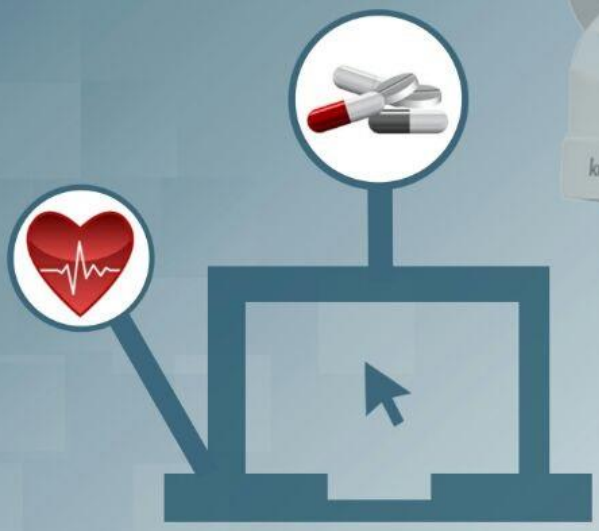
HARNESSING TECHNOLOGY FOR HEALTHCARE IMPROVEMENT



Walter Moyo

AUTHOR'S PROFILE

Walter Francisco Moyo was born on September 9, 1993 in Lilongwe, Malawi. This is his first publication.

In high school in 2009, he won a gold medal in the Malawi National Schools Science Fair for a chemistry project. Walter later studied Bachelor of Science in Nursing & Midwifery at the University of Malawi. However, he became dissatisfied with the Nursing profession after he realised that it did not match with his personal aspirations and style of thinking. He decided to switch to Public Health, and this book was developed during his pursuit of a Master of Science degree in Public Health. He chose Public Health due to its wide perspectives regarding health, and also that it doesn't involve hospital work. Walter realised that his passion is in science and technology, not in traditional (hospital-based) healthcare. He envisions a PhD in Epidemiology (a branch of Public Health), which he would like to use as a pathway into a career as a scientific researcher.

Apart from the 2009 award, Walter also won 2 other innovation awards: the Smart Challenge Innovation Award (2016) from Telekom Networks Malawi and the ICT Association of Malawi Innovation Award (2016) in the category of healthcare. He has also attended various international forums both within Africa and overseas.

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DEDICATION

“To all people who are part of my life”.

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PREFACE

The world is changing. Its population is increasing at an alarming rate. Scientific and technological discoveries and inventions are increasing in frequency and pace. International travel is much more frequent than ever. Civilization is at its helm. These changes are exerting a numerous effects on human health- both negative and positive.

Global travel has contributed to the spread of diseases across the world, but it has also allowed scientists to explore spatial determinants and patterns of disease across different lands. It has also allowed health and Public Health professionals to render services to remote areas. Scientific and technological milestones have intensified industrial activity, which has led to the rise of acute and chronic health problems. Some of these health problems occur directly (such as through the dispersion of inhalable toxic industrial pollutants) while others are indirect (such as through the rapidly changing climate as a result of industrial activity), which has repercussions on human health. Despite this, the same scientific and technological endeavors have contributed to the improvement of peoples' health and well-being. This can be seen in improved diagnostic and treatment techniques, and life-enhancing aids such as artificial/ prosthetic organs.

For most communicable diseases, they have either been eliminated or their treatments have been found. Only a handful of communicable diseases with no cure or vaccine, remains (this statement, of course, is made without overlooking the epidemic of drug-resistant microorganisms, which is slowly emerging and baffling scientists). On the other hand, a surge in non-communicable diseases in both developed and developing worlds is causing concern in the Public Health circles.

Whether or not we are making progress in healthcare in general as humankind on the colossal scale depends on the side of the spectrum one wishes to view these events in the light of. One fact that cannot be denied, though, is that science and technology will continue to blossom and to strive to work around these problems. This also means that healthcare will further continue to experience enhancements.

Science, Technology, Engineering & Mathematics (STEM) are often categorized as one constellation. There is a direct relationship between STEM and healthcare/ Public Health. The

role of medical science in improving the lives of human beings is unquestionable and dates back to antiquity. The same applies to technology, despite that many developments which were considered ground-breaking in healthcare circles in the past few centuries can hardly be marveled at in our times. This very statement shows that technology in healthcare is very fluid.

Engineering has for so long been dissociated from healthcare, at least by the neutral observer. But the case is continually changing, with Biomedical Engineering (which concerns itself with the application of engineering principles to biological, bionic and biohybrid materials) emerging as a subspecialty of engineering. Biomedical Engineering goes beyond simply engineering electronic medical devices. It extends its focus to human tissues and organs as well. Environmental Engineering, a sister-field to the profession of Environmental Health, has also come afore.

Mathematics also has an important bearing on healthcare. Since primitive times, humans have performed censuses and other related activities in attempts to measure/ record cases of illnesses and track health and demographic indicators among their populations. Biostatistics, a mathematical field, has gained recognition as a fundamental Public Health science. It is not only significant in quantifying disease occurrence in populations, but it can also go as far as developing models for predicting and analyzing patterns of epidemics in populations. Again, of key importance is the fact that individual disease experiences such as pain are difficult to quantify. Here, mathematical applications come in again, as can be seen from objective, utility-based measures of "quality of life following illness/ treatment", which Public Health scholars have devised.

A lot can be said about the relationship between STEM and healthcare. In brief, STEM is responsible for numerous unprecedented milestones in the attempt to curtail pressing health problems.

This treatise seeks to explore the existing relationship between healthcare and technology. ICT is emphasized since the "Internet of Things" idea (which considers all devices as potentially having a place in the ICT world) is prominent in this age. The book briefly looks at historical underpinnings to technological improvements in healthcare in the past years. It then covers concepts such as Artificial Intelligence (AI), *gamification* of health messages, Health 2.0 and the

"Open" movement, relevance and irrelevance in health-related technological innovations, and more.

It is not the intention of the book to make this content technical, nor to be used by any particular profession. However, it may be used for both academic and non-academic purposes. This book has been written between August 2016 and February 2017. In part, I have written it in an autobiographical nature, based on my experiences at various innovation-related events in Malawi, South Africa and the United States. My participation in these events and my journey as a fledgling healthcare-innovator ignited in me a sense of stimulation to share not only what I experienced, but also what I drew from those experiences.

As regards technology in healthcare, one of the issues worth analyzing is how well it is welcomed and considered part and parcel of contemporary healthcare practice.

It is important for me to clarify that this book does not intend to *recommend* any healthcare technologies to be adopted in Malawi. Its purpose is to make two arguments namely: i) New technologies that are capable of further enhancing healthcare are abundant ii) Although some of these technologies have infiltrated healthcare, the Malawian health sector has not fully tapped into these technological resources at our disposal. We can still benefit much more from them. Since everyone at some point becomes a consumer of healthcare, there are no limitations to who ought to read this book. This book may therefore be used by ICT professionals, healthcare professionals, academicians from various fields, policymakers and even the general public!

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INTRODUCTION

Dr. Richard Kamwezi, my friend and at the time of publication of this book, an intern physician at Queen Elizabeth Central Hospital, said and I quote: "The adequate provision of health needs brings in the need for research in order to improve diagnostic and therapeutic methods. Such strides cannot be taken without new technologies, ICT or otherwise. Outside health research, information about health needs to be shared and technology has a very big role in the sharing of such and thus in the improvement of the health status of people. In other words, information and communication technology has an important and inevitable role in health and as people in the health sector we, need to embrace and integrate this technology into our systems". End of quote.

From these views, the following points are apparent: i) Technology has a vital role in health service delivery ii) ICT is at the core of those technologies of importance to healthcare (just as it is in most technologies of importance to other fields too) and iii) Healthcare workers need to concern themselves with issues of technology.

Technology is at the center of world civilization today. It characterizes every aspect of modern civilization- from education to agriculture to military operations to sustenance of personal relationships to healthcare. Surely technology has never had more significance to humankind. With each passing day, this becomes truer.

The word "technology" itself denotes a wide spectrum of tools and practices/ processes. Yet in the minds of many, technology is synonymous with ICT. It is not accurate to conceptualize technology as solely denoting ICT, yet it is not unreasonable to view ICT as the engine of modern-day technology. ICT is at its zenith today. Most technological advancements of this era would be virtually impossible without ICT. In the present day, almost all technologies (including health-related ones) are being designed and re-designed to have ICT components. In many hospitals, digital thermometers have replaced mercury thermometers. Digital blood-pressure measuring machines (sphygmomanometers) are much more efficient and accurate than analog ones. Digital x-ray machines have also been developed, which are time-efficient, enable digital transfer of images and produce less radiation. Digital scales for weighing newborns are now preferred to analog ones, as they show weights to two decimal places (hence they have more accuracy). The list of digital devices which have replaced or are replacing conventional analog

devices can go on and on. All these display information digitally, and that is where ICT comes in despite that the devices are not traditionally designed to function as communication devices, for which ICT is typically known. The point here is that when we think of ICT we usually think of computers, smartphones and other computer accessories like printers. But ICT also plays a huge role in other technologies, like we have just seen. The concept of *"Internet of Things"* (IoT) further cements the prominence of ICT in health and in daily life. This is why this book focuses more on ICT, although it is meant to discuss the role of technology in general in healthcare.

Innovators are upbeat that ICT can still play even more roles in modern day healthcare. In the sphere of healthcare, devices like blood sugar monitors, heart monitors and fetal monitors can be connected to the internet through IoT. This can ensure that valuable patient data is delivered to physicians, and treatments initiated remotely or automatically where necessary- reducing the need for direct interaction between physicians and patients. Of course this raises concerns around data privacy and security, but such discussions are deeper than what this book intends to cover.

Currently, IoT is only minimally used in Malawian healthcare circles, but this is changing although the progress is slow. What is considered high-tech at the moment might not be considered such in 50 years' time, just as what were groundbreaking technologies of the 70s and 80s are no longer considered marvelous today. Therefore, it is imperative to provide reference to time when discussing technologies.

Another fact worth remembering is that having an array of technological arsenal at our disposal is not enough. The essential thing is to *embrace* that technology. As earlier said, a lot of technologies exist today that would make our healthcare work more efficient, yet they are still not widely used in our country. Our under-developed technological infrastructure is partly to blame, but the problem goes beyond that. These issues also have deep roots which germinate from political factors, mentality factors and other multifactorial factors. Dr. Eric Topol, author of "The Creative Destruction of Medicine" argues in his book that while technology has been leveraged substantially in other sectors, that has not been the case in healthcare. Healthcare has remained relatively rigid. This also appears to be the case in Malawi. We have already seen that healthcare has changed to accommodate new, efficient and technologically advanced tools and methods. However, we are not using technology in healthcare maximally- at least if we look at the existence of some technologies which are affordable yet we aren't using them. It necessitates

complete mindset- changes among Malawian consumers of healthcare, healthcare administrators, healthcare professionals, policymakers and others.

Advancements in technology do not represent instant breakthroughs in healthcare. We must constantly rethink on how best we can tap into these resources. Are we ready to take advantage of this technological revolution? All of us as consumers of healthcare must constantly ask ourselves this question.

Chapter 1: Technology and the Health Professions over the Years

"Indeed, technology is changing the world at warp speed and nowhere is this more evident than in healthcare settings"- Carol Huston.

Healthcare practice dates back to millennia. Technology in general was not rampant back in the day, and thus healthcare services were also not technologized. In various civilisations, medicine-men provided treatments to sick people. Their practices were based on mysticism and other acts and beliefs which are not recognized as being in the domain of today's modern medicine. This also occurred in ancient kingdoms and tribes in the land which today is called Malawi. Here, people were living in tribes and many cults were existent, which formed the basis of medicinal practices not grounded in scientific understanding. Stories passed down traditionally discuss figures like *M'bona*, who allegedly possessed mysterious powers, including powers to heal.

Elsewhere, as time passed, physicians saw the need to offer more effective treatments, and therefore sought out to devise more efficient methods of carrying out their practices. Of particular interest is the Greek civilization, from which great thinkers such as Aristotle and, more notably, Hippocrates emerged with ideas to serve as explanations for the causes of disease. Although these great thinkers advocated more rational approaches to explaining diseases, their craft was far less mechanized, thanks to the low if not absent technology levels of the day.

Centuries later, the industrial revolution in Europe played an indispensable role in the mechanization of healthcare. Of course not every medical innovation was developed by medical practitioners. Engineers and other inventors also deserve applause. Their wild imaginations led to different innovations which produced all kinds of tools for use in medical circles. Over the years, some of these have been discarded or improved, while others are still in use. The following are brief accounts of historical developments which have characterized some of the most commonly-recognized health professions. It is worth noting that many of the innovations overlap these different fields. An innovation that might be useful to a medical laboratory scientist might also fall under the category of innovations of importance in the field of paramedics… and so forth.

The following accounts are not intended to be rigid, detailed, specific or comprehensive. There is a lot that happened which will not be discussed here. Additionally, since technologies are developed on daily basis, some of those described here may be losing popularity already. The historical account of the transformations in these professions will take a scope which peers beyond Malawi. For the obvious reason that the developments in these disciplines were not

produced in Malawi, we cannot exclusively look at the developments from the Malawian setting. That way there would be very little or nothing to write about.

Dentistry

This is one of the oldest medical professions, having emerged 7000 years ago. According to American Dental Association, as early as 300 BC, philosophers Aristotle and Hippocrates had already written about dentistry, including extracting teeth with instruments and stabilizing loose teeth with wires! However, proper scientific explanations for dental diseases only emerged in the 18th century. Previously, dental diseases were believed to be caused by "tooth worms". It was in this same century that Pierre Fauchard introduced the idea of dental fillings. In 1790, John Greenwood developed the "dental foot engine", which was basically a device for drilling through teeth using energy generated from a pedal. Today, modern dental drills are powered by turbines and are more than 100 times faster ("high speed dentistry" is said to have begun in 1957, where the first hand-piece was developed, which could reach 300, 000 rotations per minute).

The 19th century was crucial to the field of dentistry. It is in this century where technologies were developed for producing porcelain teeth. Tooth brushes were also mass-produced in this century, and it is also in the same century when X-ray was first used on teeth.

The 20th century was equally important to the field of dentistry. It was characterized by the use of dental screw implants following the development of metals compatible with human tissue. Nylon toothbrushes, the first toothbrushes with synthetic bristles, also appeared in this century. Later in 1958, a fully-reclining dental chair was invented, allowing dentists to position their patients comfortably. Lasers (which deliver energy for cutting or bonding, in form of light) and electric toothbrushes were developed in 1960 and 1961 respectively. It took up to 1997 for lasers to get approved for treatment of many other dental problems. Electric toothbrushes also flourished from the 90s. Today, although some think that electric toothbrushes do not make much difference, the opposite is the case. Electric toothbrushes have been proven to be more effective at cleaning teeth. They are also easier to use, and therefore are ideal for improving oral hygiene in children. They may also have timers which stop the toothbrush after a period of 2

minutes, the recommended time for brushing teeth. Therefore, one does not have to "guess" that two minutes is up when they are brushing teeth.

The Malawian public healthcare sector has got health centers, community hospitals, district hospitals and central hospitals. This arrangement is from the smallest to the largest institution type. Dental services are typically provided at the district and central hospital levels. Most of the service-providers are dental technicians, who have entry-level qualifications such as diplomas obtained from Malawi College of Health Sciences. Few dentists exist, mostly at the central hospital levels. Many of them are trained abroad, as there is no school which trains dentists in the country. Other dentists who exist in Malawi are in private practice. The central hospitals and some big private dental facilities now have the technological resources for performing a good number of dental procedures.

General Medicine

Before delving into depths of the actual technological milestones in "internal medicine", it is necessary to point out a few things. First of all, "internal medicine" is a specialty which has got further subspecialties under it (such as cardiology and nephrology). Therefore, it is difficult to come up with an exhaustive account of the most notable technologies in this branch of medicine. Secondly, it is worth mentioning that when we talk about improving healthcare in a country, the training of healthcare workers cannot be left out from such discussions. One of the indicators of a good health system is the number of healthcare service providers, measured against its population. The doctor-to-patient ratio, along with other indices, are frequently used.

Since it is crucial to have enough (or many) healthcare workers, then it is also crucial to invest in the education/ training thereof. Malawi has got only one medical college. The Malawi College of Medicine opened its doors in 1991, which marked an important milestone in the country's healthcare system. This college is fairly reasonably-equipped with modern, specialized labs and other resources. Over the years Malawi has mainly relied on "clinical officers" from the few colleges of health sciences to fill the void of physicians. Clinical officers are very helpful, but

their cadre is not recognized internationally. I once caused a stir on some social media group when I suggested that besides the internationally-recognized doctor-to-patient ratio, the few countries which resort to clinical officers to alleviate their shortages of doctors- like Malawi and Ethiopia- ought to have a special indicator dubbed clinician-to-patient ratio. The basis of my argument was that doctor-to-patient ratio is quite misleading. Think about this: clinical officers are more in number in Malawi than physicians. The doctor-to-patient ratio is 1: 60, 000. I agree that this is sad. However it is a misleading statistic. It is misleading because once someone sees this statistic, they would be inclined to assume that every 60, 000 patients are seen by one person. But that is not the case, since the more numerous clinical officers attend to the bulk of those patients. With experience, they function as well as doctors, without necessarily being supervised.

Now back to the main topic. Malawi has an unfulfilled need for doctors. It may be the right time to start thinking of how more of these professionals can be trained. Conventional methods have proven expensive and ineffective. Can technology play a role in improving the situation? In countries like Sweden and Australia, they have some medical specialization programs that are conducted through distance learning, using effective e-learning materials. I believe that distance education is necessary and effective. However, I did not perceive it being used to train medical practitioners, until I read about those Swedish and Australian institutions which use it.

The fact that medical specialties are full of practical skills initially made me think distance education can be ineffective in training medical practitioners. It is now proven that those countries are using it without problems. If necessary, it can be combined with face-to-face learning, collectively making what is known as "blended learning". It could be designed in such a way that the learners grasp the theoretical part through online learning, and go for face-to-face sessions in groups for the practical components. This can eliminate some of the many costs associated with physically accommodating all the learners at the same time. I have also observed that those countries that are implementing it are doing so in training medical specialists (doctors who have already qualified as generalists, but want to specialize in a specific area). This reduces any instances of them not being responsible for their own learning due to naivety, which would probably be the case if this were to be implemented for undergraduate medical training. It is clear that older students are more focused and self-reliant. Finally, the issue of quality usually

comes into discussion whenever distance/ online learning is discussed. The fact that the universities pioneering such initiatives are far more highly ranked than Malawian institutions, more than proves that they are able to balance quality with efficiency. In short, it is very practical to use e-learning and blended learning in training medical specialists. Perhaps it can allow Malawi to train more medical practitioners (primarily specialists), and maybe it is time to start exploring it. In fact, these thoughts were echoed by Weiss (2015) who advised that in developing countries with critical shortage of health workers, distance education powered by effective e-learning tools, is needed to train large numbers of health workers.

Let us drift away from health-worker training and look at medical practice. Regarding the role of technology in the practice of general medicine in Malawi, it has been a slow experience. Most health centers and district hospitals have experienced little progress, but at the central hospital level, new machinery for performing advanced tests have been installed over the years. In 2016, Kamuzu Central Hospital got a donation of a completely new intensive-care unit, complete with modern monitoring equipment. Many other modern installations such as modern dialysis equipment have also been set up, and this has improved medical practices there. The three other central hospitals have also had upgrades on a fairly regular basis.

Surgery

Surgery is another important field. Innovative technological approaches to improve the practice of surgery, are not a new phenomenon. According to Riskin et al (2006), Surgical Innovation has long existed, although as a distinct field of study it is relatively new. 'Surgical Innovation Centers' (primarily in the developed countries) are working to define the field and identify critical aspects of the promotion of Surgical.

Surgery is one of the oldest fields and it has a rich tradition. Hippocrates in the 4th century BC, made some contributions to this field. He described the first rectal speculum (a device for viewing the rectal canal). This led to the development of other speculums such as the pelvic

speculum. In 1805, Phillip Bozzini invented an apparatus for visualizing the bladder and rectum using candlelight reflected off a mirror. Other innovators later improved this development and now visualization technoques are much more advancei.

In the modern day, "keyhole surgery" has gained popularity. This is surgery whereby a very small incision is made, through which a tubular viewing device can be inserted for viewing inside. It is no longer always necessary to perform large incisions during surgery, which can leave large scars, delay recovery and increase risks of post-operative pain and infection. Furthermore, technology has allowed for development of techniques which can tremendously reduce blood loss during surgery. In addition, technology has made it possible for surgeons to perform a range of cosmetic surgical procedures that were deemed impossible 10-20 years ago. Although there have been improvements in the capacity for surgery in Malawi, not everything mentioned here is done in Malawi. Many specialized and major surgical operations, such as neurological ones, are hardly performed in Malawi. One of the proposed plans to improve the practice of surgery in Malawi is the proposed expansion of the Dae Yang Luke hospital, a hospital constructed by Korean philanthropists. This would allow the facility to have the capacity to perform some of the advanced surgeries for which at the moment people are sent to India or South Africa. The plans for this expansion were announced few years ago, yet still in the pipeline at the time of publication of this book.

Public Health

From the definition of Public Health, it encompasses many areas of health-related issues. For this reason it is difficult to come up with an account of technological advancements that are exclusively relevant to Public Health as a profession. In fact, most of the issues that concern the rest of the health-related professions can be categorized under Public Health. Public Health only differs from other fields in that it takes a population-focused approach and deals primarily with such issues as prevention and program-planning, as opposed to treatment and direct service-provision on the ground (such as prescribing as performed by physicians). Otherwise, it is not an isolated field.

The development of new surgical techniques is not only within the domain of the surgeon, but also the Public Health worker (since he is concerned with efficiency in health service provision to people). Likewise, new pregnancy-monitoring techniques and devices do not only concern midwives and obstetricians, but also Public Health practitioners and scholars alike. This very statement makes me reminisce some clarifications that I used to make to people when I indulged in maternal health innovations. I used to like to point out to them that I did this from a Public Health perspective, not a midwifery perspective (in the grand scheme of things, of course this is not very important).

Although it is difficult to exhaust innovations of relevance to Public Health, we can still make an attempt at that. Epidemiology is one of the core subjects in Public Health. While various Public Health academic programs vary in content, all scholars in this field are taught some epidemiology. Therefore, it is fair to say that the technologies of relevance to epidemiology can also be said to be technologies of relevance to Public Health.

Epidemiology is a discipline in which surveillance is core. Many surveillance systems have depended on technological modalities for improvement. According to Kant & Krishnan (2010), the World Health Organization made it mandatory for member states to develop and maintain capacities to respond to potential Public Health Emergencies of International Concern (PHEIC). Modernized communication systems play integral roles in this function. These fall into different categories of ICT tools, not just one tool. They include messaging systems, web portals and much more. Of particular significance is the usefulness of social media outlets during crises. Facebook for instance, set up a temporary function to enable users located in crisis-affected areas to provide information on their safety and wellbeing. A recent example is whereby users could "mark" themselves safe during and following the aftermath of Hurricane Matthew, a disaster which devastated Haiti and a few parts of the USA in 2016. This was a way of allowing people to convey information to others regarding their safety, and it had implications on the dispatching of medical search-and-rescue teams.

In India, an epidemiological surveillance program involved the building of various broadband infrastructure for communicating messages about infectious diseases. Call centers were also built, where people could call to alert officials about different disease outbreaks.

In Malawi, the widespread recognition of Public Health as a distinct field has mostly occurred in this decade. It is still ongoing. Health Surveillance Assistants (HSAs) collect important data at the community level. There is need to technologize the operations of these workers by providing them with electronic devices for data-collection. Typically, they collect data manually. There are some organizations that have attempted to pilot the provision of gadgets to HSAs for data-collection and communication of issues. However, this is in its infancy and there is need to adopt this on a bigger scale. This practice possesses potential to improve Public Health, and we will see how in a later chapter.

Athletic Training

Athletic Training (AT) is identified as an allied healthcare profession. In Malawi, it is not a widely recognized profession. Most of the health staff who treat athletes in Malawi are general medical practitioners.

The National Athletic Trainers Association of America defines athletic trainers as highly qualified, multi-skilled healthcare professionals who work in collaboration with physicians to provide preventive and treatment services. While their primary focus is athletes, ATs can also work in other types of settings which do not involve dealing with athletes. In this respect they optimize the activity and participation of patients and clients.

There are some notable technologies that have sprung up in this field. The Australian Institute of Sport is credited with developing a small tracking device that is helpful in optimizing the health and performance of athletes (Steinbach 2013). It fits onto the back of a jersey, employing GPS systems, magnetometers and accelerometers to provide data about what is happening to the athlete. The acceleration, deceleration, jumps and other parameters of an athlete's performance are monitored. This helps to assess how strenuous an activity was, and therefore helps to prevent athlete injury by letting them undertake moderate activities. These technologies may not reach Malawi soon, but they are still worth talking about.

There are different kinds of injuries that can be suffered by athletes. One prominent kind of is head injuries. For pretty much obvious reasons, the prevention and detection of concussions is one of the concerns in athletics. The prevention of collision with moving objects is very much associated with eyesight. The responsible body in USA recently approved a system known as EYE-SYNC, which helps to assess concussions. It tracks eye movements using a Virtual Reality headset (Virtual Reality is discussed in detail in chapter 10), which helps to determine whether a person has poor ability to keep their eyes synced with moving objects (which could hit them). This technology is helpful in following up of athletes suspected to have had concussions. This device was pioneered by Stanford University's football team.

Besides concussion-monitoring, online athletic training programs are another revolutionary advancement in AT. It is very easy to overlook this milestone. However, its importance is crucial. The internet has allowed for access to strength and training programs for athletes all over the world, many of which are personalized. Hence the athletes of today are better equipped than those of the past. To some extent, Malawian professional athletes and healthcare staff who work with sportsmen can also benefit from some of these online training programs. Not all of them are commercial. There are several kinds of these programs which are free to use. Using them to optimize the performance of athletes is not a matter of money, but basically a matter of mindset-change for the Malawian.

Audiology

Audiology can be said to date back to antiquity. People began investigating hearing thousands of years ago. Hippocrates made contributions related to investigations on hearing. Other contributors also provided treatments such as herbal treatments to correct hearing problems. However, its distinction as a profession occurred in the 1920s when technology was advanced enough to design the first audiometers to measure hearing. The term "audiology" itself was first used in the 1940s.

The founding of the American Academy of Audiology in the 1980s facilitated the growth of the profession. Later, in 2007, it became a requirement that all new professionals entering the field of Audiology ought to have the doctor of audiology (AuD) degree, which is equivalent to a PhD except that the AuD is a skill-focused rather than research-focused degree. Before then, the field of audiology had not been recognized as a separate profession, save for the United States and few other countries. This is especially true if we compare it with other fields such as mainstream medicine, under which the former has been categorized for quite so many years. In the Malawian scenario, I am yet to hear of practicing audiologists or audiology clinics. There are, however, so-called "ear-nose-throat" medical specialists in practice at the central hospitals in Malawi. It is important to avoid confusing these with audiologists.

If you ask the opinion of the average person with not much understanding of the healthcare professions, they will most likely categorize audiology under the domain of general medical practice. It is hardly surprising, therefore, that literature pertaining to technological advancements in the profession of audiology is scarce.

I am reluctant to accept the compelling yet untrue conclusion that few technological developments have taken place in audiology. The most likely explanation is that these are documented under developments in medicine/ healthcare in general, because some people still do not recognize audiology as a distinct healthcare discipline. While it is hard to identify all of the revolutionary technological developments in this field, there are several novel developments in this profession, most of which have been developed in this or the last decade. According to Clason (2014), hearing healthcare professionals (audiologists) are typically divided in their opinions on what is the most significant advancement in hearing health technology.

While that is the case, there is lesser debate on the importance of hearing aids. The first electronic hearing device was invented in 1898 by Miller Reese Hutchison. Later after the audiometer, soldiers from World War II suffered from noise-induced hearing loss due to advanced warfare technology. Between the 1950s and 1980s, many important discoveries were made. As mentioned previously, however, many other developments in audiology have taken place in the past two decades. The *Oticon* app for iPhones, developed in 2014, is a remarkable development in audiology. This app allows users to control the sound sources and volume levels of their hearing aids with a single tap of their finger. *Oticon*'s upgraded *StreamerPro* works with

iPhone through the *Oticon ConnectLine* app so users can switch seamlessly from *FaceTime* to phone call to music player. It is also worth mentioning that *Apple* filed a patent for an innovation which would detect and integrate portable electronic devices and hearing aids. Before this innovation, users had to change settings on their hearing aids in order to be able to conduct conversations on their cell phones. This *Apple* technology was built to use magnetic field-sensing from the handset to automatically detect if the user has a hearing aid in T-coil mode, making it unnecessary for the user to switch settings before making the call.

Besides these developments by *Apple*, earlier developments in audiology had already been developed, that allow computerized adjustment of hearing aids. An audiologist can adjust the settings on a computer, with the patient hearing these changes in their ears. Patients also report greater comfort, more natural sound and significantly greater reliability on today's hearing aids. Despite their amazing efficiency, today's hearing aids can still be subject to improvements. It is projected that future hearing aids may support Bluetooth, and may even have artificial intelligence and data learning extensions.

A modern hearing aid.

Obstetrics/ Midwifery

If you are a non-health person and you use the words "obstetrics" and "midwifery" interchangeably, you are more likely to be forgiven. It is hard (and unnecessary) to delineate the distinction between these two without sounding too technical. Since this book is not intended to be a technical book, let us avoid getting deep into those discussions. However, the same is not the case if you use the terms "obstetrician" and "midwife" interchangeably. These two are different healthcare professionals, although they both aim at one achievement: good health of a pregnant mother and the child (ren) she bears.

One of the most historically-significant developments in obstetrics was the invention of the delivery forceps. These are instruments used to aid in the delivery of the baby by applying traction to its head. Forceps are not used in normal deliveries but rather in assisted deliveries, whereby there are some complications that necessitate such. They consist of two metal instruments that are applied in specific obstetric maneuvers (special movements).

The history of delivery forceps is lengthy. According to Ross (2016), Sanskrit writings from 1500 BC contain evidence of forceps-like tools. Writings from Egyptian, Greek, Roman and Persian civilizations also reflect forceps. However, credit for invention of the modern forceps is given to Peter Chamberlain of England, who invented them in 1600. Although delivery forceps are less frequently used today due to the problems associated with their use, they are significant to the history of obstetrics, particularly because other interventions such as cesarean section were unsafe back in the day. In the present day, there are means to improve the safety of these alternative treatments. For instance, post-operative infection, a possible side effect of cesarean section, can be offset by the use of effective antibiotics. Hemorrhage (heavy bleeding), on the other hand, can be managed by highly technologized auto-transfusion techniques (transfusing the patient's own blood).

Scanning techniques are another of the important technologies in obstetrics. Scanning is performed for both critical purposes (such as assessing the health of a fetus) and elective ones (like checking the sex of the fetus). Ultrasound scanning (USS) is very common in obstetrics. In some clinical settings (especially resource-rich ones) it is performed routinely, while in Malawi it is performed mostly at the larger health facilities, and according to necessity- not routinely.

Ultrasound machines are expensive and where they are found in smaller Malawian health facilities, they are usually donations from well-wishers. For instance, from 2016, an organization implemented a training of healthcare staff from health facilities around the city of Lilongwe-including health centers on ultrasound scanning techniques. They would later donate ultrasound scanning machines to those facilities afterwards.

Ultrasound scanning is not only used in maternal health, but it plays an important role in this discipline. It uses sound waves to build a picture of a baby in the womb. Although it can be performed at any duration of pregnancy, results are more accurate when performed later in pregnancy. Besides scanning, health practitioners can also use other methods of examining the pregnancy, such as manual examination methods. However, these usually provide gross pictures of the actual situation. Many fetal abnormalities and other complications in pregnancy cannot be detected manually. Hence, scanning is an important component of obstetrical practice.

Despite the undeniable importance of scanning, the key challenge is that scanning machines are not only expensive, but they are also typically large and bulky. They may also be difficult to operate. The fact that there are many different models of scanning machines means that a practitioner accustomed to one model may not be proficient at another model. He might have to get used to a different model when in a new workplace. So how can these problems be tackled?

The idea of mobile scanning machines caused me to wonder why we can't just build them into smartphones. I have, for some time, thought about a scanning machine which would be built into our very own mobile devices. There were times when digital cameras, radios, mp3 players and other tools would only exist separately, yet now they have all been integrated into one device-the smartphone. Smartphones are used for many different functions now. When the first mobile phone was invented in 1973, the person behind the invention may not have anticipated that a few decades down the line, the mobile phone would become a multipurpose device, capable of carrying out many tasks which would otherwise need separate devices. With this complexity of today's smartphones, I wondered why someone still hadn't developed a method of performing ultrasound scanning (USS) using a smartphone.

From my understanding, all that was needed to perform USS on a smartphone was a set of three things: the smartphone itself, a purpose-built scanning software, and a piece of hardware for the

patient's end, to use as a scanning probe. While still contemplating this, I discovered the existence of a similar invention, which exactly matched my imaginations! *WinSenga* is a fetal-monitoring device which was invented by Ugandan students. Using an app built into a smartphone (mimicking the USS software) and a fetal-monitoring probe capable of being connected to the earphone jack of the smartphone, *WinSenga* is able to perform some of the most important fetal investigations. It is not too complicated nor can it match actual scanning machines, but it has the potential to identify a number of problems in the unborn baby. The developers of this tool got support from Microsoft to launch their project.

With this technology, why should we in the developing world, still spend thousands of dollars on the bulky USS machines instead of investing in solutions like these? We definitely cannot aspire to have USS machines in all our rural, remote health facilities, as that is unfeasible and unreasonable to expect. However, instead of completely denying patients at such facilities the chance to get better health services through scanning, we can at least offer them something with solutions like *WinSenga*. We may even go as far as developing our own country's version for this. *WinSenga* is an example of an innovation which is affordable and effective. The cost of purchasing one scanning machine is the same as that of purchasing 50-100 sets of *WinSenga*! What is the better choice between purchasing one scanning machine for one healthcare facility (whose certain functions are rarely utilized) or purchasing 100 sets of *WinSenga* or related devices (whose 75% of functions are clinically useful) for 100 satellite health facilities? Healthcare economics comes into play here.

I have for so long believed in the potential that this technology holds. Am sure it could have been developed earlier and by now could have gone viral. As mentioned, *WinSenga* has some functional limitations. It is modeled on conventional USS machines, yet the developers did not build it perfectly. More likely than not, these young innovators must have developed this innovation without reference to the actual software code that is used to build conventional USS machines. My hypothesis is that USS machine manufacturers could been unwilling to openly release the code for the software used in their devices, because obviously people might copy this and make many mobile versions of it, eventually killing the market for USS machines. They could be trying to protect their market and keep making profits. This issue of players in an oligopolous healthcare market-structure being too strict to prevent others from replicating their

products, is an ethical issue that has been around for so long and does not relate to USS machines only. Many drug-manufacturing companies have been accused of buying the rights to newly-discovered drugs, then strictly limiting the production of those drugs so that they can be sold at very high prices to allow these new proprietors to keep making astronomical profits at the expense of the suffering poor. The ethics of this is so deep. I suspect it must be the technique USS machine manufacturers have been employing by strictly guarding their software code for others not to know it. The issue regarding open and free distribution of software is discussed in detail in chapter 6. If this is really what these companies have been doing, it is hard to initially make mobile, smartphone-compatible software of comparable quality to the one in USS machines. This implies that activists ought to act to help change these policies. It requires understanding of how software are distributed and licensed. At the time of releasing this publication, I am yet to attend a US conference on mapping Open Research Ecosystems in healthcare in the world. It is scheduled for April 2017 in Seattle, Washington, USA. My proposed presentation there is about techniques which we can use to engage manufacturers of USS software to publish their software in Open-Source repositories, for easy modification in developing countries. I hope that this presentation can allow me to strike meaningful partnerships with others on this topic.

For now, the good news is that there is potential that solutions like *WinSenga* can be improved with time, to allow them to have wider capabilities and be much more like conventional USS. Malawian software developers of today can take this as their assignment.

From my clinical experience, new healthcare technologies come with an element of surprise to patients. Just like a European who gets astounded in what sociologists call “cultural shock”, the first time he goes outside of Europe and visits a cultural tribe in the tropics of Africa, those patients receive new technologies with a look of surprise (and I call this phenomenon “technological shock”). I have observed this more than once while using non-contact, infrared-powered thermometers, as well as my smartphone in assessing patients (these two examples are of course not exclusively applicable to obstetrics). Technological shock knows no frontiers. It can affect the educated and uneducated. It transcends socioeconomic statuses.

While it I do not expect patients to be familiar with *every* new technological development, in 2017 I expect some open-mindedness towards new possibilities. By now, people should have at least become used to the fact that technology is dynamic. I am always asking myself whether this problem of "technological shock" lies with the drivers of change in the healthcare industry, or the recipients of it. Technological shock may not be harmful, but in this age we should not be having it. It can affect compliance with clinical instructions (such as when the patient experiences technological shock with gadgets used for disease-management at home), as well as consenting to treatments which use technology perceived as 'heavy'. Additionally, it may also cause unnecessary distrust in the efficacy of modern medical procedures.

It is one of the purposes of this book to relieve the reader of some elements of "technological shock" regarding modern healthcare practices. The hope is that by exposing the reader to a wide variety of technologies emerging in the field of healthcare today, they as tomorrow's patient, can have wide expectations of how they would be treated. Let me once again agree with Eric Topol that the endless possibilities which technology presents to healthcare have not been fully capitalized upon.

It has been established that mobile devices like tablets and iPads are effective in enhancing the learning process. I have asked myself several times why we can't identify a few healthcare institutions to serve as pilot institutions for an initiative whereby antenatal women can be taught about pregnancy and childbirth using the digitized images offered by iPads and other media, rather than the current static, lifeless pictures drawn in pamphlets. Wouldn't live, in-motion displays portray more vivid messages which would add excitement and flavor to the learning process, and possibly facilitate future remembrance of the concepts by the women? Before you criticize this suggestion for being far-fetched, expensive and impractical in the Malawian setting, be aware that similar projects have mushroomed around the same Malawi in the field of education, where pupils in selected schools are taught using tablet devices. If it is happening in education, why should it be impossible in healthcare?

Left: a $10,000 ultrasound scanning machine (USS). Right: a unit comprising a simple feto-scope and pregnancy-monitoring software that can perform some essential examinations like those of the USS. It costs less than $100.

Pharmacy

The field of pharmacy has not been spared of the technological revolution. There are many new trends that have transformed pharmacy practice over the last few decades. One of the most notable developments in pharmacy in the world is electronic prescribing, also known as e-prescribing. It is opposed to paper-based prescribing. It can allow pharmacies to receive prescriptions in electronic format. More sophisticated e-prescribing systems are able to automatically prescribe medications for a patient without the need for a physician, pharmacist or other healthcare practitioner to do so. They can create and refill prescriptions for individual patients (meaning they are personalized, hence accurate). They can also manage medications and view patient history, connect to pharmacies, and link with patients' electronic medical records. One of the advantages of e-prescribing (automated or not) is the reduction of prescription errors

that may result from illegible handwriting. *Time Magazine* reported that doctor's bad handwriting kills thousands of people worldwide yearly- and injures millions more.

Many e-prescribing software also help prescribers make decisions on which drugs to prescribe, eliminating the need for them to simply guess. Since e-prescribing software can generally sync with the patient's medical history, they can also monitor the patient's history for any possible allergies or other restrictive factors and provide alerts to the prescriber, preventing prescription of medications that would have adverse effects on the patient. Unfortunately, e-prescribing is not yet widely practiced in Malawi.

Another development in this field that I found noteworthy is the use of codes to determine the originality of drugs. Some young innovators from Ghana developed a system whereby users can verify the authenticity of medicines by sending a unique, multi-digit number found on the packet of the medicine, through SMS to a certain given number. They instantly get feedback through SMS regarding whether such medicine is authentic, or whether it is suspected to be expired or fake. This can also be useful to prevent pilferage of medicines from public institutions, especially in countries like Malawi where this problem persists. Additionally, it can save lives, as the World Health Organization estimates that about 20,000 people die each year from consumption of fake medicines, especially anti-malarials.

Radiology

Recent advances in imaging technology—like computed tomography (CT) scans, magnetic resonance imaging (MRIs) and other technologies have hugely impacted diagnosis and treatment of disease (Griffin 2016). Almost every aspect of medicine has been revolutionized by advances in imaging technology. Imaging allows doctors to see things in a new way, providing for accurate diagnoses. Dr. William Eversman, chairman of radiology at the Mayo clinic in Arizona, USA observed that although the physical examination is not a dying art, doctors are coming to see how valuable and accurate imaging tests can be.

In recent years, there have been many improvements to imaging technology, and it is not possible to exhaustively list all of them. However, there are several that experts singled out as most important, and they are as follows:

i) Computed Tomography Angiography

Until recently, an angiography (examination of the blood vessels) could only be done by inserting a tube into an artery. In the procedure, contrast material -- a substance that makes it easier to visualize in an X-ray -- is injected through the catheter. Then an X-ray is taken of the area to look for blockages, internal bleeding or other problems. Catheter angiography can take up to several hours. It often requires being done under some medications, and sometimes a night in the hospital. It also has risks, like a small chance of blood clots or bleeding.

However, the newest CT scans allow a completely non-invasive way to get the same information as an invasive catheter angiography.

In a CT angiography, the doctor just injects the contrast material into the arm and takes a CT scan. The arteries in the lungs, kidneys, brain and legs can then be examined. The whole process takes just 10-25 minutes. It is safer, faster and cheaper than the traditional way.

CT angiography has not completely replaced the old technique. For example, traditional angiography is still commonly used to evaluate heart arteries for blockages. However, the advent of CT angiography has helped improve things tremendously.

ii) Imaging Tests Instead of Exploratory Surgery

Imagine going under the knife not for treatment- not to be treated, but just for the doctor to know what problem you have. While this sounds unpleasant, it is not uncommon. It happens a lot of times. However, advanced imaging techniques are making it obsolete- at least for some problems. One of the biggest changes in the use of imaging is that it has largely replaced exploratory surgery. Where the equipment is available, patients no longer always have to undergo surgery just to be diagnosed. CT scans, MR (magnetic resonance) scans, and ultrasound have become so good that they have largely done away with the need for the surgical approach.

It is not just the quality and detail of the images that has improved. Some advances have made the actual experience of having an imaging exam easier. For one thing, they are a lot faster. 20 years ago, a CT exam would take half an hour. Radiologists can now literally get the same amount of information in less than two seconds.

The full length of an exam varies depending on the person and the type of imaging. But it is estimated that an MRI takes between 20 to 40 minutes. However, the imaging itself only takes up a few seconds or minutes of that time (the rest is taken up by the technicians preparing the exam). Because the exams are quicker, fewer people need sedation or pain medicine to lie still.

Advanced radiographical techniques have not spared Malawi. Several facilities (both private and public) are increasingly having advanced equipment. A few years ago, Dae Yang Luke hospital in Lilongwe got a state-of-the-art-CT-scanning machine from Asian donors. The Malawi Ministry of Health announced in 2016 that it would replace the X-ray machines at Kamuzu Central Hospital with modern, advanced ones (Chauwa 2016).

Emergency Medicine, Laboratory Medicine and Paramedicine

Emergency medicine is a medical specialty dealing with illnesses or injuries that require immediate medical attention. It is also known as accident and emergency medicine. It is most often practiced in hospital emergency departments and ICUs. While there are physicians who specialize in emergency medicine, there are also still other practitioners in this field who are not necessarily physicians. They are most often referred to as paramedics.

Conditions which fall into the scope of emergency medicine are capable of causing severe complications or death within short time-frames. These conditions include trauma, sepsis, burns and poisoning. Technologies commonly used in emergency medicine include blood tests, CT scans and projection radiography (among others). Since many of the blood tests are performed by laboratory staff and not emergency medical practitioners themselves, emergency medicine intersects with laboratory work.

As will be discussed in later chapters of the book, one of the essential attributes of technological innovations is relevance. Irrelevant health technologies can be dismissed as redundant. With respect to emergency medicine, one of the ways in which a technology would be classified as relevant is its ability to lead to quicker diagnoses or provide more effective treatments within a short time span. For instance, if a machine has an accuracy rate of 98% but takes 45 minutes to produce results, then in the event of an emergency, it should be less desirable than a machine that is 95% accurate with a time frame of 7 minutes to produce results. This is so because in emergency situations, speed matters most. At the same time, the 3% difference in accuracy is negligible.

We have mentioned blood tests and imaging techniques. These are not only used in emergency situations, but also in regular medical practice. However, one would rightfully expect that techniques of testing blood in emergency situations be more rapid (without significantly compromising the reliability of results, although sometimes this is an inevitable repercussion of the need to have results quickly). Ideally, machines that can produce results more instantly would be needed in both emergency and non-emergency situations alike. If these rapid equipment are also more expensive, then it is reasonable to only have them in the emergency departments of hospitals at least.

Malawi is one of the places where emergencies are not always handled properly. Results of blood assays can take long to come out. This is not because of the methods used, but because there are usually many blood samples to be tested, against the available number of machines. I remember how we had to cross-out laboratory forms as a way of signaling the laboratory workers on the urgency of that test. This notation could be abused at times, as some practitioners would cross-out many other lab forms including those for which results are not needed urgently.

As tedious (and uncomfortable to the patient) as it is to collect blood specimens, send them to the lab and await results, in America one scientist developed a system for measuring full blood count of a person only using a small drop of blood obtained from the fingertip. Conventionally, several milliliters of blood are required, which is obtained from a larger vein through the skin. This innovation made it extremely easy to collect the blood (larger veins do "hide" sometimes). It also eliminates the anxiety borne by patients when they fear that the healthcare worker may be drawing too much blood from them, and this gets worse when more than one venous sample has to be collected.

Technologies in the practice of emergency medicine worldwide are not only related to blood measurements. Other ingenious inventions include the following:

i) *GALE Smart First Aid Kit*: This is a 'smart kit' with a touch screen capable of digitally displaying instructions on how to use the various components inside the box during a real emergency. It can also connect with health experts located remotely, to provide assistance in

more complicated situations. Voila, now anyone can use emergency first aid kits without prior medical knowledge!

ii) *Pain RelieVR*: This is a virtual reality game developed by a company called *Applied VR*. It involves interacting with fascinating teddy bears in virtual reality, which eventually takes down pain and anxiety (Virtual Reality shall be discussed later in the book).

iii) *BrainScope Ahead 300*: The *Ahead 300* is a device developed by the company *BrainScope*. It is about disposable electrodes that can be connected to a patient's head on one end, and a smartphone on the other end. It then provides a rapid assessment to determine the location and extent of brain injury. It is pretty handy for head injuries attained during accidents. This innovation not only fits the bill in terms of diagnostic speed. It is also very easy to use, light, inexpensive and portable. Before this was invented, tests for these kinds of injuries could only performed using heavy equipment. Now that more affordable and portable substitutes exist, we should start considering importing these kinds of equipment into Malawi.

Chapter 2: Health Workers, Non-Health Workers and Technology

"Attitudes of healthcare professionals can be a significant factor in the acceptance of IT use"- Rod Ward.

Telekom Networks Malawi (TNM) limited, one of the main telecommunications in Malawi, in 2015 launched an innovation challenge dubbed "TNM Smart Challenge". The purpose of this challenge was to promote innovations which had the potential of transforming the socio-economic landscape in Malawi. This challenge had three categories and the winning entry in the students' category was an entry called "*Maternitech*". This was a mobile application which was developed by myself and my two colleagues namely: Thandie Magasa and Daniel Mvalo. Thandie and Dan were into the ICT field, while I myself was pursuing a Masters degree in Public Health. The three of us later traveled to Silicon valley, USA, which is informally recognized as "the world's ICT headquarters". In no time, we made a name not only at the conference we were attending, but also worldwide.

Back in Malawi, the media kept covering our story for weeks. The State President even gave us official recognition. But what made us gain all this popularity? Had we developed a very complicated software system that only a few who had mastered computer programming to perfection would possibly perform? Ironically, the opposite was the case. Scores of people were not necessarily amused by the dexterity and craftsmanship that had been displayed (in fact, it is arguable that any other skilled computer programmer had the capacity to develop a similar app). However, the most sensible deduction to make from peoples' excitement with this development is to be seen from the importance of the app itself. *Maternitech* app had the following functions:

i) Providing customized information tailored to the Malawian healthcare delivery system, on contraceptive options to Malawian women of child-bearing age.
ii) Providing essential information and healthy tips on key issues in pregnancy.
iii) Producing delivery-date estimates for pregnant women, based on their most recent menstrual dates.
iv) Providing information on the care of newborns born prematurely.

As mentioned earlier, I believe that peoples' fascination with this app most likely emanated from its anticipated usefulness, namely the ability to contribute to reduction of some of the most pertinent reproductive and maternal health problems. Most of these problems are preventable,

and spreading of health information using mobile phone-based developments was perceived by us as one way of achieving this. The understanding we had in mind was that although many Malawian women attended antenatal services, it must have been difficult for them to always *remember* what they had been taught there. In some instances, these women had to travel long distances to reach the nearest hospitals and get this information. Worse still, younger, unmarried women sometimes had troubles accessing contraceptive information, given the cultural and social norms in Malawi which prescribed that contraceptives were for the married. Therefore, sexually-active younger and unmarried women would sometimes be alienated (directly or subtly) in their pursuit of contraceptive services. They risked acquiring unexpected pregnancies, a major cause of unsafe abortions.

According to statistics from June 2016, Malawi boasts the second-highest under-18 pregnancy rate in Africa (34%), the highest premature birth rate in the world (18.1%); 80, 000 documented unsafe abortions annually; 500, 000 childbirths annually, of which 45% are resultant from unexpected/ unplanned pregnancies.

All these problems are preventable in almost their entirety. However, we noted that most healthcare interventions focused on treating the conditions after their occurrence, instead of investing in their prevention (which is not only the most effective but also the most inexpensive and easiest approach).

Given the increase in usage of mobile phones in Malawi over the past few years (as the case in other African countries), innovations like this app, would not have come at a better time.

It came to my attention that during all our meetings and activities related to our app, my two colleagues were somewhat perceived by the public in a different way from myself. They would, most of the times, be labeled as the "technical" guys, while I myself would be perceived as simply having had the role of supplying health information to them to build the app. While that was true to an extent, I would want to suggest a different way which observers ought to have employed when looking at us. People seem to forget that anyone can be good in ICT even though

they may not have educational preparation in the same. My lack of an ICT degree did not mean that I was illiterate on these matters. ICT is not like the medical fields where to be a recognized or competent practitioner you *strictly* need to have some form of professional accreditations. Of course I recognize that with increasing professionalization of all fields, having educational preparation in a field is becoming more necessary than ever. However, I maintain my argument that the importance of having an ICT degree before you can have 'moderate' ICT knowledge should not be over-emphasized. It is not as underlined as the importance of having a medical degree as a pre-requisite for attaining a reasonable amount of medical knowledge. In fact ICT is taught as a mandatory basic course in all colleges of the University of Malawi. This is substantial evidence that ICT is applicable everywhere and that anyone can attain vast amounts of ICT mastery without being a professional in that field. Therefore, the observers should not have presupposed that I could not have been proficient in ICT due to my non-professional status in the field. After all, my involvement in this project should have at least given them a clue that I may probably have slightly average or above-average knowledge of ICT issues. I felt annoyed that they did not look at it this way.

I have a friend who is a social science student, but who has devoted most of his life to computer programming. Obviously his field of study has nothing to do with computer programming, yet he is brilliant at it. Not many people ever question this about it (at least from my observation). He is recognized as a competent computer programmer and that is it. Yet in my case, almost everyone who had heard my story came about asking whether I had some ICT background. Was it because I was a health professional? My hypothetical stance is that people wrongly conceptualize healthcare people as knowing *only* health issues and nothing else. Those in the healthcare field are seen as people whose interest lies in the hospital and treating patients. They have been categorically condemned to be confined to the hospital by society. They cannot do anything substantial, which is not hospital-related. This is one of the misconceptions people need to brush off their minds.

The ICT field does not belong to anyone. It is analogous to philosophy. Due to the universal nature of ICT, anyone who so wishes can gain expertise in ICT. Therefore the distinction between ICT "experts" and "non-experts" is of less importance. Take the following example. Someone may have great knowledge in ICT, computer programming and the like without having

formal training in that. I personally know many people who can repair hardware and software computer issues despite not having any academic certifications to do that. People trust them to repair their computers, install software and do other ICT-related tasks. The same cannot be said about people working in other fields.

Suppose a person claims to be good at surgery after reading tons of books, without having any recognized medical training. I doubt that many people in their right states of mind would trust such a person with their lives and let him carry out medical treatments on them. This is true even if the person *really* demonstrated to be good in the art of medicine. In fact, such a person may be liable for legal action. The same applies to many other fields such as law and others. The common property here is that these fields are far more seriously regulated, and people focus more on the academic and professional credits of the practitioner, than their practical abilities. People would rather receive treatment from a doctor with proper degrees and medical council licensure, than one without it (for instance one whose licensure was revoked). This is interesting because being licensed does not mean that one is more competent in the medical craft. In fact, some unlicensed doctors may be better at medical theory and practice than unlicensed ones. The problem is that competence is very hard to measure, and therefore recognition by regulatory bodies is generally accepted to be an indicator of being good at medicine (although in reality it is not).

Once again, in ICT it is not certifications which matter (at least from what I have observed in my country, where many people do not look a lot at the certification status of their computer repairers), but rather skills. Perhaps the exception of this is in situations involving large organizations. When recruiting contractors to install their information systems, networks, or create websites or perform other tech-related duties for them, these organizations would rather hire registered ICT companies which have good reputations. This underscores the fact that ICT is being recognized as a distinct, recognizable profession in itself, not just "another career". The establishment of professional bodies of ICT practitioners such as the ICT Association of Malawi (ICTAM) is an attestation to the increase in demarcation of ICT as a distinct, sovereign profession. However, its professional status is still less marked as compared to other traditionally recognized professions. Even with the existence of the professional ICT bodies, their membership is not always compulsory. In general, their regulations are comparatively loose.

Having said all the above, I think that in 2016 AD it is pointless to assume that advanced ICT knowledge can only belong to certain people (namely those who studied it academically). Anyone can have advanced ICT knowledge. This applies to all other fields, but in ICT it is more emphasized. This is not to imply that formal ICT training is redundant. Such training (or education) is important for providing the core theoretical understanding of that field, which is what academics is all about. But there is something I find confusing: to become a member of the ICT Association of Malawi, one must have a qualification related to ICT. Think of this: if Mark Zuckerberg of Facebook were from Malawi, he would not be allowed to join ICT Association of Malawi because he does not have ICT qualifications. Yet an average guy like me would easily join this body after attaining an ICT diploma from a local college. This alone, is more than enough to prove that professional qualifications have nothing to do with skill.

Malawi is a third-world country. That said, it is hardly surprising that healthcare innovations have not reached heights as of yet. However, one of the questions which troubles me is: in the same Malawi, why is it that innovations from other fields are thriving? For instance, mobile money solutions have gained remarkable popularity over the past few years. Why do we still not have a healthcare innovation of comparable popularity? My hypothesis is as follows: many Malawians still take healthcare as the business of healthcare workers. In the mind of the Malawian, the doctor is the know-it-all guy of healthcare issues. As such, the Malawian person is disinterested in engaging in the pursuit of healthcare knowledge, being expectant on getting it all from the hospital after he falls sick.

With the wealth of health-related information all over the internet and other forums characterizing the present day, the modern day Malawian has no excuse for folding his hands instead of taking an active role in learning about his health, which is one step towards improving it. Making healthcare issues a responsibility of the ordinary person can increase their involvement in healthcare issues. It would not only increase their awareness to perform health-seeking activities, but it would also ignite a sense of responsibility among potential innovators.

The modern-day concept of health-promotion emphasizes the individual's playing a role in his own wellness and we shall see more about this in a later chapter.

While fields of study that extend across both the domains of healthcare and technology (such as biomedical engineering and bioinformatics) are on the rise, traditional technology-centered and healthcare-centered fields are not going to be annihilated any soon- and probably they never will. We have seen the emanation of these 'hybrid' professions, which have a blend of medicine and technology. They include health informatics, biomedical engineering and others. Biomedical engineers learn the basics of medical science before they go on to learn engineering principles. This produces well-baked graduates specially prepared to precipitate innovations in healthcare.

Medical students of 1950 may not have learnt ICT as part of their undergraduate programs. Those of today learn it, but despite learning a certain amount of ICT, they are still generally prepared from the point of view of service-delivery in hospitals, not as innovators or problem-solvers. Their exposure to ICT is not meant to turn them into health informaticians. The converse is true for the ICT student. Although due to common experience he may be aware of some common health-related issues, and maybe even learn about some of them in class (such as HIV), his training remains focused on preparing him as a problem-solver. Traditionally, the modality of training the ICT student is the polar opposite of the modality of training the medical student. Thankfully, this has been changing, with more and more healthcare-provider training curricula placing emphasis on problem-solving in addition to skill-impartation.

In any case, members of the two polarized fields in the name of traditional healthcare and traditional tech-centered fields need to work together if any meaningful health-related innovations are to be arrived at. Knowing which specific healthcare professional to approach and work with is an essential attribute that people in the tech field ought to have. The converse is also true. While physicians will mostly be a helpful primary resource on health-related information from wide areas, they may not always provide the best information. For instance, issues of drugs (medicines) are far more understood than pharmacists than by physicians, yet not everyone knows this. Similarly, ICT is a broad field with different specialists, contrary to common belief.

This means that people in the healthcare field interested in partnering people in the ICT field on health-related innovations, should know whether to approach a software engineer, network technician, web developer etc. In other words, health professionals need more "technology-literacy" whereas technologists need more "health-literacy". This is important for identifying the right people to approach, understanding what those people can and cannot do, how those people can fit into your project, and even developing meaningful innovations.

While the traditional healthcare professions are not intended to produce innovators, quite a good number of innovations have been developed by people from this field. What this does is to substantiate the fact that innovation is mostly produced from intrinsic, innate capabilities to exercise reflective thinking necessary to identify a gap, plan and produce solutions that can bridge that gap. Simply put, it is a fact (or at least a widely held hypothesis) that people who are associated with innovative achievements mostly have histories of having had traits such as curiosity and remarkable intellect as children. Of course, this is not true for everyone. By now, most theorists agree that although *nurture* can be an important factor in shaping a person's intellect, the person's *nature* is a far much important requirement. For instance, a person can take on the difficult path of becoming a mathematics professor after being influenced by a familial environment of mathematicians. However, his achievement of this would not be automatic. He would need to study hard, eventually get accepted into a mathematics PhD program, conduct original research, defend dissertations, and so forth. These are challenging tasks and one can only accomplish them if they have the right mental capacity.

This goes to great lengths to show that many people who innovate already have the intrinsic drive for that, and training plays a lesser role. This is why not all 'tech' innovations come from people with formal training in engineering, ICT and such other fields. It also explains why not all people in these 'tech' fields are necessarily innovative. We shall look more at these themes in chapter 9.

Chapter 3: Health Informatics & ICT for Health

"The healthcare industry is undertaking a structural change by aligning health IT with the delivery of care"- Xiaomi Zeng.

I first got introduced to the term "informatics" by my friend Prince Stevens Thengo, who at that time was pursuing his postgraduate studies in that field. I had heard of the word before, but just never gave it any serious thought. Like most people, I had been unaware that ICT had various branches. All I thought was that ICT was just one narrow subject area and that everyone who dealt in computers belonged to that field. My ignorance made me attach little significance to classifying the various branches of ICT such as informatics. Later, after studying more regarding informatics, I discovered that it was an exciting field, which was classed into various distinct categories including informatics. The modern day has seen further categorization of informatics into sub-categories, such as health informatics.

Health informatics (also called bioinformatics) is a field of study which is derived from informatics, the science of information-processing and engineering of information systems. An important point to note is that this field is multidisciplinary and comprises information science, computer science, social science, management science, medical concepts and other areas. It uses health information technology in its approaches to improve healthcare.

Health informatics is involved in creating, storing, finding, manipulating and sharing health information for research and practice purposes. It is involved in developing and using informational tools for use in healthcare practice. These include computers, clinical guidelines, formal medical terminologies, telemedicine and other ICT systems. All of these aim at improving patient care by encouraging generation of high-quality data.

Many practitioners are involved in health informatics, although some of them may not be *consciously* aware that they are practicing such a specific field. However, today there are many specialized academic programs of study which train/ educate people in health informatics at bachelor, master and doctoral levels.

Julie et al (2013) had the following to say regarding Health Informatics:

"The academic Health Informatics field has evolved from grassroots, and continues to evolve as opposed to stemming from other professions. Its academic programs were developed to meet both academic and industry market needs, with implicit (as opposed to explicit) theory. Similarly to what has occurred in the Information Technology industry, an implicit Health

Informatics theory, emerging through need, will evolve through the growth and development of the discipline. As the academic Health Informatics discipline continues to advance, there will be more opportunities for further, more explicit conceptual Health Informatics theory development. Health informatics practice will likely continually inform the development of the discipline, and the discipline will in turn, continue to develop Health Informatics professionals to apply the body of knowledge and skills that lead to the development of their Health Informatics professional identity"

The role of health informatics is becoming more conspicuous. People have started to see the need for having specialists who are neither clinicians nor entirely ICT people, but who have an element of both. For so long, people have considered primary healthcare providers like physicians to be the authorities in anything health-related. However, as the world becomes more complex, the now-complex duty of handling healthcare information cannot be left to be the responsibility of people like doctors. Their training does not contain enough informatics content in line with the currently-necessary levels. Medical information has become too specialized to the extent that handling it requires specially-trained professionals.

Although the role of health informatics is becoming more marked, general informaticians may also work in health informatics, usually in lesser specialized roles. However, their non-specialization may see them grappling with medical terminologies at times. This underscores the importance of specialization. In some institutions, health informatics is offered as an area of specialization in fields like Master of Public Health (or other degrees), whereas in other institutions it is offered as a stand-alone field of study.

Most of the milestones in informatics are recent. One of the most prominent leaps in the field of bioinformatics occurred in 2016, when scientists developed a method of storing information in living cells like bacteria. Yes, we are talking about using micro-organisms as living hard-disks! By feeding strings of human-written data into colonies of bacteria, tiny cells can be turned into living, squirming hard drives (Herkewitz 2016). The information can be written (coded) and later decoded (read/ deciphered/ translated) from the bacteria. There are two important aspects about this development. First, the information that can be written through this method can be of various types, such as computer programs, mathematical formulae, et cetera. The second important aspect is that the bacteria with this information written on them can ably pass on the data to their

offspring! Because this technique can be used in storing a wide variety of information, primarily it would appear that it falls under the field of general informatics, and not strictly healthcare informatics (healthcare informatics is strictly concerned with healthcare information, not necessarily with living cells as information storage systems). However, most areas of relevance in general informatics should be relevant to healthcare informatics as well, as long as those techniques can be used to store healthcare information. Aside from storing information in the DNA of bugs, various other groundbreaking developments have arisen in informatics and health informatics.

One of the areas of concern regarding the storage of healthcare information in Malawian public hospitals is that patients' information is still stored entirely in hardcopy files. We are still that far much behind, that an unfortunate yet not-so-uncommon occurrence such as a fire or physical loss/ misplacement of a file, could wipe out information about some past clients- forever leaving no single trace. In fact it is not only public hospitals which face this risk. Most of the private hospitals, which are the Mecca for middle-class patients in Malawi, face the same problem. I was appalled one day at seeing a certain private hospital, which I hold in high regard, still using the cumbersome method of storing patient information in physical files. This is a facility mostly patronized by members of a certain popular insurance scheme. I noticed that the clerk was too busy every time a patient had a claim to make. The clerk would step out of her cubicle, go to a nearby warehouse and fumble into hundreds- if not thousands- of files kept in drawers arranged numerically, to fetch out an old patient's file to use in processing the claim.

The toughest part of this method is that the files are usually large and some pages naturally get knocked off the files due to their large size, as a result of frequent clinic visits by these clients. Many of the clients visit these private clinics regularly even when not feeling unwell. They want to derive maximal benefits from their insurance scheme (typical of the Malawian). It is hence an arduous task to work as a clerk at these institutions and clearly, the physical method of patient information storage is marked by inefficiency.

In the year 2017 we should not be in this position. Hardcopy files are bulky, eat up a lot of space, and it is grossly cumbersome to retrieve a specific file from thousands of files. In short, this practice does not belong to this year.

At present, we have other better means that we can use to store our patients' information besides physical stacking of hardcopy files (which is also environmentally-unfriendly). We could migrate to a digital information storage system whereby each file is scanned and then kept as a PDF in a departmental computer. The apparent downside of this could be the quick filling up of space in the computer's hard disks if information taken over several years is kept. However, this could be worked around by storing the files as zipped folders to save much more space. Another risk could materialize when a departmental computer gets infected by viruses or gets physically damaged. Of course the risks for viral infection could be reduced if these computers are strictly used for their intended purposes and no other.

We could also store this aggregated information in a local server or could-based server. The former could be more expensive to acquire the first time, but eventually it would be a worthwhile investment. It has been noted that most of the times, once-off purchases of heavy-duty hardware appear expensive, but in the long run these hardware are cost-effective. The latter storage option is associated with risks such as 'hacking', which poses safety risks to patients' information. Imagine a theoretical scenario where a pirate 'hacks' into this load of information of thousands of patients and demands ransom in return. While the example is unlikely and perhaps far-fetched in Malawi, it opens us up to all the different factors we ought to take into consideration regarding the storage of patient data. It gets us to weigh up the most reasonable options we could take. In the end, it remains compelling to migrate from physical data storage to electronic data storage. This is just one reality we ought to deal with.

When it comes to implementing change in Malawi, mostly factors which prevent change are connected to problems to do with funding. Ironically, Malawi is also one of the countries with a lot of donor-funded projects in healthcare. My argument therefore is that sometimes it is not funding which is the main problem, but rather the setting of priorities when allocating funds to projects. As an example, UNICEF have been funding various projects in Malawi such as piloting the use of drones to transport pediatric HIV results between health centers (small, remote health facilities) and central hospitals. One of the trials was done at Kamuzu Central Hospital and Area

25 Health Center in Lilongwe, two institutions within a radius of only fifteen kilometers apart. As an individual, I opine that this project was well-meaning but not a priority. In the British Broadcasting Corporation (BBC) documentary which televised this project, it was reported by the commentator that it can take weeks for results to be transported between the health center and central hospital. To be frank, Malawi is not a geographically-vast country. If that even happens, it is probably due to other factors such as administrative competency (or lack thereof), not necessarily long distance. One should be able to travel between Kamuzu Central Hospital and Area 25 Health Center in about half an hour. Even in many other parts of the country, the distance from a central hospital to the farthest health center in its catchment area cannot take weeks to travel. This is a gross overestimation. The explanation for the BBC report could be sheer misinformation. It has been observed that some European reporters tend to generalize Africa as having vast countries full of jungles, with towns being many dozens of kilometers apart. This does not happen to be the case in Malawi. In this country, motorcycles or other means which already exist should be able to transport these samples and sample results within a single day.

Therefore, I personally thought of the drone project as interesting but not essential. In my opinion, the funding for this project could be directed to other, more urgent projects and the digitization of health information is an example of such urgent projects. From my experience, the projects which acquire donor funding are not always the most urgent problems. Other factors may contribute to it too. The problem could be that the donors are sometimes autonomous and fund projects which they specifically want, leaving no room for the recipients to negotiate for the support of alternative projects. These issues relate more to health policy and again, that just proves that sometimes, our greatest problem is the funding policies- not the lack of funds. Government through the Ministry of Health, and other stakeholders ought to be vigilant in negotiating with donors for adoption of funding policies which allow for autonomy from us the recipients. This could allow for funding to be directed towards more appropriate projects in healthcare, including those which promote necessary technologies.

Baobab Health, one of the most prominent organizations in Malawi in terms of healthcare innovations, carries out a project which promotes the use of electronic medical records in hospitals. It uses site visits as a way of influencing change to promote understanding and adoption of electronic medical record systems. Balaka District Hospital Antiretroviral (ART) clinic is one of the clinics which uses an electronic medical records system for information storage. On a site visit to that clinic, Esther Namahella from Theresa Community Hospital said that integrating clinical services with computers would greatly improve data and patient-management due to the clinical guidelines embedded within the system. She also said that deaths due to poor clinical judgement could be avoided through the use of the system.

Baobab have been using solar-generated electricity to power these electronic medical record systems in rural areas devoid of electricity. They are not only useful for collecting health information, but also demographic information such as that relating to births, deaths, migration and others. Therefore, it is evident that electronic medical record systems can be stretched to serve many purposes; and that it is practical to implement them in low-resource settings.

Another significance of electronic medical records and information systems is that they are easy to update. For instance, clinical guidelines for patient-management are always changing. Due to the influx of new scientific research findings, ART guidelines are always being updated. In 2014, Baobab Health Trust migrated its system from Baobab Health Anti-retroviral Therapy (BART) 1.0 to 2.0, in order to keep abreast with the changes that had been made in ART guidelines.

Moving on from the said, I believe that we have some reason to be hopeful because health information systems in the Malawian health sector are slowly moving to the digital realm, although the progress is infantile. One day when I was at Kamuzu Central Hospital, I took a tour to the laboratory to get a better grasp of how they manage their data. It is there and then that I learnt of their ongoing migration from a paper-based information system to a digital one. Although this process has not been realized entirely, it is at a fairly advanced stage that a good percentage of their data-handling has been digitized. All along, I had not been aware that this giant leap-forward was taking place in Malawi. I had been busy fantasizing about possibilities

and it was unbeknownst to me that a brilliant revolution was already in the offing in one of our main laboratories in the country.

In my conversation with the laboratory staff, I gathered a lot of interesting information about this system, a laboratory information management system (LIMS). This system is basically an electronic logbook for laboratory operations. Initially, before the introduction of the LIMS, the laboratory staff had to go through the tedious task of documenting each and every individual test done, into a physical logbook. Aside from the obvious downsides of this being physically exhaustive and the information being prone to loss or damage, it would eat up much of the lab technicians' time. Now with the LIMS, they can save hours of having to manually labour with jolting down sample details such as date, patient's name, type of test done, department which requested the test, and more. They have also connected their sample-analyzer machines to the LIMS system, and therefore these machines can directly enter the results of each sample analysis into the storage system- instantly and automatically! Even where they need to intervene, the staff only need to press a button on the analyzer to command it to export the analysis results into the system. It is that easy. It is a marvel how 'smart' the laboratory department has become. This further exemplifies the Internet of Things (IoT) revolution that is discussed throughout this book, and that is sweeping the globe ideologically.

The KCH-LIMS project is underway with the support of the United States Centers for Disease Control (CDC) and unsurprisingly, it is Baobab Health Trust which was contracted to set up this system. They built the LIMS software as well as installed the hardware that comes with it such as desktops, barcode-printing devices, and a server that was set up locally (around the hospital premises). Basically, every lab worker has a personal account in the system, where they log in before conducting their operations. This serves as an auditing system for checking who has done what tests over what period of time (therefore it has the latent function of preventing laziness among workers). Perhaps not unexpectedly, some users forget to log out of the system after use, making it hard to do this auditing. One way of countering the effects of this has been to train the staff on the use of the system. The management also continually reminds the staff to check out of the system after each episode of use. This system is designed to prevent access of any other internet pages apart from this LIMS intranet.

Another important point is that this system is able to perform instant data analyses using different kinds of indicators, according to what they would like to achieve. It can give statistical readings such as means, modes, frequencies, variances and others- at the click of a button, within a split-second! Analyzing data has never been so easy. Imagine how long determining such variables previously used to take them!

I took a chance to appreciate what this system looks like, and I was impressed. It is very easy to use and once logged in, it gives the user the convenient menu options of 'Home', 'Patients', 'Tests' and 'Reports'. The only shortfall of this marvelous software, which makes the laboratory continue using a little bit more of their operations manually, is the fact that this system has no way of allowing people to sign after collecting blood/ blood products from the lab. As a result, paperwork still has to continue to a small extent. Despite that, the system has obviously transformed how they work, enabling not only efficiency but also never-thought-before levels of accuracy and precision. On another note, the server may go down sometimes, at which point they have to resort to doing their work manually. Nevertheless, tremendous progress is being made and as a country we are getting there, more so because of the fact that this system will eventually become the standard system in use in many hospitals across the country. We all know that the usage of technology in any area of life increases exponentially as time passes. I look forward to the day when other software for information-management in other departments of the hospital will emerge, that will integrate seamlessly with the LIMS and exchange data. For instance, a technology whereby results can be sent automatically and electronically to the wards after being processed, saving nurses their time and energy as they would no longer have to walk to the lab to get results on paper- or a way through which results of a blood test can be sent from a laboratory machine to the monitoring device of a patient in an ICU unit (and simultaneously to a doctor's smartphone), causing another ICU machine to instantly commence treatment to correct the abnormal findings, while on the other end alerting the doctor of the treatment's commencement.

I do not think these advancements will occur soon in Malawi. This is not because they are too futuristic (I personally do not regard interoperability of digital systems as futuristic). However, this could delay a bit because in Malawi they would be considered luxurious at the moment. Whatever time it takes for these technologies to infiltrate our system, it cannot be denied that this

is the direction that everything is slowly taking. You have to look at the bigger picture to appreciate this.

The advantages of health informatics can be seen in three areas. First, it can lead to improved outcomes. Using information technology helps to improve the quality and safety of patient care. Studies reported on the website HealthIT.gov revealed that many physicians under study were seen to believe that electronic medical records have the capability to provide a better view of their patients' total health, allowing for better diagnoses. Using information technology in healthcare has also been associated with improved efficiency in healthcare practices.

Secondly, technologizing healthcare information-sharing and storage possesses the potential of increasing patients' participation in their own health issues. As we shall see in chapter 6, an increasing number of patients worldwide are participating in their own healthcare, a phenomenon referred to as 'Health 2.0'. This is of paramount importance for patients suffering from chronic diseases such as asthma, diabetes and heart disease. These patients become accustomed to their disease and know it better. It has been claimed that patients of chronic illnesses are 'experts' at their disease than are their doctors. Health information systems can help these patients to connect with their healthcare providers to share experiences and learn to make the best healthcare choices. Of course this is being put into maximal use in the developed countries- as is the case for most healthcare-related technological revolutions. However, the rest of our countries are not completely staying idle on these matters.

Additionally, greater access to health information can be used to improve health on a population scale. Put differently, health informatics can be used extensively in Public Health. When we talk of healthcare being improved by trends such as this, most people conceptualize the effects on the individual level. However, Public Health, which has the broader perspective of looking at health from the population perspective, can also be enhanced by health informatics. Public Health informatics can help control the spread of disease and improve readiness to contain a disease outbreak. We shall see more about this in the following chapter.

There is an official movement known as 'ICT for Health', which exists in the Baltic region of Europe, spanning across countries like Norway, Finland, Germany and Sweden. It espouses encouraging e-Health among patients, healthcare workers, policymakers and other key stakeholders. ICT for health indicates how ICT solutions empower patients to take more responsibility for their own health. It also demonstrates how to enhance effectively the acceptance of e-Health among the said stakeholders.

This movement is based on the premise that a greater and better acceptance of ICT is central to ensure future healthcare provision in the regions which are part of this arrangement. Several delegates converged in 2012 in Brussels to discuss how to increase the acceptance of e-Health among stakeholders. Movements like this show that even in the developed countries where they have the adequate technological infrastructure to implement new tech-based health solutions, resistance can still be met. From this we can conclude that having the necessary technological infrastructure is not sufficient to bring about acceptance of technological methods of healthcare service-provision. There must be other social reasons, which policies must target. The receptivity to e-Health is probably least among underdeveloped countries. Replicating movements such as the ICT for Health movement in countries like Malawi should therefore have more usefulness.

It is not difficult to imagine that some people still strictly prefer physical hospital visits to telehealth services. Some of these preferences are based on beliefs like the purported ineffectiveness of telehealth services (which can be implemented by healthcare workers located remotely). These beliefs are simply not true. Research has shown that ICT-based diagnostic health services and other health services are as effective as face-to-face encounters with healthcare providers. In fact, as we will see in chapter 5, most Artificial Intelligence (AI) systems in existence today can make diagnoses more accurately than physicians.

It appears, therefore, that lack of acceptance of these technologies is mostly based upon lack of understanding of what they can offer. Of course in some instances, patients just have to physically see a physician. This includes in the cases of serious illnesses. However, the argument

here is that it is not every time when a physical encounter with a physician is necessary- at least when we consider all the possible technologies in existence that can replace a physician visit in the event of a mild illness. The only problem with this is that sometimes serious illnesses may appear as 'mild'. With increased health-literacy, consumers of healthcare services should be better able to recognize illnesses which can only be managed through physician visits. Fortunately, health-literacy among the population is increasing.

Why some people will not accept telehealth and other ICT-enabled healthcare solutions is largely rooted in the same reason why some look down on online learning. The two are analogous. It has been demonstrated that online learning can be as effective as physical learning, and almost all major universities in the United States and across the world, now have at least one program of study that is taught online. Interestingly, certain countries in Europe use online learning to train medical specialists, like we discussed in chapter 1. Yet some (usually those with lesser knowledge on this matter) believe that online learning is 'inferior'. It is the same line of thinking that is shared by those people who believe that physically visiting a doctor's office is superior to talking to the same doctor remotely through a device. I would ask those people the following question: "How can remote medicine be 'inferior' when it offers possibilities of being integrated with other innovations like artificial intelligence capabilities that make more accurate diagnoses; and patient empowerment?" Surely, e-Health needs to be rethought by everybody. It is the future of healthcare and slowly but surely, healthcare is going that direction.

There is one area where those who look down upon the extensive use of technology and ICT in health have a point. Communication between patients and healthcare workers through technological means leaves no room for what I call the 'compassion complex'. Simply put, non-verbal messages from the healthcare practitioner to the patient cannot usually be appreciated when communication is technologized. For instance, nurses' training emphasizes much on maintaining ideals like empathy and other feelings. Through the use of good eye contact, touch and well-organized sitting arrangements, a healthcare provider can communicate messages to make the patient have trust and feel more comfortable. Some theories believe that these minute

practices can have an effect on the patient's healing process. While this text is not meant to neither substantiate nor dispute those propositions, it is clear that digitized communication leaves healthcare providers and patients emotionally distanced. In trying to counter these barriers without resorting to non-artificial means, scientists are making telehealth services much more interactive and personalized. The hope is that patient-provider communication through technological means can be as personalized as patient-provider communication through a physical encounter.

Sometimes, the uptake of healthcare technologies is not affected by individual factors. The success of these innovations can depend on other factors upon which no individual can have control, such as policy factors. Shiferaw & Zolfo (2012) stated the following:

"Telemedicine implementation does not only depend on technological factors, rather on e-government readiness, enabling policies, multi-sectoral involvement and capacity-building processes. There is no 'one size fits all' approach, technology and the use of interoperable applications, according to the local context, is highly recommended".

From the above statement, it follows that the maximization of e-Health necessitates not only mindset-change in individuals, but also willingness and supports from governments, non-governmental institutions and many other sectors. NGOs are outspoken in Malawi, and they could do a good job by increasing awareness on e-Health.

It ought to be noted that when we talk of ICT in healthcare, we are not only talking about some advanced software. The mere practice of healthcare workers sending e-mails containing healthcare information (such as patients' scan results) to each other, or digitally sharing best healthcare practices, is an example of how ICT has infiltrated the healthcare sector. The rise of social media platforms such as Facebook and various instant texting platforms has allowed healthcare workers to have the ability to share information more quickly and in better-than-ever ways. A group of medical interns stranded with a complex case can instantly communicate with a medical consultant located remotely. Groups which can be created on these social media

platforms allow the multiple participants to synchronously exchange a wide variety of information on different topics. Of course these platforms do not come without their vices. There have been several reported cases of practitioners abusing these platforms, such as by sharing images of suffering patients obtained without their prior consent. Such issues relate more to medical ethics than medical informatics, so we shall not go into depth on them. Nevertheless, it cannot be denied that these platforms provide a good means of information-exchange among healthcare professionals, and we can be sure that they are contributing to improvement in healthcare practices.

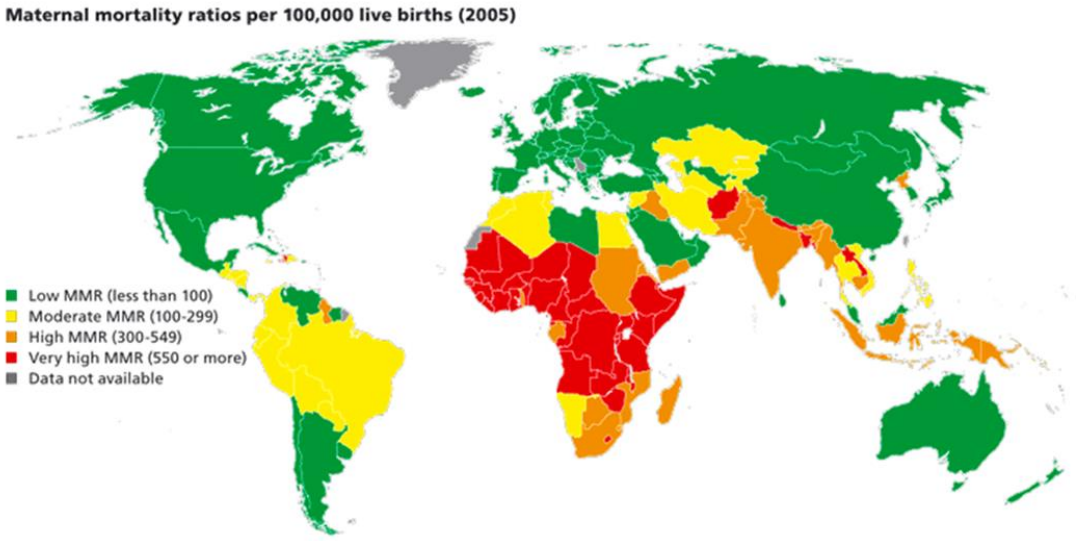
Chapter 4: Geographic Information Systems: Using Location Data for Health Action

"GIS and analytics can help the health care industry make better decisions"- Stephen A. McElroy.

I so much love the field of Public Health. One of the reasons for this is that unlike the clinical professions, Public Health views health and illness from the context of a broader perspective, such as placing focus on the population and not individual.

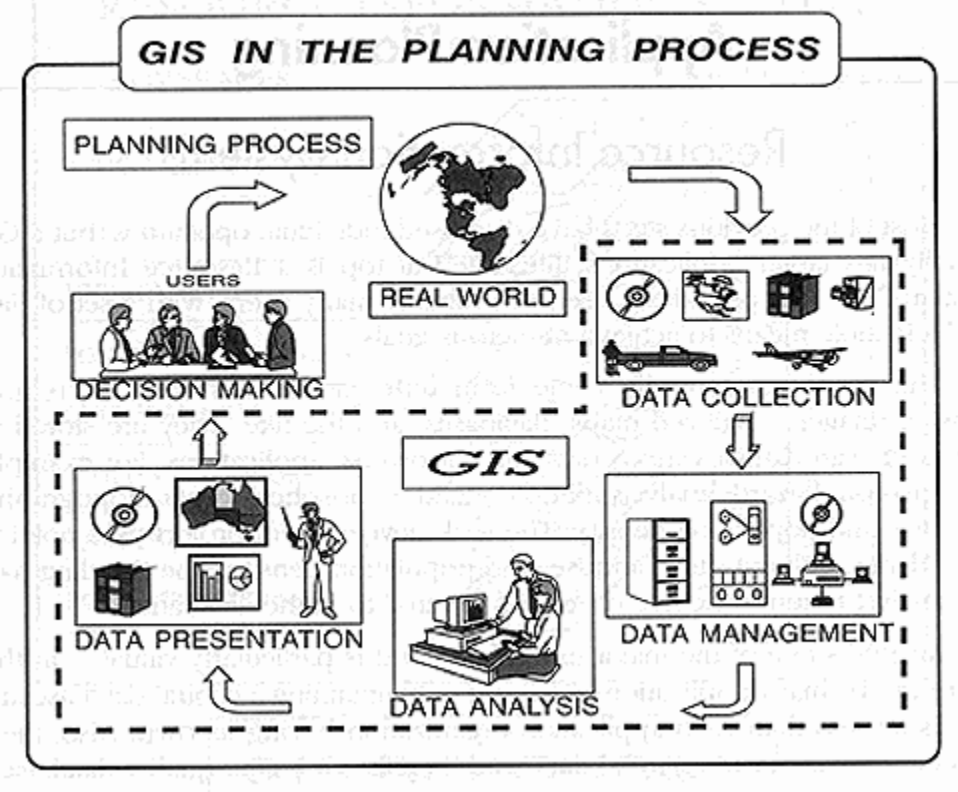
One of the fundamental attributes of Public Health is that it is primarily prevention-focused, unlike medicine which places primary emphasis on treatment. In preventing and controlling adverse health conditions in populations, Public Health experts do collect data from the populations, which can be used for decision-making. One of the ways of collecting this data is by using Geographical Information Systems (GIS).

A Geographical Information System is a system which is designed for capturing, storing, manipulating, analyzing, managing and presenting spatial or geographical data. However, GIS can also be used to refer to any system that integrates, stores, edits, analyzes and displays geographic information. There are a number of technologies, processes and methods which fall under GIS. GIS is useful in many fields such as engineering, planning, transport, telecoms and business. It is also used in health, although its potential in this field has not been fully tapped into. Since GIS deals with location-specific information, it can be used to present data about health variables in different places. For instance, it can show the distribution of several different diseases across several mapped areas, allowing experts to get an impression of which parts of an area (district, country or region of the world) are badly affected by particular health problems, allowing for possible strategic intervention (delivering resources in accordance with how much they are needed in each area). GIS can also be used to show areas which have received various healthcare interventions (such as during community outreach services or relief programs). Indeed, there is a lot that can be accomplished with this technology in the field of healthcare.



A sample of what a GIS-generated projection may look like.

Although GIS is relatively new, scientists of the 19th century used similar techniques to portray epidemiological scenarios (epidemiology is a branch of public health). In 1854, John Snow, one of the founding fathers of epidemiology, was able to map out the source of a cholera outbreak in London by marking points on a map depicting where the cholera victims resided. This was one of the earliest examples of successful application of geographic principles in Public Health (particularly epidemiology). Although Snow's methods were crude and paper-based, they were able to accomplish their purpose and set trends that would eventually propel the advancement of GIS. It took another 66 years for a notable leap in progress to manifest. In 1960, the first *real* Geographical Informational System was developed in Canada. Although this system was primarily designed for collecting and analyzing agricultural data, it later became important for use in the sphere of healthcare as well. More recently, there have been releases of a number of various free GIS packages that are available for free to anyone and are compatible with various operating systems, and can be customized to perform several different purposes.



An illustration of how GIS is used in planning.

In countries like Malawi, Community Health is one of the most emphasized areas of healthcare. A lot of research is done in this field. Noticeably, most research practitioners still use paper-based data collection tools. I can imagine that it should not be very difficult for researchers who collect data using digital devices such as tablets/ iPads or others which, upon collection, can immediately be entered into a database. This has numerous advantages. First, papers are bulky. Second, paper-based collection methods necessitate the performance of manual data analysis after the data is collected, and this is tiresome and some research assistants may actually falsify a portion of the results in trying to reduce the cumbersome workload. I am not quite sure how many, if any organizations in Malawi have gone partially or wholly digital in the way they do their research data-collection. However, the fact that many bodies still do it the old way means that we still have a long way to go.

Most, if not all new technologies are often perceived as unsustainable at first. If we look at them from a different lens, they help us cut off long-term costs in the form of money and other costs.

If we factor in the purchasing costs of stationery as well as the environmental costs of producing, storing and getting rid of bulk loads of paper, we can get a glimpse of the merits that digitizing Community Health research (and other forms of research as well, of course) can be able to offer. Not to forget, it is possible to obtain instant or near-instant results through the use of GIS tools in research operations. Think about this example: data-collectors collecting their data from rural communities in the remote districts of Machinga and Balaka, with officers instantly receiving graphical displays of results at a central office in the city of Blantyre. How good does this sound? This is not even futuristic. It is quite feasible and within the reach of technologies which already exist. Why we are not embracing these innovations, or at the very least not using them to their fullest potential, is a question we cannot keep avoiding.

When I was attending one of my international innovation summits, I was at some point in what I would like to call an 'idea hackathon'. This was whereby we had to brainstorm some game-changing ideas in their most detailed form, in a matter of a few hours. At a point, I got an epiphany whereby I thought of developing an innovation that could potentially provide healthcare information to a person based on the person's location and other personal/ demographic data. Initially, I hatched the idea as a kind of 'Google-maps of health'- a system which would give the user health-related advice depending on their location and direction to which they were headed.

Suppose you were about to take a walk in Lilongwe- or any other city- for a few hundred meters or a few kilometers, this hypothetical solution would tell you the health hazards you're more likely to meet at every turn of your journey. It would go from pin-pointing mosquito-rich swamps to highlighting areas where you would be more likely to be hit by a motorcycle (from recorded accident statistics and density of traffic), to indicating where there typically is bad air due to industrial gas-emissions or mining activities. What bothered me with this idea was the unsettling thought that probably a similar system might already exist, and also the fact that this system if actualized, might end up being more useful for scientists interested in collecting health data, not ordinary people. Even if this system could alert a user that area X has a 59% malaria

risk, it would be meaningless to this user (unless if they were a scientist or flat-out nerd). As such, this innovation would not be immediately useful to the lay person.

My interest was in innovating for average person, not the scientist. Therefore, these possibilities defeated the whole purpose of this possible innovation. This line of thinking prompted me to refine the idea and add more to it. I finally came to a point whereby I thought of it in a different way. I thought about creating this system in such a way that users should have accounts. In creating the accounts, they would need to provide some demographic information such as age and other factors. While navigating places, this system would provide alerts to the user, based on a hybridized mixture of the most pressing environment-related health problems in the area they were in, and their health vulnerabilities stemming from their demographic and other personal information. For instance, if you were asthmatic, the system would alert you through an alarm whenever you are passing through a high-altitude area (which has less oxygen) or an area filled with certain asthma-triggering factors like pollen or noxious chemicals, which may trigger asthmatic attacks in some people.

However, I still had trouble convincing myself of the feasibility of this system because for instance, some people do have asthma attacks from recognized triggers whereas others' attacks can be triggered by random substances. Secondly, some triggers exist permanently in certain geographical areas while others may be temporal. For instance, spraying insecticides or pesticides can trigger attacks in some people, but the system would not be able to alert people about things like these, because pesticides or insecticides are not permanent geographical features that one can always find at some place. As a result, the system would only (or mostly) be able to provide alerts based on permanent environmental hazards of a given place, which actually are/ would be predictable anyway. In not being able to alert users about temporal hazards, the system would be useless.

It is very well-known that in many parts of China such as Beijing, there is badly polluted air, for example. World Health Organization, as quoted in Vaughan (2016), stated that China is the worst country for outdoor air pollution. More than 1 million people died from polluted air in China in 2012 (Vaughan 2016). But one does not need an app to alert them about this, because this has been the case for a very long time and has become "obvious". Perhaps the only required alert-system would be one for alerting residents of these already badly-polluted cities of

temporary surges in the levels of poisonous smog, which do occur occasionally. For instance, alerting users when the air quality has gone from bad to worse. But this would require very sophisticated, widely-integrated and non-personalized technology to provide temporal updates.

Environmental factors such as air pollution, bad water and traffic contribute to 25% of the world's health problems. Therefore a system like the one I conceptualized, for warning people on the go about health problems, would be important and would be like a health guide-book or atlas. However, the technicalities of how to design it including how it should operate and what information it should contain, I still found elusive.

Another note-worthy issue related to GIS is Google Flu Trends (GFT). This was a service that was operated by technology giants, Google. It provided estimates of influenza activity for more than 25 countries. It aggregated Google search queries in attempts to accurately predict the patterns of flu activity, with the aim of predicting outbreaks of flu. Although the project by Google no longer continues, others conduct similar projects by analyzing data from Twitter and elsewhere, using structural models to infer how the disease is spreading over time and space. The exciting thing is that the estimates of the numbers of flu in populations provided by Google were found to be correspondent to those provided by health authorities. It is quite interesting to see how search engines and social media can be used for health-surveillance activities.

The fact that most social media sites request and/ or obtain the user's location means that the internet is a potentially powerful tool for doing health surveillance. GFT was discontinued after it gave incorrect information on flu prevalence at some point, but it had been accurate to as much as 97% previously. Most likely, the reasons for its failure were more related to poor customization and adaptation of the system over time. Nevertheless, it set a precursor for other systems which would follow, and it also showed us the potential that the internet has of contributing to healthcare improvement. The mere decision by Google itself to indulge in health surveillance demonstrates how useful technology can be in the domain of healthcare, and how people in the technology sector ought to broaden their horizons to help out in the health sector (like we discussed in chapter 2). Of course, this was not the first time for Google to meddle in

health affairs. They had previously introduced Google Health, which run between 2008 and 2012 and acted as a centralized health profile. Although this product was not GIS-related, it showed the occasional interest of Google in health matters, and this makes a statement- that ICT can definitely be used for health-promotion. Even currently, *Alphabet*, the parent company of Google, has got various health projects being carried out.

Brittni Brown, a Masters student at University of Idaho, categorized the benefits of GIS in healthcare into five categories as follows:

i) Identifying Health Trends
ii) Tracking the spread of infectious disease
iii) Utilizing Personal Tech
iv) Incorporating Social Media and
v) Improving Services.

He observed that GIS software could offer healthcare professionals the ability to identify health-related trends. Citing an example of the University of Southern California's Public Health Program, which utilized specific GIS software in its cancer research, Brown consolidated the significance and indispensability of GIS today. The University of Southern California's program took account of demographic data such as home address, workplace, cancer type and even data collected from wearable health technologies (such as smart wrist bands) worn by patients registered into the system, after geo-referencing and mapping. This way, healthcare professionals could look at the locations of clients and determine if there were specific types of cancer associated with similar working conditions or working areas.

On a different note, GIS has also been widely used by researchers in prominent academic institutions such as Havard University. Briney (2014) stated that GIS in Public Health basically answers the question *Where?* It is worth noting that incidence and prevalence are two more important foundations for using GIS in Public Health. While incidence refers to the number of new cases of a health problem, prevalence measures existing cases of a disease over a specific

period of time. A disease which kills fast will have a higher incidence than prevalence (because many of those who would have been suffering from it will have been killed by it in no time). The implication of this is that health officials and researchers can be able to see how deadly diseases are distributed across an area.

The use of GIS is not limited to epidemiological studies. It can be stretched to reach as far as health policy. This is because GIS can be used to monitor the distribution and accessibility of health services. Health service utilization, with respect to locational constraints, can be displayed visually using GIS, to determine hindering factors against acquisition of healthcare services. Of course increasing the number of facilities does not necessarily guarantee increased service usage, since access to healthcare also depends on cultural, social and economic barriers (Musa et al 2013). However, it is still undeniable that GIS can significantly improve health service distribution by pin-pointing gaps in healthcare service-provision. We could use GIS in Malawi to evaluate the outcomes of large and medium-scale healthcare interventions. Collecting data to use in GIS would be more problematic than in developed countries, because few people use gadgets that can provide GIS data. However, this does not mean GIS cannot be used in Malawi.

Despite all its merits, GIS is not without its limitations. People have questioned whether it is best suited for healthcare research, and whether it offers anything novel in epidemiology. Some GIS applications have been the subject of criticism for 'not providing the necessary tools for detailed epidemiological research'. Others have reached as far as saying that GIS applications only give an insight into location, while lacking a temporal component, which makes them incomplete as epidemiology is meant to describe causal relationships according to three variables: time, place and person.

However, improvements have been made on GIS applications to enable them to overcome the said shortfalls. For instance, the 'Dynamic Continuous-Area Space-Time' (DYCAST) is a system which was successfully used in predicting the spread of West Nile virus in New York City. Therefore, new developments like the DYCAST possess the potential of improving GIS and making it more suitable than ever for health research. The rapid increase in availability of GPS devices also has a role to play in increasing the popularity of GIS usage in healthcare.

Chapter 5: Artificial Intelligence and Healthcare

"Despite the progress in other industries, healthcare is likely to be the one market where AI can truly have an impact that goes beyond convenience and positively affects human life"- Reda Chouffani.

I first read about Artificial Intelligence (AI) in 2009, from a philosophy book. I still remember that the book was titled "*Classic Questions & Contemporary Film: An Introduction to Philosophy"*, and it was written by Professor Dean Kowalski. In one of the chapters, it sought to answer questions such as "Can machines think?"

The ancient philosophers would never have dreamt that a couple of millennia down the line, philosophers would genuinely become interested in finding answers to questions such as whether lifeless, impersonal, man-made devices could *think.* Philosophy has always concerned itself with abstract issues, but the interest in understanding whether machines can *really* express cognitive ability has increased due to the fact that machines (especially computers) seem to be "smart" in this era.

Today, computers are able to solve problems better than humans. Not long ago, a supercomputer was developed, that managed to beat a world champion in the ancient Chinese board game called *Go*. With these endless increases in the 'smartness' of computers, philosophical debates on whether the attributes of these computers ought to be classified as 'thinking', are not so misplaced. It is now 8 years since I first heard about AI. While I maintain my curiosity regarding the phenomenon, my focus has now shifted from the academic debates with metaphysical focus-areas like whether to class computers as conscious beings, to the practical implications of AI in healthcare.

By definition, Artificial Intelligence is intelligence exhibited by machines. It may mean the ability of machines to "learn" and solve problems. It also includes the capabilities of computers to understand and communicate in natural language, and to read and absorb knowledge. Today, some experts believe that we are experiencing the 'fourth industrial revolution', which is full of numerous technologies with amazing capabilities. The first industrial revolution was an age of steam engines, which powered production processes and nurtured industries. The second industrial revolution was characterized by the advent of electricity, which was multiple times more effective that steam engines. The third was marked by the inception of electronics and ICTs in production processes. Now, we are in the fourth one, which builds on its predecessor and whose paramount feature is the blurred line between the physical, digital and biological spheres. It is in this age that we have, for example, materials that can be classed as *bionic*, to mean that

they exhibit both electronic and biological properties. Advanced bionic prostheses are an example of this. They exhibit properties of biological organs and properties of electronic conductors at the same time!

We have, for the first time ever, built computers and computer programs that can 'think' better than humans, in the form of AI. Milestones like these have never been seen before.

Artificial Intelligence has useful applications in healthcare.

It is due to the fact that this new era of hybrid technologies is unleashing fundamental, irreversible changes in the way we live, that thought leaders are convinced that we are in a new industrial revolution- not just merely an extension of the past one. Experts have predicted that by 2025, AI systems could be involved in everything from population health management to digital avatars capable of answering specific patient queries. Perry (2016) also predicted that the use of AI in medicine would increase tenfold in the next five years. However, some companies (especially in developed countries) are already applying machine learning techniques and predictive analytics to reduce drug discovery times, provide virtual assistance to patients and diagnose diseases (usually at a faster rate than humans). The ways in which AI is impacting healthcare can be divided into five areas, which shall be discussed as follows.

Diagnosis and Treatment

AI is able to assist physicians in making diagnoses and determining treatments. It can sort through latest medical information to find relevant patterns for individual patients. An example is *Watson Oncology*, which goes through thousands of cases and articles, helping the physician to decide the most effective treatment for a specific tumor. This supercomputer was able to provide a diagnosis of leukemia in a woman with a complicated case, within 10 minutes- a feat which doctors had failed to achieve in months! The machine achieved this by studying the patient's medical information and cross-referencing her condition against 20 million oncological (cancer-related) records, which had been fed into the system. The patient had a unique form of leukemia, which the doctors had failed to identify. Thus, she required special kind of treatment not the usual one. Eventually, she got treated successfully.

With technologies doing the job better than healthcare staff today, it is worrisome that some healthcare staff could lose their jobs in coming decades. According to Billington (2016), technologies like IBM's supercomputer 'will have the medical profession looking over their shoulders'. Obviously that would not be a good thing, but it seems inevitable with time. Here in the so-called less-developed southern hemisphere, I do not expect this shift to come of age in this decade. Nevertheless, one day this will be the story.

When modern technology has overshadowed every practice in each healthcare institution all over the world, some technological solutions shall become a cheaper alternative to human healthcare workers. This is when the developing countries, like their developed counterparts, will begin to worry about job-losses for healthcare staff (as a result of their replacement by robots). Due to the inevitability of this, the best that people will be able to do might be to start preparing to re-define the roles of healthcare providers with the passage of time. That time, healthcare workers will need to take on more hands-off, administrative kinds of roles, overseeing the performance of tasks by machines and computer systems.

Disease-Management

This is when AI provides treatment regimens for patients (especially those with chronic illnesses). To achieve this, an AI tool is used to provide doctors with insights for patients, who use them to understand the patients' needs. This tool also takes into accounts patients' personalities and socio-economic statuses in understanding and predicting differences in responses by patients to similar treatments.

In 2016, Dr. Cory Kidd, a computer scientist, gave a speech on the role of AI in the management of chronic diseases. He was the founder of *Catalia Health*, a company focusing entirely on patient-management. This company developed patient-engagement tools built on the principles of psychology and machine learning. Designed to promote patient-to-patient interaction through several platforms, the system could provide support to patients when they needed it. Chronic illnesses are known to cause emotional/ psychological distress among patients, and these tools had come in handy. Kidd's speech set a pace in the adventure of widening the use of AI in managing patients.

Scientific Research

For a long time, clinical trials have been conducted through a method of directly obtaining data from respondents. That practice is still maintained to date, although it is slowly changing. Soon, it might no longer be the way to do things. There are already calls from various quarters for replacements of this method.

Thought-leaders argue that this conventional data-collection method may have reached its limit. They argue that this method is no longer cost-effective. After all, data collected in this way may not always reflect real-world situations. For instance, in measuring the blood pressures of study subjects, results may be jeopardized, with some subjects recording high measurements due to stress associated with being involved in the study. There is a phenomenon which is known as "white coat hypertension", where subjects can have psychological discomfort due to fear and anxiety associated with being in the presence of healthcare providers. The results manifest through altered physical measurements, such as elevated blood pressure. This and other

phenomena are sufficient reasons for considering collecting data remotely through means such as those generated by artificially-intelligent computers and retrieved from databases. For example, peoples' blood pressures and other readings, collected at a time when a study is not being done, can be kept in databases. Later on, researchers can simply use that previously collected data.

The increase in the use of smart wearable devices like smart watches (that can collect peoples' biometric data such as sleep patterns, pulse rates and more) presents an untapped opportunity that can be used to engage effective data-collection tools. All we need to do is to scale up ways of depositing that data into repositories from which AI tools can extract it if needed.

The stumbling block here is that wearable devices are relatively new and are not yet as popular as mobile phones. Since few people use wearable devices, limited data can be obtained from such devices. However, we have cause to be optimistic as most technology companies are investing in the scaling up of wearable devices. The goal is for people to use devices which feel like part and parcel of them. Smartphones have many advanced functions, but they are still separate from the user. On the other hand, wearable devices like advanced 'smart watches', 'smart lenses' and other similar devices are a new trend among the technology companies. With time, we will see these devices becoming cheaper and more common. Jean Quinlan, a specialist on wearable technologies, predicted that wearable devices will become more prominent in this decade and the next. At the moment, some companies are already producing 'smart clothing'- garments made from a blend of textiles that are designed to have electronic capabilities. In 2015, Google partnered with jeans manufacturing company, Levi Strauss & Co on a project for manufacturing clothing with electronic threads and buttons- with 'natural' appearance and without visible electronic features. João Wilbert, creative technologist for Google, said the following about this innovation: *"The goal is to allow electronics to disappear into the fabric of daily life"*. This is enough evidence that innovators are actively engaging in the process of making 'smart clothing' a regular, everyday thing. These kinds of clothes would have capabilities such as measuring vital signs and other health and biometric indicators. As these become more and more common, there will be large enough pools of health data provided into databases from wearable devices.

Wellness

The University of California defines wellness as an active process of becoming aware of and making choices toward a healthy and fulfilling life. Wellness goes beyond merely being free from illness. It represents a dynamic process of continuous growth. In other words, wellness is multifactorial and multidimensional.

One way in which AI is being used to promote wellness is being championed by IBM's Watson software. Watson is partnering with Johnson & Johnson, an American pharmaceutical product-manufacturer, to assist patients whose joints were replaced in better managing their health. The two collaborated in 2015 to use advanced data analysis and develop solutions tailored to the needs of each individual patient who underwent hip-replacement surgery. These solutions would tally with the patient's specific issues and would include coaching on how to live an improved life.

Another notable AI-powered wellness solution is called *BioBeats*. They create products underpinned by AI algorithms to help and support wellbeing. They measure indicators like heart rate variability, sleep, activity levels and suggest interventions for the individual. Abnormalities in these measures represent problems such as stress. Thus, *BioBeats* helps individuals get back on track from abnormal patterns in their daily living. This truly represents evidence-based insight and intervention.

Despite having immense potential to transform healthcare, AI faces some setbacks. The obvious key setback in developing contexts is the shortage of data as a result of low usage of gadgets capable of providing this data into the necessary databases.

Another setback (particularly in developed contexts) relates to policy issues. Rowley (2016) argued that one of the reasons why the use of AI in medicine is hindered has to do with fiscal and policy issues. This specifically applies to fee-for-service health systems, which are structured such that patients can only pay for health services after face-to-face encounters with healthcare providers. According to Rowley, this hinders the progressivity of technologies that streamline

non-face-to-face encounters with patients. Rowley advocates for *value-based healthcare*, which does not require payment on the spot but rather through health insurance and related means. Here, we witness a very good example of how healthcare systems could be structured differently to accommodate technological innovation. Conventionally, many governments usually arrange healthcare systems to be based on structures which do not require payment on the spot (although they may do this is due to economic reasons not technological reasons). However, we can now see, from Rowley's proposition, that such deliberate structuring of healthcare markets to follow risk-based payment patterns is not only useful for economic purposes, but it is also technology-friendly. As countries like Malawi become more developed and gear towards the use of these technologies in healthcare, policymakers will need to bear in mind that the enactment of these technological solutions necessitates corresponding changes in other areas as well (such as electronic payment methods).

Chapter 6: Health 2.0 & the "Open" Movement

"Physicians should not be expected to be all-knowing; expert yes, but not omniscient. The best chance we have of improving healthcare systems is to adopt more collaborative models and involve everyone"- Dean Giustini.

We most frequently see the importance of technology in healthcare from the different advancements in diagnostic and treatment options. However, we less often see the role of technology in its contribution to health information-provision.

For so long, health information has been seen as entirely belonging to physicians. The most prevalent model of healthcare service-provision has been one whereby the physician is seen as knowing everything. Many people visit health facilities to be diagnosed and treated- without having a say over what their problem could be, or what treatment options could be best for them.

As already seen, the medical profession is one of the professions whereby only those trained in those fields are considered to have expert knowledge on health issues. It differs from other professions, where this consensus does not always exist. Over the years, however, things have begun to change concerning the medical profession. People not formally trained in healthcare are having increased knowledge of health issues more than ever before. The internet is one of the reasons for this. Today, some people come to health facilities with pre-existing knowledge of the causes of their symptoms, the possible diagnosis, treatments, side effects of all possible treatments and more. In some cases they may have more information about their disease than physicians. A research by Snow, Humphrey & Sandall (2013) showed that diabetes patients under study had more knowledge about their condition than their healthcare providers. This is cemented by contributions by Hesse et al (2005), who stated that more and more patients first go to seek information online before talking to physicians. In their 2003 study they found that 63% of the US adult population reported ever going online to seek health information at least once in the past twelve months. In the Netherlands, the internet is more popular than television, radio and newspapers (Van De Belt et al, 2010). The use of the internet as a health information-resource is projected to increase much further (Van De Belt et al, 2010).

Even in developing countries like Malawi, the number of people resorting to the internet to get medical information is increasing, especially among the middle-class. I was astounded one day when a pregnant woman asked me about the possible cause of her discharges- from a choice of two possible diagnoses (which she mentioned)! The manner in which she posed the question showed that she had near-full understanding of the issue but just wanted a little bit of clarification. There is need to encourage people to seek health information as a way of taking

control of their own health. A greater understanding of health issues implies greater awareness, and subsequently the ability to prevent illnesses and comply with health advice.

Health information-sourcing from the internet should not replace hospital visits, but the two should be complementary. In addition, seeking health information from the internet needs to be done with great care to avoid getting wrong information. The healthcare sectors of our developing countries need to establish active mechanisms for guiding the public regarding health information obtained from other sources. In Malawi, there is no multi-purpose online repository for health issues. If anyone is interested in seeking health information online, all they find are resources from foreign countries.

Sometimes, random pieces of health information written by professionals from other countries, may be accurate and fitting to many contexts, but this may not always be the case. For instance, treatment options for various diseases vary across countries according to country-specific guidelines. Obtaining information from the web could thus be misleading if not done without advice from local healthcare professionals. People still need to get health information conveniently. The absence of local online health resources in countries like Malawi could be a hazard to those Malawians who like obtaining information online. There is need for healthcare institutions and professionals in developing countries like Malawi to develop active, robust online resources that are in tandem with their countries' health systems. Perhaps some key figures from the Malawian health sector might not be willing to invest in online health resources based on the current low number of people who would be willing to search for information online. The problem with that kind of thinking is that it is not progressive. The numbers of consumers of online information could be smaller now, but it cannot remain static for, say, twenty years. Things are always changing and so are people. Long-term planning is what we need if we are to make progress.

Let us now go to the concept of Public Health 2.0. Before we define Public Health 2.0, we first need to define Public Health. Public Health is the art and science of preventing disease, prolonging life and improving health through organized efforts and informed choices of society, organizations (public and private), communities and individuals.

As mentioned in chapter 4, Public Health differs from mainstream medicine in that the former emphasizes on prevention and working with populations, while the latter places primary emphasis on treatment and working with individuals. However, the two are intersecting and in the context of this book, the difference is not of remarkable significance.

Public Health 2.0 is fairly a new concept. The term Public Health 2.0 (also called Health 2.0) was initially associated with concepts like collaboration, openness and social networking between patients, their caregivers, medical professionals and other stakeholders in healthcare. It has evolved to also mean the role of cloud-based computing (use of a network of remote servers hosted on the internet in data storage and management, as opposed to local servers or personal computers), and their associated applications on multiple devices. Public Health 2.0 describes the integration of these into much of both clinical and administrative duties in healthcare. Public Health 2.0 was derived from the concept of Web 2.0. This is a term which is used to describe websites which emphasize user-generated content, ease of use and interoperability (ability of a product or system to work with other products or systems, present or future, without restrictions). Thus, web 2.0 websites tend to support forms of content such as blogs, wikis, chats, videos and other forms of media created by users of such websites rather than their developers. Facebook, Twitter and all other social media platforms are examples of Web 2.0 websites. Hence, it is easy to use these for Health 2.0 purposes.

Early examples of Health 2.0 were the use of tools such as blogs, online communities, tagging, Twitter, videos and more by healthcare professionals, patients and scientists in order to personalize healthcare, to collaborate and promote health education. Health 2.0 allows patients to have much more hands-on approach to their healthcare than ever before. It equips them to take control of their own health needs, which may lead to improved overall population health. Health 2.0 is about collaboration, participation and openness on health matters. There is a Christian hospital in Malawi, called *Blessings Hospital*, which is actively present on Facebook. It allows the public to provide complaints on health problems they may have, promising to act as a bridge with medical specialists. This is a primordial example of Health 2.0 at work.

As mentioned previously, Health 2.0 goes as far as providing the opportunity for patients to share their electronic health records with medical professionals, researchers and caregivers.

Since Health 2.0 can be designed to focus on preventative care, it has the power to shape Public Health for the better.

Health 2.0 relies heavily on the use of 'Open Source' principles. The Open Source ideology emphasizes making available of software code to the public, where users may study, modify and distribute the software to anyone and for any purpose without restrictions. There is an informal worldwide movement called the "Open" movement, which comprises individuals who support the use of Open Source principles for some or all software. Open Source software is intended to promote learning, development of high quality software and collaborative work. Open Source is not any less-important in healthcare than it is elsewhere. Health-related software such as health informational apps and other kinds of apps can benefit from this movement. If many developers of health-related software make their products openly and freely available, they could help in improving healthcare information-sharing. Many people movement do not even know of the existence of the Open movement. They are unaware of the Open Source ideology. As such, they do not take deliberate efforts to seek health-related Open Source software for their own use.

The emergence of new collaborative platforms where users (mostly sufferers of chronic diseases) exchange information has heralded the birth of a new era of user-generated health information. The users of these sites exchange information such as that relating to their own long-term experiences with their illnesses, and other extensions such as lifestyle and coping advice to their colleagues newly-diagnosed with similar conditions. These forms of interaction are helpful in helping patients to get well-acquainted to the key issues relating to chronic diseases. Forums like these include blogs, groups on messaging platforms, groups and pages on social media platforms like Facebook, and many others. Many Malawians now interact on social media platforms. An example of this is the 'positive living' groups on Facebook and Whatsapp, where HIV-positive

people share their experiences. Some even take a step further to converge in real life after meeting on these forums.

These developments are a representation of the growth in patients' steps towards improving their own health, and how technology is playing a role in the process. In the past when platforms like these did not exist, patients had lesser options. The only other main way to get such essential information was to visit physicians. Hospital visits can sometimes be uncomfortable. There are some issues patients just want to discuss with those who have the same legacy (such as HIV experiences to some patients).

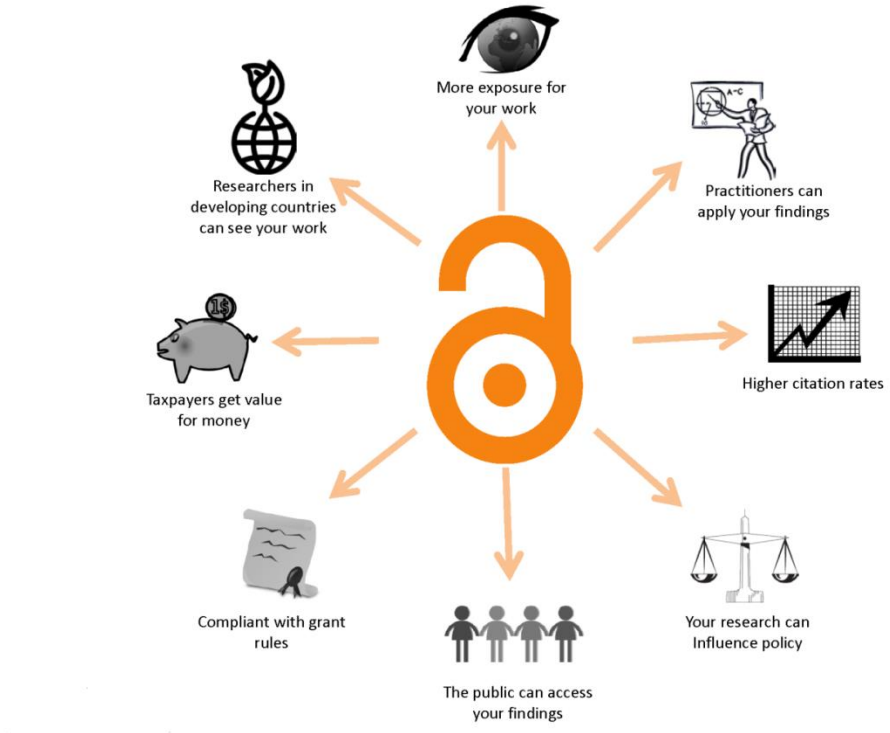
Furthermore, while healthcare providers have the theoretical and clinical-experiential base from which to draw their assistance, getting information from someone who *actually* suffers or suffered from a particular disease possesses the ability to unravel deeper thematic insights regarding the problem. A doctor will explain the possible side-effects of antiretroviral (ARV) drugs based on the terms that he/ she knows professionally, but a sufferer of those actual side effects will share the information differently, in a way that may be contextually richer. Peer-to-peer learning is a proven method of effectively sharing information. These user-to-user platforms employ this model. It is impossible to exhaust in writing all the benefits of user-generated health-related content. One thing which is clear, however, is the fact that the use of these platforms ought to be promoted. Healthcare professionals should take an active stance in encouraging patients to collaborate using these means.

The Open movement is not all about Open Source. It also emphasizes on another concept, Open Access (OA). This refers to online written outputs that are free of all restrictions on access (such as charges, copyright and license-of-use restrictions). It can be applied to academic journal articles, conference papers, book chapters and more. It has applications to the academia in the healthcare sector. Students from developing countries, who study in fields like medicine, nursing and Public Health usually face challenges in accessing online resources. Some online journals and books require users to subscribe or pay to access the information in its entirety. This is burdensome to academicians from developing countries. Fortunately, there are many resources

nowadays that are published in line with Open Access principles and that are easily accessible and less-restrictive. This is why academicians from developing countries need to be sensitized about the Open movement and how to identify and find Open Access material. By providing enlightenment regarding where to find easily accessible, high quality publications, it can ease the training of high-quality healthcare professionals.

Some websites containing OA material have logos or icons to show that. There is no official logo for this movement, but the most widely-used logo integrates the letters "O" and "A". It is important for academicians seeking Open Access resources to be able to recognize Open Access sites.

An Open Access logo.



The many advantages of Open Access research-publishing.

The purpose of OA is to promote availability of research information and to spread knowledge. It is particularly advantageous to developing countries, where individuals and universities may find it hard to pay subscription fees to access journals. OA is of particular importance in the practice of medicine, in the sense that new medical discoveries are made on daily basis and newer medical technologies are developed continuously. This means that physicians, pharmacists, laboratory technologists and others must always keep abreast with latest information in order to provide their patients with the most recent, evidence-based interventions and services.

In short, the health professions require that one updates oneself regularly. This is the reason why health professionals do undergo Continuing Professional Development (CPD) sessions once in a while in order to absorb the latest information and practices. This underscores the importance of accessing health literature easily. When health literature is easily and freely available, healthcare

professionals are able to access it and this leads to improved knowledge and skills, which in turn can improve the health outcomes in patients.

As previously said, some publishers/ researchers/ scientists in the health field might not make their publications openly accessible in order to commercialize them and earn something. That may be understandable as they may want to recover some of the costs incurred during publication. We have already seen that the problem can sometimes lie at the information-users' end. In any case, it is the responsibility of everyone passionate about making health information available to promote "OA-literacy". I personally have intentions to establish an Open-Access society specific for Public Health in Malawi. At the stroke of funding, this is possible.

Some advocates from the academic field have attempted to improve researchers' compliance with OA recommendations by strictly allowing for the publication of only those journals that fit the OA description. While the advancement of OA for purposes of enhanced health knowledge should not always be driven by compulsion, it needs to be encouraged by all reasonable means possible.

The amount of new medical research findings is enormous, and it only makes sense to create ways that can encourage sharing of this information as much as possible. The field of healthcare is unique. Its research findings do far more than just inform theory or serve other superficial interests. Healthcare and medical research is a serious matter- a matter of urgency and importance to the human species. For example, research into how to make healthcare services widely available or equitable; and research into how we can overcome the looming disaster of multi drug-resistant bacteria that have emerged and ravaged the world today is undoubtedly precious. Ideally speaking, there should be no debates as to whether the findings from these kinds of studies should be regulated. The definite moral choice is to provide such publications freely and to make them widely available, for use by other researchers and the general public.

I fondly remember my story when I was applying to attend the OpenCon 2016 conference in the USA. I had to write an essay to justify why I was a rightful candidate for that conference. The

basic theme behind my response was that after the conference I would advance the Open movement by promoting OA-literacy through social media posts, forming OA-clubs comprising academicians (students at postgraduate level, researchers and scientists) and conducting OA-campaigns through branded T-shirts, posters and other means.

The Open movement is getting more and more formal. It is a pretty serious movement, with there being global conferences and other international and regional events over it. Usually these assemblies promote awareness of both Open Source and Open Access concepts. This is great. However, it would be imperative for these initiatives to have sub-concentrations and discuss them at such assemblies (such as forming sub-movements like Health Open movements, Agriculture Open movements, and so forth).

Chapter 7: Relevance: A Key Concept in Healthcare Technologies

"The best innovations are about relevance, not invention"- Gabor George Burt.

In 2016, I got selected to attend the "Brightest Young Minds" summit in South Africa. It was a gathering where 100 young Africans from 14 different countries were chosen to come together, discuss some of the continent's most pressing problems (in health, agriculture, infrastructure, environment and other sectors) and be empowered to tackle them. As part of the activities, we were divided into eight groups according to sectors of interest (healthcare, agriculture, et cetera). I was in the healthcare group myself. Each group was tasked with identifying one pressing issue relating to their sector, and discussing practical approaches to possibly use in dealing with it. We then had to make presentations. We were not aware that we as teams were competing against each other (we only found this out at the end of the summit).

In my group, we correctly noted that healthcare was not accessible and personalized. The problem, however, came in regarding what to implement. We proposed a conceptual model of healthcare known as "HAPI", upon which we suggested healthcare ought to be based. H stood for "Holistic", A stood for "Accessible", P stood for something I cannot remember and I stood for "Individualized". The proposition behind HAPI was far more intricate than it appears here. According to what we discussed, achieving each of these four components would involve doing a whole lot of complex activities. It would also involve immense levels of technological tools such as some sort of wrist-bands to notify the user of fluctuations in their health status, and some sort of nanosensor-filled capsules which subjects would ingest to track their health status. I cannot remember all the actual details, but this is a general picture of what our pitch idea comprised.

On the final day of the summit, we were gathered in floor 20 of Green Park center in Sandton, Johannesburg. It was a gala dinner. The organizers suddenly announced that they had chosen four successful teams to be funded to carry out their pitched projects and bring them to reality. These teams would also be entitled to visit the offices of the seat of government in South Africa for advocacy purposes. As is the norm, the names of the teams were announced from position 4 going upwards. After three had been mentioned and our name was not there, anxiousness gripped me. At the same time, I did not have the confidence that perhaps we had won.

They finally announced the winning team and it was not us. I was not surprised, because I had not expected us to win. From the point they had announced the team on fourth place, I knew we

definitely would not make the cut. According to my observation, the pattern was such that they were naming teams which seemed to have realistic projects. From my outlook, ours clearly did not qualify. We had conceptualized solutions which were too abstract, futuristic and impractical for immediate implementation in the African setting. Our rivals' projects on the other hand, were feasible and seemingly effective yet straightforward. They had talked about such activities as installing solar-powered streetlights to alleviate crime rates. They had pitched simple yet practical issues. I bet that even if we were to be selected and funded to implement our idea, we would have nowhere to start from and would have to create a new idea altogether. From this I learnt the lesson that innovations need to be practical in addressing the pertinent issues specific to the particular place and time for which the innovation is meant. I have firm belief that if our ideas had been straightforward, we would have made it. Healthcare in Africa is too indispensible to be neglected, and definitely we lost because of the unfeasibility of our concept, not the unimportance of healthcare.

The issue of relevance in innovations takes me back to the story of one Malawian welder, Mr. Godfrey Kambwiri. He lived in Dowa district, 90 kilometers remote from Lilongwe, Malawi's capital. This man made headlines after he had constructed a model of a helicopter from tin scraps. It was a one-seater vehicle in the shape of a conventional helicopter, with a rotor atop it. But the "helicopter" never took off the ground- only the rotor on top of it spun. Mr. Kambwiri harboured the dream of building his own functional helicopter since childhood. After constructing this model, it was reported all over that police threatened to arrest him should he test his machine in the airspace of the republic without an aviation license. The story attracted divided responses on social media, particularly after the man had been invited to give a speech at a TEDx event (a highly notable event meant for inspirational speakers). While some observers endorsed Mr. Kambwiri as a fit speaker at such a top-notch event, others argued that he had done nothing worthwhile to deserve such a spot. They further observed that the organizers may have selected him on the basis of sympathy or other emotion-related issues (such as recognition of the trauma he may have gone through while tussling with law enforcers), but not the essentiality of his "innovation".

One observation that raised a hot debate on social media was from a post which a certain man made, which went viral. He observed that Mr. Kambwiri was not a worthy candidate to speak at the TEDx as he had achieved nothing remarkable. First, he had attempted to mimic an innovation that had been existent for many decades. Second, he had failed, as his "helicopter" never took off. This commentator went on to say that what Mr. Kambwiri had built was not even a helicopter, as helicopters were known for their ability to fly. He hit out at the Malawians who were celebrating him for his efforts, saying that in 2016, it was mediocre to celebrate anyone for "trying" to build a helicopter. Finally, the commentator proposed that there were probably already many engineers in Malawi with knowledge on helicopter-construction, only that they lacked resources and were aware that Malawi could not be competent in the helicopter industry, anyway.

This observation itself received mixed reactions from respondents. I sought to contribute my own responses to the issue, and in my discourse I expressed agreement with the idea that Mr. Kambwiri had not done anything TEDx-worthy. I pointed out that at the very most, he should have made a helicopter with some superior features in design or performance in comparison with conventional helicopters, and at the very least he should have built a helicopter which could fly. His structure met neither criterion, cementing its similarity to toys. It occurred to me that this was not too much to ask for, as the ability to fly was the general property of helicopters. With these comments, I attracted a fierce debate. One remarkable moment I easily recall was whereby someone in defense of Mr. Kambwiri asked me a personal question. After I had suggested that Mr. Kambwiri's structure could have been built by any other welder, my proponent asked me if *Maternitech*, the mobile app I co-developed, could not have been developed by any other team of mobile app developers. My response was that it could have been conceptualized by someone else (theoretically speaking, like all other apps), but at least the app had the immediate potential of empowering a woman with maternal health knowledge. Therefore, the app's superiority was to be found in its capability to benefit people. Mr. Kambwiri's helicopter, on the other hand, was not useful.

This line of thinking goes to show how serious would-be innovators need to be. They need to come up with work that is groundbreaking at the very best, and functional at the very least. Innovations should be able to accomplish what they are meant to accomplish.

I remember that on the final day of the TNM Smart Challenge innovation competition, one contestant lost because the software they presented to the judges failed to accomplish some of its purported abilities, reportedly due to a technical issue which emerged at the eleventh hour. This also reminds me of when we had submitted a presentation at UNFPA, where they gave complaints that the prototype we had provided them had malfunctioned. Of course this was just down to a temporary database error, which we promised to resolve within a day. Nevertheless, all this shows that innovations which do not appear to accomplish what they are purported to accomplish, attract less value. The whole promise of the success of an innovation could hang on a thread just because of a simple mistake which potential partners may have discomfort with. The public always has a lot of expectations from innovators and innovations. Innovation is serious business and ought to be considered as such.

Regarding the many international innovation competitions to which I have been applying over the past year, I noted that there is usually a section where they ask the applicant why he/she thinks his/her innovation is any special compared to other similar innovations. In other words, why he/she thinks no one else (or to be more realistic, not many people) could have thought about a similar idea. This asks why the applicant's idea is hard to replicate. I usually find this question hard to answer because it is difficult to assume that if I have a creative idea, no one else could have conceptualized the same idea.

I cannot say that the organizers of innovation competitions should not look at the uniqueness of products (this would be an absurd expectation). At the same time, the concept of uniqueness is marred with ambiguity, meaning that this issue is very complicated. In answering people why

our app was any better than other (international) maternal health apps, I used to say that ours was specifically meant for Malawian women while the others were general. Sometimes, however, I think really hard and I tend to view such a question itself as invalid. Take this example: we have many organizations which work to improve health, food security, education, environmental protection, social inclusion of the marginalized, and more. Why does anyone never ask any one of these organizations why they are replicating efforts already being exercised elsewhere by other similar organizations? Why are social impact institutions exempt from this question while innovators are forced to answer it? Why is no-one questioned when starting a charity organization despite there already being dozens (maybe hundreds) of such organizations? Does uniqueness exclusively apply to innovations but not social impact schemes? The probable answer to this may be that people expect developers of tech-related products to bring new products, while it is not the case with other industries. The word "innovation" itself means bringing a new kind of solution. Thus, to claim to be an innovator is to challenge oneself to produce new kinds of products. Due to the rapid changes in technology, people expect a lot (usually new things) from those who claim to be technologists.

Apart from the TNM Smart Challenge innovation competition, our app also won another award in 2016, which became our second award. This was the ICT Association of Malawi Innovation award, and we won under the category of "best healthcare innovation in Malawi in 2016". One of our most notable competitors was an innovation called T-Dose (short form for "Today's dosage"). This was a USSD-based, personalized, automated medication-reminder system through SMS, which the innovator had developed with plans to scale it up. I found the innovation to be interesting, but I had other reservations regarding it. When the developer took the stage to pitch it, I being part of the audience, provided a comment regarding the presentation. I pointed out that it was a good innovation, but it had a certain issue which needed to be resolved. Specifically, the issue was as follows: When physicians prescribe medications, they typically prescribe *milligrams* of a certain drug that a person ought to take. They do not prescribe in number of tablets or such other folk methods.

I was interested in knowing whether the T-dose system provided medication reminders through means such as milligrams (typically used by healthcare workers), or number of tablets (typically used by non-medical people). The problem is that the milligram system would be complicated to ordinary (non-medical) people. On the other hand, the tablet terminology despite being easy to understand, would be confusing. This is because different manufacturers prepare their medicines to different strengths. For example, company X can put 250 mg of paracetamol in each tablet, while company Y can make each of its tablets to contain 500 mg of paracetamol. Additionally, medications come in different forms such as capsules, tablets, sprays, pastes, elixirs, liquids and many more. Therefore, telling someone to "take two tablets daily" could be misleading, and might lead to overdosing or under-dosing- unless all patients in the country would always buy paracetamol made by the same company.

To address this paradox, the developer of T-dose would need to come up with a complex solution which would need critical thinking and also the input of medical professionals. Perhaps he would need to introduce a "briefing" mechanism to alert users that for medications, their milligrams and numbers of tablets/ puffs/ capsules, et cetera, are variables. Still, this would not be easy to achieve effectively. Nevertheless, this scenario goes to lengths to show the extent to which context matters in innovations. Clearly if T-dose mentioned drug doses in milligrams only without any elaboration, it would be out-of-context to the uninformed users it was meant for. On the other hand, it would be meaningless if it only provided medication reminders according to lay measures such as "number of tablets. The conclusion was that the innovator had an enormous task to deal with. In any case, it was a manageable task. This scenario also underscores the importance of multi-sectoral collaborative work in developing innovations.

Winning the ICT Association of Malawi award got me reflecting upon a lot of things. I came to think that although winning awards was desirable, it should not be the end goal. The goal of innovators needs to be mass social impact using the innovation. Awards are good but they do not guarantee success of an innovation in the real world. Success of innovations is measured by social impact. Achieving social impact is reliant on a host of other factors such as the relevance

of the innovation, political will, the presence of other technologies with which the innovation should go together, the presence of competing technologies, and many more. It is normal for people to question the progress of an innovation in terms of its social impact, a while later following its development. This means that with time, each innovation will slowly lose its "wow factor". People cannot keep getting amazed by the same innovation forever and for that reason, innovations must be adaptable. This explains why all serious apps developed by reputable innovation/ technology companies, are updated on regular basis. Upcoming innovators need to borrow a leaf here. They need to establish mechanisms for their innovations to always be up-to-date. This is one of the issues we had considered in our maternal health app- to build it in such a way that information would not exist *within* the app itself like a book, but rather for it to be piled up in a database and fetched automatically whenever the user is using the app. This design, we thought, would simplify the periodic updating of the information.

I am reminded of a conversation I had with one of my good friends, Emilliana Mlagha. Before we participated in the ICTAM competition, I told her that I might not participate due to other factors. She tried to give me hope to perhaps apply again the following year, but in my dismissal of that suggestion I said that it would not make sense to use *Maternitech* again in the following year's application into the same competition. Although it was permissible, it would hardly make sense and it would have probably lost its "wow factor". The healthcare industry is a business today, and healthcare services and products are seen as commodities. As such, all healthcare innovations need to maintain their attractiveness to maintain their relevance.

Chapter 8: Gamification of Health Messages: Turning Health Education into Games

"Gamification is about building strong relationships between experiences that users enjoy and responsibilities that we want them to assume"- Justyna Wojtczak.

June 2016 was one of my most exciting experiences. I was attending the "Brightest Young Minds" 2016 summit, of which I am now an alumnus. On the very first night of the event, we were taken to a place known as Katy's bar in Sandton, Johannesburg for the opening ceremony. The most fun moment was whereby we were treated to a mind-boggling game. All 100 of us were divided into ten groups. We were given the task to collaboratively build a machine called the *Rube Goldberg machine,* a task which was to be accomplished by joining many pieces from a collection of random materials. Each group was allocated its own station in the hall. The plot was for each team to build its own section of the machine, so that the parts would eventually fit up together. In the end, a ball would be rolled from the entry point of the machine, which would have to move smoothly across all the stations of the teams up until the end station, where it would have to raise a flag through some mechanism.

Team members of each team were given roles. Some were "engineers", others "negotiators", others "liaison-persons", others "designers", and so forth. Each group also had one project manager (PM). The PMs were assigned to a specific circle which they could not exit, or they would get punished. They had the duty of drafting the operational plans of their teams. There were no specific instructions to each team on how to build its part of the machine- each team had to see that for itself.

The general rules were that the ball had to be smoothly passed from a station, get relayed through the next, and continue the cycle up until the last station. Each station therefore had to liaise with the previous and next stations regarding their designs, so that they could modify their design to fit in with those of the neighbouring teams (for smooth passage of the ball). Teams could use any of the material stored at the "bank" to achieve the construction of the machine. Available materials included planks, pipes, tape, fans, ladders, mouse-traps and others. No team was allowed to get more than two of the same material. Furthermore, to be allowed to get materials from the bank, the negotiator of each team would need to convince the banker of why they needed that material, and this would require them to show the design of their project. All teams were given a time-limit within which they ought to have completed construction and subsequently raised the flag. Eventually, the machine was built and although it had some functional errors, the whole experience turned out to be fun, interactive and educational.

The whole purpose of this exercise was to impart in us the virtues of team work, speed, strategic planning, critical thinking, and others. Alternatively, instead of making us do that exercise, the organizers could have simply stood in front and said: "In order to come up with good innovations, team work, speed, strategic planning and critical thinking are important". However, that could have been a less-effective way of passing the message to us. We could have easily *forgotten* that statement in no time. We needed a more practical and engaging experience to understand that. The exercise achieved that very purpose.

The transmission of information can be enhanced through the use of interactive features and activities. When information is passed on in an interactive and engaging manner, it is more likely to have greater impact. Leclaire (2011) observed that interactive learning experiences are more effective than other means. How can interactive features be made part of the learning process? One way in which this can be done is through a process known as *gamification*.

Gamification is the application of typical elements of game-playing such as point-scoring, competition with others, rules of play and various other elements to other areas of activity. It is frequently used in online marketing of products and services to encourage engagement with the products and services. This technique can also be applied to various other contexts such as the process of dissemination of information to students during educational processes, as well as provision of health information to the public.

The prominence of gamification has been consolidated with the increase in the role of technology in daily life. Many modern technological platforms (apps, websites and other platforms) have the capacity to allow for gamification. Designing health apps/ platforms to be more engaging can increase the popularity of those apps/ platforms, thereby spreading health information even more. However, this does not mean that gamification always needs to be technologized. Any incentive-granting, learning activity that creates a game-like atmosphere among participants can be considered to be an exemplification of gamification. It also does not necessarily need to be complicated. The only prerequisites are the incentives and game-like structures. Getting children to run along a maze and collect sweets as prizes, can be used to

motivate the children to exercise. This can be more appealing to them than just asking them to exercise in a direct way.

During my promotion efforts of *Maternitech* mobile app, I was regularly asked why we placed focus on android platforms instead of USSD platforms (automated SMS-based response systems), which may be better suited for Malawi's predominantly rural population devoid of smartphones. It is true that the Android platform has few users in Malawi if we factor in all possible target-people, including people in the remotest areas, where the most basic phones in existence are had. Again, these questions were well-placed considering that many interventions probably target middle-class citizens, yet it is those in the lowest class who make up the largest portion of the Malawian populace. However, the other face of the coin is that Android holds a promise for being effective, as it is more easily customizable and has a greater allowance for gamification.

I would get caught up in a dilemma when I weighed up the two options at hand: whether to build for Android and make the service more enjoyable and engaging; or to build for the most basic devices available and reach out to the greatest number of people but with rigid and less-exciting messages. The immediate solution in my mind was to continue investing time in both Android and USSD formats. After all, the usage of smartphones had and has been rising steadily in all parts of the country over the past few years. New small-scale industries have blossomed all over the country, where people upload music from their computers into customers' phones at a fee. This kind of trade had been nonexistent some few years ago, and its sudden popularity is a sign of an ongoing transitioning from the most basic handsets in the world to moderately-equipped phones, or what I would like to call *semi-smartphones*. These are devices with the capacity to store and play music, and perform other functions which were not typical of mobile devices owned by most rural Malawians in the past decade. In actual fact, this kind of enterprise (of uploading songs at a fee) at its peak at the moment and mostly unfolding in rural and semi-urban areas, and not much in proper urban settings (this could mean that the rate of transition is more noticeable in rural and semi-urban areas).

The lesson I have drawn is that technological change remains inevitable. While it occurs at the speed of light in the so-called first-world and its pace is sluggish in countries like ours, still it occurs everywhere. As a result, investing time and resources in developing Android-based applications in Malawi is justified. Android devices are going to keep on flooding the market each coming year (thanks to cost-effective smartphone manufacturers from Asia in the names of *Tecno, Itel* and other affordable middle-range smartphone manufacturers). Innovators who feel discouraged to develop Android-based applications need to start changing their minds. It is not misplaced for technological innovators to make Android-based healthcare solutions.

I once had a conversation with Dr. Joe Sclafani, obstetrician-gynecologist at Kamuzu Central Hospital in Lilongwe. During the conversation he mentioned that SMS-based maternal health education systems had been attempted before in the USA in 2012 and did not turn out successful. They provided very general messages such as: "If you want to remain healthy, eat well"…without properly defining what eating well meant in relation to maintaining good health.

From my interpretation, there might be several reasons why that well-meaning initiative failed in the US. First of all, the generality of the messages might have been the problem. Users might not have liked them for that. Generality is associated with ambiguity. One may argue that including too much detail in the messages would complicate the messages and probably make them less-attractive. That might be true. In one of my courses in my Masters studies, *Health Communication,* I learnt that health messages should be kept as brief as possible. A possible solution of improving this in the USA could have been by gamefying the information (such as including trivia questions to encourage users to engage with the service), although the disadvantage of this would be the possibility of driving people away from the purpose of the service.

The second hypothesis is that the content of the messages itself may not have been that very significant to the US context. They may not have had a lot of problems relating to maternal health, therefore they might have felt that they had no reason to take those messages very seriously. This brings us back to the discussion of contextual relevance as a key concept of

healthcare technologies. In the developing countries, the same messages could be more appealing since many people here have had firsthand experiences with maternal health problems. For instance, as of 2013, the maternal mortality rate in the USA was only 18.5 deaths per 100, 000 live births, while in Malawi it was 624 around the same period. It is reasonable, therefore, to make the assumption that Malawian people would be better recipients of these messages. It is not that the few maternal deaths which occur in the USA are insignificant, but they might even occur due to other means than lack of information among women. Some causes of maternal deaths are beyond our control, which is why no country has ever achieved zero maternal mortality rate. While many of the maternal deaths in developing countries probably result from poor access to services, the few maternal deaths in developed areas of the world could be due to uncontrollable factors.

The issue of lack of maternal health information correlates with illiteracy. This is not to say that all well-educated people automatically know much about health issues, but at least they are far less vulnerable to most health problems than are the least educated. General literacy and health literacy are not the same thing but they usually go together. Fairly-educated people may find it easier to understand health messages than illiterate ones. As Benjamin (2010) put it, there is a strong correlation between health literacy and health disparities. If we assume that better general literacy equals better health literacy, then it is not difficult to see why there are better maternal health outcomes in countries with better literacy rate than Malawi. I do not think that all those women in Malawi and other poor countries who suffer from maternal health complications and deaths have never heard some information about how to keep healthy. They may have acquired such information from radios or health assistants in their villages, but their processing and understanding of the messages could be compromised.

The third possible explanation might be that SMS have been considered obsolete in the USA for some time now, and in 2012 mobile messaging apps had already gained popularity there. This redirects us to the issue of relevance versus irrelevance of innovations. SMS might still be a

relevant (and effective) means of communication in remote regions of developing African countries, yet they lost relevance in the developed world some years ago.

Today, people in developed countries would like to use interactive experiences in acquiring health messages. They would like to use services with aesthetically-appealing, graphical interfaces rather than dull, plain texts. Psychological findings point to the fact that visual cues help people learn better. Kouyoumdjian (2012) had the following account on that:

"A large body of research indicates that visual cues help us to better retrieve and remember information. The research outcomes on visual learning make complete sense when you consider that our brain is mainly an image processor (much of our sensory cortex is devoted to vision), not a word processor. In fact, part of the brain used to process words is quite small in comparison to the part that processes visual images. Words are abstract and rather difficult for the brain to retain, whereas visuals are concrete and, as such, more easily remembered".

This observation is suggestive of the need to invest in more interactive health-education experiences.

In 2011, James Mulvey had predicted that four years down the line, 50% of organizations would include gamification in their customer retention strategies. Mulvey also stated that health institutions had started to adopt gamification techniques to use in health-promotion campaigns. Aside from that, students from the University of Utah created a game to help children diagnosed with cancer to increase their empowerment and physical strength. Other examples of gamification strategies which were used in health promotion in the USA included the following:

i) A program by *Mango Health*, which encouraged medication-compliance among patients for them to earn points usable in redeeming rewards in the real world.

ii) *Gympact*: This was a program for rewarding users with money for doing healthy activities such as going to the gym. When they failed to fulfill this pact, they would pay a small amount of money. To verify attendance of the gym, they would have to "check in" electronically at the gym.

iii) *GameMetrix*: It created trivia games meant to enhance knowledge about diabetes. Players worked through questions and get scores, and appeared on charts based on their scores. Getting more scores would result in incentives such as test strips for diabetes.

Not all of the above strategies would currently work in health-promotion in Malawi. However, they serve to act as examples which we can emulate and come up with gamification strategies in providing health information. We could use any gamification methods which we can afford in our public hospitals, and they may include not-so-technologized methods. Health workers could simply hand small rewards to clients for answering questions correctly, and this is a good example of non technology-based gamification.

Besides, better-equipped private health facilities which receive middle-class clients may want to go a step further and add a technological touch to their services by gamifying health educational experiences. For example, their prenatal units could be designed to have Android tablets to be used in teaching pregnant women about different experiences such as labour and delivery. These devices could be superior to educational methods where no teaching aids are used, or where lifeless, not-so-vivid pictures and charts are used.

The devices could also be used by pregnant women in answering different questions, as a way of testing their understanding of taught messages. Those who answer questions most correctly could be given small rewards such as baby hats and other items. This is something which private health facilities in Malawi can afford to do. It cannot only be exciting, but it can also enhance the understanding of health messages, as well as possibly draw more customers to them.

Chapter 9: The Environment for Innovation

"A wide range of actors is convinced that hubs represent a genuinely new and exciting model for supporting tech entrepreneurs, in particular in sub-Saharan Africa"- Nicolas Friederici.

One day I went to a certain place where I had observed scores of ambitious young people frequently converging. Being unfamiliar with this place, I kept gazing about to see what these busy, energetic young men and women were up to. To my amazement, I saw the people doing exercises that caught my attention. Arranged in teams, they stacked up towers using strands of spaghetti, in what seemed like a competition to see who would build the tallest tower to stand for the longest time period. I paused for some minutes to digest what I was seeing. It took me some minutes to figure out that the exercise was not merely for fun, but rather a purposeful activity to stimulate their minds. It was a gamified learning experience.

This place was *mHub*, a center where many young people with creative ideas from the vicinities of the city of Lilongwe would patronize in order to be stimulated, challenged and empowered. The hub has grown bigger in popularity and patronage today. *MHub* are a Malawian organization that seeks to align technology and innovation. Not only do they conduct mentally-stimulating exercises to participants, but they also provide them with the physical working space for them to hatch and grow their ideas. Additionally, they impart skills into participants on topics such as entrepreneurship, innovation and other areas of contemporary concern.

The inside of the place was designed to look like a workshop. From power outlets which purposefully hang from the ceiling to inspirational graffiti drawn on the colorful walls, the hub boasts a captivating interior. Almost every guest coming into the room probably realizes with immediate effect that the young people gathered there, assemble for some kind of serious business. There are chalkboards where attendants, wildly wandering in their creative imaginations, can scribble anything on their minds- be they motivational quotes, affirmations, insights or just something out of the blues.

Psychological theories that point to the need for expression of thoughts as they emerge, could not have been put to practice in a better way. The mHub environment is designed to stimulate relaxation and free-mindedness, states in which concentration can peak. I further learnt this later when I visited Google and Facebook premises in USA, where I saw that the design of their environments was such that they could allow for flexibility of thought and conduct. At Facebook, workers can do some of their job assignments while walking on the lush gardens of the premises. At Google, they have seven-seater cycling devices which can be cycled into any direction, 360

degrees. Several officials can ride and cycle this unusual device in the midst of a serious meeting. They also have nap-pods where one can go to relax if exhausted.

Flexibility and reduced rigidity characterize the typical setups of those famed *Silicon Valley* giant technology companies. These giant companies offer incentives to their workers such as onsite haircuts, complimentary laundry and much more. The idea is to create a workplace where workers do not want to leave- to create a supportive physical environment, with the view that this will improve their productivity. The physical demands usually associated with technological innovations (such as coding) may be time-consuming and tiresome, hence refreshing setups of those companies make sense. These setups would probably be thought of as counter-productive in many African settings, whose leaders might believe in forcing loads of assignments onto workers.

Google, Facebook and many other excellent companies know that their setups promote open-mindedness and free-thinking, attributes which can precipitate relaxed states and subsequently, innovative thoughts. They are aware that tasks are not accomplished using coercion, but through supportive environments. Google also has sessions whereby subordinates can publicly reprimand or advise more highly-ranked officials. With such designs, it is not surprising that these companies come up with many amazing ideas which lead into useful innovations.

I have for so long held the belief that insightfulness is not best achieved by coercion. During my undergraduate studies at the University of Malawi's Kamuzu College of Nursing, I developed an opposition for their methods of training, assessment and grading of students. It appeared to me that they sought to impart knowledge through means of pressurizing and threatening students into performing certain tasks in predetermined, non-negotiable fashion. This, I thought, represented an element of treating students as puppets, and I theorized that it would inevitably fail. It would cause students to *memorize* concepts, as opposed to grasping them with full understanding. It was not surprising that my criticism of these controversial methods of instruction co-occurred with my drastic drop in performance, despite that I always believed I was capable enough- even more capable than necessary- to deal with the academic tasks that were

conveyed at this institution. The point of emphasis here is that rigid systems are associated with lesser output of ideas. Any system which aspires to nurture thinkers ought to be designed in such a way that ideas can flow freely. This is not only true for academic institutions and technology companies. It is a truth which can be applied in a number of situations, healthcare institutions inclusive.

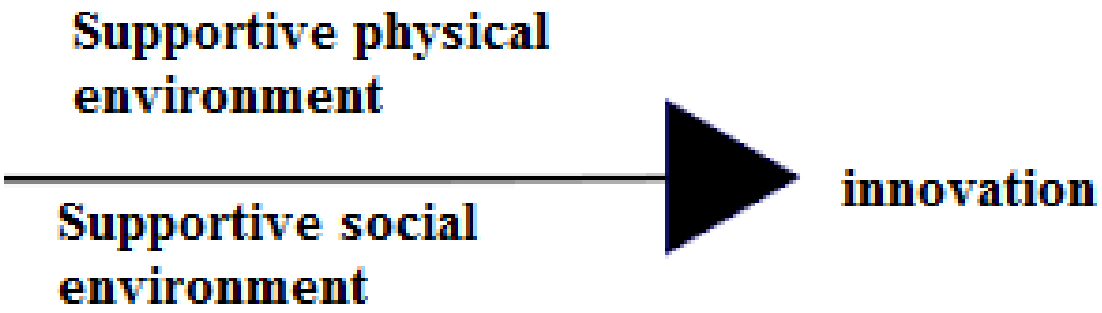
We have talked about many different kinds of innovations in healthcare, which characterize the present day. For these and all other innovations to be realized, there is need to have a supportive "innovation environment". This refers to the physical environment (including essential material resources such as computers; and also good working space), the social environment (such as the presence of peers to support each other in idea-formulation and mentors to nurture the talents of upcoming innovators) and others. We can also refer to the physical environment as the *economic environment*, since the requirements in the physical environment are basically resources which are finite. Of course social support systems are also resources but unlike physical resources, they are not easy to quantify.

Therefore, innovation can be conceptualized as an end-product of the combination of supportive physical and social environments. Although supportive environments are not sufficient to give rise to innovations/ inventions, they are necessary in most cases.

Let us consider a hypothetical situation involving a young innovator by the name of John, who would like to develop a digital solution for helping mothers learn breastfeeding techniques. John will need physical resources such as computers, books and also a working space. He may also need a supportive social environment such as additional ideas or advice from experts in health and/ or ICT-related fields. During the planning phase, John may or may not already have the required knowledge and technical competencies for executing his plan (such as computer-programming skills). Either way, that knowledge will be necessary and if he does not have it, he will need to acquire it. The knowledge and competencies form the context for the innovation. The supportive physical and social environments build on the mostly pre-existent knowledge and competencies essential for innovation. However, these environments may also help inculcate

such knowledge and competencies. Let us call this **"Walter Moyo's innovation-support model".** This model can be illustrated as follows.

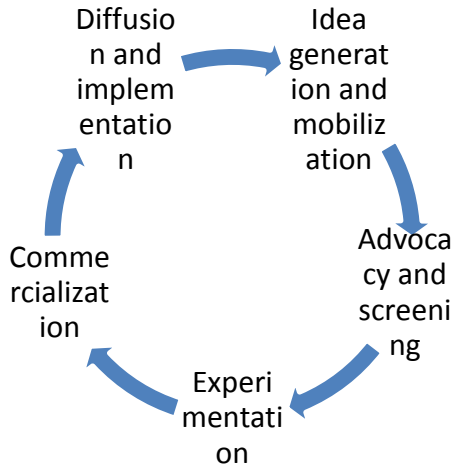
SKILLS



KNOWLEDGE

Walter Moyo's innovation-support model: supportive physical and social environmental support systems, when existing in the context of knowledge and technical skills, are likely to yield successful innovations.

Although innovation is shown on that model as a static point on the arrow, it is actually a separate process on its own. There are dozens of models for the actual process of innovation, which were proposed by different theorists. All these are used for different purposes. The following is one of them, proposed by Rivier University.



Rivier University's innovation process model. Adapted from "Cultivating a Robust Organization: 5 Stages of the Innovation Process".

The steps in Rivier's model are broken down as follows:

1. **Idea generation and mobilization**: Idea-generation is whereby new ideas are created, and idea-mobilization is whereby the idea is moved to a different physical or logical location.

2. **Advocacy and screening**: Before ideas can be implemented, there is need to check them to determine if they are worth implementing. The potential benefits and problems of an idea ought to be examined.

3. **Experimentation**: This involves testing an idea, such as with a prototype or pilot test. The end goal is to determine whether the idea is efficacious.

4. **Commercialization**: This aims at creating market value for an idea by focusing on its potential impact. The idea is made appealing to the audience, such as by packaging it with other ideas or by clarifying how it can be used. This also includes giving a good aesthetic appeal to nonprofit high-impact ideas. NB: Non-commercial ideas also pass through this phase, although in that case it doesn't involve profiteering motives.

5. **Diffusion and implementation**: This process is often aided by "knowledge-brokers", who are effective at presenting an innovation by using their awareness of the specific content and application into which an idea, product or service can be inserted (Neese, 2015).

At each of these steps in the process of innovation, an innovator requires supportive physical and/ or social environments, as theorized by Walter Moyo's proposed model. In mobilizing an idea, the efforts of other players may be needed. The same applies to advocacy and screening; and experimentation.

When initially conceptualizing an idea, one may not perceive its limitations or associated problems at first. They may need others to advise them and help them make more realistic resolutions (for example, the way I provided advice to the developer of the medication-reminder system).

On commercialization, an innovator may also need a supportive social environment in the form of advertising companies or other partners that would help them boost the popularity of their service/ product. As the developers of *Maternitech* mobile app, we signed a memorandum of understanding with Telekom Networks Malawi to popularize this app by means of advertising the app to all their customers through SMS notifications about the app. Otherwise, it would have been difficult and perhaps ineffectual had we decided to self-market the product. There are many brilliant innovators who have amazing technological innovations capable of transforming the health, agricultural and other sectors of countries like Malawi. What they mainly lack is the support of established organizations, which can help these innovations to become successful. Organizations need to actively solicit partnerships from young innovators, who may have potential innovative solutions to some of the biggest social problems.

The implementation phase of an innovation is the action part, where the innovation-plan is finally executed. Therefore this is arguably the phase whereby social supports are needed most.

At this point, we are tasked with examining whether there is sufficiency of supportive physical and social environments for technological innovation in our midst. Regarding the latter, it is rather evident that they are bountiful in presence in 2017. For one, there are many experts in the

field of ICT in the present day, from which one can get the necessary support. There are also many others who, despite not being "experts", are knowledgeable enough to provide support to other people. There are also a lot of online resources including free courses and materials on topics such as computer programming (therefore I find healthcare professionals who lack interest in healthcare innovations as lacking a genuine excuse). In addition, there are more healthcare specialists these days than there were decades ago. Potential innovators can always use these people as information-resources. I do not expect innovators to come up with solutions which are out of context (such as a health-software made in Malawi, whose information is not tailored to the Malawian context) yet there are many experts to consult.

Like we have seen throughout the book, experts from hybrid fields such as health informatics have infiltrated the atmosphere. Therefore anyone keen to develop ICT-empowered health solutions has no excuse for not including accurate, relevant and up-to-date health information as the professionals to guide them with this are abundant (as are reference materials). As for supportive physical environments, one may create them himself, but if we look closely, we can see that the emergence of "innovation hubs" like mHub has also set the pace in the availability of conducive physical environments for the performance of innovative activities. In Blantyre and Limbe, innovation hubs have also sprung up- a sign which shows that the innovation culture in Malawi is maturing.

According to Friederici (2014), hubs are convening points for communities (such as communities of software developers). They see themselves as enablers of innovative acts, emphasizing adaptation of innovations to local settings while still viewing themselves as part of a global entrepreneurial/ innovative movement or revolution. They facilitate creativity and collaboration in physical and digital space. Friederici also pinpointed that hubs aim to convene like-minded individuals, while at the same time bringing in people with different backgrounds and knowledge. I particularly witnessed this at mHub. I had previously thought that probably all the staff at the hub must be ICT professionals. To my surprise, some had backgrounds in different, non-tech fields such as Business Administration. It was then that I figured that at this hub, it was not always about tech-talk, but also managing businesses, gaining leadership skills and more. This inter-professional collaborative approach can also be extended to accommodate

specialists (for instance, hubs can hire specialists in healthcare innovations to be responsible for overseeing healthcare technologies developed by innovators at these hubs).

We can infer that Walter Moyo's innovation-support model explains why hubs do what they do. The slogan for mHub is *"where technology meets innovation*". I particularly like this slogan because it implicitly connotes that someone with an innovative idea will get the technological expertise (and resources) from the hub. In other words, it affirms that supportive physical and social environments are important to the sustenance of innovations.

Hubs are relatively quite popular nowadays and represent a genuinely new model of supporting tech entrepreneurs, particularly in sub-Saharan Africa. Innovation hubs have been widely celebrated by practitioners and policymakers for their ability to boost creativity and collaboration (Toivonen & Friederici, 2015). As of 2017, some of the most popular hubs in Africa are: *kLab* (Rwanda), *iHub* (Kenya), *mHub* (Malawi), *Co-Creation Hub* (Nigeria), *BongoHive* (Zambia), *Smart Xchange* (South Africa) and *Ebene Cyber-City* (Mauritius) among others. The role of hubs in facilitating healthcare innovations is multifaceted. Hubs are designed to promote innovation in general, but if empowered by the health sector, they can come up with purpose-built healthcare solutions. For instance, healthcare authorities could use hubs as providers of some of the most pressing solutions in the healthcare sector.

Innovative: Young people innovating at mHub in Lilongwe, Malawi.

Hubs organize various kinds of events. One type of events which can be categorized as supportive for emerging innovators is the "pitch events". This is whereby innovators/ entrepreneurs pitch (present in a convincing way) their ideas to audiences of people such as potential business partners, policymakers, the media and the general public. The purpose is to encourage the generation of creative entrepreneurial ideas, and to create a platform for up and coming innovators and entrepreneurs to sell these ideas/ products/ services. In Malawi, there exist the Blantyre Pitch Night, Lilongwe Pitch Night and more recently, Zomba Pitch Night. These are monthly events and mHub is one of the organizers and partners.

Innovation contests are another type of event that also play a significant role in inculcating the spirit of innovation among youth. Some innovation contests accept entries from a wide array of areas of interest. For instance they may combine innovations related to healthcare, agriculture and others and then select overall winners from the applicant pool, irrespective of what field their innovation falls in. Others would set up categories (healthcare, agriculture et cetera) and let innovations of a similar category compete against each other in that category. Inviting competition per category is arguably the more reasonable option, as it allows for focus and concentration on a specific field.

In addition, contests which let entrants compete across categories may be prone to judgemental biases. For instance, the judgement criteria of most such contests do not only consider the significance of the innovation, but also other factors such as business plans, design of the apps/ platforms, and other areas. If a particular innovation scores highly in significance (for instance, health-related innovations are almost always more likely to be labeled more significant than financial innovations), the judges may become psychologically intrigued to vote in favor of the healthcare innovations, even though they may have weaknesses in other dimensions such as design or business-plan. This behavior can be explained by Leon Festinger's theory of cognitive dissonance. The theory states that people sometimes have contradictory beliefs regarding things, and they mentally have to repel one of the beliefs to create harmony and avert dissonance (disharmony) brought about by the starkly-contrasting beliefs.

In the practical world, the judges in the aforementioned kind of innovation contest may believe that a healthcare innovation deserves to win the contest because healthcare itself is indispensible, while at the same time believing that it does not deserve the top spot because of its other

weaknesses. Eventually they may brush off the doubts and declare it successful. The use of rating scales for determining the magnitude of the score of each entrant in each category (such as scores for significance, potential scalability of the idea, et cetera) can add some objectivity to the judgement decisions. Besides, the segmentation of tech contests to reflect category-specific awards holds the promise of giving visibility to a lot of innovators at once, plus it can instill among participants the realization to innovate in certain disciplines which are often forgotten.

Hackathons are another type of event organized by hubs and other institutions involved in tech issues. They are also known by such names as "tech fests", "hack fests", "code fests" and "code days". They bring together computer programmers, graphic designers, project managers and others to collaborate intensively in developing software. Hackathons usually last between a day and a week, and have specific focus (for instance, to develop educational apps). Due to their intensiveness, hackathons can be mentally stimulating to those involved. Participants are challenged to come up with problem-solving ideas in a short spell of time. On the down side, however, hackathons may not provide sufficient time for the development of more complex projects. As a way of contributing to the development of healthcare, innovation hubs need to partner with the healthcare industry and organize more healthcare-focused hackathons. In 2016, mHub once hosted a hackathon for the development of solutions for assisting people living with albinism, who were the subject of torture and ritual killings in Malawi for the better part of that year. This is an example of hubs bringing about clear social impact. The same approach needs to be attempted the next time we have a sudden health crisis such as an epidemic of infectious diseases. Innovators should be challenged to make applications, services, gadgets or other tools to help in addressing that.

Entrepreneurship programs represent another trendsetting category of innovation-friendly schemes. Entrepreneurship schemes may cater for both technological and non-technological entrepreneurial/ innovative activities. They are most frequently targeted on the youth (with the specific age groups varying across the programs). Their packages also vary, but usually include training/ mentorship activities on such topics as innovation management. They may also increase

networking among members and provision of funds known as “startup funds” or “seed funds”, which allow the entrepeneurs to kick-start their startups. A startup is a proposed or newly-hatched entrepreneurial project. The definitive duration for considering a project as a startup is variable. Most quarters would take it as any period of less than three years. Regarding *Maternitech* project, I often used to have fears about whether we would get any funding or support, as time kept passing. My greatest concern was that once we clicked three years in existence- maybe even before that, many would start to consider us irrelevant and we would stand lesser chances of receiving grants or being accepted into entrepreneurship programs. This is true for any other innovation. People tend to have high expectations from innovators, who are expected to deliver results within a time frame.

Innovations go through several cycles ranging from a mere rough idea, to a viable concept to a working prototype to an impactful solution on the market. Most entrepreneurship programs tend to support innovations and other entrepreneurial ideas which have both the potential to solve major problems in at least one defined community, and at the same time those whose proprietors have a sensible business-plan. The idea behind social entrepreneurship is that your solution needs to have social impact, while it rakes in benefits to you at the same time.

One of the most impactful entrepreneurship programs in Africa is the Tony Elumelu Entrepreneurship Program (TEEP). Founded by Nigerian billionaire and philanthropist Tony Elumelu, this scheme chooses 1000 youth from across the African continent every year who, through their applications to this program, demonstrate outstanding ability to produce quality entrepreneurial initiatives in different sectors such as agriculture, healthcare and others. They are given online training for some months, before being handed a $5000 war-chest each to kick-start their endeavors. There are also other entrepreneurship programs across the African continent with focus on agriculture, healthcare, ICT, good governance, infrastructure and other categories.

A friend of mine successfully got accepted into the Tony Elumelu program, with his healthcare business idea. He is now running his healthcare service company. Although his business idea is not technological in nature, the internet aided him both in applying to this program and undergoing the online entrepreneurship course which equipped him with these skills to enter the healthcare business arena. He successfully harnessed internet technology to come up with his company, which works to improve the health of the clients it serves.

Lately, innovation and entrepreneurship are being studied as academic disciplines in tertiary institutions across the world. As an example, the University of Malawi through the Polytechnic now offers Bachelor's degrees in entrepreneurship. Malawi University of Science & Technology (MUST) offers Master's degree programs in both entrepreneurship and innovation. This is a good sign- that people have started to realize the value embedded in entrepreneurship and innovation. It is paramount that such academic programs contain relevant, context-specific and up-to-date information if the graduates from those programs are to make any meaningful impact in society. As is stated in many sections of this book, one needs no formal training to become a good entrepreneur or innovator. However, the programs are not unnecessary. The graduates which they will produce can help in mentoring the coming generations of entrepreneurs and innovators in Malawi in many sectors including healthcare.

The concept of hubs is synonymous with innovativeness. However, innovation should not be confined to particular places such as those. Innovation can and ought to be practiced in many different places. With this book being about healthcare-related innovations, perhaps it is not far-fetched to make the statement that healthcare institutions ought to be innovation-friendly. In 2017 we ought to be redefining our institutions, and I strongly believe that the long-held perception of what healthcare institutions are or ought to be, needs updating.

I believe that it is time to migrate from perceptions whereby healthcare institutions are perceived as institutions whose activities aim solely at treating diseases. Just like many academic institutions have undergone overhauls and now identify as "centers of excellence", it is also high time for healthcare institutions to follow suit. They need to intensify innovation for these redefinitions to befit them. Healthcare institutions ought to challenge, engage, inspire and motivate their staff to act as identifiers of problems, and propose innovative solution, which may be technological or non-technological.

There are two paramount factors that I have identified and believe to be the causal factors for the Malawian healthcare sector's rigidity and resistance to this said change. First and foremost, I believe that most Malawian healthcare institutions have fixed, one-way chains of command. Leaders in this system, like hospital matrons, medical consultants, administrators and others are treated as having the ultimate authority in planning and decision-making. Their decisions are linear and non-negotiable. They exercise totalitarian command over their subordinates, who submit to them in fear. Definitely this kind of environment does not allow for constructive input from subordinates. This kind of administration sharply contrasts the flexible and innovation-friendly environment which is typical of the fruitful *Silicon Valley* institutions. It is no guarantee that making leadership in healthcare circles more flexible will increase innovation. However, that phenomenon is more likely. It is not unreasonable to assume that healthcare settings have some people with innovative minds. Thus, it is better to create a conducive atmosphere for these to thrive and bring out their innovativeness.

Secondly, I think healthcare institutions have been resistant to image-restructuring because of the inherent expectations and stereotypes placed upon healthcare workers. These stereotypes prescribe that healthcare workers are supposed to dedicate *all* their time to their patient-care activities. Through this lens, the typical healthcare worker is seen by himself, his peers and the public as a person whose interest is only in patients' matters. Anything else outside of that circle is believed not to be his concern. These stereotypical perspectives kill the spirit of innovation among healthcare workers-cum-would-be-innovators. It is more than once that I have had innovative ideas, but felt discouraged because everyone else in the environment seemed to be disinterested in these creative ideas, and instead focused on their caregiving activities.

I once had an idea of developing a machine for warming baby wrappers which are locally known as *chitenje*. In the labour and delivery department of Kamuzu Central Hospital, newborns are covered in these wrappers. However, sometimes these wrappers may have low temperatures, which may cause the baby to lose some heat. It is not a deadly problem as the babies are placed under warmth later, but still it may be discomforting for the babies and may cause them to lose some energy.

As a way of dealing with this, I thought about the concept of a machine for warming these wrappers instantly before they can be used to coat the babies. It is a concept on which I would

need to work with engineers, and I have complete belief that my prototype is executable. However, I have never felt the motivation to proceed with these intentions because I noticed that I was the only one in that department who seemed to have creative ideas such as these. Everyone else concerned themselves with doing routine patient-management tasks, making me the odd one out. Even if I proposed this idea, most likely I would not get support and encouragement from anybody. I was surrounded by people who did not think like myself. I felt being condemned into being in the wrong profession, a profession whose values differed from mine. Without being emotive any further, let me express hope in the possibility of Malawian healthcare workers changing their attitudes and starting to perceive themselves as problem-solvers besides being routine providers of patient care. To the healthcare worker who may be interested in spearheading innovativeness, I recommend they take the following steps in so doing. These are steps I have devised from my experience:

1) *Problem identification:* This is whereby the healthcare worker-cum-fledgling-innovator senses a problem in need of an innovative solution.

2) *Solution conceptualization:* This is whereby the aforementioned searches their mind for a possible solution to the identified problem.

3) *Collaboration:* The healthcare worker will then seek the support of potential partners with which he can join arms in tackling the identified problem. These could be members of the same profession, members of relevant technical professions (such as welders, engineers, computer programmers and others), donors and more. This step may come second in some circumstances.

4) *Solution testing:* At this stage, the collaborative team ought to test the proposed solution for its feasibility. The test could either be hypothetical or real.

5) *Solution implementation:* At this phase, the solution has passed the test. The team ought to put the solution into practice.

6) *Solution evaluation:* This is whereby the innovation is evaluated for effectiveness. Evaluation may be ongoing or terminal.

These are steps I have thought of and would recommend for use in coming up with innovations in the healthcare field. We can call this series of steps: **"Walter Moyo's Healthcare Innovation Model".**

Chapter 10: Current Trends and Key Issues in Healthcare Technology

"The 21st century has brought a number of discoveries and medical advances…they have opened up possibilities beyond what doctors thought was possible years ago"-

Lauren Cox.

Imagine a doctor trained 30 years ago, who in the past two decades has not been practicing medicine. He now wants to get back to the ward to render his services. Would he find his work easy? We can only hypothesize. The first hypothesis is that he would find it easy, because how the human body works never changes with time. The second hypothesis is that he would find it hard to adjust, because medicine is not only a science about the human body- it is also an art, and therefore its successful performance depends on the current tools being used that time. We can hypothesize as much as we can fantasize on this topic. One thing is certain, though: that doctor would have to re-orient himself to the system. It is difficult for us to imagine how long the re-orientation would have to be for him to regain his grasp of accurate diagnostic and prescriptive skills. In any case, it would surely depend on factors such as his memory, and most definitely how much things would have changed at the time of making this dramatic return.

Situations like these aren't just hypothetical. They happen in reality. I recall the period between 2013 and 2014, where a nationally-acclaimed doctor, Dr. Heatherwick Ntaba, returned to his medical trade at Kamuzu Central Hospital after a long absence. He had been busy with politics and after some time, decided to revert to his original calling. As I saw him grace the corridors of the referral hospital, questions kept popping in my head as to whether he could still *remember* the craft of surgery, which was his interest area. Within the timeframe of his departure and arrival, some newer technologically-enhanced surgical practices had become the norm. He must have had no choice but to refresh his skills before touching patients. He must have felt like a stranger in his own world.

That is the power of technology. The realization of this power will make us understand the importance of training healthcare professionals in accordance with current relevant technologies. Technologies are always emerging in healthcare, as they are everywhere else. What were the technological trends that revolutionized 1980s healthcare are no longer marvelous today. There is a fast-paced evolution of technology at work.

ICT is a discipline in itself, but it is a discipline whose importance cannot be observed without being seen from the perspective of how it contributes to other fields. ICT cannot be discussed in isolation. For instance, ICT contributes to the field of education by supplying different tools which have an insurmountable degree of usefulness in learning. They enhance communication between tutors and learners; and also among learners themselves. The same is the case with healthcare. The role which ICT plays here cannot be overemphasized. Healthcare practice needs to always change in order to remain relevant. This has the implication that newer, more efficient technologies need to be developed to sharpen the art and science of diagnosing, treating and managing health problems.

In 2014, there was a global outbreak of Ebola, a rapidly infectious viral disease which caused panic and worry all over the world. It accounted for deaths of thousands. In the most-affected countries like Guinea and Liberia, social activities stood stock-still. But this gruesome epidemic was not new. It had first appeared in 1976, about four decades earlier. However, unlike in the first outbreak, the 2016 outbreak was more problematic for a number of reasons. First, the world's population had significantly risen, and since this ailment was spread by contact of persons with other infected persons or with infected body fluids, a greater population of people meant a greater disease burden as a result of increased potential channels. Furthermore, 2014 was an age where the world had become a global village and international/ intercontinental travel was the order of the day. The world had come face-to-face with a thrilling disease capable of wiping out a large number of people in a snap.

The prospects of Ebola killing many people had numerous implications for scientists and healthcare professionals. They were faced with an uphill task of finding effective ways of diagnosing the disease. The only rapid-diagnostic technology that was available was a non-contact, infrared thermometer for detecting fever. Its use was based on the well-known fact that Ebola-infected persons exhibited symptoms like fever. The device was used in airports and other similar places. However, this was an inefficient device. Its use was not because it was the most effective device capable of being produced, but because it was what was available. The

inefficiency did not only lie in the fact that non-contact thermometers provide unreliable results after prolonged use, but also that fever in itself could not indicate Ebola. The end-result of the use of this device was that many people had to be detained after being suspected of possibly having Ebola, and this included many who did not have it. This caused a lot of inconveniences to travellers, yet it *still* had to be done because there was no other way.

Besides, those found to truly have the disease were only given treatments such as rehydration and other non-curing treatments. This, plus the diagnosing problems, pointed out to one fact: that the world was in dire need of a rapid, unambiguous way of diagnosing Ebola plus an effective cure for the same. Therefore, scientists kept investigating ways of achieving this, in a desperate attempt to race away from a ticking time-bomb.

The need for developing better diagnostic and treatment techniques is not only reflected in the example of Ebola. Many other diseases which burden the world need these. In fact, all diseases do. The difference, however, is that there are already effective diagnostic and treatment techniques for some diseases. These do not always involve high-tech solutions, but the fact that technology is used in the diagnosis and treatment of many diseases is undeniable. After all, if we extend the use of the word "technology", it has wide applications and we find that almost all diagnostic and treatment options depend on some form of technology. Of course it is hard to adopt such a definition of technology because for instance, plastic color-coded strips for diagnosing abnormalities in urine content are now too basic to be considered "amazing technology" in 2017, an age where 3D-printing of human organs is being explored.

Let us go on to something different. The healthcare services of developed countries are more technologized than the ones for the developing countries. Their laboratories are better-equipped and carry out vast combinations of tests. They are stocked with good supplies of imaging machinery, which bring precision to diagnoses. In contrast, the systems of developing countries rely more on symptoms reported by patients, and signs observed physically by healthcare providers.

This disparity exists even within the developing countries themselves, between poorer and more affluent regions. As explained earlier, symptom-based systems of diagnosing diseases are tricky because the same symptoms may stand for a wide variety of diseases. They may therefore mislead physicians. In many cases, it takes long for a disease to be finally uncovered using this method. An example is when a patient is suffering from a new or not-so-well-known disease with clinical symptoms similar to another known disease. When making diagnoses using symptoms, the physician must assume that the patient is suffering from a disease which is common in that region/ country. Treatment, then, is based on those assumptions. If it does not work, trials are given in favour of other hypotheses. The process is repeated until the patient is treated successfully. In so doing, time is wasted and the patient may deteriorate or even die before the correct diagnosis has been made. Therefore, symptom-based diagnoses may be unreliable.

It does not mean that lab-based, X-ray result-based and other tech-enabled diagnosing techniques are 100% reliable. In fact, physicians use results of tests alongside observed clinical signs, plus reported symptoms to make diagnoses. However, tech-enabled tests may expedite the process of coming up with correct diagnoses. They also support differential (hypothetical) diagnoses.

It is understandable that poor countries do not use diagnostic technology throughout their healthcare systems. The high costs of these solutions make them unaffordable. In Malawi, most advanced diagnostic services are available at the four central hospitals only. Fewer are offered at the district-level hospitals, which are less than thirty. In the "health centers", they typically have to use basic observations like palmar pallor to diagnose anemia, and jerking manifestations to diagnose meningitis- diseases for which ideally, laboratory blood analyses would be best. This is one of the reasons why scientists and others from developing countries need to innovate to come up with affordable, effective diagnostic and treatment systems to bridge this gap.

Having said that, let us look at some of the current tech trends that have shaken the healthcare world and can be presumed to grow in significance for years to come. The trends discussed hitherto are mostly those that people unfamiliar with them would call "high-end". They are the

technologies that are shaping the healthcare practices of advanced countries, which are the epicenter of technology. Although this book is generally meant to put its propositions in the developing-country context, where currently many of the so-called high-end technologies have not taken root, it is sensible to take a brief look at some of the most notable advancements taking place elsewhere. That way, we can use them as a compass and to appreciate how technology is capable of changing healthcare.

Pharmacogenomics

This is one of the most notable healthcare trends of this decade. It is a new field that has emerged from a combination of pharmacology (the study of drugs) and genomics (the study of genes and their functions). Pharmacogenomic practices aim at encouraging the production of medicines that specifically match a person's genetic makeup. They involve analyzing a person's genetic formation and producing drugs that specifically fit them. This is touted to have effects such as the production of highly effective medicines.

The basic premise behind pharmacogenomics is that regular medicines, despite passing clinical population trials, may not work effectively in treating *everyone*. For instance, Paracetamol may cure 99.9% of headaches but the 0.1% that are not cured, still matter and that is why medicines should be designed based on potential of efficacy for individuals. Another example is that some patients' bodies break down the molecules of medicines too quickly or too slowly, making the medicines less effective. Pharmacogenomics can help counter this. It also reduces the risks of adverse events following medication consumption. Finally, here is another example: we still largely use patients' weight or age as determinants of required drug dosage. These measures do not always lead to proper estimates of the required drug dosages for individuals- but pharmacogenomics does. It is also important in that it reduces 'trial and error' in taking treatments (meaning that due to it, patients no longer need to *try* a bunch of medicines before the best one for them can be arrived at).

Eric Topol in his book titled "The Creative Destruction of Medicine" argues that medicine needs not be population-centered (i.e. merely assuming that since a drug was effective in 9900 out of

10,000 study subjects, it should be relied upon), but rather it ought to be person-centered. Pharmacogenomics seeks to achieve just this.

Three-Dimensional Printing

Three-dimensional printing, also known as 3D printing, is a technique through which 3-dimensional objects can be produced/ manufactured instantly under the control of a computer. A 3-dimensional printer is used to perform this. The term 'printing' is actually a misnomer because this process is not necessarily *printing* in the literal way that we print out documents. 3D printing is actually a form of manufacturing, called *additive manufacturing*. It is a revolutionary technique as objects of almost any shape or geometrical structure can be produced through the technique, which makes objects by laying out material layer by layer. People can literally 'print' out anything ranging from toys, to guns, clothing and construction material! Few years ago, the Chinese built a six-storey building using this technique. People have also been able to 'print' vehicle parts in a matter of a few hours, and assemble them into fully-functional cars! It is unbelievable and sounds like something from the future, but 3D printing is real and sweeping across the world.

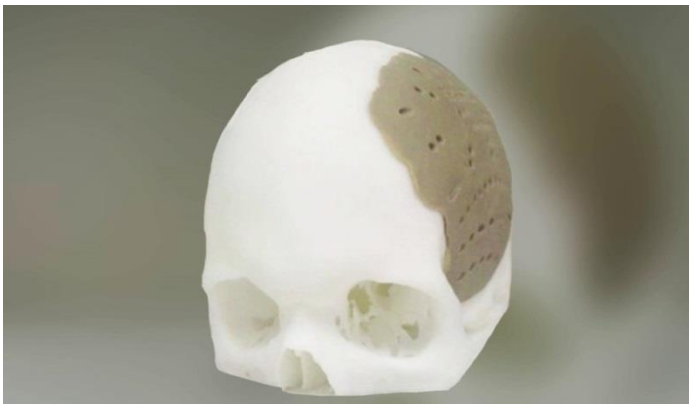
To be able to 'print' anything, all that is needed is a 3D printer and a 3-dimensional digital image of the object that is to be printed. Then a real-life form of the required object can be produced.

One reason why 3D printing will continue to shake the globe is that 3D printers are increasingly being made available on commercial basis, meaning that more and more civilians are owning them. Secondly, they are becoming more affordable while their effectiveness continues to increase. The cheapest 3D printer came from $18,000 to $400 within a decade! I liken the increasing domestic ownership of 3D printers to the increasing domestic ownership of drones. Drones are also widely available now and people can purchase them from electronics stores, and this includes in countries like Malawi. The same can be said about 3D printers. Soon many people will own 3D printers (initially in the developed countries, and later elsewhere too). They are becoming a basic domestic tool that every home needs to have.

Dr. Robert Goldman, World Chairman for the International Medical Commission, predicted that the ability to 3D-scan will eventually be integrated into smartphones. To 3D-scan is to obtain a digital image of an object, which can then be used to 3D-print another object. Dr. Goldman further predicted that people will be able to get 3D images of their feet using their smartphones, and use them to 3D-print perfect shoes at home. In fact, all major shoe manufacturers already use the technique in making shoes. Jeremy Rifkin, a futurologist, labeled 3D-printing the beginning of the 'third industrial revolution'.

The medical field has not been spared from the inevitable transfiguration resulting from the 3D-printing revolution. 3D printers are being used to manufacture a variety of medical devices including those with complex features, and those that can specifically be matched to a patient's anatomy. Various implants and prostheses such as artificial hip joints, artificial limbs and more are being produced through this technique. Some of the prostheses that have been developed through this technology have a human organ-like appearance, indistinct from real organs. For instance, some medical companies are now able to 3D-print artificial ears using a mixture of human cartilage tissue and some artificial substances. These ears look exactly like natural ears and can be implanted through cosmetic surgery. It is almost impossible to notice that these organs are 3D-printed organs.

Scientists are working on ways of taking medical uses of 3D-printing to the next level, where they would be able to manufacture *living* organs such as liver and kidneys, through 3D-printing and using living human tissues. James Yoo of Wake Forest School of Medicine developed a printer that prints artificial skin straight onto the wounds of burn victims. He successfully demonstrated this by printing a 10cm piece of skin transplanted onto a pig. It scans a wound and determines the number of layers of skin to fill the wound with. The US Army adopted the technology to use it in treating wounded soldiers.



A 3D-printed skull implant.

3D-printed organs.

Telemedicine

This is another key issue in contemporary healthcare practice. By definition, it is the use of ICT tools to provide clinical health care from a distance. It is a subset of telehealth. Telemedicine focuses specifically on clinical services, while telehealth is broader and encompasses public health, health education and more. The 1960s saw the inception of telemedicine, which was initially done only experimentally. However, the initial concept of telemedicine had already been conceived in the 1920s, whereby a cover of *Science & Invention* magazine depicted a tool which

would be used in examining a patient from afar. Perhaps this initial concept was so ahead of its time and that is why it did not immediately materialize.

The rapid advancements in technology have contributed to the rise in prominence of telemedicine. Both software and hardware for holding live video conversations have exponentially increased in popularity. In the West, many telemedicine companies have emerged, which offer services around the clock. In Malawi, mobile network provider *Airtel* runs a project called *Chipatala cha Pa Foni* (phone-based clinic). Rival company, TNM, is also apparently plotting a similar service. This reminds me of a conversation I had with friends. I remember once having said that mobile phone companies would eventually take over many industries. Telecoms companies are not only introducing services like investment and financial services, but they are going to extremes to even cover services relating to health. TNM is expanding its services to offer health information. In a related development, the same company offers life insurance cover. This is not health insurance, but insurance which provides funeral benefits. It is free life insurance, in that there are no insurance premiums that are charged- one simply needs to register and keep using airtime to be liable for these benefits. It is easy for them to add healthcare to the list of what their insurance covers. They could go a step further to pre-register each SIM card, so that each subscriber becomes automatically registered in the insurance cover upon purchase of the card. This would allow for near-universal health insurance coverage, as the number of phone users among adults in Malawi continues to grow. If adopted, this business model would work in their favor, earning them far more customers than traditional insurance companies, due to its good conditions as well as the fact that many people already own mobile phones.

With respect to telemedicine services, telecoms companies in countries like Malawi have got an unexploited business area and it is up to them to dominate it. First of all, the telemedicine industry is in its infancy in Malawi. Secondly, the telecoms experts themselves are better placed to leverage this business area. In our busy world, it is high time that Malawians got used to getting some physician services through the phone- at least for mild to moderate health problems. Diagnoses can be made through the same phone calls, and prescriptions given, which can be obtained from pharmacies. The telecoms company would make money from the credit used up during the phone call.

Telemedicine is generally beneficial. It expands access to quality patient care, covering areas that would otherwise not be reached. In Malawi, doctors are very few in number. Worse still are the specialized ones, who are only found at the four central hospitals in the country. Telemedicine can allow patients in remote regions to interact directly with these specialists. Not allowing these specialists to give services to these underprivileged people is unethical. On the other hand, referring every complicated case for consultation with specialists is expensive and sometimes wasteful, such as when the specialist later determines that a patient could have been treated at the local hospital without being referred. Additionally, letting the specialists periodically travel to remote clinics to provide services is intangible and hardly practical. Clearly, telemedicine is a useful tool in these and other matters, waiting to be fully utilized.

Smart Robots

A robot is a machine- especially one programmable by a computer- capable of carrying out a complex series of actions automatically. Robots have been used to replace humans in doing work which is repetitive or risky. Lately, robots are being developed to have an emotional dimension besides their mechanical dimension.

Smart robots are robots that are able to exhibit emotional characteristics in their interaction with humans. Their de facto standard design focuses on mimicking the human body or animals' bodies. These robots are infiltrating healthcare institutions (particularly in advanced countries). They have been proposed as a solution in the care of seniors 65 years and above, who suffer from problems like the inability to care for themselves. Carelli et al (2009) stated that the introduction of affective dimensions in human-robot interactions possesses the capability to increase robot acceptability. It is in the light of such considerations that these new traits are being embedded in a new generation of cognitive and relational robots.

Social robots can be used to help people suffering from dementia (chronic loss of memory associated with old age). They can provide care to people within their homes, allowing them to stay out of social care institutions. The advanced countries, where these seemingly futuristic innovations are taking place, typically already have good social care institutions for the elderly. However, many seniors dislike being transferred from their homes to these institutions, since

they feel bonded with their long-term homes. An alternative way has been for senior care services to be provided in clients' homes. However, at times this is expensive. The smart robots have the potential of reducing these costs. In a related development, Cristina Costecu & David O. David wrote about how robots are helping people with a disease known as Autism Spectrum Disorder (ASD).

Some of the robots in this category are what are known as the *biohybrid* robots. These are robots that do not have a wholly metallic appearance. Animal flesh and other material such as fur can be added to them for aesthetic purposes. Some of these robots can be cuddled in the same way pets are cuddled. This would help to reduce mental crises such as stress in the user. The technology behind these androids has been engineered to unbelievable levels. For instance, some of these are designed to have sensors in their "fur", such that when the user is cuddling them, they can also collect data on indicators such as temperature and other measures.

Another category of 'smart' robots used in healthcare are the robotic nurse assistants. In 2014, a group of Engineering and Nursing students from Duke University developed a robotic nurse assistant called TRINA (Tele-Robotic Intelligent Nursing Assistant). It was designed to assist nurses in high-risk environments, especially with the advent of the Ebola outbreak that year. This smart robot could do a lot of things ranging from passing medications to inserting intravenous (IV) lines! It was remotely operated by human beings and has proven to be a big hit so far.

One of the concerns people raise regarding smart robots is the potential of people losing jobs in the coming years, as robots would be able to do most of the work. The developers of TRINA claim that they intend to use it to assist human nurses, and not replace them. We cannot be sure of the veracity of that claim, and it is beyond the purpose of this discussion. What is undeniable, however, is the fact that over time, these robots will change the face of the healthcare system.

Virtual Reality

Virtual Reality (VR) refers to computer-generated simulations of 3-dimensional environments that can seemingly be interacted with. It typically requires the user to put on a VR gear that covers their eyes, and through which they can "see" 3D environments that make the user feel as

if they are in this imaginary environment. VR is an old concept but since 2016 it has gained tremendous popularity, one of the reasons being Facebook's engagement in projects that use VR extensively. A lot can be done on VR ranging from playing 3D games to watching 3D videos. It allows the user to "look around" the virtual world and interact with various features that are in the virtual environments.

VR is more than just about games. It has proven to have wide applications, including in healthcare. The growing importance of VR in healthcare practice cannot be overstated. Its uses range from diagnosis and psychotherapeutic treatment, to training of medical personnel. Medical students in some schools are able to use VR to learn about the human body in virtual environments. This is superior to using conventional, static pictures because images in VR look so real. Of course medical students sometimes learn using real human cadavers, but these are lifeless and so they do not have beating hearts or moving lungs. Using VR can help medical students *see* how processes like these occur in reality. Hence, a combination of lessons from VR projections and cadavers can combine uniquely to produce unprecedented understanding of the science of medicine among medical students. VR devices are now available in Malawi for less than $100. For this reason, the medical school in Malawi might perhaps need to start considering using VR simulations to teach their students. This is not expensive and there is no reason not to do it.

In the case of treatments, VR is used to educate and counsel patients in lifestyle choices such as quitting smoking and exercise. It can be used to teach skills for overcoming mild mental health problems like stress and phobias. This is achieved by engaging the users with precisely-designed virtual environments that present before them specific tasks. Finally VR can be used by doctors in preparing for surgical procedures. Surgeons can visualize VR simulations of patient's tumors, being able to understand the precise anatomical position of the tumor and determine what surgical approach to take when removing it during the surgery. The patients themselves can also benefit from this privilege that VR offers.

One story that made headlines was the story of controversial Italian neurosurgeon, Dr. Cannavero, who in 2016 claimed that in 2017 he would perform the world's first human head transplant. This doctor announced that his patient would be trained using VR to adjust to his new body and deal with unexpected psychological reactions.

For some time, I have thought about the possibility of doctors being able to perform surgical procedures without their physical presence in the operating room- through the use of a blend of VR and robots controlled remotely. A surgeon located far away could wear a VR headset and see the inside of the patient's body part which needs to be operated on, through live video feed coming from a 360 degree camera mounted within the operating theater. The surgeon would then use a hand-held device to remotely control a robot located in the operating room, which would do the actual cutting and sewing characteristic of the surgical procedure. This is quite a feasible thing to do, especially because robotic surgery alone already exists and has been safely and effectively performed several times. This proposition, what I call 'remote surgery', is therefore very possible with the aid of robot-surgeons integrated with a remote VR system. It would allow surgeons located thousands of miles away to operate on individuals in distant places. Specialized surgeons, who are scarce and are needed in many places across the world, could perform operations on people located anywhere in the world- without the surgeons actually having to step out of their offices. Whether or not it is already in practice is beyond my knowledge. However, since the infrastructure for making this a reality already exists, we should not be surprised to hear of it being implemented soon.

An artist's impression of Virtual Reality (VR). It is known for making users 'feel like they are in the virtual environment'.

Self-Service Kiosks

Self-service kiosks are machines that people can use to help themselves perform various transactions/ activities without the assistance of attendants. They are growing in use in the United States healthcare industry. Patients and clients use them to check into hospitals as well as to carry out other functions such as making hospital payments electronically. Self-service kiosks are touted to be able to reduce stationery costs for the hospital, reduce nurses' time-wastage by allowing them to do other patient care activities, as well as reduce errors associated with manual patient data recording. They are maybe a few decades away from hitting the healthcare market of the developing world. Nevertheless, we need to be expectant of the revolution that this will bring.

Instant Anti-Bleeding Gel

This is a gel that is able to stop bleeding with immediate effect when applied. It was invented by a young undergraduate student from New York University in 2013, and now it has been adopted for use in veterinary surgical hospitals. It is composed of what is known as an extracellular matrix that instantly clogs platelets together and initiates instant wound healing without the application of pressure. The gel, called *Veti-Gel*, has been used to close wounds to rats' arteries. It is yet to be approved for human trials. It represents an astonishing breakthrough that will change emergency medical practices forever.

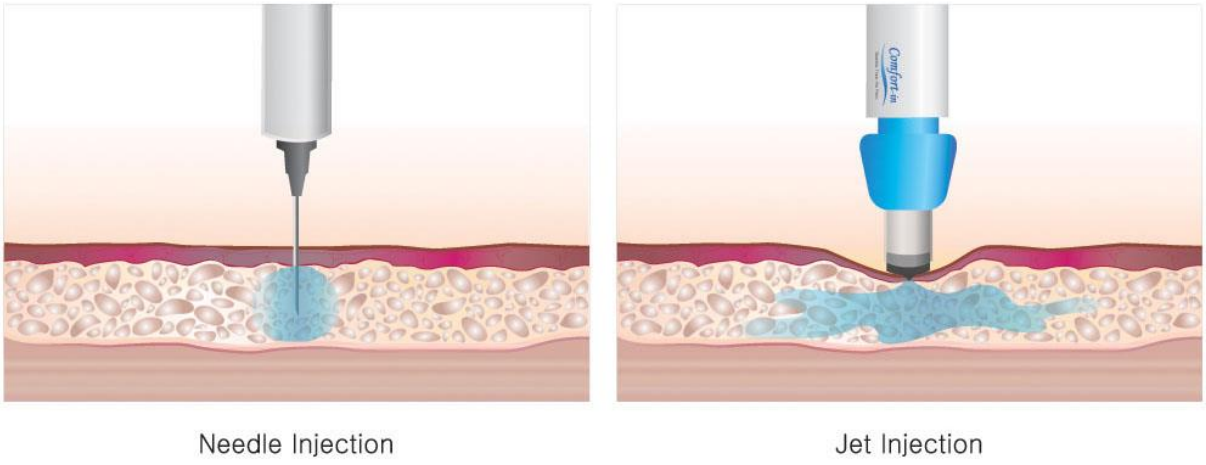
Needle-Free Diabetes Management

Diabetes, a so-called "lifestyle disease", is one of the most prominent non-communicable diseases. Despite the danger it poses, patients are able to manage themselves at home through the use of small blood sugar-monitoring devices and injectable insulin. Many of these patients have to get used to injecting themselves for many- if not all- days of their lives.

Unfortunately, not everyone gets used to daily injections. Some people have too much fear of needles that they never get used to daily self-injection. This is a factor that needs not to be

overlooked. Many of those who suffer from this serious fear end up not following the requirement of injecting themselves daily. This may cause their disease to get worse. The veiled danger behind this is the increased risk of heart attack, eyesight problems and stroke among these treatment non-adherents. To be fair, we cannot really blame the patients for failing to adjust to daily needle usage.

Fortunately enough, a needle-free insulin-delivery device was recently invented. It uses jet technology to deliver insulin below the skin (a jet is a rapid stream of fluid forced out of a small opening). This is achieved as a pressurized stream of insulin is forced beneath the skin, giving the patient a feeling of 'being given a little slap on the thigh' rather than a sharp, pricking sensation. Studies have already demonstrated that this invention is equally effective in administering insulin. In a few years' time, we may be saying goodbye to insulin needles.



Needle injection versus jet injection.

Remote Monitoring Tools & Sensors

Remote patient monitoring uses digital technologies to collect medical and other forms of health data from individuals located in one place, and transmit it to healthcare providers in a different location. Data that can be collected through this means ranges from vital signs (temperature, pulse rate, respiration rate and blood pressure), blood sugar, oxygen levels and others. This can be beneficial in allowing elderly persons to remain in their homes and avoid being moved to

nursing homes. It can also help in improving patients' quality of life and in cutting down the length of hospital stays. Sometimes patients stay longer in healthcare facilities simply for monitoring purposes. Remote monitoring techniques will make this practice archaic. A 2015 study found a 50% reduction in hospital stays among patients who used remote monitoring tools.

In 2009, a retired doctor from Texas, USA, developed a system which could monitor the fetal conditions and labor progress in the form of contractions, of an expectant mother and transmit them directly to doctors' smartphones many kilometers away.

Remote monitoring is also being used for blood glucose monitoring among diabetics. A sensor was invented, which can be implanted under the skin to continuously monitor a person's sugar levels, which can be transmitted wirelessly. Not only does this save the patient the burden of being pricked multiple times a day, but it is also superior in that it provides continuous monitoring rather than once-off measures of blood sugar levels.

Antibacterial Light Bulbs

Hospitals are known to be highly infectious environments. Patients sometimes get cured of some diseases but contract other infections from the same hospitals. But this could soon go down the annals of history as antibacterial light bulbs are being produced en masse. They are designed to inactivate a wide-range of harmful micro-organisms using ultraviolet light, rendering them harmless. Others, however, use other forms of light emitted at precise wavelengths, that when absorbed by bacterial molecules, produce chemical reactions that kill the bacteria from inside.

Electronic Underwear for Preventing Bedsores

One of my most unforgettable hospital memories was in 2011, when I was in first year of my studies. I was assigned to ward 1A of Kamuzu Central Hospital along with some friends for practical placements. I came across a patient whose waist area was entirely bandaged, with pus visibly dripping through the bandages. At first I thought this person must have been the victim of some serious accident, but that was not the case. This patient had undergone surgery, from which

he had recovered. However, he had developed severe bedsores due to his long stay in the hospital, which had become badly infected.

Bed sores, also known as pressure sores, can result from prolonged staying in the same position without turning. They are mostly suffered by patients who are confined to their beds with little or no movement. This includes disabled patients, patients on bone-tractions, patients with burns and patients who underwent major surgical procedures. Nurses are supposed to reposition patients every now and then but in the overcrowded health facilities of countries like Malawi, it is far-fetched to expect them to meet the basic needs of every individual patient. The incidence of pressure sores, therefore, can be expected to persist. In fact, even in countries like the United States which have many nurses and good nursing care services, pressure sores continue to be a problem. According to Dr. Sean Dukelow, intensive nursing care as a way of preventing bedsores is not only expensive- it is also only partially effective.

The good news is that there is a technology which was designed to address this matter. The electronic undergarment, *Smart e-pants*, is an invention meant to reduce the occurrence of bedsores. It provides a small amount of electric current that intermittently 'shocks' the bottom, reducing skin over-compression and effectively preventing bedsores. Ultimately, this invention can save costs and improve patients' quality of life.

Artificial Retinas

These are small, implantable retinal prostheses that were developed with the hope of restoring vision in people who lost eyesight due to progressive retinal damage. So far, they are only capable of giving the blind the barest sense of what is visible. However, research and improvements are ongoing, and it is anticipated that someday they may be able to completely restore eyesight in the blind.

Advances in Prosthetics

Prosthetics are artificial devices that are modeled on lost body parts. They have been around for many years. However, it is only in recent years that prosthetics have been made 'smart'. The lifeless, plastic or metal prosthetics that merely resemble human limbs may eventually become history, because scientists are developing bionic limbs that have machine intelligence. They can be totally integrated with the human nervous system and be made to sense their environment. They are truly life-like and allow people to do everything else that they used to do before losing their limb. Besides, they are affordable. Engineers at Johns Hopkins University developed a 'robotic arm' which a person can control with their mind, just as they can do with their real arms. Additionally, it is reported that this arm is able to generate sensations such as those of texture. Indeed, slowly or not, serious advancements are being made.

Chapter 11: Healthcare Technologies and the Future

"Healthcare may be evolving at a rapid pace because of the impact new technology can have on almost every aspect of the system"- Jacob Morgan.

I am a person who always likes to imagine how things will be in the future. This is an attribute that stems from my natural curiosity towards things. Sometimes I debate with myself regarding which civilization is best: past, present or future. I ask myself questions like "would it have been better to exist in the bronze-age when there were no sophisticated tools and processes for supporting our existence? Or is it far much better now? Or does the future hold promises that could outweigh the merits of living in the current and past civilizations?" Until we have built a time-machine, we certainly have no way of knowing. However, one thing that is for sure is that new developments are always exciting. I also expect the future of healthcare to be exciting.

We have seen using many examples that technology is on the driving seat of the healthcare industry today. The least we can do is to acknowledge that this will continue over a prolonged period of time. In both the fields of science and logic, current occurrences can be used to make reasonable predictions of what is possible. In logic this is known as "induction". The current trends characterizing the modern-day healthcare system can serve as platforms which we can use to exercise inductive reasoning regarding what future healthcare is likely to be like. We can posit what I like to call some "enlightened guesses" regarding the future of healthcare technologies. While we cannot be guaranteed that our predictions have the utmost measure of accuracy, we can have confidence that the picture will likely not be very different from our projections.

One of the predictions I would like to make about future healthcare practices concerns healthcare industries. Chances are very good that the future healthcare industry will be tech-centered. As earlier mentioned, companies that have traditionally concerned themselves with ICT (and not health) recently extending their arms into the healthcare sector. Google expressed interest in a program for developing blood glucose monitors for diabetic patients. Even before that, it had initiated the now-defunct Google Flu Trends and Google Health, as we have seen. Google's Life Science Unit is working on various hardware products that can be used in discovering and managing diseases. Google's arch-rival, Apple, has repeatedly emphasized on the healthcare benefits of their smart-watch. Another tech giant, IBM, in 2015 launched the IBM Watson Health platform. San Francisco-based transportation company, Uber, announced a flu vaccine delivery service in 2014. Examples of how companies primarily associated with technology are showing interest in the health sector are abundant.

There are limitless superiorities that technology companies have over other companies. Since they offer a wide range of services, they can spread risks across their wide spectrum of investments, using the profits from one division of their company to sustain the operations of another.

My thoughts align with the predictions made by 1940s economist, Joseph Schumpeter, who said that companies that do not produce value are destined for doom, a term he coined "creative destruction". Healthcare may have been artificially shielded from this phenomenon, but things are clearly changing. From the observable change, we can confidently believe that tech companies will dominate the healthcare market of the future (as opposed to traditional healthcare companies). Rich Gliklich, former CEO of 'Outcome', a health IT company, said and I quote: "Prior barriers to participation in the healthcare market were largely based on the fact that the industry was built on really poor technology" end of quote.

If that hypothesis is true, we can now expect more tech companies entering the healthcare market, since technology is becoming a cornerstone in that industry. In conclusion, there is a possibility that the private healthcare industry in many countries, which is dominated by various traditional medical companies, may be dominated by ICT companies including telecoms companies.

Predictive Medicine

Another trend that may characterize the healthcare industry in the forthcoming time period is that healthcare may become more and more predictive. In fact, we can already sense this mushrooming if we look closely. The increase in patients' data collection and tracking, coupled with the increase in data analysis tools, will increase our ability to predict individuals' health events. AI systems may be built which would make analyses based on patients' vital sign patterns and other indicators. Apps are being developed that can analyze behavioral or biochemical indicators of people and let them know what risk they have of developing certain diseases. There are apps which give estimates users' probability of having certain cognitive illnesses, using their patterns of movement, for example. These apps will likely turn out to be a big hit in the next one or few decades to come.

Anti-Aging Drugs

In addition, anti-aging drugs may be a central feature of tomorrow's healthcare arena. Research is already being done on them and it looks promising. Scientists have been curious and eager to find anti-aging solutions for a long time. In fact, many civilizations over the centuries have concerned themselves with attempting to find such things as 'fountains of youth' and 'elixir of immortality' that would prevent/ delay death while reinvigorating youth. With advanced scientific techniques, studies are at their peak to find the solution to this and so far, scientists believe that the drug *metformin* could hold the key to longevity. This has already been proven in animals, but now studies are underway in humans to determine this. Obviously, this research will not stop until anti-aging pharmacological agents are discovered. Thus, healthcare research of the near future will likely continue to concern itself with anti-aging drugs.

Nanobots

Nanobots are microscopic particles that have the capacity to act like robots. These infinitesimal bugs can be manipulated remotely to perform various functions. It is hoped that in the future, nanobots could be injected into a person's blood stream where they would monitor the conditions therein and provide feedback.

While this might sound like science-fiction, it is not far from being realized. A research team at the California Institute of Technology injected nanobots in a trial, which turned off the "switch" in cancer cells, which causes them to multiply. Said differently, nanobots are designed to identify the mutated cancer cells and kill them with chemicals. They are so accurate in their cellular annihilation, such that no healthy cells are harmed (Grunberg 2015). It is believed that nanobot technology poses the ability to cure *all* diseases known to mankind. Their research and development is still in its infancy but so far it is very promising. As nanobots are costly to manufacture, the treatments they would offer would also be pricey. However, with time, perhaps it would change.

Do-It-Yourself Medicine

This has increasingly become an area of speculation, as 'smart' devices and wearable devices hold the promise of possibly transforming homes, workplaces and smartphones into centers for health monitoring and intervention.

Today, a remarkable number of players are placing emphasis on enabling consumers to make their own reliable health "diagnoses". At the very least, we are seeing an increase in the number of patients that have remarkable levels of health-literacy as a result of surveying the web for health information. In the near future and beyond, this should be expected to peak. The advent of faster internet services and increased presence of reliable health sites is poised to further spice up the drama. Facebook introduced the internet.org initiative that allows users in selected (mostly poor) countries to access several essential and informative sites even if they don't have data in their devices. This and Facebook's deployment of the Aquila unmanned aircraft to beam internet signals to underserved regions of the world from space, will tremendously empower people to have access to essential information including health information.

In the past, many people perceived procedures such as injections and medical examinations as scary. In the present day, increased commercial availability of health gadgets has allowed people to do things such as check their own vital signs and blood sugar in the home. It is no longer always necessary to visit a clinic just to have one's blood pressure or weight checked. Many now do that in the convenience of their homes, taking advantage of the user-friendly medical devices that have infiltrated the market. Few would disagree with the notion that a lot of people nowadays perceive procedures like blood pressure checking as 'simple' procedures. It is no longer a necessity to pay the physician a visit for some mild health concerns. Some simply visit the internet to get information on that condition, after which they self-medicate. Whether this is commendable or not is another issue, but it is what is happening and it can only be expected to continue.

Chapter 12: Conclusions

Many issues have been discussed in this text and from those, there are several conclusions that we can derive. The first notable derivative is that people in the healthcare sector need to stop viewing technology as only belonging to people in other professions. Much as some specialize in ICT and other tech fields, technology today is a contemporary issue. It affects everyone, and what may have been considered advanced technological techniques and knowledge in 1995 may not be considered such in 2017. This makes it sufficient for us to conclude that non-technologists (including healthcare professionals) need to concern themselves with technology.

The healthcare sector in many countries today still resists total change. Partly this could be because many healthcare workers are trained to act as practitioners/ direct service providers, and not as problem-solvers. Secondly, many healthcare workers view technology as the domain of others, not their business. Finally, some would-be healthcare innovators from the technology field find healthcare information too complex that they are hindered from making any meaningful innovative contributions. Many young computer programmers would rather come up with solutions relating to other areas apart from healthcare. This, however, is slowly changing and we have good reasons to be excited.

Healthcare workers can do better at being receptive to, and interested in technology, despite not being technologists. We have seen that some individuals who, in spite of having no formal training in traditionally-acclaimed technological fields, defied the odds and came up with innovations in the healthcare area. This is how it ought to be, and after all, it is healthcare providers that better understand needs in that domain than do technologists. The only aspect they lack (typically) is the technological dexterity, and it would appear that it is easier to gain knowledge in that than it is for technologists to gain recognizable knowledge in health issues.

That aside, another conclusion we can draw is that academicians/ planners of academic curricula for training healthcare providers need to continuously update their curricula so that they reflect more technological issues and practices, beyond the ordinary basics like Microsoft packages that healthcare providers training are taught in their training. As said, the world is getting more complex each passing day, and the number and depth of skills one needs to be trained in is as

dynamic as ever. Healthcare providers may need to be trained in new areas of relevance such as health informatics and the use of smart health gadgets. For instance, medical students are trained to use the *gestational wheel* to calculate pregnant women's dates. In the digital age, maybe it is time to use apps that can do that, which also do it quicker and more accurately. If the training of healthcare workers fails to undergo this transformation, these healthcare providers, upon qualifying may get stranded in a 'technological shock'. It does not give a good picture when patients are more proficient in using healthcare gadgets than healthcare workers are. While it is not possible to train healthcare workers on the use of each and every new gadget or software that appears on the market, it is imperative to train them with a sense of being open-minded and curious toward ground-breaking technologies that they may not be familiar with. This means being emphatic on the specific attitudes these fledgling healthcare workers ought to harbor. Additionally, a know-it-all mentality is not helpful. They always need to be willing to refresh their knowledge and skills in alignment with current practices.

It is not trainee healthcare students only who need to get familiarized with most recent health-related innovations. This also applies to practicing healthcare staff, who must never tire at refreshing their knowledge and skills relating to technology usage in their work. They must take efforts to continuously update themselves as individuals and as groups, to keep abreast with modern medical technologies. Nurses in Malawi have what is known as Continuing Professional Development, where their skills are updated. While this is a good initiative, it is really a recycling of the same old practices they learnt in training. It is not necessarily done with new healthcare technologies in mind. This, however, could be reshaped so that it specifically reflects transmission of new technologies that keep entering the healthcare system. Otherwise, 'drilling' one another on the same old practices changes little. This also calls for guidelines for healthcare workers to be regularly updated to reflect current tech issues. Apparently, professional healthcare bodies have got work to do.

One more thing is that there needs to be inter-professional dialogue in the healthcare professions. Awareness should be provided to traditional healthcare providers regarding the role of people from the 'hybrid' professions like health informatics (which blends health knowledge and informatics knowledge) and biomedical engineering (which blends engineering knowledge with medical knowledge) and other professions, on what their specific roles are. Similarly, those

'hybrid' professionals, who serve not primarily in healthcare but in supporting healthcare systems, need to get more acquainted with the specific scopes of practice of various healthcare professionals like otorhynolaryngologists (ear-nose-throat specialists), radiographers and others. This is important for interdisciplinary, collaborative innovation efforts.

Furthermore, public campaigns should take place to increase the acceptance of technologized healthcare in the general population. As discussed in chapter 3, there are hurdles in the acceptance of and trust in healthcare which uses modern technologies. Due to ignorance, many people still see these approaches as alien. For that reason, people need to be made aware that technology makes healthcare services more affordable and effective. Telemedicine and other ways of uniting technology and healthcare need to be scaled up and encouraged.

Regarding the talk of promoting the acceptance of technologized healthcare among the populace, there are five main categories of issues whose existence I have discovered. They are as follows:

i) *The effectiveness concern:* Users question whether e-Health solutions are more effective/ accurate than manual ones. They want to know whether telemedicine can be as effective as visiting physicians' offices. Thus, campaigns should focus on highlighting the superiorities of e-Health, because like we have seen, some systems like AI are far more superior to human doctors.

ii) *The privacy concern:* Secondly, there arises the issue of data privacy. There are concerns with security risks associated with e-Health, such as patients' data being hacked into. There need to be mechanisms of bolstering the safety of e-Health systems, to give consumers more trust in them and increase their acceptance.

iii) *The depersonalized communication concern:* There is also the issue of depersonalized communication that ensues from patients interacting with computer systems, or doctors through computer systems, than is the case in face to face encounters. The emotivists argue that modern, technological ways of providing healthcare services are killing the emotional/ psychological relationships between

health professionals and patients, that would exist in physical encounters. This case is complex, but it is worth it to point out that many AI systems provide solutions tailored to meet the needs of specific patients. Secondly, machines are being designed to exhibit artificial affection, so this may no longer be a problem. Finally, while therapeutic patient-provider relationships are important, they are not necessarily *essential,* for treatment to work, at least for most of the non-mental diseases.

iv) *The affordability concern:* The final kind of issue which forms the basis of most peoples' rejection of technologized healthcare is the issue of affordability. Many associate technology with expensive treatments/ procedures/ hardware. While this is true for some technologies, it is not true for others. As a general rule, technological solutions get cheaper as the years pass by. It may still not yet be time to overhaul the healthcare system in Malawi completely to the digital version. The internet is still bad or absent in many rural areas. In addition, some find it costly and may not yet have smartphones. However, things are changing. High speed internet coverage is extending to many areas. Besides, companies like Google and Facebook are intensifying their campaigns to provide free essential services. They are also extending internet signals to remote parts of the world. Soon, the whole world will be connected.

Gadgets are also decreasing in price rapidly. There was a time when cellphones were so expensive that they were for the rich. This is rapidly changing and the phone is becoming a basic tool for survival. It is also increasing in capabilities. Thus, soon enough, the issue of affordability of technologies as a hindrance to embracing e-Health, will become historical.

v) *The feasibility concern:* Many people, especially in developing countries, resist or reject new technological solutions on the basis that they may be too futuristic and unfit for their situations. However, it is crucial to bear in mind that technology is advancing at a fast rate anywhere in the world, and as it keeps being produced, it keeps heading to newer areas. It might take longer for some advanced technologies

to reach developing countries, but they will definitely arrive. It only makes sense, therefore, to plan ahead and anticipate them. After all, the world is a global village today.

The healthcare sector and the general public need to stop applying limitations on what technology can do to transform healthcare. Many brand some technologies as 'too futuristic' and not applicable to their environments. However, we need to embrace technology with open arms because it does not stay static for too long. We may become shocked to see many of the technologies we did not accept, being the main or only way of doing certain things. Let us embrace technology and not put limits to the possibilities that it can offer.

Another worthwhile recommendation to make is that policymakers should consider adopting and scaling up low-cost healthcare technology solutions. The point is that there are some technologies which we use that are expensive and yet more affordable and effective substitutes for them exist out there in other countries or even within, in the form of novel innovations from up and coming innovators. Proper research needs to be done to figure out what innovations from elsewhere can be applied to our contexts. We cannot buy hundreds of scanning machines for all the Malawian health centers, but we can buy hundreds of smartphones and install in them apps which perform functions that mimic scanning machines.

In addition, innovation hubs need to do more to stimulate healthcare innovations. We have seen that they are doing a great job in shaping the next generation of innovators and entrepreneurs. However, they ought to encourage health-specific innovations by holding events that can specifically stimulate innovations in health, such as health-focused hackathons (fast-paced innovation workshops) and events of other natures. They may also possibly want to demarcate themselves into divisions (such as division for healthcare innovations, division for agricultural innovations, et cetera). This can allow for more focused innovations, than just promoting innovations in a general way. Certainly we know that healthcare is a key category and it should be given special consideration. Another part of the onus also lies on the healthcare sector itself, which must recognize the importance of hubs and thus engage with them in various projects as a way of promoting innovation for health.

Finally, there is need for the healthcare sector through healthcare institutions, professional healthcare bodies as well as authorities such as Ministry of Health, to incorporate technology in their strategic plans. Any healthcare system which does not have technology at its heart cannot excel.

The 2011-2016 Strategic Plan for the Malawi Ministry of Health did not contain any objectives relating to the promotion of technology usage. In the few areas where technology issues were tackled, they were tackled indirectly. For instance, the Plan talked about training staff in the use of software for Physical Assets Management, stocking workshops with equipment and upgrading technologists. However, the Plan ought to have gone beyond this to possibly cover other areas such as strategies to promote the development of locally-relevant technological innovations; promoting engagement of healthcare staff with technologies, and more. Future Plans of this nature ought to have technological issues at their epicenter, to allow for technology to fully be the driving force for the healthcare system. They also need to be adopted at institutional levels.

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