology in LMICs	-Use of teleophthalmology as a user-friendly tool in national eye screening program in LMICs. -Barriers of application.
Chua et al., 2018 [147]	Singapore, Ireland	DR in Asia Pacific	-Demonstrated which Countries in Asia Pacific have national eye guidelines. -Barriers of application.
Sreelatha et al., 2016 [148]	India	Teleophthalmology patient outcomes	Illustrated high patient satisfaction of Teleophthalmology.

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국문요약

배경: 안구 건강에 대한 다양한 글로벌 공중 보건 부문의 적극적인 노력에도 불구하고. 현재 사용할 수 있지만 아직 모든 사람이 사용할 수있는 것은 아닙니다. 여기에서 안구 건강 서비스 제공의 사회적 불평등을 줄이고 안과 진료 서비스 범위를 개선하기 위해 보편적 안구 건강 개발에 대한 요구가 나타났습니다. 모바일 건강은 오늘날 건강 관리 전달의 중요한 영역이되었습니다. 이 연구는 보편적 인 안구 건강의 가용성과 접근성과이를 개선하는 추가 요소로서 디지털 건강의 역할을 연구하는 것을 목표로합니다.

방법: 이것은 관찰 후 연구입니다. 저소득 국가의 디지털 안구 건강 현황에 대한 심층 연구에 사용 된 2 가지 방법 다른 세계 보건기구 지역에서 연구 된 국가의 국가 프로필 및 체계적인 분석. 문헌은 세 개의 검색 엔진에서 검색되었습니다. 리뷰 기사의 개요는 환자, 개입, 비교 및 결과 프레임 워크를 사용하여 수행되었습니다. 검색 키워드는 "모바일 건강", "스마트 건강", "눈 건강", "백내장"등입니다. 당사의 37 개 간행물은 세 가지 예상 결과 범주와 관련하여 적합한 것으로 확인되었습니다.

결과: 디지털 건강은 연구 대상 국가에서 보편적 인 안구 건강을 달성하는 데 중요한 요소로 밝혀졌습니다. 디지털 건강의 효과를 나타내는 결과의 세 가지 범주는 안구 질환 환자의 삶의 질, 안구 건강 서비스의 질 및 안구 건강 서비스에 대한 접근이라는 안구 건강 시스템 개선에 도움이되는 체계적인 분석에서 발견되었습니다. 이러한 결과가 이집트의 디지털 안구 건강에 미치는 영향도 확인되었습니다.

결론: 디지털 건강은 많은 연구 국가에서 보편적 인 안구 건강의 달성과 확장에 중요한 추가 요소로 부상했습니다. 휴대용 스크리닝 장치, 안저 영상 및 망막 진단 AI 혁신과 모바일 안과는 오늘날 눈 분야에서 흑마가되었지만 이러한 기술이 필요한 많은 국가에서 여전히 사용이 제한적입니다. 백내장 수술 지표에 대한 연구 및 데이터 수집을위한 전자 건강 기록의 사용은 확장이 필요한 매우 좁은 범위에서도 여전히 사용되고 있으며, 국가에 대한 실제 평가를 할 수 있도록 UEH 지표를 모니터링하는 것이 매우 필요하기 때문입니다. '국가 안구 계획의 진전과 특히 저소득 국가에서 안과 서비스 및 환자 생활의 접근성과 질을 개선합니다.**핵심 단어: 보편적 인 안구 건강, 백내장, 당뇨병 성 망막증, 망막 진단 및 디지털 건강.**