E-Science Masters Research

Constraints and Consequences of Implementing Digital Health: Cross-National Evidence and Implications for Africa

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A research report submitted to the Faculty of Humanities, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of e-Science.

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Declaration

A research project submitted in partial fulfilment of the requirements for the degree of Masters in e-science, in the Department of e-science, School of Humanities, at the University of the Witwatersrand, Johannesburg (30 April 2020).

I, (Yusuf Loonat), declare that this research project is my own, unaided work. It has not been submitted before for any other degree or examination at this or any other institution.

30 April 2020

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(Yusuf Loonat) **Date**

(896010)

Masters in e-science

Abstract

Introduction: African countries lag the rest of the world in terms of adoption and implementing e-health policies. This in turn severely affects their health outcomes. **Objectives:** The objectives of this paper where to explain: 1.Africa's low level of adoption of e-health policies.2. To what extent does Africa's low level of adoption of e-health policies translate into inferior health outcomes in specific life expectancy. **Methods:** Data of 125 countries from the World Health Organization (WHO) were used in regression analysis. **Results:** Africa's low level of adoption of e-health policies are as a result of poor economic development and lack of public expenditure in healthcare. Africa's low level of adoption of e-health policies translate into having inferior health outcomes such as a lower life expectancy of 8 years less than countries from other continents. **Conclusion:** This study has provided evidence that African countries have lagged in their adoption of e-health policies and even after taking into account their general low levels of economic development and insufficient health expenditure their adoption capacities still are low.

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Chapter 1: Introduction

This chapter will be divided into five sections. The first section will include the aim of the research, followed by the rationale for the study. The third section will discuss the literature review to provide the reader better insight into the subject matter of this paper. The fourth section will consider the contribution of this research paper and lastly the design that will be utilised in this research paper will be provided.

1.1 Aim of the research

The twenty first century has shown to offer great promise in technological advancements and continues to improve in various aspects that exist in the modern era, thus pertinent to better health outcomes globally. The new age has offered Big Data analytics, a noteworthy tool used to equip health care professionals and practitioners to be able to reach a wider spread of people in managing and possible elevation of emerging and current pandemics which plague the globe. Therefore, by optimising extensive universal health coverage through the utilisation of digital health care facilities, the aim is to approximately save 200 billion dollars in Africa within the next decade (WHO,2015). However, for this heath care system to be realised there are certain basic conditions and country readiness which need to be realised.

Viewing this from a global context, countries may err in focusing on the technological advancements rather than systematically conditioning and developing basic health care systems which is needed to support the digital health systems. Fulfilling the requirements of basic health care readiness will catalyse these initiatives to continuously achieve real scale and long-term sustainability using digital technologies. This will give rise to their capability to deliver healthcare to people living in rural parts of Africa.

The arrival of technology in the 21st century, specifically the internet has made it much simpler for African countries to provide better healthcare services to its citizens. However, owing to the poor quality and lack of access to internet led solutions, poorly trained health professionals and a dearth of overall medical education are one of the prime reasons as to why the majority of African countries lag behind the rest of the world in terms of adoption and implementation of e-health

policies (WHO,2015). This in turn severely affects health outcomes. An example of such an outcome is that of life expectancy, low life expectancy in the African continent is driven mainly by young deaths as a result of a poor healthcare system. Higher life expectancies in other countries, however, are driven by their stronger ability to implement better health policies than what is prevalent in Africa.

The aim of this research paper is twofold .Firstly, by analysing the socio-economic data of 125 countries from the World Health Organisation (WHO) latest e-health survey; this research will aim to understand the main constraints African countries encompass from achieving digital health by evaluating differing e-health determinants from the sphere of economics, health and mobile infrastructure. This will assist the reader to better understand the reason Africa lags the rest of the world in terms of its adoption of implementing e-health policies.

The second aim of this paper is to investigate the extent to which e-health policies measured by EHR (Electronic Health Record) prevalence and an e-health index variable), help to explain health outcomes (measured by life expectancy) in Africa. This will be achieved by modelling e-health policies and significant variables (if any) from the e-health determinants against health outcomes. This will assist the reader to better understand the reason Africa has inferior health outcomes as opposed to the rest of the world.

1.2 Rationale for this study

The recognition of health and the wellbeing of individuals as a key component of development and economic wellbeing has become an increasingly important facet of the modern era. Unfortunately, Africa holds the most severe poor health statistic around the globe, surprisingly a mere 1% of health care expenditure worldwide is spent in Africa. It is rare to find a region with more than a 1:1000 physician patient ratio, as stated by the WHO (The Medical Futurist,2018).

Sub-Saharan Africa has only 2% of the entire world's doctors and whilst it makes up 13% of the world's population, it bears a high 24% of the global disease burden. Reports by the World Health Organisation shows that 36 out of 46 of Sub-Saharan Africa countries are facing HRH (human resources for health) crisis. It is estimated that there is a current shortage of approximately 800 000 health workers. The only

solution to this problem is that human health resources need to be increased by 140% (Piabuo, Tieguhong, J.C, 2017). These concerning statistics are a result of the low investment in healthcare in the Sub-Saharan African region which is a low 1% (de Morais,2017). These ratios are a common occurrence in many parts of the continent (The Medical Futurist,2018).

An all-encompassing health care system would serve as a key mechanism in assisting the leaders in overcoming this problem. Developing a strong financial system is a common objective for all countries, but the economic deficit and rising health costs of developing African countries and economies makes it challenging to reach these objectives (Piabuo, Tieguhong, J.C, 2017).

Most African countries fall in the category of low-middle level income earners, thus causing a scarcity of funds in providing quality healthcare. As of 2010, in African countries US$135 per capita was spent on health whereas in high income countries US$3150 was spent per average this is where the disparity can be observed (Piabuo. Tieguhong, J.C, 2017). Overall, there is a shortage of basic health care professionals, adequate hospital beds and medical equipment (The Medical Futurist,2018).

Millions of African people die each year due to unsafe and low-quality healthcare, resulting in trillions of dollars loss each year. The significant financial cost spent on managing the loss of life could instead be directed towards improving the health facilities (WHO,2018). This could be negated by the implementation of digital healthcare technologies. It is forecasted that global growth is this field will increase by 30% in 2019 (XelphaHelath,2019).

Majority of Africans do not have access to modern health care facilities. Innovation in Africa will assist in combating everyday challenges and improve basic conditions for a large portion of the population. The wide and rapid spread of digital technologies allow for industrial revolutions without the large investments in traditional infrastructure (The Medical Futurist,2018).

The end goal is to ensure that these digital technologies actually provide an effective long term solution to provide rural areas with digital technologies for sustainable healthcare, hence placing focus on developing and aiding the community in providing thorough health care to all (de Morais,2017).

The internet and its services have paved the way to enable healthcare services to be provided to Africa and its citizens, notwithstanding the notion that well-trained health care workers are required. However due to insufficient training as well as a gap in continuous medical training this poses yet another concern in Sub-Saharan Africa (de Morais,2017).Ahead of describing where Africa currently stands in terms of their ability to implement such health care strategies, this paper will now give the reader a better understanding of what digital health care is by reviewing the current literature of e-health and Big Data on this subject matter.

1.3 Literature Review

The healthcare industry is an ever-evolving industry as it stands to be highly significant in the global sphere. Companies, health professionals as well as patients all place emphasis on demanding better health care facilities and treatment. This continuous strive for better solutions in modern healthcare, newer advancements and technologies are brought forward. This has given rise to "Big Data in the healthcare industry, along with industry analytics having made a mark on healthcare" (Starci,2018).

Currently billions of dollars are being spent in the process of capturing substantial amounts of data, as Big Data in healthcare may be essentially utilised for treatment innovation, personalised medicine, research and many other benefits (Adibuzzaman, DeLaurentis, Hill, Benneyworth, 2017).

There are three characteristics which distinguish Big Data from the traditional electronic medical and human health data which is used for decision-making; "1. it is available in massively high volume, 2. it moves at high velocity and spans the health industry's massive digital universe and thirdly derives from many sources, it is highly variable in structure and nature" (NEJM,2018).

Life expectancy has changed, and thus revolutionising treatment models has been driven by use of Big Data. By having access to these technologies, it will enable health professionals to diagnose illnesses and diseases at an early stage which would also aid in prevention thus saving costs.

It is well established that prevention is better than cure, thus creating an opportunity for data analytics to enable insurance companies to offer their clients with the most

suitable and tailormade insurance packages. This will facilitate all information pertaining to patients in a coherent and structured manner which is easily accessible when required, as opposed to archiving documents in a single often not that easily accessible site (Lebeid, M.2018).

It is an expensive and arduous task in gathering large amounts of data for medical use. This laborious task has been improved to collect relevant data which also aids in converting it into insightful acute information that can be used to provide better healthcare. “This is the purpose of healthcare data analytics: using data driven findings to predict and solve a problem before it is too late, but also assess methods and treatments faster, keep better track of inventory, involve patients more in their own health and empower them with the tools to do so.” (Lebeid, M.2018).

It has been observed that the use of Big Data is anticipated to grow more rapidly in the healthcare sector when compared to other sectors such as financial services, manufacturing or media as has been projected by an International Data Corporation (IDC) report. It is projected that by 2025 healthcare data will encounter a compound annual growth rate of 36% by 2025 (Lebeid, M.2018).

Market research has provided evidence to suggest that Big Data in the healthcare industry could be expected to reach up to “$34.27 billion by 2022. By 2024 it is estimated that on a global scale a total of over 68 billion dollars would be invested into the Big Data analytics segment (Lebeid, M.2018).During the course of this paper it will explore the role of Big Data in healthcare by presenting examples that are found to be real world applications.

One can only hope that medical experts make the crucial decision for patients regarding better health care service. Health professionals are often faced with the challenge of making diagnoses and treatment decisions in the absence of complete patient medical history. Digital health supports and helps overcome this challenge by providing medics with a predictive analysis tool. Predictive analysis allows for health professionals to make decisions based on future predictions and keeps them in check with the patients’ health status. Predictive analytic tools will be able to predict what risk a person is at and treat them accordingly. Algorithms and programming can be used to make decisions and predict the health of patients over a period. This will ensure improvements in patients’ safety and the quality of healthcare

(Researchnest,2018). The other most notable examples of real-world applications include alerts in real time, electronic health records and the employment of Big Data in possibly supporting the cure for cancer.

A promising application in Big Data is real-time data. This enables medical experts' access minute-to-minute insights which can be retrieved by combining streaming data with real-time data. Medical devices can be used to facilitate the channel to relay data to integrated patient administration systems. Wearable devices enable healthcare practitioners to monitor patients that are admitted into hospital and once they are discharged (Maike,2018). "Wearables will collect patients' health data continuously and send this data to the cloud. Additionally, this information will be accessed to the database on the state of health of the public, which will allow doctors to compare this data in a socioeconomic context and modify the delivery strategies accordingly. Institutions and care managers will use sophisticated tools to monitor this massive data stream and react every time the results will be disturbing" (Lebeid,2018).

It is of utmost importance to proactively care for patients and this can be done by monitoring and analysing a patient's vitals in real time and providing the best care plan. The combination of a patient's medical records together with the analyses of large data sets can assist in detecting the patients who may need focused attention in hospital or even added healthcare equipment or service at home (Maike,2018). "For example, if patient's blood pressure increases alarmingly, the system will send an alert in real time to the doctor who will then take action to reach the patient and administer measures to lower the pressure" (Ibigdata).

A single tumour comprises of billions of cells which results in a complex and strenuous disease better known as cancer. Previously this type of disease could only be cured by health professionals in a hospital setting. In recent trends the treatments which hold the highest success and recovery rates can be planned upfront using analytics (Researchnest,2018). "What researchers do have, is data, and lots of it. A single cancer patient can generate nearly one terabyte of biomedical data, consisting of routine diagnostic data as well as all the patient's clinical data. It is the equivalent to storing more than 300,000 photos or 130,000 books" (CanweLiveBetter,2018).

Genetic data has become a strategic instrument in fighting the battle against cancer. The volume of data available on patient and tumours has increased tremendously due to the huge drop in the price of DNA sequencing. Today DNA is compared to metastases and secondary tumours rather than only researching the genetic code from where the cancer cells originated. “it is estimated that research based around genome sequencing of patients generated one Exabyte of data annually – that’s a million terabytes (the equivalent of 130 billion books – a thousand times more than have ever been published)” (CanweLiveBetter,2018). An example of how a tumour can be examined is: “researchers can examine tumour samples in biobanks that are linked up with patient treatment records. Using this data, researchers can see things like how certain mutations and cancer proteins interact with different treatments and find trends that will lead to better patient outcomes” (Lebeid,2018). For oncologists the end goal is to be able to provide each patient with tailor made treatments to target specific cancerous cells while eliminating the acute side effects (CanweLiveBetter,2018).There are however challenges that can impede the implementation of these above mentioned solutions. This paper will now theoretically discuss a few of the challenges African countries may encounter in the implementation of digital health.

The first challenge is lack of co-ordination; activities that are carried out by e-health systems are not well coordinated. Similar issues are attended to by the various departments and bodies working on health issues consequently resulting in the duplication of indicators. It is often found that there is a major problem with coordination by parties who are investing in digital health technologies. A major problem lies in the fact that investors tend to invest or spend their capital on funding their own mobile applications, which has a high possibility of failing, rather than investing in solutions that are already in place and have already been proven successful. As reported by the 2015 e-health survey, 63% of countries that responded to the survey have developed e-health strategies. For implementation of various health digital systems to be successful there needs to exist commonality of goals and alignment from all stakeholders. Thus, indicating that all investors should prioritize investments on a few key projects rather than aiming to simultaneously engage multiple projects.

The second challenge faced by African countries is that of piloting. Many of the pilot Digital health projects that are set up do not reach scale as they are unsustainable and thus continue to remain as pilot projects. e.g. just over 80 of 183 health care projects in Kenya have been properly implemented and are working efficiently and sustainably.

Results have shown that due to the growing access of mobile technologies there will certainly be an increase globally for digital health systems by 2030. The slow implementation of EHRs remains a challenge even though there are about 69-73 countries out of 116 countries that have implemented e-health systems. According to studies there has been a 30% increase in data health projects in developing countries between 2005-2011 however most were fragmented, and majority remained pilot projects.

The third challenge faced is that there is an alarming rate of improper governance, legal and regulatory basics relating to health care. Whilst working within the complex healthcare sector it is a responsibility to ensure ethical decisions, privacy and confidentiality. The doctor-patient relationship including the open exchange of sensitive information should not be compromised by the implementation of e-health systems and core values between the parties must be maintained. A challenge that the healthcare sector is facing; is the regulations and legal aspects relating to the inappropriate access to patient data. The e-health systems that are put into place should ensure that every health practitioner working with an individual patient has full access to patients data which includes full medical history while at the same time a responsibility undertaken to ensure that confidential information is protected. “In an analysis of regulatory and governance aspects across 48 Sub-Saharan African countries covering 64 e-health items, a measly four countries scored high with respect to their “regulatory readiness”, six more were assessed as ready and the remaining 38 countries— achieving on average only 50 % of the scores compared to “ready” countries—were judged as not ready ”.

The next challenge is that of integrating into a national platform. It is an intricate challenge to access patients records at multiple different health facilities since each health system is being rolled out independently and thus failing to integrate the digital health infrastructure nationally. The setback with this is that quick decisions

cannot be made by health professionals in cases of emergency. Additionally, timely information or track records are not available to public health stakeholder causing issues across the entire health sector. Digital health applications do not meet requirements for data layouts and interoperability causing connection within the digital health ecosystem to fail even if they are well executed and complement each other. Interoperability will not be achieved by standardization alone.

A fifth challenge is that of sustainability. For digital health projects to be successful there must exist a long- term plan and funding. Implementation of digital health systems must have sustained benefits e.g.: improvement in service delivery or providing basic access to healthcare for the wider population. In order to achieve maximum benefit from the budget that has been allocated to the e-health systems that are put in place, they must complement the infrastructure of hospitals and healthcare facilities or the various project will result in failure. It would be most beneficial to prioritize digital health opportunities that are guaranteed to reap improvements in service delivery within the sector (organisations, processes and procedures).

The next challenge is that of human resources and absorption capacity. A factor that majorly affects the success or failure of investments in e-health solutions is the knowledge and expertise in ICT of human resources. The lack of expertise could cause demand to exceed the availability of skilled workers or technicians especially in the fields of IT support, software developers, health informatics, electronic engineers and service providers as previously experienced in Tanzania. It is critical that Africa absorbs and utilizes resources at the right place and time for regional and national developmental plans. The impediment to the effective and efficient implementation of projects and programs in Africa is the very limited absorptive capacity.

Additionally, infrastructure and connectivity are also issuing the need to consider in an African context. African countries being underdeveloped or developing countries are lagging in ICT infrastructure, this includes mobile phone connectivity with the biggest gap prevalent in the rural areas. These limitations are a major disadvantage to e-health technologies as these technologies need to be adapted to suit the limited availability of infrastructure in a country. The electricity crisis which afflicts Africa is a

greater concern, as alternative power sources such as solar power, wind power etc. are costly when used on a larger scale. Furthermore, the required funds to invest in such power sources are further marred by the fact that the knowledge and maintenance also remains inaccessible. A full digital transformation is hurdled by the lack of widespread access to high speed internet connection. It has been reported that, “Nearly 300 million Africans live more than 50 km from a fibre or cable broadband connection”. Lastly, the steep costs of internet services in Africa is largely problematic as majority of the population use mobile data as a primary source of internet access. This is a result of uncapped and unmetered internet access as unaffordable and inaccessible.

This paper has thus far provided a theoretical perspective of the challenges faced in Africa in the implementation of digital health care. To further elaborate on these challenges, this study will incorporate variables from three spheres of analysis. These variables namely; from a economic perspective (GNI per Capita) ,general health care(physician density and health expenditure) and ICT capability(internet and mobile phone subscriptions). The chosen variables each carry their own relevance as well as hold strong correlation between them, this will be further discussed.

Health investment is less of just a desirable but rather for most societies an essential priority. This paper thus found it appropriate to utilise GNI per capita to explain health investment from an economic development perspective.

Whilst it is well comprehended that GNI per capita does not entirely encapsulate a countries level of welfare or measures development, it is an easily available and useful gauge directly correlated with important non-monetary measures such as mortality rates of children, life expectancy at birth and general quality of life, consequently it was chosen for this study (Mundial, 2019).

Stronger healthcare and overall economic development are as vital as just one dimensional investments in healthcare. Therefore, when health finance policies are designed they need to be planned in a manner that encompasses an interaction between the economy and healthcare. This will result in better health conditions as fulfilling health requirements would not just hinge on standards of living “but rather on the actual performance of health systems themselves”.

It well documented as discussed above that health and economic performance are interlinked. Its a common observation that countries with more wealth have healthier populations. It also a basic truth that countries with more poverty have much lower life expectancies mainly through high levels of infant mortality (Frenk,2004). Countries health systems and their lack of development are affected largely through low national income. An example of this is the USA which has the highest per capita income and consequently had the highest density per 1000 of health workers. Adversely, sub Saharan African countries have the lowest per capita income hence the lowest number of density of health workers per 1000 (Stella ,Anyangwe and Mtonga ,2007).

Under ideal circumstances, countries which suffer the largest burden of disease should logically be having the highest number of skilled health professional. This however is unfortunately not the case. In the sub-Sahara African region it has been documented that this area “bears over 24% of the global disease burden, is home to only 3% of the global health workforce, and spends less than 1% of the world’s financial resources on health. The World Health Organization estimates that globally a total of 4¼ million health workers are needed to fill the gap” (Stella ,Anyangwe and Mtonga ,2007).

One way that governments are seeking to do this is through the usage of technology. There is huge potential in technology to grow capacity in the health care sector. The process of health planning needs to evolve by the use of ICT technologies in healthcare delivery and distribution and public health decision making at every level. This will ensure delivery of right health services to right people at the right place as well as on right time (EH news,2019).ICT has the capacity to influence all aspects of the health sector. For instance, in public health, management of information and communication processes are very crucial and are assisted or limited by the availability of information (Adeola,Evans.2018).

Patients become more engaged in their personal care through the help of ICT services. Chronic conditions such as diabetes, asthma and heart diseases are more manageable by patients themselves .For example those in rural areas, in some cases sacrifice a days work to meet their doctor and need not to for minor ailments. Primary health care costs can therefore be reduced through innovation in facilitating

telemedicine. “Telemedicine can also streamline processes and decrease administrative overheads, thereby leading to creation of new, high-tech markets and jobs. It is also being used for education, research and data management”(EH news,2019).

Adopting ICT in healthcare has numerous advantages which include accurate and improved access to EHR which improves diagnosis by gathering information that averts errors which saves valuable times for health professionals. Additionally ICT directly correlates with one of the two main dependent variables in this study , the EHR (EH news,2019).

It was thus appropriate that this study utilised variables from an economic perspective, a general health perspective and an ICT perspective as they are all strongly correlated. It is also from a logical point of view understood that digital health care implementation has the following drawbacks; firstly costs money, secondly necessitates implementation by health professionals and lastly requires technological infrastructure. The appropriation of choice for the studies main independent variables were provided with strong arguments for their strength from an individual and correlation perspective. Even though a vast amount of literature focuses on the political stability or rather instability as a factor of varying health care outcomes, this study felt it to be potentially misrepresentative. A justification for this stemmed from the notion that the independent variables (mentioned above) are all strictly objective measures as they are numerical values. Adding in a variable from a political perspective potentially could have been regressive in directing the measurements into a potential subjective level of measurement, hence its lack of inclusion in this study.

1.4 Research Contribution

Thus far a vast amount of literature relating to this subject matter has placed emphasis on what can be achieved rather than focusing on the process that needs to be followed. It is vital to understand the benefit of digital health in the African continent but is more pivotal to begin focusing on key factors that will bring forth this technological impact. Previously, research overlooked the importance of examining from a quantitative perspective, the constraint variables that are preventing Africa from utilising digital health. The constraints which Africa faces emerges from several

avenues and this research study will attempt to explore these various variables. The GNI per capita indicator views this economically, the total health expenditure and physician density views it from a health perspective and lastly the percentage of population using internet views it technologically. Therefore, this research will aim to culminate these factors and analyse variables that have not been analysed in previous works.

Additionally, the factors that limit the implementation of e-health policies in different health-care settings in this region have not been previously studied. This study will review both the challenges that may hinder the wider adoption of e-health polices and factors that facilitate the implementation to gauge the effect these have by quantitively assessing its effect on life expectancy. Identifying the challengers of adopting e-health polices and its effect in Africa is essential to inform health policy makers. This assists in both the public and private sectors considering overcoming the widening gap in adequate health care to Africans compared to the rest of the world.

1.5 Research Design

The first analysis this paper will undertake will be to identify which health determinants under three clusters of factors affect e-health policies both globally and in Africa specifically (measured by a country having an EHR system).These factors will include general economic development (to be measured by log GNI per capita),general health policy (to be measured by total health expenditure and physician density) and Information and IT and communication technologies connectivity (ICT) to be measured by cell phone coverage and internet usage.

The second analysis which this paper will discuss holds an almost identical trajectory to the first study. The difference being rather than comparing the health determinants across the three clusters against an against an EHR system, it will be compared against a variable termed e-health index (comprised of five themes namely :general e-health infrastructure ,e-health training capacity, maturity in legality surrounding e-health, the use of social media to promote heath and the use of Big Data in e-health in a country). Analysis one and two will attempt to achieve the first aim of the study listed on page 9 under “Aims”.

The third analysis this study will undertake will attempt to achieve the second aim of this study by comparing an actual health outcome of life expectancy against an EHR system, the e-health index variable, as well as any significant predictors, if any, from the first two analyses. These aims will be achieved by constructing this paper in the following way :

This study will be split into five chapters. The first chapter will comprise of the aim, rationale of the study, review on the current literature of subject matter for digitised healthcare, the research contribution and design of the study. Chapter Two will be further divided into three sections. The first section will provide a conceptual overview of all the variables utilised in this study. The second section will provide the empirical analysis of these variables and the last section of the chapter will provide descriptive illustrations and a comparison of Africa contrasted to the rest of the world on each of these variables. Chapter Three will present the main analysis of the study through running and comparing differing regression models. This will include the analysis of the health determinants against the e-health polices of a country utilising EHRs and an e-health index variable. Chapter Four will develop on Chapter 3 and will run regression models on the significant health determinants founded in Chapter Three .These will be analysed parallel to e-health policy variables against the health outcome of life expectancy. Chapter Five, the final chapter of this study will be split into three sections. The first section will discuss the summary of the findings of this paper followed by solutions to overcome the main constraints of the e-health determinants founded in the analysis of Chapter Three and Four. The final section will include a discussion surrounding the scope of future research based on the findings in this study.

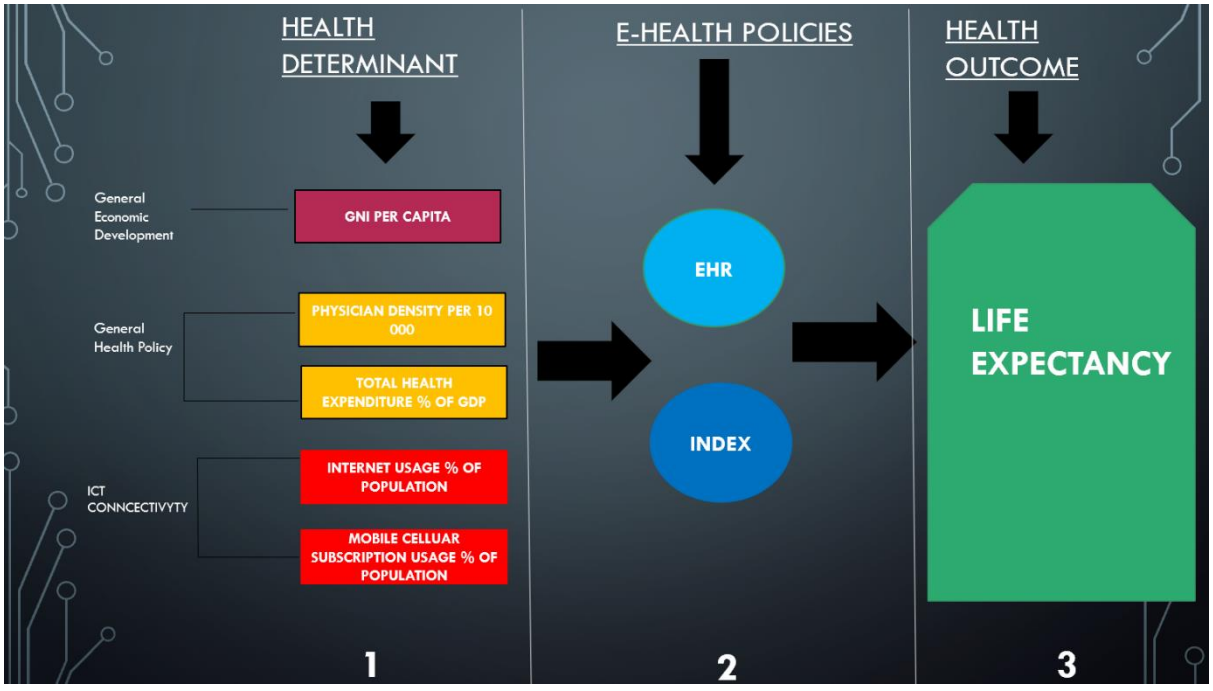
For the above-mentioned solutions to be achieved, an effective electronic health record system is contingent on certain basic systems to be functional. These will be discussed through certain e-health determinants which has been selected for this study. This paper will now further elaborate on these e-health determinants in Chapter Two.

Chapter 2: Descriptive Statistics

This chapter will be divided into three sections. In section one a causal diagram of the design this research will undertake will be provided. From that diagram the variables from a conceptual point of view will be discussed in part one of this chapter. The way these variables will be modelled, and the empirical meaning will be discussed in section two. In section three, descriptive illustrations will be presented to the reader to visualise where Africa as a continent compares with the rest of the world in terms of the variables discussed in section one and two.

Figure 1 - Causal Diagram

The causal diagram below provides a clearer explanation on the design of the study. Featured on the left-hand side of the diagram are the determinants of e-health, which this study deemed necessary to model against e-health policies.



The causal diagram above provides a clearer explanation on the design of the study. Featured on the left-hand side of the diagram are the determinants of e-health, which this study deemed necessary to model against e-health polices as a start. Prior to the discussion of the design of this diagram, information regarding all the variable's in this study will be provided as this will improve the readers understanding of these variables from a conceptual

point of view. This will begin by explaining the dependant variable in this study, life expectancy.

2.1 Theoretical Variable Explanations:

2.1.1 Health Outcomes

Life Expectancy

Life expectancy is a statistical measure of the average time an organism is expected to live, based on the year of its birth, its current age and other demographic factors such as gender (Shryock, Siegel Larmon,1973). Life expectancy across various income distributions is one of the leading causes of economic inequalities. Economic gradients clearly depict that income differences affect mortality rates. Expectedly, those with lower incomes are reported to have more physical health conditions such as stroke, diabetes, depression etc. as opposed to individuals with higher income levels (Shryock, Siegel Larmon, 1973). “In a nearly stepwise fashion, low-income Americans have higher rates of physical limitation and of heart disease, diabetes, stroke, and other chronic conditions, compared to higher-income Americans. Americans living in families that earn less than $35,000 a year are four times as likely to report being nervous and five times as likely to report being sad all or most of the time, compared to those living in families earning more than $100,000 a year” (Khullar and Chockshi, 2018). It is for this reason that this study has used general economic development (measured by GNI per capita) as a measure to provide empirical evidence on the above claims. Diseases and illnesses that are common to African countries such as HIV and AIDS, malaria, cholera, tuberculosis can be prevented and treated if more investments are made into the general and e-health sectors for appropriate medical care. Due to this knowledge, this study has used health indicators (measured by physician density and total health expenditure) to provide empirical evidence if these e-health determinants affect life expectancy. Additionally, the arrival of digital led health solutions, specifically (internet solutions and electronic health records) has simplified the process of providing better health care to Africans which should result in longevity of African lives. Hence the thought behind including ICT infrastructure capability (measured by mobile cellular subscriptions and internet usage) and usage of EHR system variables were utilised in this study. The use of EHR has been identified to be an integral part of an efficient health-care information system that promises positive health outcomes. This variable will now be discussed in broader detail.

2.1.2 E- health policies

Electronic Health Records (EHRs)

In recent years, there has been a growing interest in electronic health records (EHR) adoption in many countries. The International Organization for Standardization (ISO) defines an EHR as a “repository of patient data in digital form, stored and exchanged securely, and accessible by multiple authorized users. It contains retrospective, concurrent, and prospective information and its primary purpose is to support continuing, efficient, and quality integrated health care” (Suebnukarn,Rittipakorn, ThongyoBoonpitak, Wongsapai and Pakdeesan, 2013).

There are a myriad of studies conducted in differing health-care settings, these studies has indicated that EHRs aim to assist health professionals in “reducing medical errors, effective care coordination, improve safety and quality, and importantly reduce health-care expenditure.’’ Health-care systems, like other industries, are information-intensive organizations. Health-care professionals require comprehensive and current data of patient information to enable more accurate decisions to be made regarding patient care(Cline, and Luiz, 2013)

Several highly developed nations such as United Kingdom, Canada and the United States of America are either in the process of implementing or have implemented an EHR system due to its promised benefits. There is however a limited adoption of EHR in Sub-Saharan African countries, despite its glaring benefits (Williams and Boren, 2008). The study conducted by Akanbi on the use of EHR in Sub-Saharan Africa showed that EHR usage in Sub-Saharan Africa is largely driven by HIV treatment and most functionalities used in Africa on EHR systems are administrative rather than clinical (Akanbi, Ocheke, Agaba, Daniyam, Agaba, Okeke and Ukoli 2012). The factors that limit the implementation of EHR in different health-care settings in this region have not been widely studied. Therefore, for a further explanation this study will review the challenges that hinder its wider adoption in the region through health determinants from general economic development (to be measured by log GNI per capita), general health policy (to be measured by total health expenditure and physician density) and ICT connectivity (to be measured by cell phone coverage and internet usage). Identifying factors that affect EHR adoption in this part of the world is essential to answer the question as to the reason the adoption of EHR in this region is low, it is imperative to identify and understand the factors that limit broad adoption of EHR. Moreover, to accelerate wider implementation of EHR, there is a prerequisite to fully identify the EHR adoption facilitating factors. This study will now discuss the second e-health policy indicator in this study, the E-health index variable.

E-health index

This study will now begin to analyse the E-health Index variable which is comprised of data provided by the WHO. There are five themes which the data covers from the WHO which will be examined. This will be the; e-Health foundations, legal frameworks for e-Health, use of e-Learning in health sciences, social media and Big Data. Each of these groupings provide a landscape of an overview of the e-Health in each country for each theme. The five themes mentioned above will now be discussed. The first theme of Health foundations is based on an overall enabling environment. “This includes a selection of indicators on e-Health related policies or strategies, funding, multilingualism and capacity building” (World Health Organization, 2015). The first indicator represents data to identify if a country has a National universal health coverage policy or strategy. The second one specifically indicates if a country has a National e-Health policy or strategy. Additionally, both indicators comprise of a set of closed ended questions such as “yes”, “no” or “don’t know” response as well as an adoption date (World Health Organization, 2015).

The second indicator under theme one includes that of funding. The four differing funding options which are mentioned include public funding, private or commercial funding, donor funding and public private partnerships (World Health Organization, 2015).

The third indicator under this theme is that of multilingualism,” it reflects a government’s commitment to inclusion of linguistic minorities in the country with respect to e-Health activities”. This indicator additionally includes government- supported internet sites in multiple languages (World Health Organization, 2015).

The last indicator under the theme of health foundations is that of e-health capacity building. This indicator is highly significant as is demonstrates the readiness of health care professionals and students in the operationalising of e-health in a real clinical setting (World Health Organization, 2015).

The second theme covers the legal frameworks for e-Health. For the purpose of this research, the indicators to be used here include if certain legal components are present in a country such as; “protecting the privacy of personally identifiable data of individuals irrespective of paper/digital format, protects the privacy of individuals’ health-related data held in electronic format in an Electronic Health Record (EHR), governs the sharing of digital data between health professionals in other health services in the same country through the use of an EHR, governs the sharing of digital data between health professionals in health services in other countries through the use of an EHR, governs the sharing of personal and health data between research entities, allows individuals electronic

access to their own health-related data when held in an EHR, allows individuals to demand their own health-related data be to corrected when held in an EHR if it is known to be inaccurate, allows individuals to demand the deletion of health-related data from their EHR, allows individuals to specify which health-related data from their EHR can be shared with health professionals of their choice" (World Health Organization, 2015). This research will analyse this data by doing a comparison on the 125 countries to ascertain which areas need attention in terms of legality of patient data.

The third theme is that of e-Learning in health sciences. This includes indicators of pre-service education in terms of health science students well as in service training for health professionals already working in the field. The scope of this indicator goes through differing health services. These include medicine, dentistry, public health, nursing & midwifery, pharmacy and biomedical/life sciences (World Health Organization, 2015).

The fourth theme discusses the role of social media, the indicators here are divided into two segments. The first being health care organizations use of social media and the second segment deals with individuals and communities use of social media. Under the umbrella of health care organisations, this research will look at whether countries though these organisations and social media: promote health messages as a part of health promotion campaigns, help manage patient appointments, seek feedback on services, make general health announcements and make emergency announcements. Additionally, under the umbrella of individuals and community use of social media this research will look at whether countries though individuals and communities educate themselves regarding health matters, assist in decision making, provide feedback to health facilities or health professionals, run community-based health campaigns and participate in community-based health forums (World Health Organization, 2015).

The fifth and final theme is that of Big Data, this theme examines the strategies and policies which have been adopted by the health sector to govern the use of Big Data for both public and private health entities (World Health Organization, 2015).

The E-health Index variable has been established via a scoring system. As noted above the themes and the topics under each theme was answered by the countries by means of a closed ended yes/no questionnaire. In the event the answer was a yes it would produce a score of 1 and if no then 0. The scores under each theme and topic were then tallied in order to yield the index variable. Further empirical information on the use of this variable will be given in part two of this chapter. In order to have achieved a high score on the e-health index variable certain pre requisites would have been required. These could potentially have included having a strong financial system to invest in all these spheres, a strong healthcare

system in general to able have a strong e-health infrastructure and e-health training facilities as well as sufficient ICT infrastructure in order to implement e-health, social media and Big Data solutions. With this in mind the three clusters of factor : general economic development (to be measured by log GNI per capita), general health policy (to be measured by total health expenditure and physician density) and ICT connectivity (to be measured by cell phone coverage and internet usage were felt to be good empirical measures to assert the claim that these factors could be a reason behind having a strong or weak e-health index score. Part one of this chapter will now conclude by presenting a conceptual understanding of these clusters of factors beginning with general economic development which is measured by log GNI per capita.

2.1.3 Health determinants

GNI Per Capita

Gross National Income (GNI) is the amount of income that is earned, this includes the income from investments which is circulated into the country. The first step towards gaining an understanding of a country is by identifying the country's GNI per capita, its strengths as well as the needs and the overall standard of living of the population (The balance). The GNI per capita of a country is connected to indicators that measure the well-being of a country, this includes social, economic and environmental factors. In relation to measuring the global GNI per capita, poverty has been declining the fastest and wealth has been distributed unevenly around the world. Five percent of the global population live in North America leading to 27% of the gross domestic product worldwide (Comen,2018).

In the interim, 24% of the global population live in South Asia leading to 4% of Gross Domestic Product globally. Worldwide, severe poverty has declined rapidly. According to the World Bank, extremely poor people live off $1.90 per day and sometimes less, this is a strong indicator of GNI per capita. The GNI per capita has decreased in the year 1990 from 1.9 billion to 736 million in the year 2015 (Comen, 2018).

Calculations indicate that by the year 2030, almost 9 in 10 severely poor people will live in Sub-Saharan Africa. Currently around 413 million people in Africa experience severe poverty, this accounts for more than half of the world's population (Comen, 2018). As a result of these statistics, this research thought it necessary to add in GNI per capita as a variable because this may be an appropriate explanation for the reason health policies in Africa cannot be implemented, affecting life expectancy. The following indicator which will be discussed in this research will come from the general health policy sphere and total health expenditure.

Total Health Expenditure

Health is progressively being acknowledged as a fundamental aspect of economic and human development in the African continent and countries are expanding their investments in actions and reforms for an improvement in health outcome and accelerated progress (WHO, Africa).

The will of the political national leaders to place health at the forefront of development has at a continental level been reiterated through events such as the "Abuja Declaration of 2001 on increasing government funding for health, the Addis Ababa Declaration of 2006 on community health in the African Region and the 2008 Ouagadougou Declaration on primary health care and health systems in Africa" (WHO, Africa).

One of the key areas that offer valuable opportunities to translate commitments of the politics to results is that of health financing. A common objective for all countries should be to develop strong health financing systems. An ever-increasing cost, healthcare expenditures are found as being difficult to fund even by the wealthiest countries in the world. In terms of African countries, majority of them are ranked as low and middle income countries, hence scarcity of funds being an all more acute problem (Musango, Elovainio, Nabyonga, Toure, B, 2013) "The average total health expenditure in African countries stood at US$ 135 per capita in 2010, which is only a small fraction of the US$ 3150 spent on health in an average high-income country "(WHO database). In order to tackle both the social as well as environmental determinants of health, insufficient investing in the African health sector is an obstacle that needs to be overcome. This is of utmost significant and relevance especially considering the African continent bears the mass of the global mortality and morbidity burden for both adult and infant mortality as well as HIV/Aids mortality (Musango, Elovainio, Nabyonga, Toure, B, 2013).

Additionally, the increase of non-communicable injuries and diseases has put a double burden of pressure on countries. One of the biggest constraints that arise from fund shortage in Africa is that the mechanisms and strategies underline the health financing system present challenges. Out of pocket expenditure from households account for over 40 percent of total health expenditure in more than half of African countries, this is believed as being perhaps the most regressive means of financing health care (Borghi, Ensor, Somanathan, Lissner, Mills, 2006).

Large financial barriers are created as over reliance on this mechanism of payment causes a risk to people's access of health services which in turn creates a possibility of their impoverishment. "In 22 of the 45 countries the level of funding for health is below the

minimum level of US$ 44 per capita recommended for 2009 by the High Level Task Force on Innovative International Financing for Health Systems" (Musango, Elovainio, Nabyonga, Toure, B, 2013).

The goals set out at the Abuja Declaration targeted an allocation of 15 % government expenditure to healthcare which most Member States of the African Region of the World Health Organization are far from achieving. It has been documented that only three countries have attained these targets. Taking into consideration that the core of a health systems building blocks are interlinked and interdependent, implementing and developing financial strategies for healthcare need to run in parallel with strengthening efforts in other "health system dimensions in order for a country to move towards universal health coverage" (Musango, Elovainio, Nabyonga, Toure, B, 2013). With the lack of funds for health expenditure noted above it would seem highly unlikely that physician density would likely also be a cause of concern. This study will now provide a detailed discussion on the theoretical aspect of physician density.

Physician density

Disparities in many countries regarding the health care distribution capacities are a significant concern for policies in health cares for a couple of reasons. Firstly, by comparing health care services to that of categorical goods imply that all citizens should have an agreed minimum standard regarding health care. Secondly inefficiencies and disparities in health care capacities could be caused by a maldistribution (Gaynor, Haas-Wilson,1999). Disparities apply to all health faculties and none more than that of a concern over outpatient care by a lack of physicians (Gächter, Schwazer, Theurl and Winner, 2012).

Sub-Saharan African countries brain drain of health professionals has exacerbated the damage in an already ailing health system. The consequences of this brain drain are now being aired by the media which add to service delivery challenges in the health sector. For a better understating of the reasoning behind the brain drain a former Nigerian doctor by birth, now applying his trade in the US, was quoted as saying," "I see up to 20 patients a day. I left Nigeria because I wanted to earn more money, learn new things and to practise in a better environment" (Ighobor, 2017). On average, surgeons in New Jersey earn $216,000 annually, while their counterparts in Kenya make $6,000 per annum and Zambia $24,000 (Ighobor, 2017).

Osahon Enabulele, formally the president of the Nigerian Medical Association has estimated that in the United States there are over 8000 Nigerian doctors. In Nigeria however this number is as low as only 35 000 doctors to attend to a population of 173 million citizens.

According to the WHO, the doctor to patient ratio in Nigeria is a lowly 0,3 per one thousand which is grossly inadequate (Ighobor,2017).

According to 2015 WHO data, " the doctor-to-population ratio in Liberia and Sierra Leone (two countries recently hit by the Ebola epidemic) is severer as the ratio is 51 doctors for Liberia's population of 4.5 million (0.1 per 1,000 people) and 136 doctors for Sierra Leone's 6 million people (0.2 per 1,000). Ethiopia has 0.2 doctors per 1,000 and Uganda has 0.12 doctors per 1,000 inhabitants, while South Africa and Egypt, at 4.3 and 2.8 per 1,000 respectively, producing better ratios" (McPake,Dayal, and Herbst, 2019).

The greatest challenge faced by countries is that they bear major financial loss in investing in the training of health care workers who emigrate. Statistics have shown that African countries have lost up to 2,1 billon dollars in health care professionals departing to destination countries until 2010. For an African country it costs them between $21000 and $58 000 to train each doctor, this loss equates to the destinations countries gain, it has been estimated that these gains cumulate to the region of to "$2.7 billion to the UK, $846 million to the United States, $621 million to Australia and $384 million to Canada". From the above stats it would mean that the likelihood of an e-health policy implementation would be low due to the increasing amount of brain drain and loss of training investments. This study will now under the ICT scope, discuss mobile cellular subscriptions and internet usage (Ighobor, 2017).

Mobile Cellular Subscriptions

Digital revolution has influenced almost every aspect in everyone's lives, including health. According to research in the health market, revenue is expected to exceed half a trillion dollars by the year 2025 (digital journal). In low and middle-income countries, it has been seen through applications that text messaging via cell phones had good results. Due to smartphone technology, the scope for m-Health has increased vividly (Mills and Lester,2019). The applications are designed for the public as well as health care benefactors, allowing patients to have more control over their health. Even though the number of applications downloaded on smartphones has declined, the usage of health applications has improved. The millennials, whose usage of smartphone technology is the highest are also the largest users of health applications. However, as the number of m-Health applications increase (3 billion downloads), challenges related to bringing it into practice also increases (Skardziute, 2018) .The challenges include moving initial studies of m-Health studies to diffusion as well as use, the determination and need for evidence of extensive adoption, determining which framework will be best suited to conduct the research in relation to the everchanging technology (Tomlinson, Rotheram-Borus, Swartz and Tsai,

2013). In Africa, lower prices on smartphones is leading to a digital revolution, this allows people to use the internet as they desire. Mobile networks also allow for the transformation in education, water management, health, energy and agriculture. In the last two years, smartphone connections have doubled throughout the continent leading to 226 million subscribers (Dahir, 2016). As reported by GSMA in relation to Africa's mobile economy, selling prices have dropped from $230 in 2012 to $160 in 2015. More than 60% of people in Sub-Saharan Africa can access a cellular phone, but if those phones have no access to the internet it will not be beneficial. Secondly, internet usage will be discussed under the ICT banner (Dahir, 2016).

Internet usage

The ability to access the internet via the World Wide Web is to be able to connect to the internet via devices such as computers as well as other devices, and to be able to send emails. An individual can use the internet through service providers (ISPs), these service providers allow for connectivity as well as the transferring of data through various networks. Municipal entities as well as other organisations provide wireless internet at no cost (Hunt, 2003).

At one point there was a limitation of access to the internet, however this has largely evolved. In the United States, 0.04 percent of the world's population was able to access the internet in the year 1995. In the developed countries many people used faster broadband technology in the first decade of the 21st century, by the year 2014, 41 percent of people around the world were able to access the internet with speed connections of one megabit per second (Hunt, 2003).

According to reports, in the year 2000, Africa had a smaller amount of internet access when compared to the country Luxembourg (Fukui, James and Kelly, 2019). Currently, Africa continues to grapple with poor internet connectivity. It is pivitol to close the gap between countries that can access the internet and those countries that are unable to. In order to close this gap by the year 2030, 100 billion dollars is needed, however this proves to be a major challenge as one third of Sub-Saharan Africa has no access to the broadband signals. In Africa, mobile growth is increasing as other markets begin to grow. Smartphones with 3G and 4G connections is common in Africa, however some users are limited to 3G. The lower income earners in Africa are not able to access 4G connections due to financial restrictions. In Africa, a mobile phone is most likely to be the only device that an individual owns, leading to mobile networks having a heavier load to carry when compared to developed countries (Kahla, 2019). The speed of uploads become more important as mobile users create content on large scales which travels back-and-forth between the networks. Uploading speeds in

Africa is poor, even in South Africa. In Ethiopia, Libya and Burkina Faso the upload speed is less than one megabit per second, leading to an unpleasant experience. It is a major challenge for people to share content across the continent and this is something that network operators must address, especially because there is a boom in mobile users in Africa. In relation to e-health implementation abilities, it will hold no value if users are not able to access the internet efficiently (Kahla, 2019). The design of the empirical measures of how these e-health determinants and e-health polices link to the health outcome of life expectancy will be discussed in part two of this chapter under the methodology section.

2.3 Methodology

This research paper will use indicators in three clusters of factors which affect e-health policies both globally and in Africa specifically (measured by a country having an EHR system and the E-health Index variable).These factors will include general economic development (to be measured by log GNI per capita), general health policy (to be measured by total health expenditure and physician density) and ICT connectivity (to be measured by cell phone coverage and internet usage). This paper will now individually discuss the empirical method used to gain a better understanding of their application in this study, commencing with the GNI per capita indicator.

The GNI per capita indicator is the “gross national income, converted to U.S. dollars using the World Bank Atlas method, divided by the midyear population. GNI is the sum of value added by all resident producers plus any product taxes (less subsidies) not included in the valuation of output plus net receipts of primary income” (HDI).The value of this variable was logged as the concave logarithmic transformation this makes clearer the notion that an increase of GNI per capita by $100 in a country where the average income is only $500 has a much greater impact on the standard of living than the same $100 increase in a country where the average income is $5,000 or $50,000” for a more equal and accurate scale (HDI).

The physician density indicator includes all generalist and specialist medical practitioners. For the purpose of this study the GNI per capita will be calculated through the log function as it is better understood in terms of proportion rather than a percentage figure (World bank).

The total health expenditure (% GDP) estimates current health expenditures which includes healthcare goods and services consumed during each year. “This indicator does not include capital health expenditures such as buildings, machinery, IT and stocks of vaccines for emergency or outbreaks” (World bank).

The mobile-cellular subscriptions (% population) are subscriptions to a public mobile telephone service that provide access to the PSTN using cellular technology. The indicator includes (and is split into) “the number of post-paid subscriptions, and the number of active prepaid accounts (i.e. that have been used during the last three months). The indicator applies to all mobile cellular subscriptions that offer voice communications” (World bank).

Internet users (% population) are those individuals who have used the Internet (from any location) in the last 3 months (World bank). These will be modelled against the presence of an active electronic health system (EHR).

The selection of the EHR system is because it is viewed to be the most important component in implementing digital health care and achieving a 100 response on the above cluster of factors. The reason behind this is that through EHR, health care professionals utilise data from patient records for improvement in quality outcomes. Health care professionals then combine multiple types of patient data from EHRs health records to help stratify and identify chronically ill patients (Top Mobile Trends, 2014). This results in an overall improvement in quality care by providing a basis for both treating sick patients in a quicker time as well as preventing hospitalizations in its entirety for ill patients. This measure was taken from the WHO study which asked the question “Does the country have an active EHR system”. In order to code this into the model an answer of yes was calculated as “TRUE” and no “FALSE”. This logical argument was then tuned into TRUE being rated as 1 and 0 as FALSE in order to empirically model it. The model type utilised will be that of a generalised linear model (glm) the reason for this is the response variable of EHR is a logical response. The model will take EHR as the dependant variable with the five health determinants mentioned above as independent variables .This model will seek to identify which if any, of those determinants are significant predictors to a country having an EHR system or not.

The second model will again mimic the first study with the only difference being the dependant variable being the E-health Index variable as opposed to EHRs variable. As mentioned above the E-health Index variable was calculated by tallying the scores under each theme. The way the data is reported includes a closed ended questionnaire response. The responses being a “yes” or “no” to each indicator question it represents. For example, under the first theme of e-health foundations and the indicator answers if a country has a National e-health policy or strategy, for e.g. Ethiopia has a YES response meaning their government would boast one. This will result in 1 being added to the score of Ethiopia. The scoring system goes across each theme and under each heading of the theme. As a result of certain themes having less headings under them for example Big Data having three and

legality having six, a factorisation system was employed and calculated with a Highest common factor. In this example, if Ethiopia had a score of 4 (4 yes responses) under the legality theme but 3 (3 yes responses) under the Big Data theme the score of 3 would be multiplied by 2 as Big Data merely had three headings as opposed to six under legality, in order to gather scores under a level playing field for each theme heading. The model utilised in this case would again be a generalised linear model as stated above as a result of the response variable of EHR being a binary response.

There are two reasons behind mimicking study one with only changing the dependant variable to the E-Health index variable. Firstly, the themes covered under the banner of the E-health Index variable differ from those of the e-health determinants in the first model significantly. This provides a wider spectrum of analyses, as the first model focused on economic status, general health measures and ICT development. Conversely, the E-health Index model covers differing themes such as social media, legality, the role of Big Data and the overall infrastructure of e-health capacities. Secondly as a result of the difference and the wider spectrum , a comparison between the two models would be useful in order to ascertain more thoroughly which determinants ultimately have the biggest impact on the health outcome of life expectancy.

The last model this study will run would be to evaluate models based on a total health outcome and this study opted for life expectancy. Life expectancy will be modelled as the response variable against predictors from the e-health policies variables EHR and the E-health Index variable. In order to gain a more accurate outcome, variables from the initial e-health determinants model found to be significant (if any) will be controlled in the model to fully grasp the effect e-health policies of EHR and the E-health Index variables have on health outcomes. This model will be done through a simple linear regression as all the variables are numeric. In order to visualise a continent comparison in the differences in the figures under the e-health determinants, EHR and the index and its themes -part three of this chapter will conduct descriptive illustrations, hence prior to the modelling process comparisons will be made under each of these wherein Africa is compared to the rest of the world.

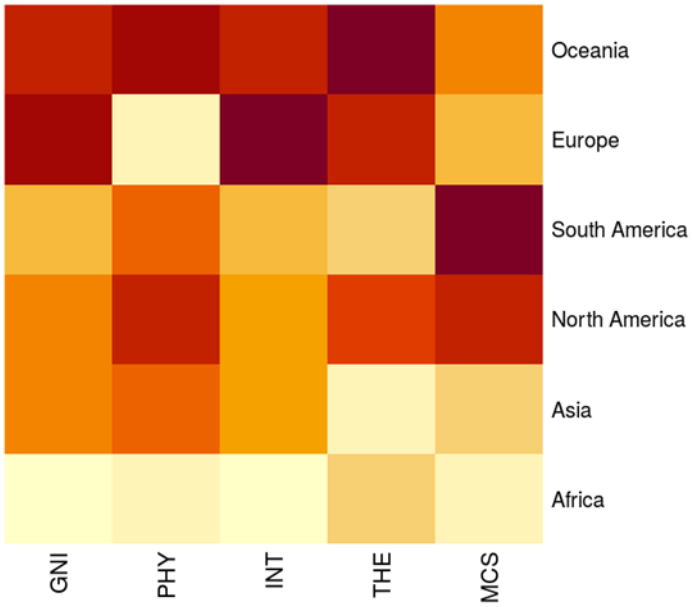
2.4 Illustrations of health determinants and policies

Part three of this chapter will focus on descriptive illustrations to give the reader insight into where Africa compares to the rest of the world under all the variables listed above. These will include the variables of the e-health determinants, overall EHR capability and a detailed account of the index variables which will cover all the themes under it. To begin, a heatmap

of the e-health determinants will be presented. Furthermore, a dot plot and balloon plot with multiple legends combined will be utilised to compare the differing themes under the E-health Index variable.

Figure 2 – Heatmap

The heatmap below has been generated with the e-health determinants total value of each variable by continent.



Key

GNI- log GNI per capita

PHY- Physician Density

Int- Internet usage

THE- Total Health Expenditure

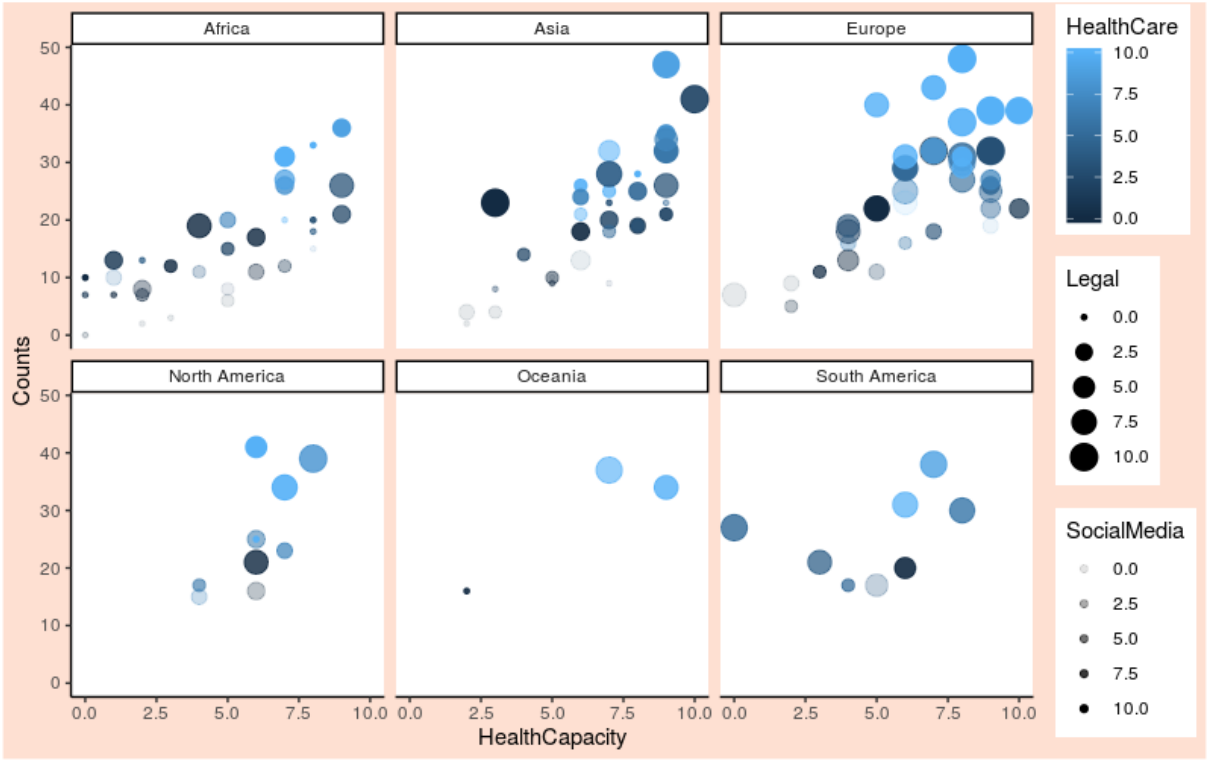
MCS- Mobile Cellular Subscriptions

A heatmap is organised according to the categories having the strongest values listed first. To further emphasise the difference between variables the colour of tiles that are darkest signal high data points, therefore the lighter the tile the lower the values associated. Using this differential method, the African values are positioned at the bottom of the heatmap and

all their tile indicators are extremely yellow (light) in colour and stand in stark contrast to the other continents. Africa's tiles under all health determinants are lacking behind all continents .Oceania and Europe (countries from the global north and developed) unsurprisingly have high values on all these clusters of factors. A worrying aspect is that Asia which has many poor countries still scored higher on every aspect as compared to Africa .The above heatmap provides insight that improvements are needed in general economic development, health care and ICT infrastructure in Africa The next plot which will be illustrated is the dot plot of the E-health Index variable measures.

Figure 3-Comparative dot plot

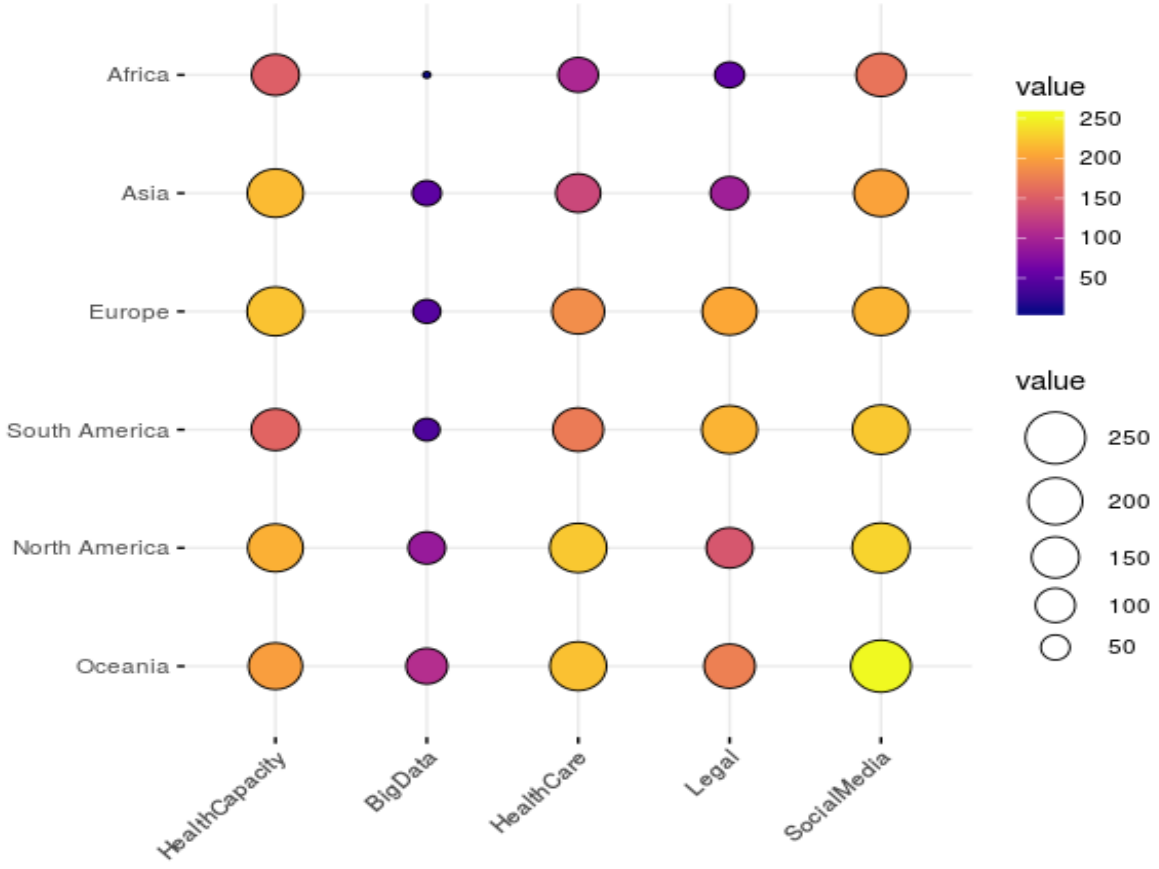
The comparative dot plot below is an illustration of a continents E-health Index variable score under 4 of its themes namely: e-health capacity (x axis), health care training (intensity of blue), legal maturity (size of circle) and social media prevalence (level of transparency) in order to simultaneously identify where Africa stands on these indicators comparatively to the rest of the world.



By examination of the plot above, it is easily conceivable that Africa lags far behind the rest of the world especially behind developed continents such as Oceania, Europe and North America. The graph has been plotted by the overall Health Capacity as the main variable on the x axis. It is imperative to identify which of the levels are low and need to be heeded. It is noted that Africa in comparison has most dots placed on the left-hand side of the plot, indicating that their overall ability of Health capacity is much lower than the rest. The health care infrastructure has been indicated by the colour of the blue dots where a light circle, indicates a higher score and a darker circle indicating a lower score. Africa as oppose to the other continents has a vast number of darker circles indicating it is very much behind in this category as well. The legal maturity is indicated by the size of the dot. Comparing Africa to the other continents it is observed that their circle is relatively small as compared to Europe, Oceania and North America. The final indicator presented in this plot is that of social media prevalence in health care systems and this has been indicted by a legend function where higher values have solid circles and weaker values show more transparently on the plot. In this indicator, once more Africa presents its values mostly as transparent, comparative to the other continents, indicating a low prevalence of this indicator. To further establish and emphasis these indicators, a balloon plot has been generated to investigate more specifically which indictors are of greater concern, by reviewing their total scoring.

Figure 4- Balloon Plot

The balloon plot dot plot below is an illustration of a continents E-health variable Index score under all its themes namely: e-health capacity, health care training, legal maturity, social media and Big Data prevalence in order to identify in which specific categories Africa is lagging, the above balloon plot has been illustrated to present additional details from the comparative dot plot in Figure 3.



The balloon plot is more readable when analysing individual counts rather than the above dot plot which looked at the counts collectively. The balloon plot is understood by observing both the colour and the size of the balloon. Colours which are smaller, darker and more purple in colour depict lower values. The colours which are closer to yellow and larger in size depict higher values.

Overall, Africa's health capacity shows the darkest and smallest dot, but this scoring is not far off from South America which yielded around a 100-value point score. The remainder of the continents have shown to have overall values closer to 200 which indicates a 100 percent value difference in their overall health capacity proficiencies.

From the perspective of Big Data, it has been realised that most continents have relatively small values indicating that a high maturity level regarding Big Data usage in healthcare is yet to be established. Oceania has the largest dot, however its scores about a 100 which indicates a lower capability. Again, Africa's dot is almost non-observable and considerably smaller than the others, as they do not present any high values on the plots.

In terms of health care ability of medical professionals, it is found that the higher developed nations in Northern America and Oceania produce a score closer to maximum indicating that they are greatly equipped to have better standard health personal and their likelihood of future professionals being well trained in e-health is high. Europe and South America are plotted on the halfway mark overall in this aspect, though Asia and Africa are found to be severely deficient. The African score seems to be in the 50 to 60 range which leaves Africa to be outlying behind most continents.

In terms of legal maturity pertaining to healthcare matters, surprisingly among the world leaders in this regard is South America, ahead of Northern America and Oceania. The scores between these continents are relatively high between 200 and 250. Asia is much further behind with an estimated total score of about 100, Africa is however especially poor in comparison to continents with a total score of roughly 50 points. This aspect is especially worrying as a rather large cause of Big Data and innovative health plans are delayed by red tape surrounding lack of legal insight.

In terms of social media health awareness, campaigns and information, most of the continents have scored close to a maximum value. Africa too, scored its highest amongst its own scoring on the social media indicator, however this remains fairly behind the other continents. The above balloon plot has illustrated conclusively which areas Africa is required to improve on regarding infrastructure, knowledge and mobile competence.

This chapter has provided the reader with a better understanding of the design this paper will undergo through the causal diagram in part one. All the variables that will be utilised and their importance were also discussed in part one of this chapter. Part two of this chapter gave the reader a better understanding of the empirical meanings of the variables as well as how they would be modelled. Additionally, this chapter concluded by providing the reader with a viewpoint of where Africa compares to the rest of the world in terms of all the variables

utilised in the study before the modelling process. This study will now proceed into that modelling process in Chapter Three.

Chapter 3: E-Health Policy Models

Chapter Three of this study will be divided into different sections. The first analysis this chapter will undertake will be found in Model A ,B and C in Table 1, this will be to identify which health determinants under three clusters of factors affect e-health policies (measured by a country having an EHR system) both globally and in Africa specifically. These factors will include general economic development (to be measured by log GNI per capita),general health policy (to be measured by total health expenditure and physician density) and ICT connectivity (to be measured by cell phone coverage and internet usage). Section two of this chapter will be analysed using the same approach by means of applying Models D, E and F. The difference between the two sets of models is that the independent variable in Table 2 will be the e-Health index variable.

3.1 EHR Model

Table 1

Table 1 consists of the summary output of a generalised linear model (GLM) which modelled the dependant variable of e-health policies (measured by a country having an EHR system) against the independent e-health determinants (to be measured by log GNI per capita, total health expenditure, physician density, mobile cellular subscriptions and internet usage) and an African dummy variable (measured by the status of a country being African or not).

	Dependent variable:		
	EHR		
	(A)	**(B)**	**(C)**
logGNI	1.330**	0.794	0.630
	(0.550)	(0.598)	(0.500)
PHYDEN	0.003	0.003	
	(0.005)	(0.005)	

THE	-0.064	-0.074	
	(0.078)	(0.079)	
MCS	-0.004	-0.005	
	(0.005)	(0.005)	
Intusage	0.004	0.003	
	(0.006)	(0.005)	
Africa		-1.352**	-1.327**
		(0.595)	(0.584)
Constant	-0.961	0.130	-0.539
	(0.697)	(0.850)	(0.640)
Observations	123	123	123
Log Likelihood	-78.505	-75.705	-76.671
Akaike Inf. Crit.	169.011	165.410	159.341

Note: *p<0.1; **p<0.05; ***p<0.01

Essentially the question that needs to be investigated here is; what are the health determinants(log GNI per capita, physician density, total health expenditure, mobile cellular subscriptions and internet usages) actual contribution to a countries proficiency in having EHRs and does the level of proficiency vary between African countries and other countries around the globe?

Table 1 presents a set of three regressions which provides the answers to these questions, by comparing the dependant variable of EHR against the health determinates and then adding an African dummy variable to observe if being an African country impacts the results.

The first element of output to be discussed from the table above is the Akaike Information Criterion (AIC) .The AIC is analysed above residuals as residuals in a logistic model are not very useful as they do not emanate from principals of least squares minimalizations as they are fitted with max likelihood estimation (Hamrick,2012). Therefore, in order to determine the goodness of fit of the model the Akaike information criterion (AIC) will now be discussed.

The AIC is determined in a logistic regression in a similar way as multiple regression. The difference being the logorrheic of sigma hat squared is replaced by -2 times the value of the log likelihood function valued over all the data. AIC is used to make like

for like comparisons in a dataset and is a good indicator of the goodness of fit of a model, a lower AIC indicates a better model (Hamrick,2012). From the table above it can be observed that Model A had an AIC of 169,01. When adding the African dummy variable in Model B the AIC lowered to 165.41 indicating that the model has a better fit with the African dummy variable. When analysing the AIC in Model C the value has decreased even further to 159.34. This indicates that by having only the significant predictors of log GNI per capita and the African dummy the Model C fits the data best. To understand which determinants are statistically significant or not the study will now discuss further element outputs from Table 1.

In Table 1, by summarising the elements of output of the GLM model A ,the second bit of information of the output that will be analysed is that of the coefficients. The coefficients suggest a positive relationship between whether a country has an EHR or not with the log Gross National Income(logGNI), Physician Density per 10 000 people (PHYDEN) and Internet Usage (Intusage). Contrastingly, the variables of Total Health Expenditure (THE) of a countries GDP and mobile-cellular subscriptions percent of population (MCS) have a negative relationship with EHR. Therefore, to test statistical significance of these variables the p value is utilised.

The p value holds much significance and a very tiny p value would result in a rejecting of the null hypothesis thus confirming that variable to be of statistical significance. From this summary output it is noticeable that only the log GNI per capita variable seems to be statistically significant in Model A. Overall this implies that a country with stronger economic power results in having the ability to promote electronic health records. Understandably, a key factor in this is that healthcare organizations resist in their EHR adoption due to the financial burden incurred, though in the long run it may lead to greater revenue, the initial costs may be burdensome to economies that are already stretched. A Health Affairs study “estimates that the typical multi-physician practice will spend roughly $162,000 to implement an EHR, with $85,000 going toward first-year maintenance costs” (Keller,2018). This provides evidence that an electronic health record system is costly, hence economic status may determine if the system may or may not be adopted.

In Model B the study ran the same regression as that in Model A, however it has incorporated an African dummy variable. This variable was created in order to verify and quantity if there were any differences in the presence of an EHR system in African countries compared to the rest of the world. After running this output, the p values of the determinants were consistent with those in Model A.

This suggests that the variables under the general health policy (measured by total health expenditure and physician density in this study) were not founded to be significant for a country having an EHR system or not irrespective if it were an African country or not. This could be as a result of a general lack of maturity within the scopes of physicians utilising EHR services. It has been argued that a cause of weakness is due to the lack of readiness of organizations to undergo the transformation process during EHR implementation (Ajami S, Ketabi S, Saghaeian-Nejad S, Heidari A,2011). According to researcher Meinert, “the slow rate of adoption suggests that resistance among physicians must be strong because physicians are the main frontline user-group of EHRs “(Meinert,2004). Additionally, this study consistently found statistically insignificant coefficients for cellular telephone subscriptions and internet usage under the e-heath policy of having an EHR system. This could be since ninety percent of healthcare professionals are confused about what makes a highly interoperable EHR. A research done by Black Book, had surveyed 11,838 doctors, clinical leaders, technology managers and healthcare administrators globally. Their survey discovered that “72 percent of health professionals stated that their preferred strategy for EHRs is to link disparate systems through messaging, APIs, web services and clinical portals but only seven percent of all international EHR survey respondents described their regional IT system as having meaningful connectivity with other providers” .This provides further evidence as to the reason that connectivity is not a significant predictor of the prevalence of an EHR system (Moingain,2018).

The core difference in Model B is that the African dummy variable shows a negative relationship which suggests that being an African country negatively impacts a country from having an EHR system. To further emphasize this, the p value is 0.023 suggesting that it is statistically significant. Interestingly the same variables that were insignificant in Model A were also insignificant in Model B. The exception to this however was the log GNI per capita variable which lost its significance after

incorporating the African dummy variable. This provided evidence that in other parts of the world, general economic development is a factor in contributing to a country having an EHR system or not, however shows lesser of a factor in Africa with other competing determinants.

For Model C this study generated a model by using only the statistically significant predictors from Model A and B which was the log GNI per capita and African dummy variable. The reason behind this was to test that if the African predictor would still be significant even after controlling just for log GNI per capita without the noise of the other competing variables. The results once again provided evidence that the log GNI per capita became insignificant once the African dummy variable was added to the model. Furthermore, the African dummy variable showed a strong negative relationship to EHR and the p value that emanated from the model was that of 0.022 which was slightly smaller than that in Model B. This informs the study that even with log GNI being a significant predictor of a country not having an EHR system globally, African countries continue to be constrained in their ability of having an EHR system as this is not limited to their general economic drawbacks. This suggests the strength of the African variable and that the systematic differences in the outcomes of African and non-African countries, holding the other predictors in the model are constant.

3.2 E-Health Index Model

In this section, the key question that will be answered is which health determinants under three clusters of factors affect e-health policies (measured by the e-health index score) both globally and specifically in Africa. These factors will include general economic development (to be measured by log GNI per capita), general health policy (to be measured by total health expenditure and physician density) and ICT connectivity (to be measured by cell phone coverage and internet usage). Table 2 presents a set of three regressions which provides the answers to these questions, by comparing the dependant variable of the e-health index score against the health determinates and then adding an African dummy variable to observe if being an African country impacts a country's e-health index score.

Table 2

Table 2 consists of the summary output of a simple linear model which modelled the dependant variable of e-health policies (measured by a countries total e-health index score) against the independent e-health determinants (to be measured by log GNI per capita, total health expenditure , physician density, mobile cellular subscriptions and internet usage) and an African dummy variable (measured by the status of a country being African or not).

	Dependent variable: E-health index		
	Counts		
	(D)	**(E)**	**(F)**
logGNI	5.741**	3.491	4.768**
	(2.296)	(2.563)	(2.269)
PHYDEN	-0.004	-0.007	
	(0.020)	(0.020)	
THE	0.801**	0.768**	0.768**
	(0.352)	(0.349)	(0.345)
MCS	0.025	0.022	
	(0.024)	(0.024)	
Intusage	0.014	0.011	
	(0.019)	(0.019)	
Africa		-4.747*	-5.011**
		(2.508)	(2.464)
Constant	6.846**	11.130***	12.459***
	(3.146)	(3.848)	(3.481)
Observations	123	123	123
R2	0.207	0.231	0.222
Adjusted R2	0.173	0.191	0.202
Residual Std. Error	9.779	9.673	9.603
F Statistic	6.099***	5.792***	11.320***
Note:	*p<0.1; **p<0.05; ***p<0.01		

To begin evaluating the summary output of the linear regression above, this study will firstly analyse the p value of each variable for significance. The p value as with the glm model in part one of this chapter provides an interpretation of how statistically significant each estimate is. The p value is not on the intercept, rather on

the variables. A very tiny p value would result in a rejecting of the null hypothesis thus confirming that variable to be of statistical significance. This can be completed in this study in the case of Model D on the log GNI per capita and the Total Health Expenditure variables only as their p values are 0.014 and 0.029 respectively which is close to the significant value gauge of 0.05 for a p value. It is no surprise the log GNI per capita variable is significant in this model as most of the e-health index variable contents require financial expenditure. It is usually economically developed countries that have a general strong health infrastructure and large number of medical students to train. Additionally, there are more lawyers in wealthier countries hence creating a larger number of lawyers available to study e-health laws. Moreover, in terms of social media and Big Data ability, wealthier states have many more citizens that have adequate mobile data in order to utilise these services. Furthermore, the Total Health Expenditures significance could be due to the fact that the e-heath index indicator being utilised in this model is that of overall health enablement, albeit with a stronger focus on e-health it all falls under the scope of health in various spheres. Due to this reason, logically investment in the health sector will assist many aspects of health matters which is what is contained in the e-health index variable, hence the statistical significance between these two variables.

The Physician Density, Mobile Cellular Subscriptions and Internet Usage all have extremely high p values, hence are insignificant in Model D. The intercept values of the significant predictors of Model D also provide value insight. The intercept value of log GNI per capita of 5.74 corresponds to Bata one, this number is of relevance as it offers practical significance by providing the numerical relationship that is observed between two variables. It is generally defined as an instant where the unit increases in x there will be an expected change of y in average by this amount (Brown,2016). In terms of this model it translates to a one count higher increase in log GNI per capita indicating that there should be an expected increase in the e-health index count of 5,74 score on average. The total health expenditure value of 0.80 gives insight that a one count higher increase in total health expenditure means that there should be an expected increase in the e-health index score of 0,80 points on average. For a better understanding of the effect in an African country on the model's predictive ability, as in study one, the African dummy variable will be added in Model E.

Taking the African variable into account, the notable difference from Model D to Model E is that the same variables that were insignificant in Model D were also insignificant in Model E. As with study one, variables under the ICT scope (internet usage and mobile cellular subscriptions) are found to be consistently insignificant. Potentially, under the e-health index variable, although social media and Big Data requires connectivity which contributed to the overall score, the other three themes the data covered such as health training, legal maturity and overall health infrastructure does not require much ICT solutions. The only variable that the significance status changed from Model D to E was with of log GNI per capita which is consistent to study one in section one of this chapter. This provides evidence that when modelling all countries together, economic development is a factor in affecting the e-health index score. However, the negative coefficient on the Africa dummy and the lack of significance on the log GNI per capita variable when the African dummy variable is added indicates that general economic development in African countries are not a factor in influencing their lower e-health index score.

In terms of the THE variable, the intercept value of THE remains quite like that of Model D. Interestingly, the African variable showed an intercept value of -4.75 which indicates that a one count higher increase in the African dummy variable shows that on average there is an expected decrease in the e-health index count of 4,75 points. To understand if this is due to African countries having a lower THE, similarly as in study one, Model F ran with only the significant indicators of Model D and E. These were the logGNI per capita and the THE variables. Surprisingly, after running Model F the results above indicate that when dropping all other insignificant variables, log GNi per capita continues to show significance. Model F indicates that logGNI per capita, THE as well as the African variable are all significant. The most significant information emanating from Model F is that even after controlling for log GNI per capita and THE, the African variable showed significance. The intercept value of -5.01 indicates that African countries apart from a poor economic system and minimal investment in healthcare are still likely to have an e-health index score of 5 points less than countries from other continents.

The summary output contains more insightful measurements, these include: The Residual Standard Error, the Multiple R squared, the Adjusted R squared and the F statistic. The analysis will begin with the residual std error.

The Residual Std Error is a basic quantification to measure how correctly or poorly the model is at achieving predicting the data on average (Brown,2016).The Model in study D is off by only 9.779 on 125 countries which is about 7,8 percent off to give a strong indication of this model's predictions ability. In Model E, when adding the African dummy variable this decreases slightly to 9,673. One can further observe that Model E has a very minimal difference to Model D by having a Residual Std Error of 9,603. The difference here is too minimal to analyse any difference between the three models.

Multiple R squared has a limitation in this quantification in that it does not consider the variation based on the qualities of the explanatory variables which is why the Adjusted R squared was rather utilised in this study (Brown,2016). The Adjusted R squared of Model D is at 0.1729 which indicates that the model predicts the variance in the data approximately 17% of the time. By adding the African dummy variable in Model E, it produced a value of 0,19 which is 2% higher. In Model F, taking only the log GNI per capita, THE and African dummy this number increases by 1 percent to 0.20. The difference once again is too minimal to analyse any difference between the three models.

The next statistic to be discussed will be the F statistic which is a ratio of how effectively the model is doing as opposed to its Std Error (Brown,2016). An F value in the case of Model D of 6.10 on 5 and 117 Degrees of freedom provides insight that this model contributes more explaining than its error. For Model D this is at 6 percent. Comparatively Model E oddly has a lower F statistic of 5.79 on 6 and 116 degrees of freedom which indicates that Model D predicts better than the error as opposed to Model E when adding the African dummy variable. However, Model F has a F statistic of 11.32 on 3 and 119 DF which is almost double than that of Model D and E. This provides insight that Model F predicts much more effectively than its error as opposed to Model D and E when modelling only the significant predictors.

From the above analysis it is evident to the reader that in almost every quantifier Model E performed better than Model D. This provides useful insight that the African variable is highly significant and a good quantifier for this study. Additionally, it is observable that Model F by merely employing the variables of logGNI per Capita,

THE and the African dummy variable concludes as being the strongest model and the best quantifier that predicts the data.

3.3 Conclusion

Following, the running of the six models in this chapter it was established that the only significant predictors of e-health policies of the EHR and e-Health index are that of log GNI per capita and Total Health Expenditure. Log GNI per capita however is a far stronger predictor as it was the only significant predictor in both sets of models. It was also established in this chapter that by adding the African dummy variable, it produced a significant outcome on the e-health policies. This significance was quite compelling. Even though the significant predicators were controlled, it was found that African countries continued to have a large negative effect on both e-health policies in this study. In conclusion, the interpretation of these models have demonstrated that regardless of the economic status of the country and lack of sufficient investment in healthcare by government, African countries present with other challenges that need to be examined to understand their limitations in implementing e-health policies.

Chapter 4 : Health outcome Model

Chapter Four of this study will continue to develop on the analysis conducted in Chapter Three. In order to analyse the health outcome of life expectancy, a further two models will be included and analysed. From the information collected in Chapter Three, the variables of log GNI per capita and total health expenditure were founded to be significant e-health determinants. Therefore, these two significant determinants will be controlled for in the new models and analysed simultaneously with the e-health policies of EHR and the e-Health index variable. The second model to be analysed in this chapter will include the same variables as mentioned above, however as with in the studies in Chapter Three the African dummy variable will be included to understand the effect an African country has on having a lower or higher life expectancy. This study will now further analyse these two models through Table 3.

4.1 Life Expectancy Model

Table 3

Table 3 consists of the summary output of a simple linear model which modelled the dependant variable of health outcomes (measured by life expectancy) against the significant e-health determinants from Chapter Three (to be measured by log GNI per capita and total health expenditure) and an African dummy variable (measured by the status of a country being African or not).

	Dependent variable: Life Expectancy	
	(G)	(H)
Africa		-8.009***
		(1.105)
logGNI	11.525***	7.882***
	(1.044)	(1.006)
THE	0.455**	0.420***
	(0.184)	(0.154)

```
E health Index          0.141***        0.098**
                        (0.048)         (0.040)

EHR                      0.376          -0.708
                        (0.963)         (0.817)

Constant                53.636***       61.214***
                        (1.478)         (1.616)


-----------------------------------------------
Observations              123             123
R2                       0.670           0.772
Adjusted R2              0.658           0.762
Residual Std. Error      4.988           4.160
F Statistic            59.791***       79.257***
===============================================
Note:                 *p<0.1; **p<0.05; ***p<0.01
```

Evaluating the summary output of the linear regression above this study will begin by looking at which variables were statistically significant through the p value. A tiny p value results in a rejecting of the null hypothesis and confirms that variable to be of statistical significance. This can be done in this study in the case of Model G on the log GNI per capita ,the Total Health Expenditure and the E-health Index variables only, as their p values are 2e-16 , 0.015 and 0.004 respectively which is close to the significant value gauge of 0.05 for a p value. The EHR variable however has a high p value of 0,69 and is not significant in this study. The intercept values of the significant predictors of Model G also provides valuable insight. The intercept of value log GNI per capita of 11.53 corresponds to Bata 1, this provides the reader with practical significance as it provides a numerical relationship that is observed between two variables. It is generally defined as a case of there is a unit increase in x there will be an expected change of y in average by this amount. For example, a one dollar increase in log GNI per capita, means that there should be an expected increase in Life Expectancy of 11.53 years on average. The Total Health Expenditure value of 0.455 gives insight that a one count higher increase in Total Health Expenditure means that there should expect an expected increase in life expectancy of 0,46 years on average. Additionally, the E-health Index variable of 0.14 means that there should expect an expected increase in life expectancy of 0,14 years on average. One may conclude from the above, that log GNI per capita has the largest effect on Life Expectancy. To provide further insight into the effect an

African country has on the model's predictive ability, once more the African dummy variable was included in Model H of this study.

Once accounting for the African variable, the notable difference is that the same variables that were of statistical significance in Model G were also significant in Model H upon accounting for the African variable. This provides insight to the reader that regardless of being an African country or not; general economic growth, Total Health Expenditure and the E-health Index variable which comprises of general e-health infrastructure across different sectors, all affect life expectancy. In terms of the log GNI per capita variable, several studies have suggested that having a higher incomes translates into better access to education, health services, housing and other items "which tend to lead to improved health, lower rates of mortality and higher life expectancy" (Bacci, 2001). Thus, it is no surprise that historically aggregate income has been a strong predictor of life expectancy .

Additionally, the variable of total health expenditure is also strongly correlated to life expectancy regardless of being an African or not. In relation to the positive effects of healthcare expenditure on health outcomes, as indicated in the current study, it seems that increasing the health expenditure, especially public health expenditure "develops health facilities and improve the functions of health systems" (Novignon J, Olakojo SA, Nonvigno,1991). It is evident that increased expenditure in the health sector translates to health care facilities that are better equipped to offer better overall health care treatments for patients. These results are consistent with several researchers including the study by Panahi and Aleemran, which showed "a positive effect of health expenditure on life expectancy" (Panahi H, Aleemran ,2016).

Moreover, the E-health Index variable has also shown significance in influencing health outcomes in both countries globally and in the African continent. This result was expected as the contents of the E-health Index variable compromises of differing health maturities from varying sectors. This gives this variable a larger scope in which to transform health systems positively to result in better health outcomes.

One of the more noteworthy observations in the study was the lack of significance of the EHR variable in both Model G and H. Even though most healthcare providers, patients, and industry stakeholders agree EHR technology has the potential to yield

marked improvements in population health management, predictive medicine, and clinical decision-making. EHRs use also introduces new risks to patient safety (Monica,2018). A study released in October of 2017 found EHR use has been listed as a contributing factor to patient injury at an increased rate over the past decade. Poorly designed EHR systems “combined with human error have resulted in patient safety problems in an increasing number of malpractices claims from 2007-2016 “(Monica,2018). Conversely, this may be what is balancing the effect EHRs has on health outcomes and producing a deadlock in the statistical significance of this variable.

The most significant deduction emanating from Model H is even once controlling for log GNI per capita, THE, the E-health Index variable and EHRs, the African variable continued to be statistically significant. The intercept value of -8 indicates that African countries aside from being economically weak, having limited investment in healthcare and a low E-health Index count, are still likely to have a lower life expectancy of 8 years less than countries from other continents.

The summary output presents more insightful measurements. These include, the Residual Standard Error, the Multiple R squared, the Adjusted R squared and the F statistic. The analysis will begin with the Residual std error.

The Residual Std Error is a basic quantification of how well or poorly a model is doing at predicting data on average. In terms of this study, Model G is off by merely 4. 9 on 118 countries which is only about 4,1 percent off to give a strong indication of this model’s predictions ability. In Model H, adding the African dummy variable decreased this slightly to 4,16. One can further observe that Model G has a very minimal difference to Model H by having a Residual Std Error of 4,16. The difference here is too minimal to show any difference between the two models .

Multiple R squared has a limitation in this quantification in that it does not consider the variation based on the qualities of the explanatory variables which is why the Adjusted R squared was rather utilised in this study. The Adjusted R squared of Model G is at 0.65 which indicates that the model predicts the variance in the data about 65 percent of the time. Model H when adding the African dummy variable has a value of 0,76 which is 11 percent higher. An Adjusted R squared value of 0.76 is extremely high which shows how strong this model is in predicting life expectancy.

The next statistic to be discussed here is the F-statistic which is a ratio of how well the model is doing as opposed to the std error, the higher the F-statistic the better. A F-statistic value in the case of Model G of 59.79 on 4 and 117 DF provides insight that this model contributes to more explaining than its standard error. For Model H this is at 79.26 on 5 and 117 DF. Comparatively, Model G oddly has a lower F statistic of about 20 less which indicates that Model H predicts considerably better than the error as opposed to Model G when adding the African dummy variable. The next value to be interpreted is that of the p-value.

From the above analysis it is well established that in almost every quantifier, Model H performed better than Model G. This provides useful insight that the African variable is highly significant and a good quantifier for this study.

4.2 Conclusion

Chapter Four has presented additional information and insight as to which e-health determinates and policies are the most significant in predicting Life Expectancy. It was found that log GNI per capita ,Total Health Expenditure and the E-health Index variables were all statistically significant variables in predicting Life Expectancy. A country having an EHR system however was found not to be a significant indicator of Life Expectancy. Furthermore, the African dummy variable once again was highly significant even after controlling for all other competing variables in the model.

Chapter Five: Conclusion

Upon completion of the studies that were conducted in this research and the information gained from Chapter Three and Four, it was established that two variables were significant in determining e-health polices and the health outcome of life expectancy. These were the log GNI per capita variable and the total health expenditure % of GDP variable. This chapter will begin by summarising the findings of this paper. The second part of this chapter will discuss solutions in overcoming the drawbacks present in Africa which are hindering their ability to adopt e-health policies, and the link between e-health initiatives and better health outcomes which is the focal point of this study. The study will then be finalised by discussing the scope of future research based on the insights founded in this paper.

5.1 Summary of findings:

In this research, study one has recognised the vast potential for the utilisation of digital healthcare, especially in Africa. The rationale behind this study has emphasised this need especially as African leaders are committed to improving the continents healthcare.

It was additionally established that current literature on this topic focuses more on the end goal of the project rather than the process it entails which should be noted as a greater priority. Analysing new e-health indicators in this research should present considerable insight into Africa's current status quo and considers avenues of improvement to ensue. Chapter Two of this study provided the reader with analytical illustrations to locate where Africa compares to the rest of the world in accordance to various sectors within e-health.

Chapter Three concluded following the running of the six models and found that the only significant predictors of e-health are that of logGNI per capita and Total Health Expenditure. Log GNI per capita however is a far stronger predictor as it was the only significant predictor in both sets of e-health policy models. Notably, the African dummy variable demonstrated that it produced a significant outcome on the e-health policies. This significance was quite compelling. Even though the significant

predicators were controlled, it was found that African countries continued to have a large negative effect on both e-health policies in this study.

Collaborating the information and insights gained from Chapter Three, Chapter Four continued to develop on these insights and concluded with strong empirical evidence of the impinging factors on health outcomes in Africa. It was found that log GNI per capita, Total Health Expenditure and the E-health Index variables were all statistically significant variables in predicting Life Expectancy. A country having an EHR system however was found to not be a significant indicator of Life Expectancy. Furthermore, the African dummy variable once again was highly significant even after controlling for all other competing variables in the model.

To conclude, this study has provided evidence that African countries have lagged in their adoption of e-health policies, and that even after accounting for their generally low levels of economic development and insufficient health expenditure their adoption capacities would still be minimal. Accordingly, it may be practical to assume that the adoption of general policies that promote economic development are likely to develop a solid foundation for improvements in the health sector, it is not the silver bullet.

Perhaps Africa faces more intractable obstacles to adopting e-health policies, and more intractable obstacles to those policies translating into improved health outcomes. It is hoped that once these constraints and challenges are overcome, the future of African health conditions should have a more favourable outcome, the possibilities to better health care seems promising.

5.2 Where does Africa go from here?

At the start of the decade in Africa, there was very little improvement in the lives of the citizens as poverty was on the increase .Presently, Africa as a continent is required to implement wide spread investment in aim of improving its citizens living conditions. There needs to be simultaneous improvement in food security, education, sanitation, water and importantly job creation and opportunities which will create more income in the economy to invest further in healthcare for better health outcomes (Chiviru,2020).

Economic and health performance are interlinked, thus wealthier countries generally have healthier populations. The sad reality is that poverty affects life expectancy adversely through malnourishment and infant mortality (Frenk 2004). The importance of general economic growth and increasing individuals' per capita income is vital for better health outcomes.

The close relationship between a poor population and health needs to be recognised. Policy makers and national programme managers need to include strong economic interventions for better growth of their economies to improve overall population health. In conclusion the argument is that general economic development generates resources for government. Governments need to take appropriate actions, devoting enough resources to health, and adopting appropriate technologies so that they can get better health outcomes. This research has provided strong evidence through Model G and H in Chapter Four that an increase in general economic development has a strong effect on better health life outcomes such as life expectancy.

5.3 Total Health Expenditure Solutions

The challenge which many countries are facing is the difficulty in collecting public revenue largely as a result of the vast informal economy. This in turn makes tax challenging and the opportunities for investing in health is thus limited. Prioritising government spending on health through innovative mobilisation instruments can assist in bridging this gap to a certain extent. The effective usage of external funds is critical and more should be done to ensure the improved flow of these funds into mechanisms that are of national priority (Musango, Elovainio, Nabyonga, Toure, B, 2013).

Recently there has been an increase in successful health financing reform implementations among several African countries. This initiative has mobilised these countries closer to attaining the policy objective of universal health coverage, by increasing financial risk protection of their citizens and a growing access to health services. Procedures have been put in place by many countries to protect the vulnerable groups in the population through measures such as reduction in user fees for all health services (Musango, Elovainio, Nabyonga, Toure, B, 2013).

Investments are required systemwide in order to effectively increase quality health service usage. In relation to other aggregate health finance indictors, health outcomes can be observed as being widely variated. As a result, context specific and more in-depth solutions and design analysis are required. These include health financing systems that seek to improve key indicators such as “equity in resource allocation and efficiency in resource utilization”(Masiye, Chita and McIntyre ,2010). Taking into consideration the constraints with regard to raising sufficient financial resources in the health sector, the distribution of the financial burden if this expenditure needs to be undertaken in “ an equitable manner ,addressing the need for efficient use of the scarce resources and close collaboration between the ministries of finance and health is vital. Inter-ministerial committees and other policy orientated bodies of dialogue can enhance such interaction between the health and finance ministers for information sharing purposes. Support from the ministry of finance will be required to support capacity building finance in the health sector, whilst the health minister will need to engage with the finance minister in “sectoral planning, budgeting and implementation reviews” (Musango, Elovainio, Nabyonga, Toure, B, 2013). This inter-ministerial dialogue between the health and finance ministers will need to be included in the process of designing a health financing policy that is based on strong evidence which consider the opportunities and constraints in every specific contact (Musango, Elovainio, Nabyonga, Toure, B, 2013). Strong investments in the healthcare sector are vital for any country. Even though these compete with other vital areas of investment such as education, healthcare is essential as a healthier population is an economically stronger population. In the face of ill-health and high mortality rates a country will continue to remain in a cycle of poverty and poor living standards. Thus, rendering investment and development in the economy immaterial if there is widespread low life expectancy. This research has provided strong evidence through Model G and H in Chapter Four that public investment in healthcare has a strong effect on better health life outcomes such as life expectancy.

5.4 The link between e-health initiatives and improved health outcomes

E-health initiatives have a strong association with improved health outcomes. Previous research has indicated that an e-health initiative programme for pregnant women in Brazil resulted in an increase of pregnant women completing all their six prenatal visits from 10 to 80 percent (Lewis, Synowiec, Lagomarsino and Schweitzer, 2012). It has been further found that communication through SMS messaging and other tools for communicating with patients between appointments increases the health behaviour and physiological outcomes of patients (Cole-Lewis and Kershaw,2010).

Preliminary evidence shows that e-health systems can have a beneficial impact on health outcomes such as life expectancy. Empirical evidence of this was provided in this study through Table 3 in Chapter Four. The E-health Index variable which contained e-health maturity levels in different sectors was found to be strongly correlated to having a positive effect on life expectancy. This is unsurprising as the contents of the e-health index variable compromises of differing health maturities across various spheres which may assist in better health outcomes. For example, in terms of the total e-health infrastructure capability, adopting effective e-health policies and information systems can assist in keeping better patient records to benefit the patient with tailored treatments. An additional example under the E-health Index variable is that of medical training in the e-health field. Health professionals who are equipped with e-health tools are better equipped to provide more accurate diagnoses and swifter treatments which can save more lives, thus resulting in an overall better health outcome and higher life expectancy. To further amplify this system, Big Data capability is also included in the E-health Index variable and as noted in Chapter One, Big Data capability could largely benefit health outcomes by utilising data to take preventive measures in sick patients in an effort to save more lives. A further example under this scope is to create better health awareness campaigns on social media, which would promote instant awareness as well as easy access of information concerning health matters.

5.5 Future research based on the results

The rationale behind the research conducted in this paper is based on identifying the disproportion which is constraining African countries in adopting digital health solutions. The variables constraining them were identified in this paper. The next step would be to invest in these areas so that African countries may be able to bridge the gap for a successful adoption of digital health solutions. The next research to be conducted would be a follow up study based on time series data to understand if further investments in the sectors of general economic development and an increase of total health expenditure by African governments have narrowed the gap in enabling Africa to achieve better health outcomes (possibly conducting a study from 2019 onwards). Once this has been achieved, the next step attempts the adoption and implementation of the health systems. Each country could conduct suitable researches that are appropriate to the diseases which are most prevalent in their country, hence adopt machine learning and Big Data techniques to improve their digital health tools to overcome the high death rates caused by those diseases. This will in turn assist countries globally and specifically in Africa to achieve better health outcomes such as increased life expectancy and an overall enhancement in health amongst all citizens.

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