A SYSTEM DYNAMICS MODEL OF THE IMPACT OF E-HEALTH SYSTEMS ON CERVICAL CANCER VACCINATION IN KENYA

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DECLARATION

I, the undersigned, affirm that this research project is my original work and has not been bestowed for a degree in any other university.

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This research has been submitted as a partial fulfilment of requirements for the degree of Master of Science in Information System Management through my endorsements as the University overseer.

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List of Acronyms and Abbreviations

CVD	Cardio vascular Disease
E--health	Electronic health
FDA	Food and Drug Administration
GLOBACAN	Global Cancer Database
HPV	Human Papilloma virus
NCR	National Cancer Registry
SD	Simulation modelling
SDM	System dynamics modelling
STD	Sexually transmitted disease
WHO	World Health Organisation

ABSTRACT

Cervical cancer is the second most regular disease among women of conceptive age in Kenya. It has one of the most astounding rates and mortality cases in Kenya. This is in spite of a ton of noticeable quality being put on preventive and screening administrations while there is a scarcity of consideration on the effect of utilization of e-health frameworks in the vaccination and treatment of cervical cancer patients in Kenya. The e-health scope of this study referred to use of electronic devices in accessing information on cervical cancer management. The impact of this knowledge would be translated to increased positive attitude towards vaccination and screening as well as an increase in demand for these interventions. The effect of e-health frameworks is crucial for therapeutic and aversion metastatic spread of the sickness and decrease in mortality cases in Kenyan malignant growth care focuses. The aim of this study was to create a system dynamics model of the impact of e-health systems on cervical cancer Vaccination in Kenya. As part of the research a literature review of documentations related to the study was done from which a methodology to conduct the study was drawn. In Phase one of the study a qualitative evaluation to establish experiences, opportunities and challenges faced by cervical cancer managers in Kenya was done by issuing out google questionnaires. 20 Cervical cancer managers drawn from cancer care centres in Nairobi who filled out the questionnaires and 102 participants on their take on cervical cancer vaccination. It was established that Mobile phones were highly accessibility. Negative attitudes towards screening procedure and Cervical Cancer patients need urgent attention. In phase two of the study the simulation model to evaluate possible effects of vaccination and e-health tools was developed using Stella by i think. Model valuations to evaluate the effects of different mediations were done they showed that that at all different ages the quantity of ladies being vaccinated against malignancy will increment massively until they achieve a steady level. In phase three of the study a validation test of the model was done using regression and analysis that saw the predictability of the model being of an acceptable level. The study therefore concluded that the access to e-health systems increases the number of vaccinations over time. E-health would be a complementary measure to cervical cancer vaccination in Kenya.

CHAPTER ONE
INTRODUCTION

1.1 Background of the Study

In the course of the most recent decade, wellbeing frameworks around the globe have progressively perceived the capability of advanced wellbeing arrangements. The thought is that quality medicinal services could be conveyed better and quicker by a lot of productive advanced instruments to help the organization of human services benefits, the accumulation of secure wellbeing information, help patients screen their conditions, and advance solid ways of life and counteractive action. (WHO, 2018)

E-health is an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology. (Journal of Medical Internet Research, 2001).

E-health is an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the internet and related technologies (Neuhauser & Kreps, 2003). E-health is part of the broad cultural shift toward Internet and technology use, such as portable music devices, cell phones, instant messaging, and interactive voice-response systems, as a normal part of everyday life (Neuhauser & Kreps, 2003).

The main e-health domains of activity consist of Health Information Systems data and software tools and Health Services Delivery work practices and processes. E-health has contributed to changing behaviour of health professionals, care personnel, citizens and improving patient safety in general. Due to its impact on medicocultural, legal/regulatory and socio-economic factors, e-health is a new way of thinking and a commitment to networking globally with the aim of improving health care globally (Maeder, 2008).

Malignant growth is a nonexclusive term for an enormous get-together of diseases depicted by the advancement of unpredictable cells past their standard restricts that would then have the option to assault adjoining segments of the body just as spread to various organs. Other typical terms used are hurtful tumors and neoplasms (GLOBACAN, 2018). Disease can impact for all intents and purposes any bit of the body and has various anatomic and sub-nuclear subtypes that each require express organization frameworks. Malignant growth is today one of the world's fundamental driver of death, and influences one of every three individuals in Western nations. It is a very heterogeneous gathering of illnesses. The WHO World Cancer Report features that worldwide malignant growth rates could increment by half to 15 million by 2020. Given that four out of ten diseases are connected to utilization of wellbeing hurtful items, a developing number of computerized arrangements enable patients to monitor malignant growth medications and have more advantageous existences when all is said in done.

Digital applications (Apps) for cancer patients were mainly designed to support the continuum of care; they help patients to better cope by facilitating improved organisation of treatments, healthcare visits, and results. Some solutions contribute to improving patients' lives by sending personalized information about when and how to take a prescribed treatment, some provide assistance during the crucial patient-doctor dialogue, and others simplify patients' disease management, e.g. by compiling a calendar that contains all medical visits and check-ups. (Bright & Fleisher, 2005)

In the recent past, e-health frameworks around the globe have progressively perceived the capability of advanced wellbeing arrangements. The thought is that quality medicinal services could be conveyed better and quicker by a lot of effective advanced instruments to help the organization of social insurance benefits, the accumulation of secure wellbeing information, help patients screen their conditions, and advance sound ways of life and counteractive action.

In the meantime, shoppers and patients have quickly grasped cell phones. Cell phones and tablets specifically have turned into an essential device for some to encourage the administration of different life circumstances. Their implicit or included highlights, for example, versatile Internet, applications, cameras, GPS, voice recorder, scanners, and numerous others - bolster the conveyance of portable e-health for nearly everyone and in practically any area.

The utilization of the Internet, email, long range interpersonal communication locales and cell phones are quickly growing in the African Region. Somewhere in the range of 60% and 80% of individuals in the Region are assessed to utilize cell phones. These apparatuses and stages are making open doors for the successful utilization of e-health arrangements, applications and administrations to improve national wellbeing frameworks.

Tele-wellbeing and tele-prescription administrations can dispense with separation and time boundaries while urging positive way of life changes to anticipate and control basic infections. SMS or content informing can convey data to fingertips 24-hours per day. In Kenya, a number of studies on Cervical Cancer have focused on the effects of Cervical Cancer screening, prevalence of Cervical Cancer and HPV in relation to HIV (Ombech & Muigai, 2012). However, few if any, studies have focused on the impact of e-health in Cervical Cancer management or application of engineering tools in Re-designing of health care systems. The management of Cervical Cancer, a major cause of mortality among women in Kenya, would therefore act as a useful example for assessing the potential impact and the drivers and barriers to e-health in Kenya. The application of e-health tools does not occur in a vacuum. It needs to be incorporated in the existing infrastructure. System Dynamics (SD) becomes an appropriate tool in evaluating the impact of e-health tools in Kenya. SD is a methodology of mapping and then modeling the forces of change in any dynamically complex system, so that their influences on one another can be better understood and overall direction of the system can be better governed. (Rositch, 2012).

This study was aimed at assessing the impact of e-health intervention in cervical cancer management in Kenya. Particularly e-health intervention in cervical cancer vaccination in Kenya without the cost of controlled health service trials by use of a system dynamics model.

1.2 Problem Statement

This study was aimed at assessing the impact of e-health intervention in cervical cancer management in Kenya. Specifically e-health intervention in cervical cancer vaccination in Kenya without the cost of controlled health service trials by use of a system dynamics model.

Few studies, if any, have been done in Kenya to establish and or evaluate e-health interventions. This may be attributed to the slow pace of implementation of e-government and e-health policy,

hence there is limited data available on clinical, economic, social and psychological variables on e-health interventions (Kalua & Union, 2009). A number of studies have focused on challenges faced by the patients in Cervical Cancer management, such as (Kivuti, 2014) none of the studies done in Kenya have focused on the impact of e-health systems on cervical cancer vaccination in Kenya. (Kamande, 2013) also conducted a study on determinant of factors affecting adherence to radiotherapy treatment among patients with cervical cancer at the MP Shah Hospital. It is important to conduct research and studies of such an impact on the Kenyan health care system performance.

Kenya Cervical Cancer screening is low at less than 5% (Ministry of Public Health and Sanitation and Ministry of Medical Services, 2017). This has been attributed to less efforts in increasing awareness of Cervical Cancer among women, especially those in rural areas, which would otherwise lead to women submitting early to regular checks hence increase chances for mitigation. (Gatune & Nyamongo, 2005).

The formulation and evaluation of health policy in the current political, economic, sociological, technical, legal and environmental climate is hampered by growing health system complexity and the inability to reliably predict the outcomes of policy decisions. Health service changes represent prolonged complex interventions in complex systems. Controlled health services trials are difficult to design, conduct, evaluate, interpret and extrapolate for many reasons.

In health policy many real-life experiments are too costly, too risky, time-consuming or impossible to design and implement and face resistance (Sterman, 2006). Due to the nature of e-health technologies being dynamic and evolving too rapidly, pre- and post- implementation studies tend to be irrelevant and obsolete. Comprehensive economic analysis that determines outcomes such as cost-benefits and cost offsets require considerable time and expertise and are beyond the scope of many e-health projects (Catwell & Sheikh, 2009). Even though application of system dynamics including use of static linear methods to complex dynamic nonlinear systems could be a possible solution to evaluating the impact of health policy, this has not been exhaustively explored. This conceptual and contextual gaps highlighted epitomizes this research study which seeks to establish a system dynamics model of the impact of e-health systems on cervical cancer vaccination in Kenya.

1.3 Research Objectives

The main aim of this research was to model the health, social-economic effects of using e-health systems in cervical cancer vaccination in Kenya. The specific objectives are as follows:

1. To establish the challenges being faced in cervical cancer vaccination in Kenya
2. To develop a simulation model of establishing the clinical and socio-economic effects of using e-health systems in cervical cancer vaccination in Kenya.
3. To test and validate the model for effectiveness using sample data.

1.4 Research Questions

1. Which variables can significantly determine the challenges being faced in cervical cancer vaccination in Kenya?
2. What are the effects of using electronic health systems in cervical cancer vaccination Kenya?
3. Which modelling validation techniques can be used to establish the model effectiveness?

1.5 Significance of the Study

This study was aimed at assessing the impact of e-health intervention in cervical cancer vaccination in Kenya without the cost of controlled health service trials by use of a system dynamics model. The research would have impact on the following stakeholders:

The system dynamics model when adapted will have a significant impact in cervical cancer management in Kenya.

It will benefit most females in Kenya as they would they would change attitude towards cervical cancer vaccination, utilize e-health tools for Health education such as mobile applications, avoid smoking and reduce the use of hormonal contraceptives and use technology to disseminate information about cervical cancer vaccination among themselves.

The policy makers would also benefit from adoption of the system dynamic model via incorporating the use of e-health tools in the policy on cervical cancer, including attitudes and culture in policy development, Incorporating and encouraging secondary and primary vaccinations

of cervical cancer and encouraging acceptability of screening preferably provide conducive health facilities which should ensure, cultural sensitivity.

The research study will add to the existing literature on cervical cancer management in Kenya with regards to the influence of e-health systems on cervical cancer vaccination.

The study would also promote competence based training on cervical cancer management to relevant health care workers and Increase collaborative multi-disciplinary research on the use of e-health systems.

1.6 Scope of the Study

This study covers the activities and strategies employed in vaccination of cervical cancer in Kenya using e-health systems. The relationship and causal effect among key variables were explored. The study setting was conducted in selected cancer care centres in Nairobi Kenya and a sample population of Nairobi inhabitants.

1.7 Limitations of the Study

Limitations were located in the investigation and accumulation of information for this paper. A portion of the impediments included a strategy for research that was in use. Articles gathered for use were arbitrarily chosen by the utilization of critical words in a wide range of site pages and furthermore utilization of the google search engine. By use of this technique, it is more than likely that even though articles chose and utilized were appropriate, such a large number of more articles that may have been reasonable were not found or disregarded in the inquiry. A few articles that were likewise found were in the theoretical frame. The language barrier was additionally a limitation in the utilization of a portion of the materials found since they were in various dialects other than English dialect and thus, they were expelled and not utilized in the examination. The theme was genuinely broad and along these lines requesting a wide range of data gathered. In this procedure critical data may have been forgotten causing a short-back in work. A lot of sieving of data may likewise have prompted exclusion of relevant and possibly fundamental data.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This Chapter covers theoretical and empirical review to identify the knowledge gap. The theoretical review discussed the theories that inform the study; empirical review discusses past studies by other authors on the specific research objectives while the conceptual framework presents the schematic diagram that shows the interactions between the independent variables and the dependent variable. The chapter is concluded with a summary of the identified research gaps.

2.2 Empirical Review of Digital Solutions (E-Health)

According to previous studies done computer simulation has been utilized in health care policy making, health services planning, biomedical applications from the systems to the cellular and genetic level, and education (Anderson, 2010). Cancer managers have been compliant in utilizing computer simulation at different levels and structures of Cancer management. While access to data on cervical cancer growth management has added to decrease in cervical disease in created nations, data access has no noteworthy distinction in creating nations (Hanisch & Gustat, 2008). Absence of access to quality data on cervical malignant growth screening and the executives has been ascribed to the low wellbeing status in creating countries (Chingore & Munazvo, 2012). It has been contended that interest in Information and Communications Technologies (ICT) in the medicinal services segment has extraordinarily improved wellbeing status in created nations. As indicated by (Odutola, 2003), creating nations are lingering behind in usage of ICT in social insurance and henceforth may not understand the potential advantages of e-wellbeing. Advancement and speculation of e-wellbeing in creating nations should be logical in nature so as to meet the curious qualities of creating nations whereby; utilization of the cell phone is the sole ICT correspondence contraption getting up to speed quickly and the utilization of cell phone in e-wellbeing will be relatively more noteworthy in low asset setting (Patil, 2011).

E-health devices in Cancer management have been created to perform various capacities for the end client. These range from wellbeing instruction, online networks, physician order entry and

electronic wellbeing records. E-health devices have additionally been utilized in preventive, advancement and corrective parts of Cervical Cancer management.

Customers have turned out to be alright with the Internet as a wellbeing asset in this way giving access to much required wellbeing data on Cancer the board and other illness conditions (Diaz, 2012). An enormous number of Americans utilize the web to look through data on medical problems. As per (Helft, 2005), forty to eighty (80) percent of grown-ups utilize the web for medicinal data.

Numerous wellbeing instructors and human services experts, as opposed to creating their own instructive materials, allude patients to Web-based assets or download and give the data. As indicated by (López & Gómez, 2012) oncologist ought to endorse legitimate sites for their customers as the data acquired enables the customers to adapt better and cultivate the doctor customer relationship, as long as the web substance are of good quality.

The development of e-health arrangements is related with the expanding interest for adaptable, complete, and financially savvy perpetual consideration models. The extent of the applications that can be utilized to help patients experiencing unending conditions is wide. Just as approaching instructive assets, ceaseless infection patients can utilize different kinds of e-journals and frameworks for long haul observing of the disease course. Contingent upon the sickness and side effects, the kinds of gadgets used to survey the patient's condition fluctuate in any case, the need to report the side effects and estimations continues as before.

Over the last decade, health systems around the world have increasingly recognised the potential of digital health solutions. The idea is that quality healthcare could be delivered better and faster by a set of efficient digital tools to support the administration of healthcare services, the collection of secure health data, help patients monitor their conditions, and promote healthy lifestyles and prevention. (Health At a glance, 2016)

Across the board utilization of e-health frameworks in ceaseless consideration relies upon a few factors; the acknowledgment and capacity to utilize data innovation apparatuses are of key significance, close by comprehension of the ailment and helpful measures. Thus, the practicality

of e-health applications in connection to explicit patient gatherings or networks ought to likewise be surveyed with regards to building up an informed society in the nation.

Healthcare professionals remain wary of digital solutions as they worry, whether rightly or wrongly, that they increase their workload or trigger mistakes in diagnosis, leading to treatment choices that put patient safety and trust at stake.

Patients, on the other hand, appear to be quite enthusiastic about digital innovation. For example, when asked whether cardiac patients would be interested in receiving additional health support via the Internet, 77% responded positively. Within this group, patients indicated e-mail as the most favourable way (65%), followed by website information (39%) and online videos (36%). More than half of the patients surveyed reported their interest in receiving support via mobile phones. This interest decreased with age, confirming young people's relative preference for smartphones over computers (Buys R, Jomme C, Walsh D, 2016).

2.3 Existing E-Health Systems in Disease Management

2.3.1 Diabetes e-health solutions

Diabetes is one of the most expensive chronic diseases for health systems, and many early e-Health solutions were designed as support tools for diabetes patients so they could self-manage their condition while at the same time easing the workload on health professionals. The expanded utilization of cell phones, combined with a regularly developing number of versatile applications, yet in addition Internet gateways and sites are accessible to enable patients to improve their administration of day by day diabetes care. Diverse computerized arrangements can be utilized for account and following patients' eating regimens, medicine, starches admission and physical action, and they take into account simple estimation of blood glucose levels, circulatory strain and weight. Some gather all of these factors together, while others are designed to only focus on one aspect of care, e.g. coaching and education. (Diabetes Self-Management, 2017)

Diabetes patients are particularly dependent on up-to-date data because routine tracking is an inherent part of living with the disease, which is accompanied by stressful trigger points during which health and psychological needs go in parallel. The ability to log and enter relevant data, whether manually or automatically (via smartphones, tablets or computers), and to update or

change information in real time, enables diabetes patients to exert greater control over their condition. Many apps allow them to set and track personal goals, thereby providing added motivation to attain health objectives. Furthermore, automatic blood sugar readings and reminders to check blood sugar levels can provide patients with an increased sense of security. Easy-to-use digital tools have proven to be most beneficial for diabetes management. (Diabetes Self-Management, 2017)

More advanced innovations include tailored wearable for diabetes patients that integrate smart skin patches, contact lenses, and footwear equipped with sensors and wireless connectivity. Not only do wearable tools assist users with blood sugar level monitoring, they also connect them directly with healthcare providers in case of emergency; some even release medication into the body (e.g. patches with sensors that measure blood glucose in sweat and correct high levels by releasing a dose of insulin). In the case of a rapidly decreasing blood glucose level, patients receive automatic reminders to take a meal via their mobile phones. (Diabetes Self-Management, 2017)

International Diabetes Federation (IDF) Europe, note in their comprehensive position on Mobile Applications in Diabetes that, " the role of healthcare professionals, family and friends is crucial as people with diabetes typically have an easier time with diabetes management when there are other people who are interested in their medical condition ". Furthermore, they stress that healthcare professionals must become familiar with how apps work, and how their patients are using them. (IDF Europe, 2017)

2.3.2 Heart disease e-health solutions

Cardiovascular illnesses (CVD) are a main source of sudden passing and inability around the world. An expected 17.5 million individuals are losing their lives from CVD every year, speaking to around 33% of every single worldwide passing. It represents over 1.9 million passings annually, 80% because of heart assaults and strokes (Buys, Jomme & Walsh, 2016). There was a requirement for CVD patients to assume responsibility for their own condition and portable innovation came as a response to enable them to screen their illness.

According to the European Heart Network (EHN), if implemented efficiently, e-health solutions can improve prevention and treatment of CVD. Mobile solutions exist for individuals and

population groups of different ages, including for education or public health awareness purposes. Smartphone applications can help patients understand their condition after a cardiac event, and they can also improve adherence to rehabilitation programmes.

New technology can also be useful in managing CVD risk factors, including computer-based smoking cessation programmes and telemetrically supervised self- monitoring of blood pressure. In fact, mobile apps offer a broad range of solutions for treatment support: they help patients monitor their medication for anticoagulant therapy, measure irregular heart rhythm, track blood pressure, remind haemophilia patients about blood infusions, and they provide information about stroke symptoms and techniques of assistance. (Buys R, Jomme C, Walsh D, 2016) For emergency events, there are video games that provide instructions for emergency situations, e.g. how to perform cardiopulmonary resuscitation (CPR).

The European Society of Cardiology (ESC) argues that closer collaboration between all stakeholders' consumers and patient's organisations, health professionals and health organisations, public authorities, mobile applications developers, telecommunication service providers, mobile device manufacturers, and others will optimise the appropriate development and implementation of new solutions to health and healthcare needs.

2.3.3 Existing cancer digital health solutions

Cervical cancer continues to be a common cause of mortality in women and girls. Estimates reveal that over a million women globally have been diagnosed with it (GLOBACAN, 2012). Majority of these women lack accessibility to preventive, curative, palliative and rehabilitative health care services. In 2016, there were 528,000 new incidences of cervical cancer reported with a mortality rate of nearly 90% in low- to middle-income countries. If the current statistical figures continue to rise, mortality cases due to cancer of the cervix are likely to escalate by 25% by the year 2022 (WHO, 2017).

Given that four in ten cancers are linked to consumption of health harmful products, a growing number of digital solutions allow patients to keep track of cancer treatments and lead healthier lives in general (Buys R, Jomme C, Walsh D, 2016).Apps for cancer patients were mainly designed to support the continuum of care; they help patients to better cope by facilitating improved

organisation of treatments, healthcare visits, and results. Some solutions contribute to improving patients' lives by sending personalised information about when and how to take a prescribed treatment, some provide assistance during the crucial patient-doctor dialogue, and others simplify patients' disease management, e.g. by compiling a calendar that contains all medical visits and check-ups.

Cancer survivors are faced with a significant challenge: to recover from treatment while maintaining health and well-being. The focus of survivorship care lies on managing the after-effects of the treatment and early detection of a recurrence. Digital solutions can provide patients with a comprehensive survivorship care plan (SCP) including a summary of the treatment received and a follow-up plan prepared by a doctor. The active inclusion of patients in the process, e.g. establishing step by-step treatment plans with them, can make them feel more secure and aware of their condition. (Buys R, Jomme C, Walsh D, 2016) Equally important are the many apps that teach users about healthy life choices and provide advice on how to prevent cancer, whether providing direct information from healthcare professionals or compiling users' data to obtain a better picture of their lifestyle and habits.

As in different territories, malignant growth applications are not idiot proof EPHA individuals Cancer Research UK have fundamentally remarked on the results of a portable application intended to perceive skin diseases, for example, melanoma, the most genuine sort, in light of a photograph taken by clients - a 'selfie'. English specialists utilized four applications to break down 188 pictures of skin injuries. Three of them erroneously arranged 30% or more melanomas. This model exhibits that clients must not substitute the counsel of capable human services experts with innovation: finding by cell phone can produce off base outcomes (EPHA, 2018). As a correlative instrument, applications help individuals be increasingly aware of their wellbeing and oversee routine procedures, yet they are not a trade for therapeutic discussions, likewise in light of the fact that outer elements tolerant narratives, medicate connections, work-life balance, and so forth must be considered.

Meaningful and systematic consultation of stakeholders including patient advocacy groups is essential to foster e-health solutions that are sustainable and respond to the needs of users at large while addressing any individual data security concerns; Fostering digital health literacy is crucial

to achieve maximum benefit and minimalized risk to patients, and it should ideally happen in a coordinated manner involving all stakeholders rather than being a sporadic one process driven only on one side by societal and/or market trends.

Challenges

Right now, directions administering wellbeing frameworks are ineffectively adjusted to fast mechanical changes. The way can clarify this that states continue gradually with regards to advancing their principles. Reference might be made, among others, to questions concerning the endorsement and confirmation of computerized advancements, permitting of between jurisdictional practices, and designation of assignments, remedy or repayment of some versatile applications, teleworking of clinicians just as compensation of tele-health exercises. For instance, the Food and Drug Administration (FDA) needs months by and large to approve the commercialization of another therapeutic innovation (FDA, 2017). A postpone that is never again adjusted to new advanced innovations that may end up being outdated following 2 or 3 years. These circumstances could be clarified by the way that the administrative organizations are utilized to homologate "solid" therapeutic gadgets with all around characterized effects; something that the mind complex interconnections identified with new computerized advancements make practically challenging to foresee (FDA, 2017).

2.4 Methodologies for Analysis of E-Health Behaviour

There are various forms behavioural analysis techniques such as behavioural informatics, regression analysis, social network analysis, discrete event simulation and system dynamics modelling. However, in this research the focus is on techniques used in e-health behaviour analysis such as behavioural informatics, regression models and system dynamics models.

2.4.1 Behavioral informatics

Behavioral informatics refers to the study of the use of technologies by patients and health care providers as well patients and health care providers as well as the design, implementation, and implementation, and evaluation of behavior change evaluation of behavior change interventions delivered through advanced interventions delivered through advanced technologies (Gagnon & Scott, 2005). Behavioural Informatics (BI) entails the following key steps:

Behavioral data

In planning conduct information, social components covered up or scattered in exchange information should be removed and associated, and further changed over and mapped into a conduct arranged element space, or conduct highlight space. In the conduct highlight space, social components are introduced in conduct thing sets (Catwell & Sheikh, 2012).

Behavioral representation and modelling

The aim is to create conduct situated details for depicting social components and the connections among the components (Longbing Cao, 2012). The details reshape the social components to suit the introduction and development of conduct arrangements. Social displaying likewise gives a bound together system to portraying and exhibiting conduct components, conduct effect and examples.

Behavioral impact analysis

For analysis of social information, we are especially inspired by those conduct occasions that are related with highly affecting business forms and additionally results. Social effect investigation includes the displaying of conduct sway (Gagnon & Scott, 2012).

Behavioral pattern analysis

There are two different ways of directing personal conduct standard investigation. One is to find standards of conduct without the thought of social effect the other is to break down the connection sends between conduct successions and specific sorts of effect (Kasiri, Adachi & Kojera, 2012).

Behavioral intelligence emergence

To comprehend social effect and examples, it is essential to investigate conduct events, advancement and life cycles, just as the effect of specific social principles and examples on social development and knowledge rise (for example, the rise of swarm insight from a gathering of intuitive operators (Longbing Cao, 2012). A significant assignment in social displaying is to characterize and demonstrate conduct principles, conventions and connections, and their effect on social advancement and knowledge rise.

2.4.2 Regression analysis/ modelling

The regression model is a factual strategy that enables a specialist to assess the direct, or straight line, relationship that relates at least two factors. This straight relationship bridges the measure of progress in one variable that is related with change in another variable or factors. (Kasiri, Adachi

& Kojera, 2012).The model can likewise be tried for measurable hugeness, to test whether the watched direct relationship could have risen by some coincidence or not. In this area, the two variable straight relapse model is talked about. This strategy is utilized for anticipating, time arrangement displaying and finding the causal impact connection between the factors.

Linear regression

In this procedure, the reliant variable is ceaseless, autonomous variable(s) can be nonstop or discrete, and nature of relapse line is straight. (Kasiri, Adachi & Kojera, 2012).

Direct Regression sets up a connection between ward variable (Y) and at least one autonomous factors (X) utilizing a best fit straight line (otherwise called relapse line).

It is spoken to by a condition Y=a + b*X + e, where a is capture, b is incline of the line and e is mistake term. This condition can be utilized to foresee the estimation of objective variable dependent on given indicator variable(s).

Logistic regression

Calculated relapse is utilized to discover the likelihood of even t= Success and event = Failure. We should utilize strategic relapse when the reliant variable is twofold (0/1, True/False, Yes/No) in nature. Since we are working here with a binomial circulation (subordinate variable), we have to pick a connection work which is most appropriate for this dispersion. Furthermore, it is rationale work (Gagnon & Scott, 2012). In the condition over, the parameters are picked to boost the probability of watching the example esteems instead of limiting the total of squared blunders (like in normal relapse).

Polynomial regression

A relapse condition is a polynomial relapse condition if the intensity of autonomous variable is multiple (Gagnon & Scott, 2012). In this relapse procedure, the best fit line is certifiably not a straight line. It is somewhat a bend that fits into the information focuses.

Stepwise regression

This type of relapse is utilized when we manage different autonomous factors. In this procedure, the choice of free factors is finished with the assistance of a programmed procedure, which includes no human mediation (Longbing Cao, 2012).

This accomplishment is accomplished by watching measurable qualities like R-square, t-details and AIC metric to observe huge factors. Stepwise relapse essentially fits the relapse model by including/dropping co-variations each one in turn dependent on a predefined paradigm.

Ridge regression

Ridge Regression is a procedure utilized when the information experiences multicollinearity (autonomous factors are exceedingly associated (Dale 2018). In multicollinearity, despite the fact that the least squares gauges (OLS) are unprejudiced, their changes are enormous which veers off the watched an incentive a long way from the genuine worth. By adding a level of inclination to the relapse gauges, edge relapse lessens the standard mistakes.

Lasso Regression

Lasso (Least Absolute Shrinkage and Selection Operator) additionally punishes indisputably the size of the relapse coefficients. Likewise, it is equipped for decreasing the changeability and improving the precision of straight relapse models. Take a gander at the condition beneath: Lasso relapse varies from edge relapse such that it utilizes supreme qualities in the punishment work, rather than squares (Dale, 2018). This prompts punishing (or proportionally obliging the whole of the total estimations of the appraisals) values which causes a portion of the parameter assessments to turn out precisely zero. Bigger the punishment connected, further the assessments get contracted towards supreme zero. This outcomes to variable choice out of given n factors.

Elastic lapse regression

Versatile Net is mixture of Lasso and Ridge Regression strategies. It is prepared with L1 and L2 earlier as regularised. Flexible net is valuable when there are numerous highlights which are correspond (Dale, 2008). Tether is probably going to pick one of these aimlessly, while flexible net is probably going to pick both.

2.4.3 System dynamics model

Dynamic hypothesis

In order to develop the cervical cancer management process, the model boundaries, the key processes and sub-systems were identified. The key players and their roles were also enumerated. These were then synthesized and presented in a high level Dynamic Hypothesis map. The dynamic hypothesis is a synthesis of the insight that a modeler has towards the problem of study. It is dynamical in the sense that the systems behaviour changes over time and the hypothesis itself will

change continuously during the simulation. Hence it is also called transient hypothesis (Raimo Keroharju n.d.). According to the (Sterman, 2000), the generation of Dynamic hypothesis comprises of three major steps which are;

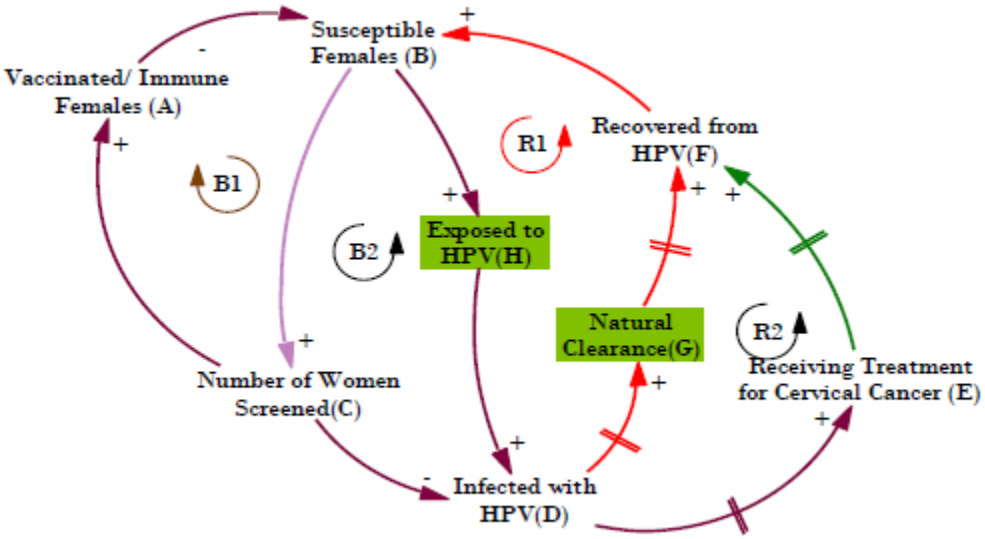


Figure 2-1: Dynamic hypothesis of cervical cancer vaccination

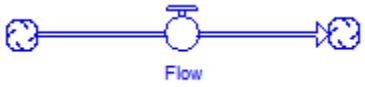
The dynamic hypothesis has two balancing loops (HPV vaccination and Screening)
And two reinforcing loops (Exposure to HPV loop and HPV recovery loop).

Methods

A system dynamics model was developed using Stella software package. The three basic elements namely stock, flow and converter.

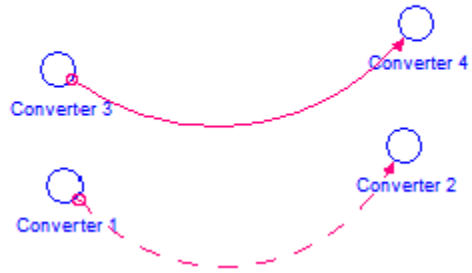
A stock represented as a rectangular shape is a generic symbol for an anything that accumulates or drains. Stocks can represent a physical entity such as number/ population of women or non-physical entity such as quality of care (Fone, 2003). Stock values depend on the systems past behaviour, hence survival of system depends on the stock.

Flow. The flow represent the rate at which the stock is changing at any given instant, they either flow into a stock (causing it to increase) or flow out of a stock (causing it to decrease) (Fone, 2003). They provide the dynamics of the system



Converter. They hold values of constants and defined external inputs. They represent the decision process in the system.

Connector(s). The connectors are curved lines that connect model elements. There are two particular sorts of connector: the activity connector and the data connector. Activity connectors are meant by a strong, coordinated line Information connectors are implied by a dashed line. Connectors show how parts of a framework impact one another.



Balancing Loop B1 (Vaccination Loop).

The aim of the vaccination loop is to reduce the number of females susceptible to HPV infection. The model assumes that once vaccinated, life time immunity is accrued HPV can be given prior to susceptibility (Primary Vaccination) or to susceptible groups (Secondary/Catch up Vaccination). This model assumes that once Primary Vaccination is given, then there is no need of Secondary/catch up vaccination. Therefore the higher the coverage rate of primary vaccination, the lower the required number of secondary vaccination. Both primary and secondary vaccinations lower the number of females susceptible to HPV infection. The dynamics involved in the uptake of HPV vaccine are discussed later.

Balancing Loop B2 (Screening Loop)

Screening aims at early detection, diagnosis and treatment of HPV infection and cervical cancer at the earliest opportunity (Fone, 2003). Women who are susceptible to HPV infection are eligible for screening. The higher the number of susceptible women, the more the demand on screening services. However only exposed women are infected with HPV vaccine. Exposure to HPV depends on a number of factors which are discussed later in this chapter. The more the number of women are screened, the higher the probability of HPV infection detection. This model assumes that once a female is screened for HPV and is found NOT to be infected then, she is offered secondary /catch up vaccination. If she is found to have HPV infection, then treatment options are availed. Screening therefore further increases the demand for both secondary vaccination and treatment for cervical cancer.

As the number of susceptible women increase, there is an increase in the demand and number of screened women. This leads to early detection of HPV infection and an opportunity for health education on HPV infection. With time, these interventions reduce the number of women infected with HPV.

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As the number of susceptible women increase, there is an increase in the demand and number of screened women. This leads to early detection of HPV infection and an opportunity for health education on HPV infection. With time, these interventions reduce the number of women infected with HPV.

Reinforcing Loop 1 (Exposure to HPV Loop)

It is noted that the higher the number of women exposed to HPV infection, the higher the number of Women infected with HPV (Fone, 2003), this translated to a higher number of women undergoing natural clearance of HPV as well as an increase in the number of women undergoing treatment for cervical cancer.

It is also noted that HPV infection could clear naturally due to biological mediating factors. The number of women whose HPV infection clears naturally or through treatment are however still susceptible to HPV infection as previous HPV infection does not offer natural immunity. Hence these groups of women, whose bodies undergo natural clearance of HPV, reduce the number of women with HPV infection but also increase the number of women susceptible to HPV infection. At the same time, the females found to have cervical cancer are subjected to appropriate treatment. This is a assuming an effective health care system. The treatment methods availed depends on the stage of the cervical cancer among other health systems factors.

HPV infection as well as the number of deaths occurring as a result of cervical cancer and its complications. The women cured from HPV/ cervical cancer are still susceptible to HPV infection and hence this group though a small number increases the number of females susceptible to HPV infection (Fone, 2003).

It is noted that infected females who do not benefit from medical interventions, die from cervical cancer. The death of these females may occur earlier than among those who benefit from treatment interventions.

A certain group of susceptible females, who get infected and do not undergo screening, also contribute to the total death s as a result of cervical cancer.

2.4.3.1 Why Systems Dynamics for the research

Framework elements strategy is most appropriate to issues related with persistent procedures where input essentially influences the conduct of a framework, delivering dynamic changes in framework behaviour (Sweetser 1999). Disease the board is a dynamic procedure because of the accompanying reasons;

1. There are different parties involved with differing notions
2. It is dynamic with unpredictable changes in relation to time and magnitude

3. Constant feedback where by a change in one subsystem will result into a change in the next subsystem e.g. an increase in number of primary vaccination will result to a decrease in screening demands.
4. It has tightly coupled as actors in the management system strongly interact with each other. For example, Vaccine Manufacturers must interact with funding agencies and government which in turn must interact with health service providers.
5. Cervical cancer management is non –linear. Effects are rarely proportional to cause. For example, an increase in health education and coverage does not necessary result to proportional demand for cervical cancer vaccination and screening.
6. Policy resistance also exit, whereby obvious interventions do not necessarily result to solutions. For example, an increase in availability of vaccine does not result to an increase in the number of vaccinated women. In fact vaccination coverage could increase in the short term and decrease thereafter due to un-intended effects.
7. Management of cervical cancer is characterised by time delays and trade-offs. A decrease in the primary vaccination coverage may have an increase in HPV incidences and prevalence in the future.

Because Cervical Cancer system is complex and experimentation of the systems is impossible, computer simulation becomes a realistic study method (Fone, 2003).

2.5 Conceptual framework

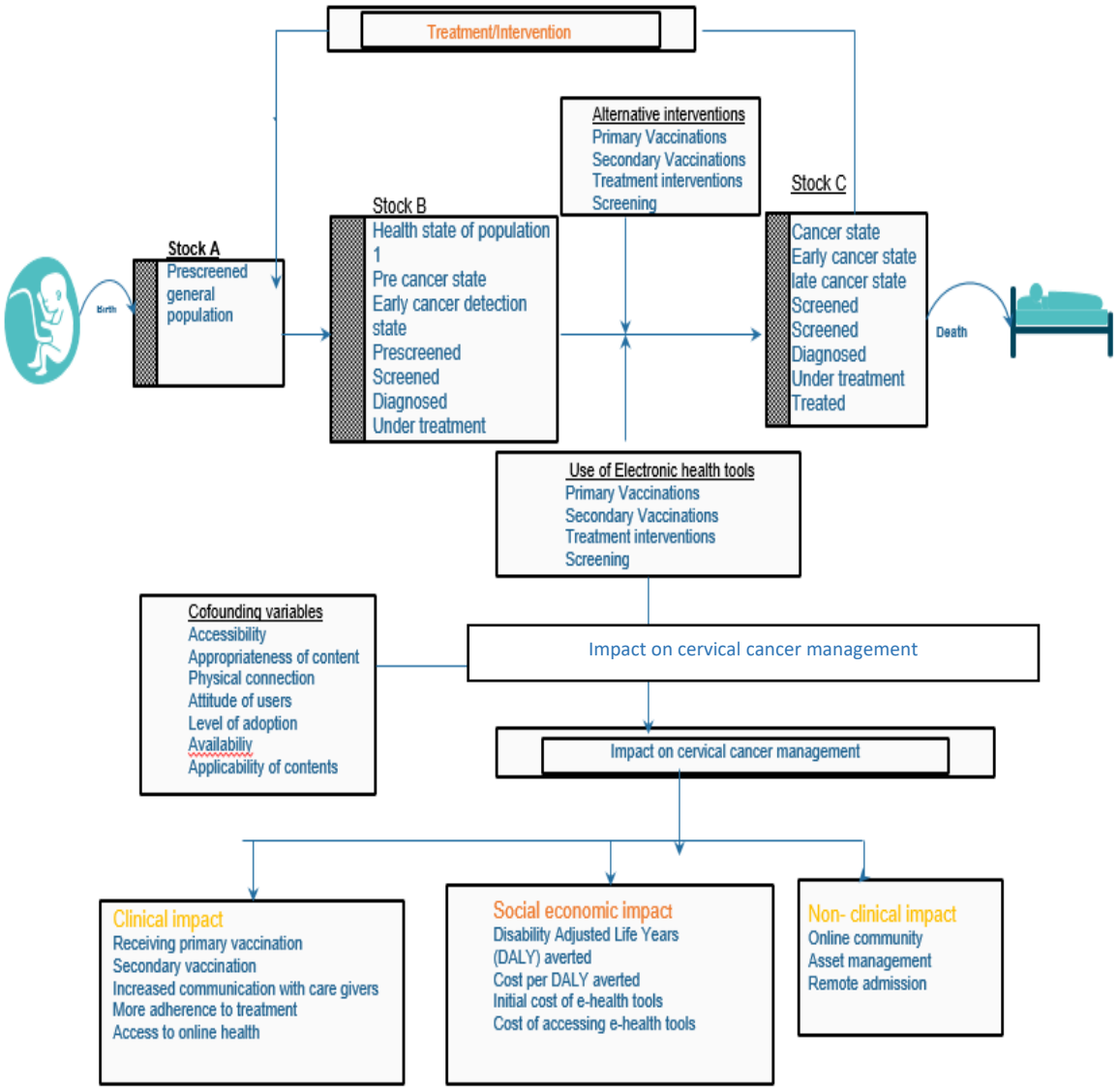


Figure 2-2: Conceptual framework of cervical cancer vaccination

2.6 Summary

Computer based Cancer management decision making model have been used to produce individualized, rational, clinically appropriate disease management decisions without physicians‟ bias. It has been used to model Cancer behaviour, predicting tumour growth and guiding treatment options (Gatenby et al. 2006). Even though these mathematical models may not be able to predict the invasiveness of Cancer cell, they can predict the size of the tumour in a given period of time.

In spite of all the above advances being used of re-enactment in cervical malignant growth the board no benchmark exists against which a model can be assessed in deciding neither the best attack of parameters nor portrayal of infection process (Kim et al. 2007). In the meantime hardly any, model concentrated on Kenya as a creating nation or displayed the effect of e-wellbeing apparatuses on patterns of Cervical Cancer. The accompanying area consequently takes a gander at the effect of utilization of e-wellbeing instruments in cervical malignant growth the executives prompting conjectured increment in usage of e-wellbeing devices in cervical disease the board in Kenya.

Advanced e-health could be the cornerstone of a fruitful change of therapeutic services frameworks for enhanced productivity and viability to support the general population. However, one condition for enhancing the capability of ICTs may likewise be to surrender various practices and models of administration, regularly set apart by disciplinary, corporate and authoritative storehouses just as laws and controls that are never again tuned in to the truth. Well-being frameworks should, as a result of their social duty, be on-screen characters (and not onlookers) of the progressing digital transformation. If this mechanical move is missed, the rise of parallel wellbeing frameworks, borne by new performing artists, is inescapable. This research seeks to assess the socio-economic and clinical impact of using e-health tools in Cervical Cancer vaccination in Kenya.

CHAPTER THREE
METHODOLOGY

3.1 Introduction

This chapter will discuss the methodology that was be used in obtaining and analyzing data, and reporting the results of the study objectives. This section will describe the research design, the system dynamics problem solving methodology, data collection procedure of the research study.

3.2 Research Design

The overall approach to this research was System Dynamics (SD) simulation modelling. SD is a methodology of mapping and then modelling the forces of change in any dynamically complex system so that their influences on one another can be better understood and overall direction of the system can be better governed. According to Milsten and Homer (2006), SD should answer five key questions;

- What aspects of a system's behaviour are of concern?
- Why are those features changing in those ways at those times?
- Where is the system headed, if no new action is taken?
- How else can the system behave, if different decisions are made?

Who has the power to move the system in a more desirable direction? Different researchers have proposed a number of SD approaches. Structured approach to System Dynamics approach by Wolstenholme (Wolstenholme 1990) , SD analysis by (Coyle 1996) the Dynamic Synthesis Methodology(DSM) by(Williams 2002) and Managing from Clarity Methodology(MCM), which combines SD and systems thinking by (Ritchie-Dunham & Rabbino 2001) , the health Systems Dynamics Framework by Marchal et al. (2012) among others. Though with a few variations, these methodologies describe a four to five stage approach emphasising on Problem description, casual

loop/ qualitative analysis, construction of SD model and Policy testing except (Williams 2002) who came up with six stages which included case study stage.

The advantages of SD methodology have been documented elsewhere. These include enabling a deeper understanding of the system, comprehension of complex systems, variation of policies via simulation, inclusion of linear and non-linear relationships, incorporation of time delays and soft behavioural relationships as well as understanding management strategies from systems approach to organizations (Cavana & Maani 2000)(Williams 2002) (Ritchie-Dunham & Rabbino 2001). An analysis of the enumerated SD methods are as stipulated in the table below:

Table 3.1: Comparison of approaches to system dynamics methodologies

Approaches to the research	Wolstenholme (1990)	Coyle (1996)	Williams (2002)	Ritchie-Dunham and Rabbino (2001)
Problem Definition	✓	✓	✓	✓
Qualitative Analysis	✓	✓	✓	✓
Model Building	✓	✓	✓	✓
Case studies	✗	✗	✓	✗
Simulation experiments	✓	✓	✓	✓
Policy analysis	✓	✓	✓	✓
Implementation	✓	✓	✓	✓

This study focused on management of cervical cancer in Kenya. Hence it was viewed as a case study and finding of various branches of science was fused into a holistic and coherent view. For this reason, a powerful Dynamic Synthesis Methodology (DSM) developed by D. W. Williams is the research approach used.

The Dynamic Synthesis Methodology (DSM) methodology was used in the research due to the following reasons:

- Requirements are very well known
- Product definition is stable
- As a problem-solving methodology it captures both the quantitative and qualitative research approaches.
- Problem-solving modelling techniques have been used to develop models of both natural and social science problems.
- Technology is well understood
- The approach combines both system dynamic modelling and case studies

The specific steps conducted during the research are outlined below:

3.2.1 Understanding of a System

The displaying procedure "starts and finishes with understandings of a framework and its issues" (Richardson and Pugh, 1981: pp 16). The procedure involved an iterative and non-direct and expanded comprehension in itself builds our comprehension of the current issue.

3.2.2 Problem Definition

This entailed the definition of the question to be addressed. Description of the time development of interest the reference mode and definition of the time horizon and the range of time constants in the model. Verbal description of the feedback loops that were assumed to have caused the reference mode.

3.2.3 System Conceptualization

This stage included the procedure of advancement and elucidation of ideas around the elements model clearing up the ideas with words and precedents and landing at exact verbal definitions. The conceptualization organize builds up the focal point of the examination, the general viewpoint and the time horizon.

3.2.4 Model Formulation

This stage involved hypothesis of itemized structure-choosing levels, choosing rates and portraying their determinants. Selection of parameter values. Testing of the dynamic hypothesis. Simulation.

This stage of the problem solving methodology involved experimentation with the models to obtain data on the behaviour of the system being modelled.

3.2.5 Policy Analysis

Revaluation and investigation of the plan, reception, and usage of a guideline or strategy planned to improve monetary, social, or other open issues. Approach examination is concerned basically with arrangement choices that are relied upon to deliver novel answers for the framework elements.

3.2.6 Implementation

The last stage included testing of model conduct and affectability to irritations testing the reaction to various arrangements. Recognizable proof of potential clients. Interpretation of study experiences to an available structure and dispersion.

The research design framework used is as illustrated below:

Table 3.2: Research design framework

Stage 1: Problem Statement	
Aim/ Objectives	**Activities**
1. Identifying parameters 2. State expected relationship between variables 3. Identify stake holders 4. Develop dynamic hypothesis	1. Literature review 2. Preliminary interviews 3. Review of documents

Stage 2: Field study	
Aim/ Objectives	**Activities**
1. Gain deeper understanding of key insights, concern, challenges and opportunities 2. Develop a descriptive model	1. Base line on use of e-health tools 2. Interviews with key informants/cervical cancer managers 3. Qualitative study/gather views from experienced people

Stage 3: System dynamics model building	
Aim/ Objectives	**Activities**
1. Construct, Test and Debug the model 2. Testing and validation	1. Develop systems map 2. Develop causal loops diagram 3. Convert causal loops to stocks and flow diagram 4. Simulation runs

Stage 4: Case Study	
Aim/ Objectives	**Activities**
1. Validate the model 2. Test for validity and reliability	1. Input empirical data into the SD

Stage 5: System dynamics model building	
Aim/ Objectives	**Activities**
1. Construct, Test and Debug the model 2. Testing and validation	1. Develop systems map 2. Develop causal loops diagram 3. Convert causal loops to stocks and flow diagram 4. Simulation runs

Stage 6: Simulation Experiments	
Aim/ Objectives	**Activities**
1. Scenario planning and modelling 2. Implementation and organizational learning	1. Construct and simulation various scenarios 2. Use trial and error methods to demonstrate impact of policy 3. Build credibility

Stage 7: Collaborative methodologies

Aim/ Objectives	Activities
1.Develop the model	1. Quantify impact of the scenarios

3.3 Target Population

The research considered two population groups consisting of cancer care centres in Nairobi and people of susceptible to cervical cancer in Kenya. The target population for the study setting conducted in selected cancer care centres mostly because the aim of the study is capturing the dynamics involved in cervical cancer vaccination management. The target source for primary data will be from the cancer care centres within the Nairobi Kenya.

3.4 Sampling and Sampling Procedure

Different methods and approaches of sample size determination exist but there is no agreement on what the minimum sample size should be (Hailu, 2012). This research study employed random sampling formula by (Singh and Masuku, 2014) to calculate the sample size as follows:

$$\mathbf{n} = \frac{\boldsymbol{N}}{\mathbf{1} + \boldsymbol{N}(\boldsymbol{e})^{\mathbf{2}}}$$

Where n is the sample size, N is the total population size and e is the level of precision (sampling error).In the research the sampling for the research consisted of a list of all cervical cancer patients who underwent cancer treatment between January 2018 and December 2018 according to the National Cancer registry of Kenya. The random sampling method was used to draw data on 838 patients using a table of random numbers.

3.5 Research Instrument

A close ended questionnaire (Appendix D) was used to record the relevant information. The closed ended questionnaire was structured to record the following information according to the specific objectives:

i. Cervical cancer care centre

ii. Years of experience in cancer care

iii. Challenges faced in cervical cancer management

iv. Effects of e-health systems

Software tools

— System dynamics tool –Stella by i Think

— Data analytics tool – Weka

— Graphs – Power BI

3.6 Validity and Reliability of the Instrument

The validity and reliability of the close ended questionnaire as a method of collecting primary data for the research was ensured by doing the following:

- Ensuring it was cost effective by reduction of travel costs.
- I shared the google form questionnaires with a wide coverage

3.7 Data collection procedure

This part outlines the method that was used to collect data.

- **Document review**

A review of the documentation of systems in the medical field was carried out in order to gather information for the functional and non-functional requirements of the model

- **Postage of questionnaires**

A questionnaire in form of a google form was shared with various focus group discussions consisting of interviews of people who are medical practitioners or cancer care givers who have interacted with the later and ask them about their perceptions, opinions, beliefs, and attitudes towards the disease, factors causing and affecting it. The analysis of respondents helped to give a firm foundation to the functional and non- functional requirements for the system dynamics.

- **Secondary data from the National Cancer Registry of Kenya**

I visited the National Cancer Registry of Kenya and shared with them the concept of my research. They proceeded to avail to me data collected by them in the year 2018 and some of the previously prepared Kenya Cancer reports. Due to the sensitive nature of the research the data provided was sufficient to conduct the research. However, for ethical considerations it did not contain bio data.

3.8 Data processing and analysis

The data analysis method applied for this study comprises of both qualitative and quantitative methods. Quantitative method was used with a view to properly address the research questions and qualitative analysis was applied in analysis of the google form questionnaires. The data collected via questionnaires was analysed via descriptive statistics and represented in charts and tables using the Power Bi analysis software.

For modelling the dynamics synthesis the tool Stella by i think was used. A macro-Level population based SD model was developed using Stella software to enable Simulation of Cancer of Cervix topography and impact of different management interventions in Kenya. Primary data generated was used to calibrate the parameters thus identify information and knowledge gaps in the dynamic model. This data was used to further redefine the SD model.

3.9 Ethical considerations in data collection

Neumann (2003) clarifies that the term 'moral' is utilized to mean standard of direct that is typically viewed as exact, especially by individuals of a predetermined gathering or calling. Research exercises may incite moral issues concerning the privileges of respondents particularly the privilege of protection. I as the scientist got an educated assent regarding the respondents before he could issue them with polls. Moreover, I guaranteed that the respondents knew about the data required from them, the explanation behind looking for the data and its motivation. Obscurity and privacy of all members was kept up.

CHAPTER FOUR

DATA ANALYSIS, FINDINGS AND DISCUSSION

4.1 Introduction

This chapter provides the results of the statistical analysis ad interpretation of collected data. It states the findings and discussions of the four objectives of the research study.

4.2 Response Rate of Primary Data

A total of 21 respondents were filled out the questionnaires comprising of 8 doctors making up 29% treating various types of cancer and 13 nurses (61%) taking care of cancer patients and administering cervical cancer vaccines. The questionnaire response rate did not affect the study results as further inquiries did not yield any new findings. The sample size was adequate based recommended sample sizes in qualitative studies (Guest, 2006). The respondents were professionals in cancer care and vaccination with years of experience in the field. Google forms questionnaire were used to collect both qualitative and quantitative data from the cancer care health practioners on the use of e-health tools in obtaining information on Cervical Cancer.

Non participation in the questionnaire was mainly associated with large workloads with the critical patients. The respondent's bio data and distribution are as shown in the table below:

Table 4.1: Questionnaire respondent's statistics

Cancer care centre	No of practioners respondents
HCGCCK	4
Texas Cancer Center	4
Nairobi Hospital	6
Kenya Network of Cancer Organisation	1
Nairobi Radiotherapy And Cancer Centre	1
Texas Cancer Centre	4
Janice Medical and Cancer centre	1

The demographic data used to establish part of the findings of the second objective of the study comprised of a total of 102 respondents filled out the google forms questionnaires. They comprised

of 45 females and 57 males comprising of 44% and 56% respectively. The respondents' distribution and biographical characteristics are indicated in the table below:

Table 4.2: Gender of the respondents

Gender of the respondents		
	Frequency	Percent
Male	45	44%
Female	57	56%

4.3 Research Findings

4.3.1 Objective one Results

The first objective was to establish the challenges being faced in cervical cancer vaccination in Kenya. In order to fully meet this research objective, an open ended questionnaire (Appendix D) was used to record the relevant information from cancer care givers in different cancer care centres within Nairobi. The questionnaire responses had the following insights:

The highest number of respondents was from Nairobi Hospital. The respondents were aged between 26 years and 60 years, their years of experience in cancer care giving ranged from 10 years to 25 years. According to the respondents the biggest challenges facing cervical cancer management in Kenya are:

Table 4.3: Response of questionnaires

Response	**Percentage**
Lack of HPV vaccine awareness	50%
Lack of funding to issue vaccines to the general population	30%
Logistics planning on which areas in Kenya to conduct vaccination	20%

Based on the findings of the first questionnaire. A second google form questionnaire was issued to a random sample of the Nairobi public using the (Singh and Masuku, 2014) random sampling technique 102 respondents were drawn. Kothari (2004) stipulates that use of the questionnaire is one of the major ways to elicit self-reports on people's opinions, attitudes, beliefs and values.

The questionnaire (available at Appendix D) sought response on a number of cervical cancer and e-health systems perceptions. The results drawn out were as follows:

The respondents comprised of 44% male and 56% female. In regards to awareness of HPV Vaccine of the 102 respondents more females were aware about the vaccine than the men. As a combined aspect most people were not aware about the cervical cancer vaccine as stipulated in figure 4.1 below:

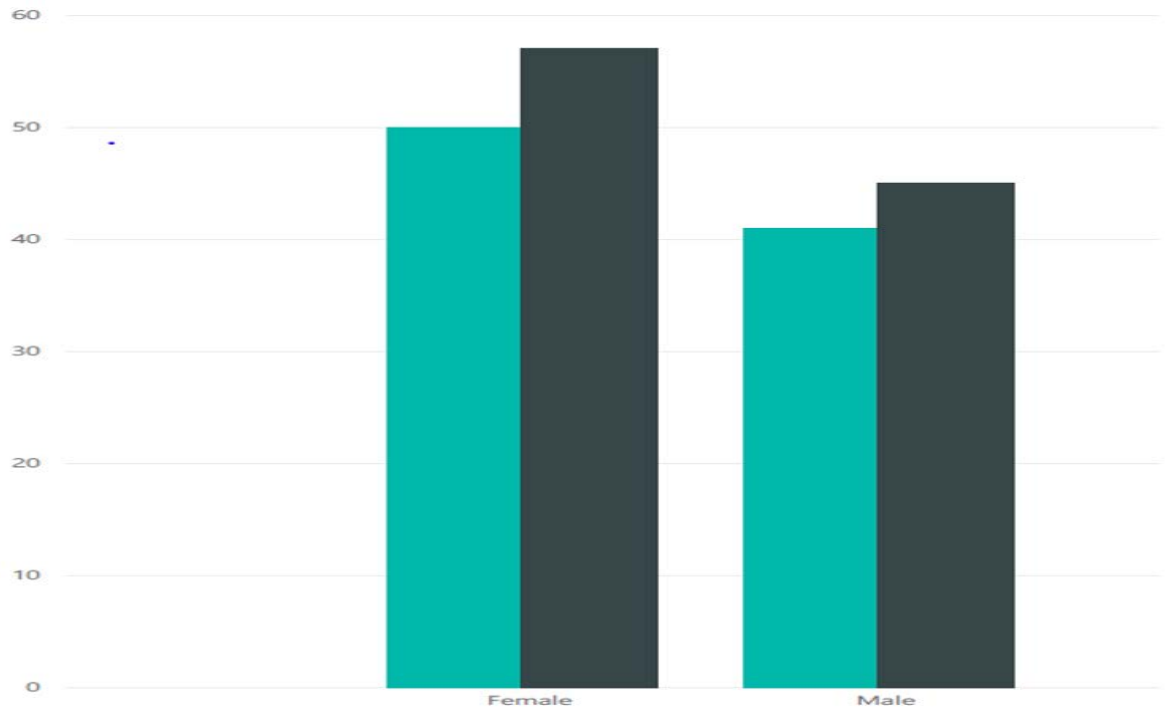


Figure 4-1: Most male and females in Kenya are not aware of the HPV Vaccine

In regards to electronic devices and their health a high percentage of the females said that they use them to browse for information on health issues they are facing. The male respondents however, opted to subscribe to health messages and reminders subscription services. As shown in figure 4.2 below:

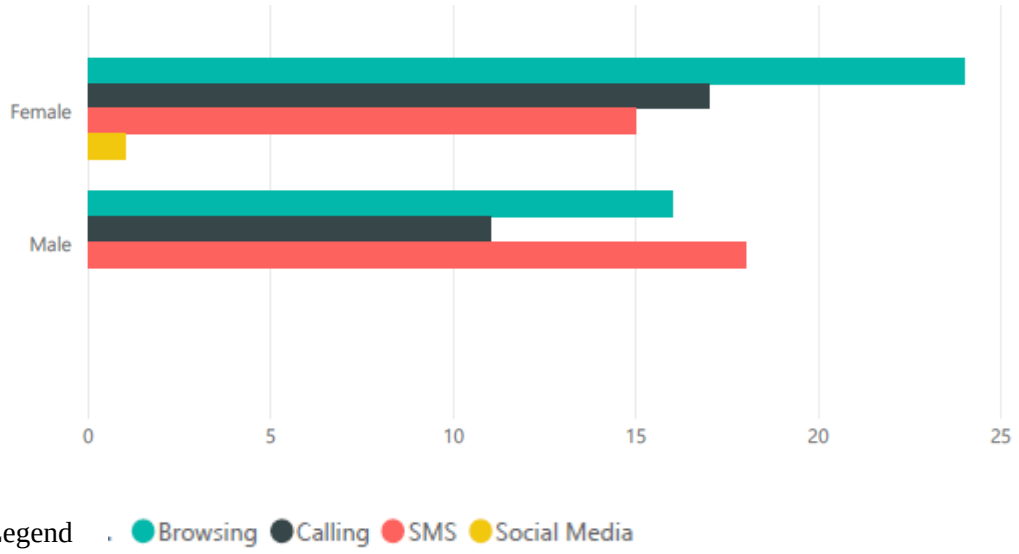


Figure 4-2: Use of electronic devices for health purposes by gender

4.3.2 Objective two Results

The second objective of the research is to develop a simulation model of establishing the clinical and socio-economic effects of using e-health systems in cervical cancer vaccination in Kenya. In order to fully satisfy this objective a simulation model of the cervical cancer management dynamics was created.

The model like all system dynamics models is formalized and underpinned by mathematical differential equations. The system dynamics model used the modelling principles in the formulation of equations in accordance with (Barlas, 2002).

a. Equations were designed with meaning where variable naming as well as parameters correspond to real world meanings.
b. Units of equation were checked for equivalency for dimensionality consistency with the units on both the right and left hand side.
c. Under extreme conditions, equations being tested must yield valid results
d. The model was designed to provide realistic description of the real processes where the major focus of the model formulation was the realism and not the mathematical exactness

4.3.2.1 The simulation model of the impact of e-health on cervical cancer vaccination

Based on previously done studies the following casual loop diagram was used a guide for the model variables. The diagram below depicts the casual loop diagram for the demand of cervical cancer vaccination.

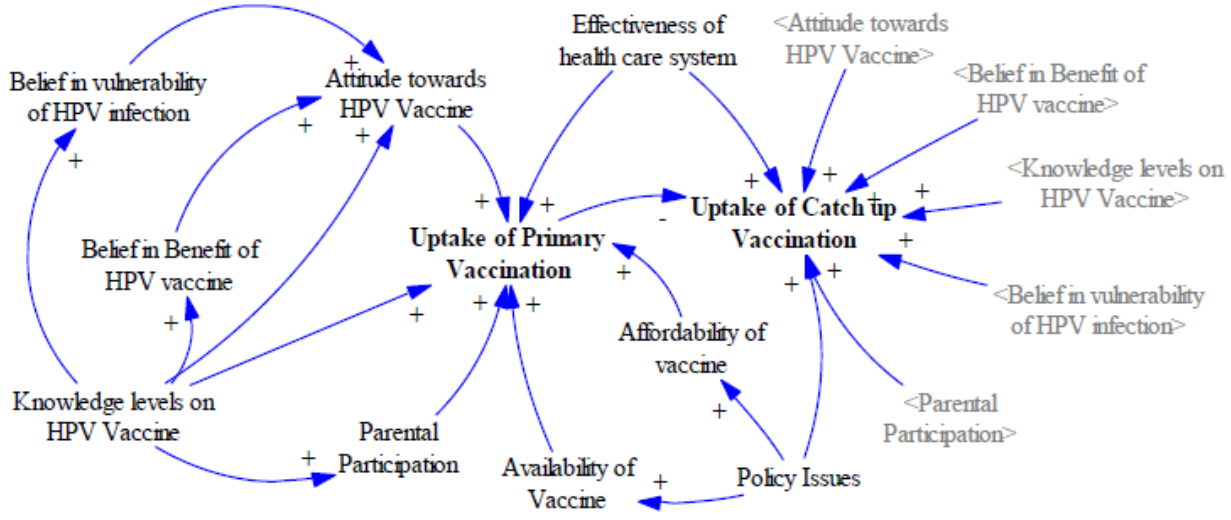
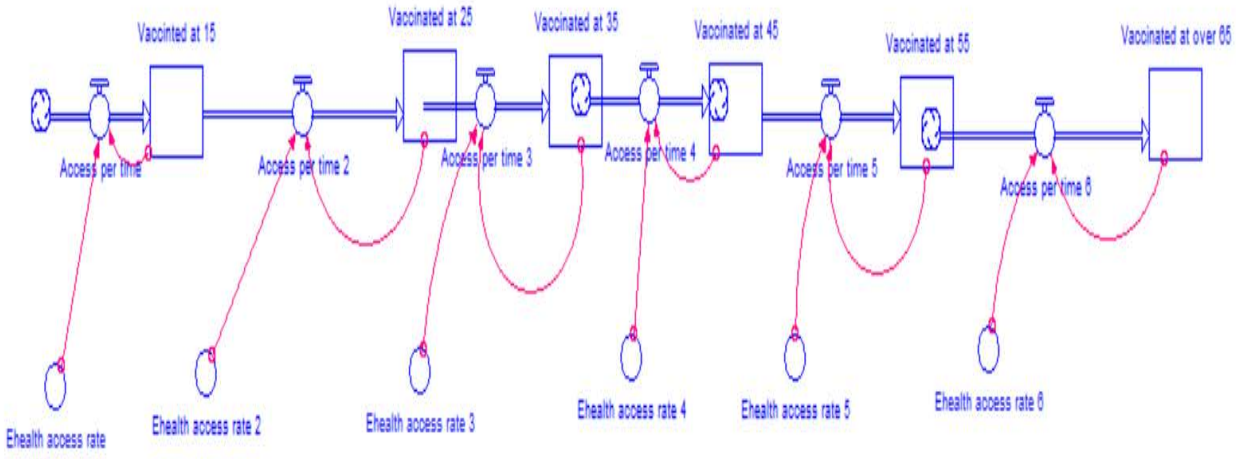


Figure 4-3: Casual loop diagram for demand of HPV Vaccine

Schematic diagram of the system dynamic model of the impact on cervical cancer vaccination due at varying e-health access rate. The impact is monitored on two variables, vaccination at different



stages and the access rate to e-health systems at that stage in life. A run of the model shows clearly demonstrated in the Figure 4.4 below:

Figure 4-4: A Stella generated sschematic diagram of the impact e-health access on Vaccination

Model computational equations

*Vaccinated_at_25(t) = Vaccinated_at_25(t - dt) + (Access_per_time_2) * dtINIT Vaccinated_at_25 = 803894*

INFLOWS:

*Access_per_time_2 = Vaccinated_at_25*Ehealth_access_rate_2{people/time}*

*Vaccinated_at_35(t) = Vaccinated_at_35(t - dt) + (Access_per_time_3) * dtINIT Vaccinated_at_35 = 803894*

INFLOWS:

*Access_per_time_3 = Vaccinated_at_35*Ehealth_access_rate_3{people/time}*

*Vaccinated_at_45(t) = Vaccinated_at_45(t - dt) + (- Access_per_time_5) * dtINIT Vaccinated_at_45 = 381873*

OUTFLOWS:

*Access_per_time_5 = Vaccinated_at_55*Ehealth_access_rate_5{people/time}*

*Vaccinated_at_55(t) = Vaccinated_at_55(t - dt) + (Access_per_time_5) * dtINIT Vaccinated_at_55 = 181749*

INFLOWS:

*Access_per_time_5 = Vaccinated_at_55*Ehealth_access_rate_5{people/time}*

*Vaccinated_at_over_65(t) = Vaccinated_at_over_65(t - dt) + (Access_per_time_6) * dtINIT Vaccinated_at_over_65 = 59265*

INFLOWS:

*Access_per_time_6 = Vaccinated_at_over_65*Ehealth_access_rate_6{people/time}*

*Vaccinted_at_15(t) = Vaccinted_at_15(t - dt) + (Access_per_time - Access_per_time_2) * dtINIT Vaccinted_at_15 = 700600*

INFLOWS:

*Access_per_time = Vaccinted_at_15*Ehealth_access_rate {people/time}*

OUTFLOWS:

*Access_per_time_2 = Vaccinated_at_25*Ehealth_access_rate_2{people/time}*

UNATTACHED:

*Access_per_time_4 = Vaccinated_at_45*Ehealth_access_rate_4 {people/time}*

Ehealth_access_rate = 36/100 {people/people/time}

Ehealth_access_rate_2 = 36/100 {people/people/time}

Ehealth_access_rate_3 = 36/100 {people/people/time}

Ehealth_access_rate_4 = 36/100 {people/people/time}

Ehealth_access_rate_5 = 36/100 {people/people/time}

Ehealth_access_rate_6 = 36/100 {people/people/time}

Running model results of impact on vaccination at different age brackets

Vaccination at 15

It is apparent from the model that the number of females being vaccinated against cervical cancer reduces evenly over time until it reaches a constant level. Based on the e-health access rate equations of the model this because number of young girls who have access to e-health systems at this stage is fewer. This is depicted in figure 4.5 below of the model run Stella output.

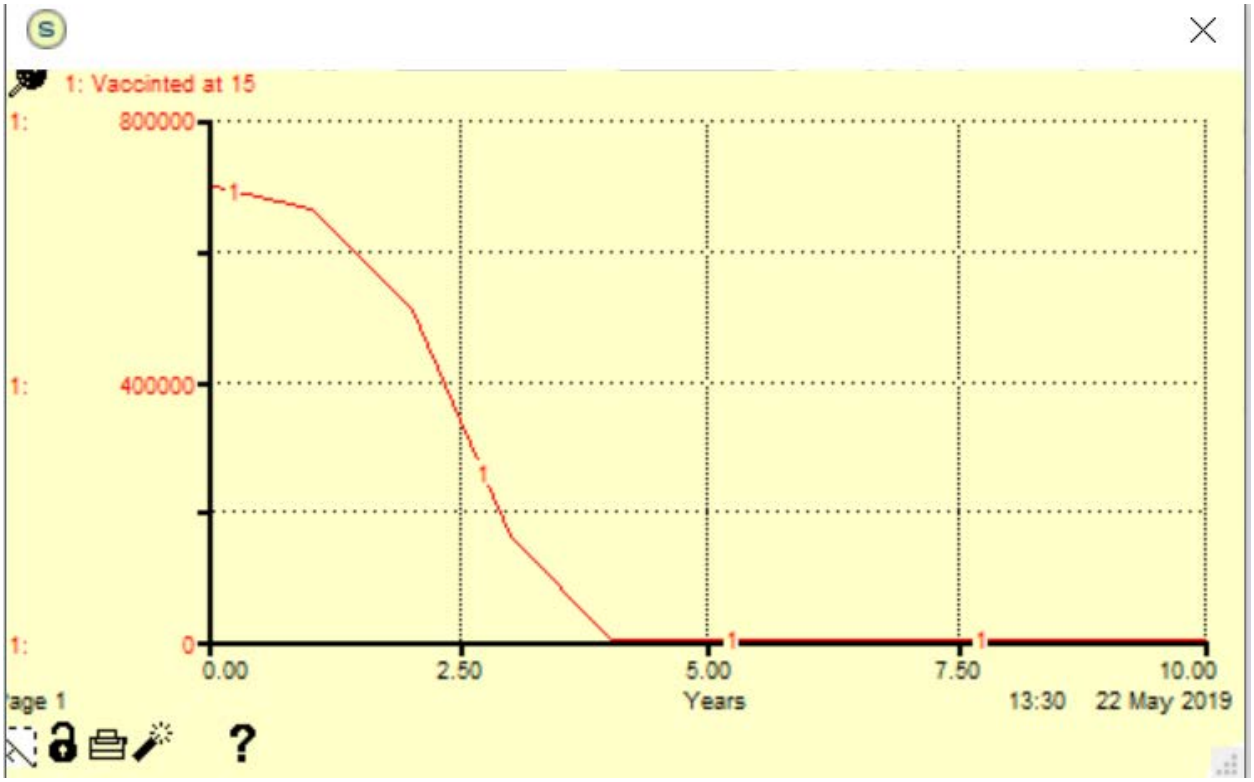


Figure 4-5: Vaccinated at age 15 reduces over time

Vaccination at 35

It can be deduced from the model that the number of females being vaccinated against cervical cancer increases steadily over time until it reaches a constant level. Based on the ehealth access rate equations of the model this because number of women who have access to e-health systems at this stage is more. This is depicted in figure 4.6 below of the model run Stella output.

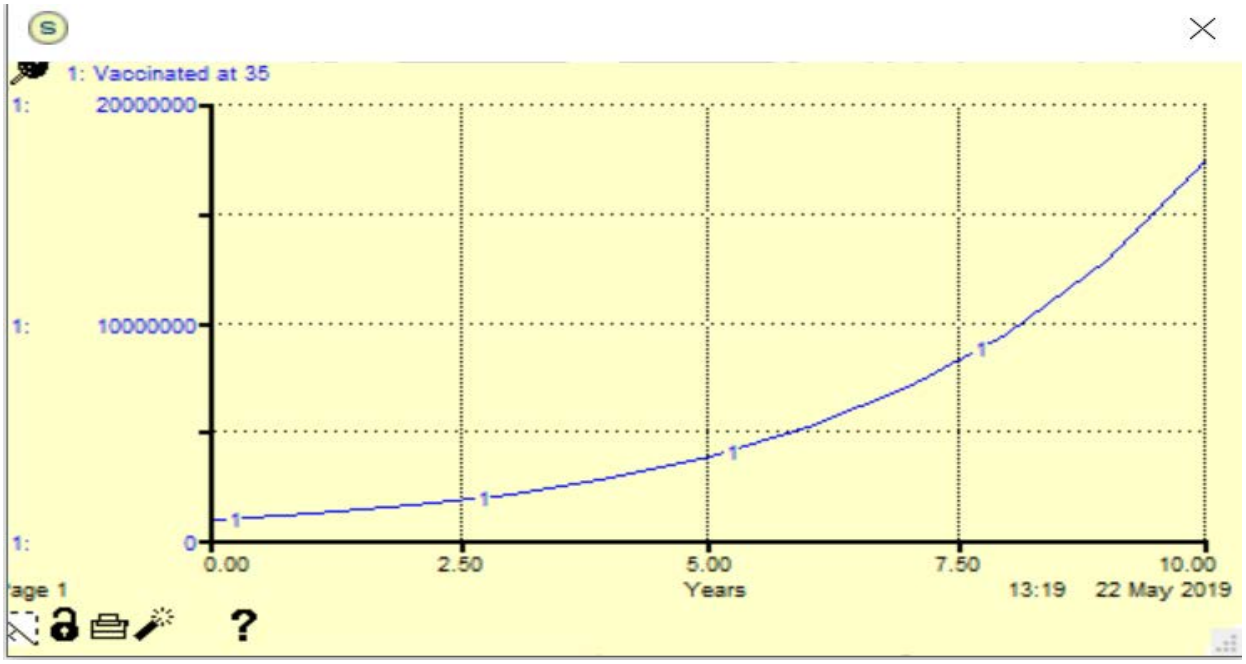


Figure 4-6: Vaccinated at age 35 increases over time

Vaccination at 45

According to the model the number of females being vaccinated against cervical cancer reduces steadily over time until it reaches a constant level. Based on the ehealth access rate equations of the model this because number of women who have access to e-health systems at age 45 is less. This is depicted in figure 4.7 below of the model run Stella output.

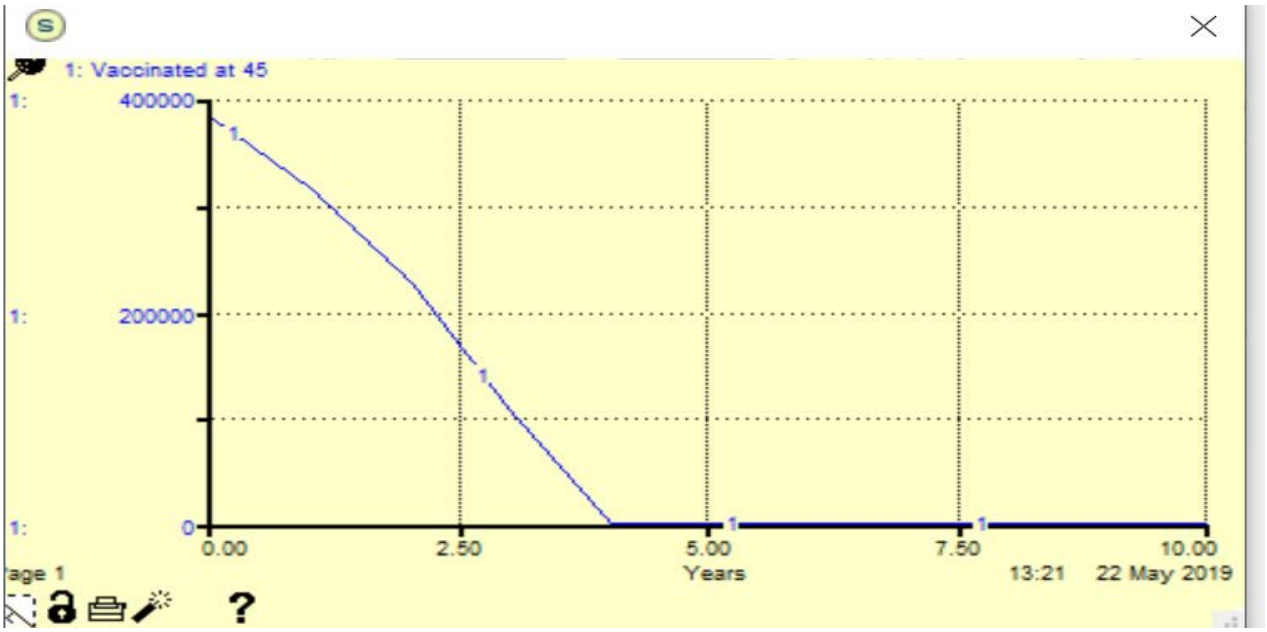


Figure 4-7: Vaccinated at 45

Vaccination at 55

It is apparent from the model that the number of females being vaccinated against cervical cancer increases evenly over time. Based on the e-health access rate equations of the model this because number of women who have access to e-health systems at this age is has also been increasing. This is demonstrated in figure 4.8 below of the model run Stella output.

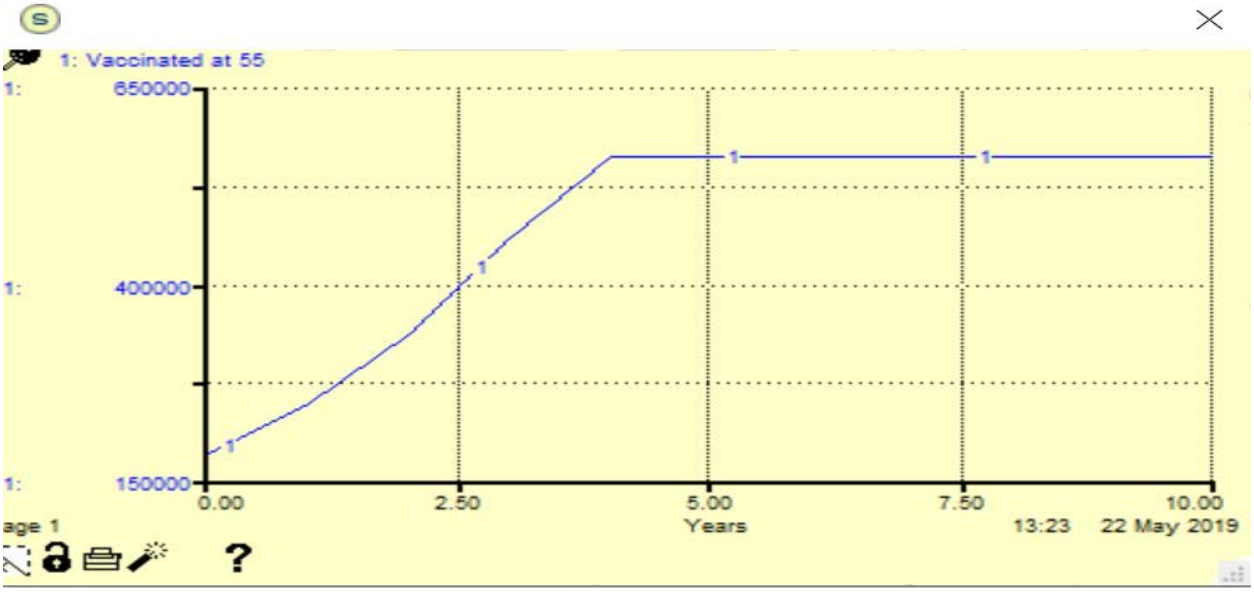


Figure 4-8: Vaccinated at 55

Vaccination at 65

It can be deduced from the model that the number of females being vaccinated against cervical cancer increases steadily over time until it reaches a constant level. Based on the e-health access rate equations of the model this is because rate at which women at this age can access e-health systems has been increasing over time. This is depicted in figure 4.9 below of the model run Stella output.

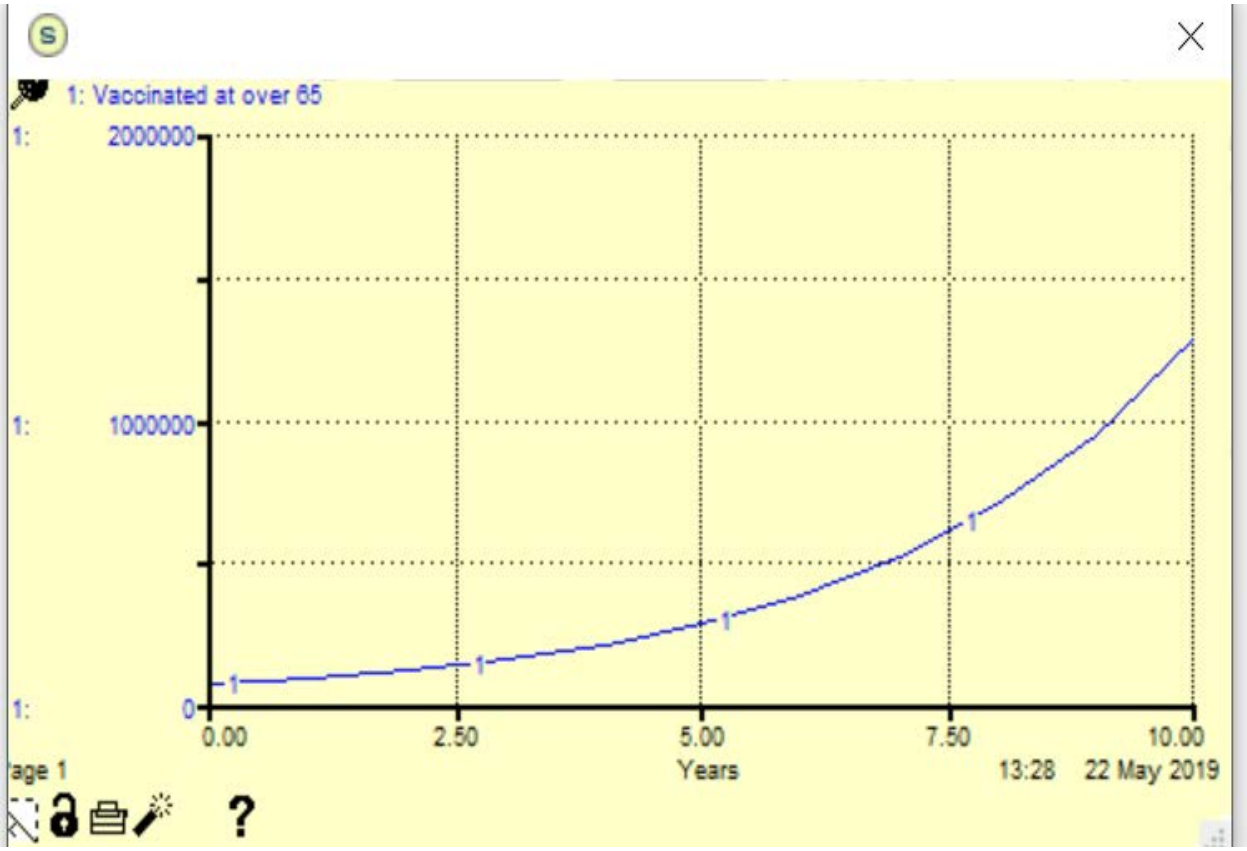


Figure 4-9: Vaccinated at 65

The access of the Kenyan population to e-health systems are very few at the ages of 15 years and 45 years. The model indicates that at all other ages the number of women being vaccinated against cancer will increase tremendously until they reach a constant level. Therefore, access to e-health systems increases the number of vaccinations over time.

4.3.2.2 The simulation model of the impact of social impact of cervical cancer vaccination

Based on previously done studies the following casual loop diagram was used a guide for the model variables. The diagram below depicts the factors directly impacting in cervical cancer vaccination.

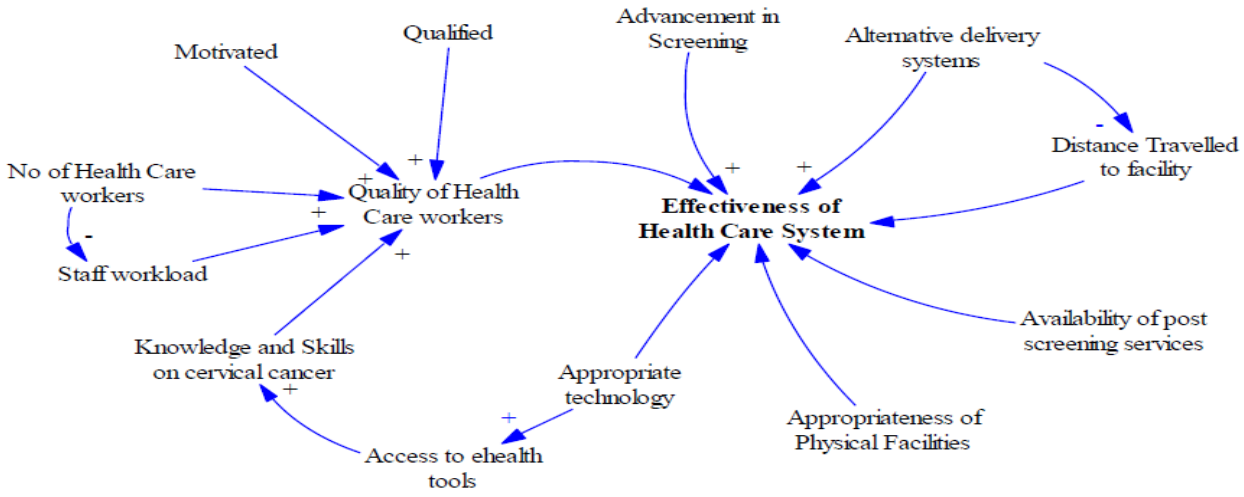


Figure 4-10: Casual loop diagram of factors impacting on cervical cancer vaccination

The schematic diagram of the system dynamic model of the social impact of cervical cancer vaccination. The impact is monitored on two variables, vaccination at different ages and the Kenyan female population growth rate. A run of the model shows clearly demonstrated in the

Figure 4.11 below:

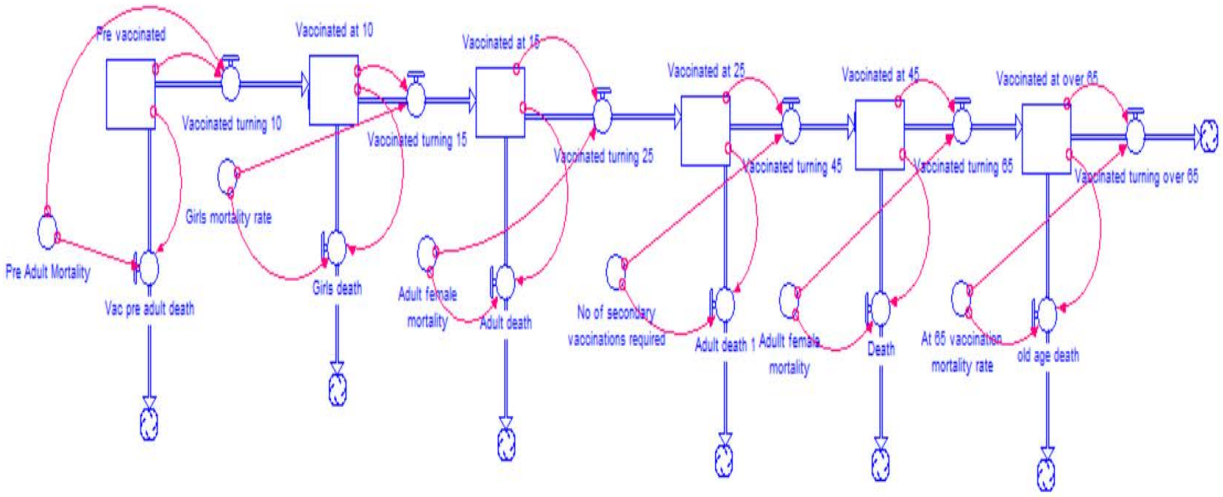


Figure 4-11: Casual loop diagram of factors impacting on cervical cancer vaccination

Model computational equations

*Pre_vaccinated(t) = Pre_vaccinated(t - dt) + (- Vac_pre_adult_death - Vaccinated_turning_10) * dtINIT*
Pre_vaccinated = 5000000

OUTFLOWS:

*Vac_pre_adult_death = Pre_vaccinated*Pre_Adult_Mortality{ people/time}*

*Vaccinated_turning_10 = Pre_vaccinated-(Pre_vaccinated*Pre_Adult_Mortality)*

*Vaccinated_at_10(t) = Vaccinated_at_10(t - dt) + (- Girls_death - Vaccinated_turning_15) * dtINIT*
Vaccinated_at_10 = Vaccinated_turning_10

OUTFLOWS:

*Girls_death = Vaccinated_at_10*Girls_mortality_rate {people/time}*

*Vaccinated_turning_15 = Vaccinated_at_10-(Vaccinated_at_10*Girls_mortality_rate)*

*Vaccinated_at_15(t) = Vaccinated_at_15(t - dt) + (Vaccinated_turning_15 - Adult_death - Vaccinated_turning_25) * dtINIT Vaccinated_at_15 = Vaccinated_turning_15*

INFLOWS:

*Vaccinated_turning_15 = Vaccinated_at_10-(Vaccinated_at_10*Girls_mortality_rate)*

OUTFLOWS:

*Adult_death = Vaccinated_at_15*Adult_female__mortality {people/time}*

*Vaccinated_turning_25 = Vaccinated_at_15-(Vaccinated_at_15*Adult_female__mortality)*

*Vaccinated_at_25(t) = Vaccinated_at_25(t - dt) + (Vaccinated_turning_25 - Adult_death_1 - Vaccinated_turning_45) * dtINIT Vaccinated_at_25 = Vaccinated_turning_25*

INFLOWS:

*Vaccinated_turning_25 = Vaccinated_at_15-(Vaccinated_at_15*Adult_female__mortality)*

OUTFLOWS:

*Adult_death_1 = Vaccinated_at_25*No_of_secondary_vaccinations_required {people/time}*

*Vaccinated_turning_45 = Vaccinated_at_25-(Vaccinated_at_25*No_of_secondary_vaccinations_required)*

*Vaccinated_at_45(t) = Vaccinated_at_45(t - dt) + (- Death - Vaccinated_turning_65) * dtINIT Vaccinated_at_45 = Vaccinated_turning_45*

OUTFLOWS:

*Death = Vaccinated_at_45*Adullt_female_mortality {people/time}*

*Vaccinated_turning_65 = Vaccinated_at_45-(Vaccinated_at_45*Adullt_female_mortality)*

*Vaccinated_at_over_65(t) = Vaccinated_at_over_65(t - dt) + (Vaccinated_turning_65 - old_age_death - Vaccinated_turning_over_65) * dtINIT Vaccinated_at_over_65 = Vaccinated_turning_65*

INFLOWS:

*Vaccinated_turning_65 = Vaccinated_at_45-(Vaccinated_at_45*Adullt_female_mortality)*

OUTFLOWS:

*old_age_death = Vaccinated_at_over_65*At_65_vaccination_mortality_rate {people/time}*

*Vaccinated_turning_over_65 = Vaccinated_at_over_65-(Vaccinated_at_over_65*At_65_vaccination_mortality_rate)*

Adullt_female_mortality = 34/100 {people/people/time}

Adult_female__mortality = 34/100 {people/people/time}

At_65_vaccination_mortality_rate = 34/100 {people/people/time}

Girls_mortality_rate = 34/100 {people/people/time}

No_of_secondary_vaccinations_required = 34/100 {people/people/time}

Pre_Adult_Mortality = 37/100 {people/people/time}

Running model results on social impact of cervical cancer vaccination

Pre-vaccinated at birth

According to the system dynamic model the number of pre vaccinated people increases the life span of the vaccinated population against their non- vaccinated counterparts by one year. This is depicted in the figure 4.12 below:

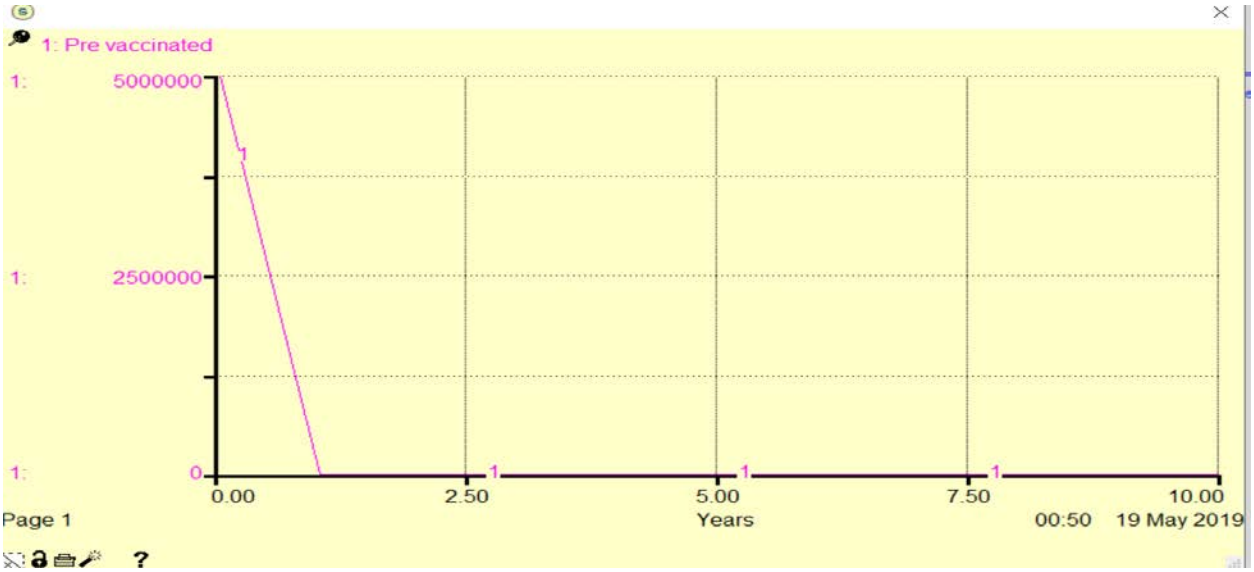


Figure 4-12: Pre-vaccinated population

Vaccinated at 10 years

According to the system dynamic model the number of women vaccinated at 10 years of age increases the life span of the vaccinated population against their non- vaccinated counterparts by one year. As demonstrated in figure 4.13 below:

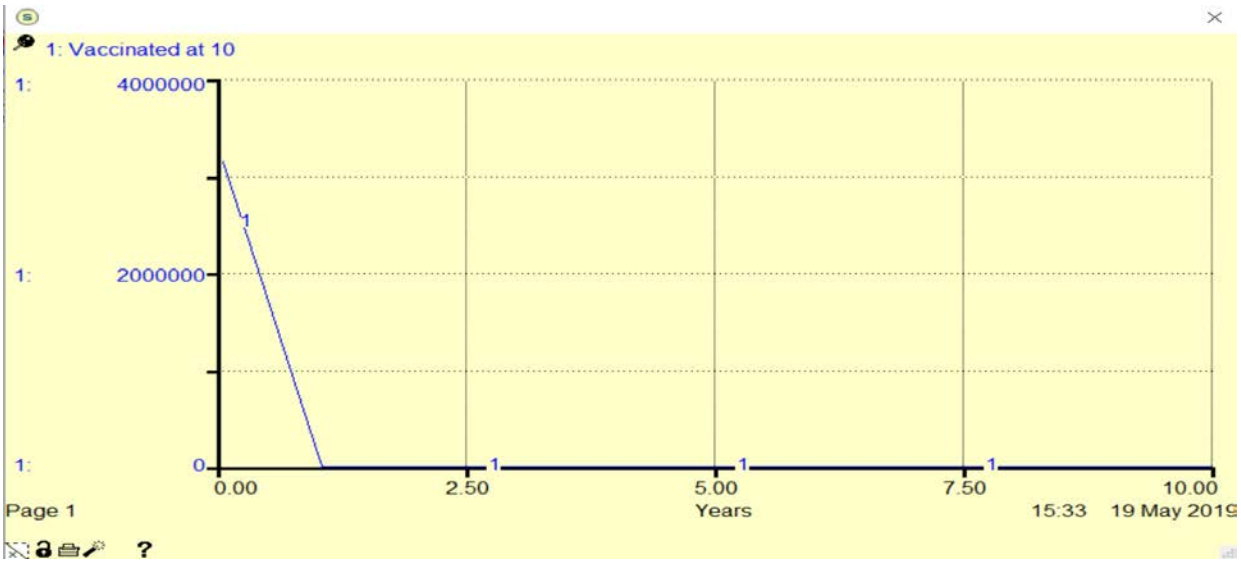


Figure 4-13: Vaccinated at 10 years

Vaccinated at 15 years

As per the system dynamic model the number of women vaccinated at 15 years of age increases the life span of the vaccinated population against their non- vaccinated counterparts by 2 years. As depicted in figure 4.14 below:

Figure 4-14: Vaccinated at 15 years

Vaccinated at 25 years

According to the system dynamic model the number of women vaccinated at 15 years of age increases the life span of the vaccinated population against their non- vaccinated counterparts by 3 years with other factors held constant. As depicted in figure 4.15 below:

Figure 4-15: Vaccinated at 25 years

Vaccinated at 45 years

According to the system dynamic model the number of women vaccinated at 45 years of age increases the life span of the vaccinated population against their non- vaccinated counterparts by 1 year with other factors held constant. As displayed figure 4.16 below:

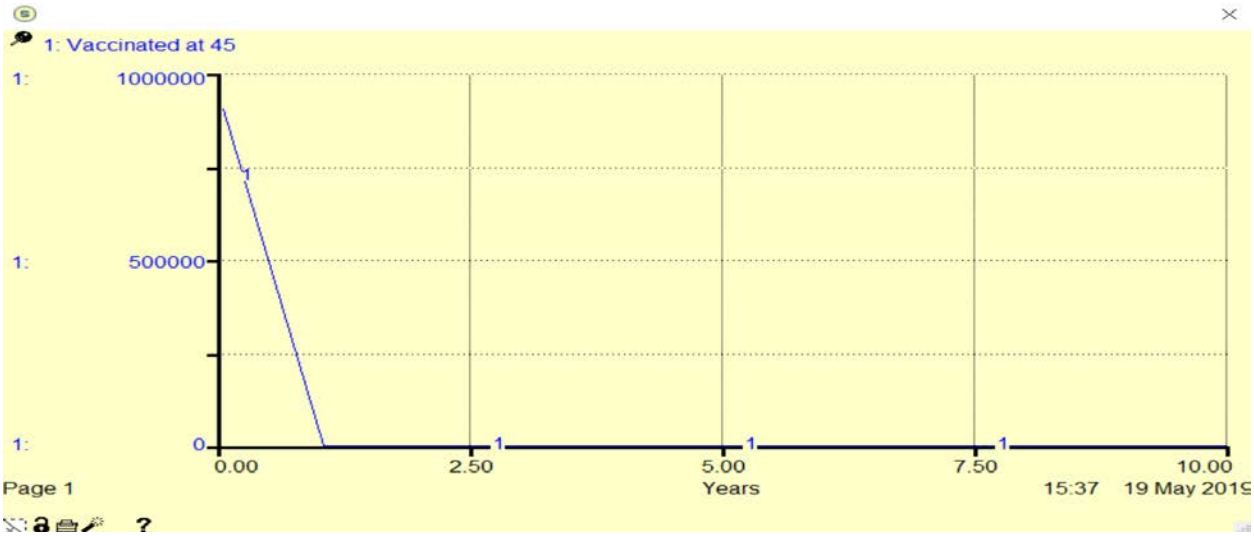


Figure 4-16: Vaccinated at 45 years

Vaccinated at 65 years

According to the system dynamic model the number of women vaccinated at 65 years of age increases the life span of the vaccinated population against their non- vaccinated counterparts by 1 and half years with other factors held constant. This is illustrated in figure 4.17 below:

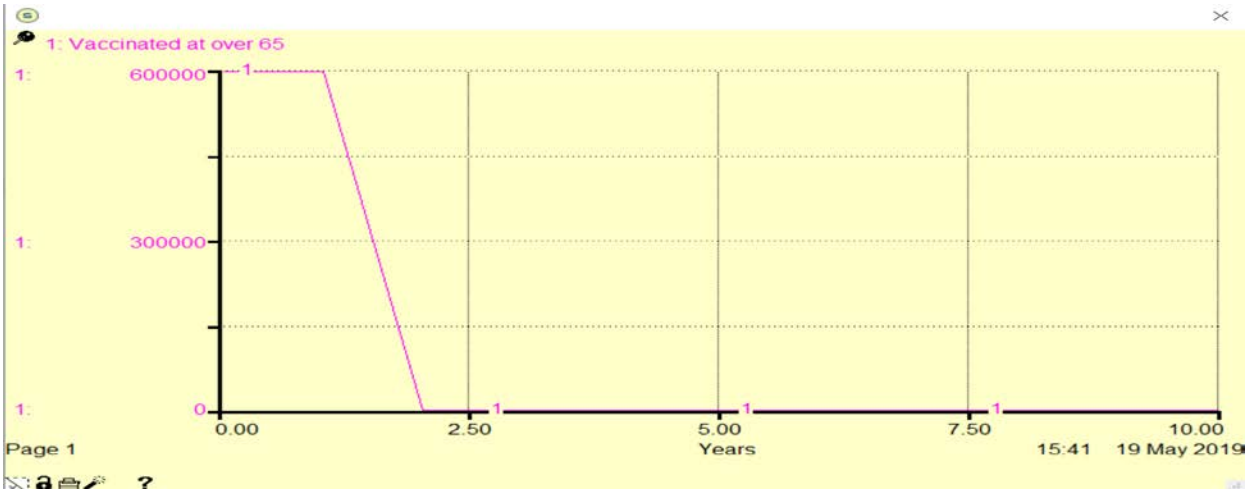


Figure 4-17: Vaccinated at 45 years

In summary as per the system dynamic model the ideal age for vaccination of Kenyan women against cancer with all factors held constant is 25 years of age. As depicted in the summary output below.

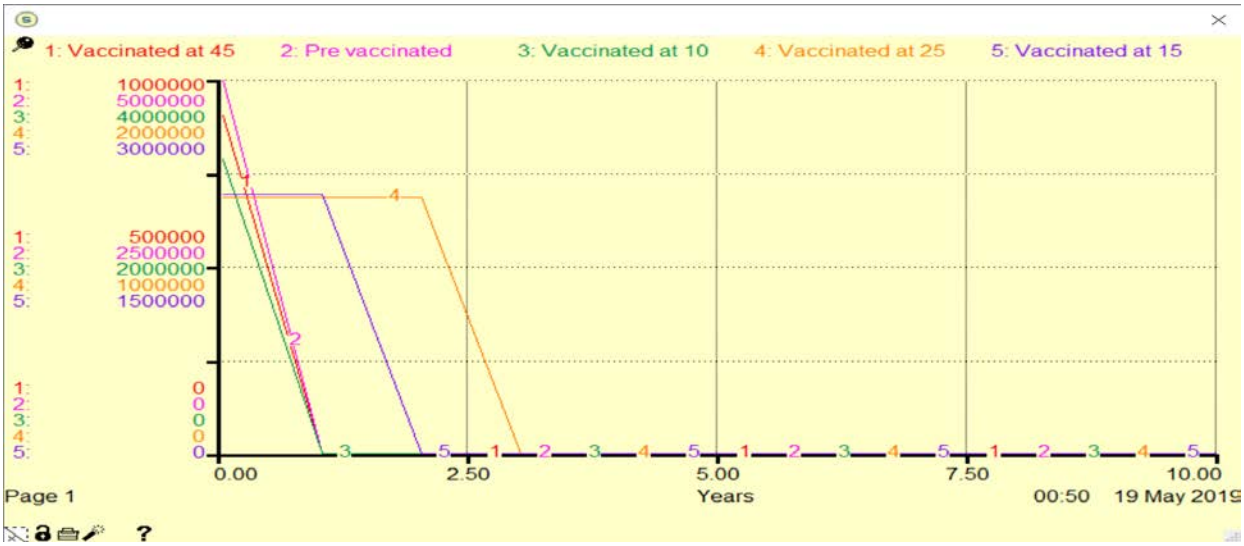


Figure 4-18: Summary of different ages

4.3.3 Objective three results

Validation and test of the dynamic model using regression analysis

The third objective of the research study was to test and validate the model for effectiveness using sample data. Validity of results in a model based SD study is dependent on the validity of the model (Barlas, 1996). A model must present a simplification of a real world problem and therefore will exclude some variables or structures present in the real world to achieve this.

Validation of the model was dependent on the following assumptions:

- That every one of the females looking for inoculation will finish the full portion of antibody.
- That just an extent of the ladies who missed both essential and optional inoculation will experience Cervical Cancer screening further down the road while others will miss this indispensable intercession.
- That all the HPV contaminations among the screened ladies will be identified and exposed to treatment.
- That HPV contamination among the unscreened ladies will advance normally with the exception of these ladies won't profit by treatment.
- That a little extent of the number of inhabitants in ladies with unscreened/undiscovered Cervical Cancer may have accidental open door for screening over the span of their looking for wellbeing administrations.
- That most external factors that may affect the model results are kept constant.

In conducting the validation of the model during the research data was divided into training data and test data and regression analyses was used to establish its validity.

A regression model was created to test the dependent variable e-health access side by side the independent variables vaccination demands, female population, age, cancer care facilities. The training feed into the model gave a significant value with a t-static of 6.121 and a p-value of 0.000. According to the validity test results all variables were significant in both the training and test data fed into the model, except vaccination demand since the willingness to get vaccinated could not be predicted accurately by the model. This is as shown in Table 4.4 below:

Table 4.4: ***Regression analysis validation test of the system dynamics model***

	Test data values versus training data values				
	Co-efficient	Standard error	t-static	P-value	Confidence Interval
E-health access	-0.022	0.002	4.123	0.000	(0.1013 - 0.31)
Vaccination demand	0.307	0.105	1.977	0.061	(0.139 - 0.581)
Female population	0.358	0.198	6.121	0.000	(0.290 – 0.0426)
Age	0.139	0.094	3.110	0.023	(-0.096 – 0.354)
Cancer care centre	0.417	0.126	3.315	0.002	(0.398 – 0.421)
N = 104					
$\mathbf{R^2}$ = 0.745					
Adjusted $\mathbf{R^2}$ = 0.691					

From the confidence intervals the error estimation was deemed at 30% .The error of estimate may be attributed to imperfect calibration and unaccounted for environmental interferences. Calibration is aimed at minimizing the error of Estimate (Corner, 1999). Calibration was done by adjusting the parameter values. This means that the models accuracy level was quite acceptable. The regressions model R2 value of 0.691 shows that the model predicts averagely. The 95% confidence intervals were not very far from the co-efficient estimates hence the variables were fitting the data. Hence the models level of functionality was of an acceptable level.

4.4 Conclusion

This simulation model generated reasonable estimates in evaluation of effects of different interventions on Cervical Cancer in Kenya. The model charts informed debate leading to development of new consensus on vaccination and use of e-health tools. Cervical Cancer needs to be managed and monitored continuously with screening being implemented as a complimentary intervention to vaccination. If technology is used in Kenya to disseminate information about cervical cancer vaccination then it was have an impact on the female population as per the model when external factors are kept constant. Therefore, when we women are vaccinated against HPV when they are above 25 year would increase cancer survivability by an estimated 5 years. Furthermore, increasing access to e-health systems of girls aged 15 and above and women of 45 years there will be an increased rate of vaccinated women in Kenya over the next 10 years.

CHAPTER FIVE
CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This section outlines discussion of the results which have been presented in chapter 4 and compares these results with results on cervical cancer management. It provides a critical assessment of how the research objectives have been achieved. It also identifies how the existing research gaps have been filled and presents the value addition of this research project. Finally, the limitation and challenges of the project are highlighted and recommendations are made for areas of future research

5.2 Discussion of the Results

This study aimed at evaluating the clinical and socio-economic impact of primary vaccination, secondary vaccination, screening and use of e-health tools in Cervical Cancer management in Kenya. In general the results presented have shown that the most common Sexually transmitted disease associated with cervical cancer patients is condylomatosis. Therefore, reduction of infection of women by condylomatosis also reduces the risk of getting cervical cancer. Insight could further be drawn from the study that the main challenges faced in cervical cancer vaccination are lack of HPV vaccine awareness, lack of funding to issue vaccines to the general population and logistics planning on which areas in Kenya to conduct vaccination

The access of the Kenyan population to e-health systems are very few at the ages of 15 years and 45 years. The model indicates that at all other ages the number of women being vaccinated against cancer will increase tremendously until they reach a constant level. Therefore, access to e-health systems increases the number of vaccinations over time. All the four objectives of the study had been achieved and the response rate from the data collection was relatively conclusive.

The results agree with previously done similar research in Kenya by (Kivuti, 2014) who concluded that Kenya should consider secondary vaccination, primary vaccination and use of e-health tools as a matter of priority these should be complemented by screening.

Whether given as a primary or catch up vaccination, HPV vaccine uptake is influenced by a number of factors. These include Knowledge level, which increase in belief on Knowledge levels of benefits of HPV vaccine. This belief in benefits, perceive parental approval and belief in vulnerability of HPV infection increase intent of uptake of HPV vaccine both by males and females (D. A. Patel, 2012). After health education, acceptance of catch up vaccination among general females was 51% while that of 12 years old was highest at 79% (Schmeink, 2011). Parental participation is influenced by safety concerns of their daughters with as much as 16% of parents in USA citing this as the reason they would stop their daughters from receiving HPV vaccine (Castillo, 2013), while low knowledge levels would reduce the HPV vaccine uptake (Okoronkwo, 2012). Other studies however noted no correlation between knowledge levels of HPV and completion of vaccine. In fact, distorted knowledge that HPV could cause HIV/AIDS would drive more recipients to completion of HPV vaccine dose (Stern, 2013). A study done in China showed that after health education the number of women willing to vaccinate their daughters increased by 84% (Chang, 2013).

Policy issues have been a vibrant debate on HPV vaccination with some of studies advocating for blanket vaccination of eligible women. HPV is primarily transmitted via sexual contact. Hence not all females are at risk; therefore a policy subjecting all the females at whatever age to HPV vaccine may be seen as unethical. It may be more beneficial to only vaccinate those at risk (Zimmerman, 2006)

5.3 Study Contributions and Policy Implications

This theory exhibits a reenactment model for assessing the potential impacts of screening and inoculation crusade against Human Papilloma virus [HPV], just as effect of utilization of e-wellbeing instruments in Kenya. In this examination, e-wellbeing inclusion levels among cervical malignant growth customers was set up. This model expands on the collection of Knowledge. It is an interesting report done in Kenya and in all likelihood in Africa. Improvement of Health care conveyance utilizing existing Health care rehearses, scientific displaying, Computer recreation and data innovation was accomplished. This model gives an approach choice help vehicle that can take into consideration decision between various mediations dependent on their normal results. This model can be altered/extended to incorporate new research discoveries.

5.4 Limitations

Simulation does NOT rely on learning feedback through real world. There are no established formal tests e.g. statistical hypothesis tests to establish if structure of model is close enough to the real structure. System Dynamics models require a casual theory therefore a greater degree does not lay concern on a single individual behaviour hence has a macroscopic point of view. For these reasons No model can claim to be absolutely objective as every model carries its modeler's worldview and assumptions.

The stake holders were not familiar with most e-health tools or the Stella software hence they had limitation in their opinion on possible benefits and limitations of the Model. This model does not allow for volatility of factors which are neither controlled nor deterministically modelled. It is important to note that models are not true or false but lie in a continuum of usefulness.

Study Assumptions

For the study to take place, the following assumptions were made;

- That the experts were aware of some e-health tools.
- The study subjects were willing to participate.
- That all study institutions proposed for this study and whose authority was sought would grant authority.
- That the study subjects would give their honest opinion.

5.5 Recommendations for further work

There is need for further studies in the development of a model on the implication of Vaccination, screening and use of e-health tools in developing economies, and Africa in particular. More work should be done in the analysis and design of strategies to overcome negative attitudes towards cervical cancer screening procedure and towards the cervical cancer clients. Over all, Kenya as a nation ought to think about reception of optional make up for lost time immunization as a prompt measure to control Cervical Cancer. This ought to be combined with pre-juvenile girl's inoculation. Of significance was the thought of the negative disposition of both Cervical Cancer customers and staff towards Cervical Cancer screening strategy. Any strategy which Kenya embraces must think about these mentalities. Either actualizes vaccination which however costly is all the more socially worthy or finds a method for improving the frame of mind towards vaccination ideally through utilization of e-health systems.

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Appendix A: Model equations

Model equations

Pre_vaccinated(t) = Pre_vaccinated(t - dt) + (- Vac_pre_adult_death - Vaccinated_turning_10) * dt
INIT Pre_vaccinated = 5000000
OUTFLOWS:
Vac_pre_adult_death = Pre_vaccinated*Pre_Adult_Mortality{ people/time}
Vaccinated_turning_10 = Pre_vaccinated-(Pre_vaccinated*Pre_Adult_Mortality)

Vaccinated_at_10(t) = Vaccinated_at_10(t - dt) + (- Girls_death - Vaccinated_turning_15) * dt
INIT Vaccinated_at_10 = Vaccinated_turning_10
OUTFLOWS:
Girls_death = Vaccinated_at_10*Girls_mortality_rate {people/time}
Vaccinated_turning_15 = Vaccinated_at_10-(Vaccinated_at_10*Girls_mortality_rate)

Vaccinated_at_15(t) = Vaccinated_at_15(t - dt) + (Vaccinated_turning_15 - Adult_death - Vaccinated_turning_25) * dt
INIT Vaccinated_at_15 = Vaccinated_turning_15
INFLOWS:
Vaccinated_turning_15 = Vaccinated_at_10-(Vaccinated_at_10*Girls_mortality_rate)
OUTFLOWS:
Adult_death = Vaccinated_at_15*Adult_female__mortality {people/time}
Vaccinated_turning_25 = Vaccinated_at_15-(Vaccinated_at_15*Adult_female__mortality)

Vaccinated_at_25(t) = Vaccinated_at_25(t - dt) + (Vaccinated_turning_25 - Adult_death_1 - Vaccinated_turning_45) * dt
INIT Vaccinated_at_25 = Vaccinated_turning_25
INFLOWS:
Vaccinated_turning_25 = Vaccinated_at_15-(Vaccinated_at_15*Adult_female__mortality)
OUTFLOWS:
Adult_death_1 = Vaccinated_at_25*No_of_secondary_vaccinations_required {people/time}
Vaccinated_turning_45 = Vaccinated_at_25-(Vaccinated_at_25*No_of_secondary_vaccinations_required)

- Vaccinated_at_45(t) = Vaccinated_at_45(t - dt) + (- Death - Vaccinated_turning_65) * dt
  INIT Vaccinated_at_45 = Vaccinated_turning_45
  OUTFLOWS:
  - Death = Vaccinated_at_45*Adullt_female_mortality {people/time}
  - Vaccinated_turning_65 = Vaccinated_at_45-(Vaccinated_at_45*Adullt_female_mortality)
- Vaccinated_at_over_65(t) = Vaccinated_at_over_65(t - dt) + (Vaccinated_turning_65 - old_age_death - Vaccinated_turning_over_65) * dt
  INIT Vaccinated_at_over_65 = Vaccinated_turning_65
  INFLOWS:
  - Vaccinated_turning_65 = Vaccinated_at_45-(Vaccinated_at_45*Adullt_female_mortality)
  OUTFLOWS:
  - old_age_death = Vaccinated_at_over_65*At_65_vaccination_mortality_rate {people/time}
  - Vaccinated_turning_over_65 = Vaccinated_at_over_65-(Vaccinated_at_over_65*At_65_vaccination_mortality_rate)
- Adullt_female_mortality = 34/100 {people/people/time}
- Adult_female__mortality = 34/100 {people/people/time}
- At_65_vaccination_mortality_rate = 34/100 {people/people/time}
- Girls_mortality_rate = 34/100 {people/people/time}
- No_of_secondary_vaccinations_required = 34/100 {people/people/time}
- Pre_Adult_Mortality = 37/100 {people/people/time}

Vaccinated_at_25(t) = Vaccinated_at_25(t - dt) + (Access_per_time_2) * dt
INIT Vaccinated_at_25 = 803894
INFLOWS:
Access_per_time_2 = Vaccinated_at_25*Ehealth_access_rate_2{people/time}
Vaccinated_at_35(t) = Vaccinated_at_35(t - dt) + (Access_per_time_3) * dt
INIT Vaccinated_at_35 = 803894
INFLOWS:
Access_per_time_3 = Vaccinated_at_35*Ehealth_access_rate_3{people/time}
Vaccinated_at_45(t) = Vaccinated_at_45(t - dt) + (- Access_per_time_5) * dt
INIT Vaccinated_at_45 = 381873
OUTFLOWS:
Access_per_time_5 = Vaccinated_at_55*Ehealth_access_rate_5{people/time}
Vaccinated_at_55(t) = Vaccinated_at_55(t - dt) + (Access_per_time_5) * dt
INIT Vaccinated_at_55 = 181749
INFLOWS:
Access_per_time_5 = Vaccinated_at_55*Ehealth_access_rate_5{people/time}
Vaccinated_at_over_65(t) = Vaccinated_at_over_65(t - dt) + (Access_per_time_6) * dt
INIT Vaccinated_at_over_65 = 59265
INFLOWS:
Access_per_time_6 = Vaccinated_at_over_65*Ehealth_access_rate_6{people/time}
Vaccinted_at_15(t) = Vaccinted_at_15(t - dt) + (Access_per_time - Access_per_time_2) * dt
INIT Vaccinted_at_15 = 700600
INFLOWS:
Access_per_time = Vaccinted_at_15*Ehealth_access_rate {people/time}
OUTFLOWS:
Access_per_time_2 = Vaccinated_at_25*Ehealth_access_rate_2{people/time}
UNATTACHED:
Access_per_time_4 = Vaccinated_at_45*Ehealth_access_rate_4 {people/time}
Ehealth_access_rate = 36/100 {people/people/time}
Ehealth_access_rate_2 = 36/100 {people/people/time}
Ehealth_access_rate_3 = 36/100 {people/people/time}
Ehealth_access_rate_4 = 36/100 {people/people/time}
Ehealth_access_rate_5 = 36/100 {people/people/time}
Ehealth_access_rate_6 = 36/100 {people/people/time}

Appendix B: Research budget

Activity	Duration(Weeks)								
	2	4	6	8	10	12	14	16	18
System conceptualisation									
Project proposal									
Literature review	To be done throughout the project								
Conceptual Modelling									
Model formulation									
Testing									
Implementation									
Documentation	To be done throughout the project								

Appendix C: Budget

The resources and budget breakdown is as follows:

Item	Cost
Internet / Research	6,500
Printing and Photocopy	2,500
Travelling	5,000
Stationary and research permits	3,500
Data Access Related Costs (Communication and movement)	10000
Overhead Costs	5,000
Total	Ksh.32,500

Appendix D: Google Forms questionnaire

Google forms questionnaire

This questionnaire will take approximately 20 mins to 40 mins. Please answer the following questions as honestly possible. You are allowed to voice as many concerns/ issues as you have during this interview.

1. What is your Age *

Long answer text

2. Which cancer care center do you work? *

Long answer text

3. How long have you been involved in care of Cervical Cancer management *

Long answer text

4. Have you been involved in caring for patients with other types of Cancer? If so which ones? *

Long answer text

5. What challenges have you faced in of Cervical Cancer vaccination? *

Long answer text

6. In what ways would the internet and computers be useful in management of Cervical Cancer in Kenya? *

Long answer text

Appendix E: Summary of statistics

Summary statistics of NCR data

	Age	STDs: Number of diagnosis	Dx:Cancer	Dx:CIN	Dx:HPV	Dx	Hinselmann	Schiller	Citology	Biopsy
count	858.000000	858.000000	858.000000	858.000000	858.000000	858.000000	858.000000	858.000000	858.000000	858.000000
mean	26.820513	0.087413	0.020979	0.010490	0.020979	0.027972	0.040793	0.086247	0.051282	0.064103
std	8.497948	0.302545	0.143398	0.101939	0.143398	0.164989	0.197925	0.280892	0.220701	0.245078
min	13.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
25%	20.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
50%	25.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
75%	32.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
max	84.000000	3.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000