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Health Systems Predictors and Trends of Access to Vaccinations in 9 sub-Saharan African Countries

Mirfin Mpundu
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Walden University

College of Health Sciences

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Mirfin Mpundu

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Walden University
2020

Abstract

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sub-Saharan African Countries

by

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MBA, Northwood University, 2003

BPHARM (Hons) University of Dar es Salaam, 1996

Doctoral Study Submitted in Partial Fulfillment
of the Requirements for the Degree of
Doctor of Public Health

Walden University

November 2020

Abstract

The purpose of this ecological quantitative study was to examine the predictors of health systems building blocks and their interactions in improving access and uptake of immunizations in nine sub-Saharan African countries. Immunization rates in this region remain lower than global targets leading to preventable diseases and mortality. Using the systems approach, the study examined the relationships among five independent variables: quality of service delivery, governance, vaccine supply, health financing, socioeconomic factors and the dependent variable, access to immunizations. Datasets from the WHO and UNICEF were used. Analysis included a series of descriptive statistics, logistic and linear regression, and correlations. The logistic regression analysis showed a predictive relationship between the quality of service delivery, governance and access to immunizations. There was a significant association between immunization and the presence of a national reporting system for adverse events following immunizations (OR = 21.630, 95% CI 2.37, 201.040, $p < 0.001$). A larger Overseas Development Assistance, calculated as a percentage of gross national income, was associated with a higher rate of vaccination ($p < 0.05$). Similarly, a higher per capita income and higher percentage of government funding for vaccination was associated with better vaccination rates ($p < 0.001$ and $p < 0.001$ respectively). There was also a significant relationship between the number of doctors in an area and BCG coverage ($r = 0.928$, $p < 0.001$) and the number of doctors in an area and DPT1 coverage ($r = 0.892$, $p < 0.001$). The positive social change implications of this study include how access to immunizations can be improved using the systems approach focusing on these health systems building blocks.

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Dedication

The path to excellence and virtue is through learning and using the knowledge acquired to serve and better others, especially the most vulnerable. This has been my life's quest, instilled in me from the very early years of my life by the most wonderful parents one could ever have. My parents laid the foundations, encouraged me and set some targets I would eventually make mine and be in pursuit of. My dad would often say, 'One day, you will be Dr. Mambwe and serve others'. From those humble beginnings and strong beliefs in education, I have challenged myself, and continue to do so, on this path of excellence. It is thus fitting to dedicate this doctoral dissertation to my dear parents, whose joy and smiles though veiled by death, can be seen. Mum and Dad, though you have been long gone, your dreams for me live on, and in your dear grandchildren. I will forever love you and be grateful. I know I have made you proud.

To my dear wife and dearest friend on this side of heaven, Marge, I will always be grateful for all your encouragements even when I was almost giving up. Thanks for enduring the long hours and weekends I spent on my studies and research. I will always love you.

To my wonderful girls Chichi and Tasheni - Cookie, the added joy to my life. You have been so patient and enduring whenever I couldn't do something with you because of my studies. Your computer tips when I needed help were so valuable. The sky for you is just but a benchmark. Always remember the NASA motto, our adopted family motto 'failure is not an option'. Here is the baton for you to do even more. Love you guys.

Above all my uttermost gratitude to my God for the many blessings He has bestowed upon me, I can only testify and declare my Ebenezer in Him, that 'thus far, He has led me' and to Him be glory now and forevermore.

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Section 1: Foundation of Study and Literature Review

Introduction to Study

Immunizations are life-saving and one of the cornerstones of Universal Health Coverage and modern medicine. They are effective at preventing common diseases and diseases that had once been controlled or eradicated, but are now coming back. Diseases like cervical cancer, the second leading cause of death among women in sub-Saharan Africa (SSA) is now preventable, so are measles, diarrheal diseases, flu, typhoid, pneumonia which kills so many children and TB (Black & Richmond, 2018). Other diseases that can be prevented with immunizations include tetanus, typhoid, whooping cough, influenza and chicken pox (WHO, 2018). Success has been seen with polio which has almost been eradicated globally except a few isolated cases being reported. Despite this success, approximately 31 million children under the age of 5 years in sub-Saharan Africa, are reported to suffer from diseases that are preventable through vaccinations with more than 500,000 dying due to lack of access to these public goods (WHO, 2019).

Vaccinations against preventable diseases (VPDs) are an effective intervention in preventing and slowing down existential public health threats like antimicrobial resistance (AMR), which is a global threat responsible for 700,000 deaths a year globally and projected to increase to 10 million deaths a year by 2050, a loss of 2-3.5% in GDP and 100 trillion USD by 2050 if nothing is done (WHO, 2019). Immunizations prevent a lot of VPDs which inevitably reduces the need for antibiotics and the selection pressure. While progress has been made globally in increasing immunizations, a recent study showed that 19.9 million (15%) of annual birth cohort of 132 million people, were reported not to be vaccinated or under-vaccinated, 10 million, of which are in sub-Saharan African countries (Madhi & Rees, 2018; WHO (2019).

The global goals on immunizations are unlikely to be achieved in low- and middle-income countries (LMICs) where targets have not been reached. Among the leading causes of low uptake of immunizations are health system related factors, such as lack of access to vaccines, financial and human resources, poor or weak governance structures, lack of and weak health information systems and poor quality delivery of services. Others are multifaceted including cultural, social, economic, structural and religious factors. Despite interventions such as the Expanded Programs on Immunizations (EPIs) aimed at increasing immunizations in most sub-Saharan Africa, like other LMICs, low immunization rates have been recorded resulting in preventable morbidities and increased loss of human life that could have been avoided.

Since vaccinations occur in health systems, they often are an existential systems issue and understanding health systems would provide the necessary information and knowledge that can contribute to increasing immunization rates. Health systems are made up of building blocks and understanding these building blocks, their predictors, and their association with immunizations is critical in addressing today's challenges. Health systems building blocks as defined by WHO can lead to sustainable access and increased uptake, averting many morbidities and preventable deaths. But this would only happen by understanding predictors of these building blocks, how they interact with each other in the system, how they can be strengthened and identifying areas where more investments can be directed to effectively strengthen the health system and allow for better decision making.

There are few or no studies I came across that have looked at predictors of immunizations in LMICs with respect to the health systems approach, focusing on health building blocks and how they affect vaccination/ immunization rates in sub-Saharan African countries and other

LMICs. There are studies that have looked at gaps in immunizations broadly and promoted various interventions, however few or no studies have looked at the systems approach in addressing access to immunizations. Some studies have looked at components of the health system but not holistically and how they interact and how their relationships can be maximized. Larahira (2015) reviewed articles and India's Universal Immunization Program (UIP) to show that strong health systems working in unison could deliver more immunizations to populations.

Kamadjeu (2018) looked at the future of immunization programs in Africa by reviewing the Expanded Program on Immunization (EPI), which most countries use, making observations that the success of immunization programs are dependent on strong delivery health systems components both structural and financial. Nnorom (2017) studied the predictors to access to maternal medicines using the health systems approach and examining the building blocks and their predictors. This study though was limited to maternal medicines and mostly solid products. Vaccine's, however, are special commodities whose supply chain is different particularly maintaining the cold chain patency and are mainly administered to children. This is more important for new vaccines that might require special conditions for transportation and storage.

This study focused on examining the health systems building blocks predictors and their interactions in increasing access and uptake of immunizations addressing the current gaps in knowledge in sub-Saharan African countries. The 2020 global goals for immunizations in LMICs have not been achieved as immunization rates remain at an average of 70% in most LMICs. If the rates of immunizations remain where they are at an average of 70% in most LMICs, it is unlikely that the 2030 goals will be achieved. The 2030 vaccination goals include targets such as reducing morbidity and mortality of vaccine preventable diseases and ensuring

sustainable access to all (WHO, 2020). For example, a low uptake of pneumococcal and flu vaccines may lead to many respiratory infections, complications and death among diabetic patients (Almusalam, Ghorab, & Alanezi, 2019). Since immunizations are provided through health systems, understanding health systems building blocks thus becomes critical in addressing current access issues to immunization.

Sub-Saharan African countries made commitments through various global and regional commitments. One of the major commitments is the Addis Declaration of 2016 intended to expand immunizations in Africa to reach everyone who needs them by committing to 10 commitments addressing political, technical, financial and investments (WHO, 2020). This is in addition to the Global Vaccination Plan (GVAP) of 2012 endorsed by WHO member states, whose focus is to present VPDs by 2020 by focusing on equitable access for all (WHO, 2020).

Knowledge from this study will allow and empower policy makers, immunization program managers to effectively design evidence-based programs and implement interventions that will accelerate vaccination goals. This will support implementation research that has been lacking in most developing countries by providing evidence-based solutions. It will also help policy makers identify where to focus more investments in the value chain with many competing priorities including challenges of low funding to increase access to immunizations and their uptake.

Problem Statement

Immunizations play a major role in preventing many common diseases including emerging and re-emerging diseases that claim millions of lives each year. The effectiveness of vaccinations can be seen through WHO's report, which reported 10 million lives saved between

2010 and 2015 globally because of vaccines (WHO, 2018). Vaccines for diarrhea such as Rotavirus prevent more hospitalizations and deaths from diarrhea a leading cause of death in children under 5- years old (Takahashi, Metcalf, Ferrari, Tatem & Lessler, 2017). Another example is the HPV vaccine for cervical cancer which has been found to be around 95% effective in reducing cervical cancer (Black & Richmond, 2018). High efficacies of vaccination have also been shown for rotavirus, measles, pneumonias, polio and typhoid.

However, immunization rates in sub-Saharan Africa remain low with 31 million children under the age of 5- suffering from vaccine preventable illnesses and more than half dying from lack of access to immunizations (WHO, 2019). Diseases such as measles which are preventable through immunizations have a high fatality rate for those who have not received the vaccine and contract it. While rates of immunizations are high in developed countries who have developed health systems, the overall immunization rates in the African region remain below the expected targets, ranging from 57% in 2000 to 76% in 2015 (Mihigo, Okeibunor, Anya, Mkanda & Zawaira, 2017). Eight (8) countries were under 50% for DTP vaccinations, Chad, Central Africa Republic, Equatorial Guinea, Nigeria, South Sudan and Somalia (Ablack & Richmond, 2018). This is concerning with the high burden of infectious diseases and non-communicable diseases in sub-Saharan African countries.

In 2014, 114,900 deaths of children occurred globally of which 63% (73,914) occurred in Africa, most of these deaths could have been avoided with vaccinations (Brownwright, Dodson & van Panhuis, 2017). Immunizations are one of the most successful interventions in public health. Unfortunately gaps still exist in in many countries with the average of immunizations being around 70% (Mihigo, Okeibunor, Anya., Mkanda, & Zawaira, 2017). Some examples

show gaps especially in the indicator vaccine DPT as substantial gaps are seen between the first dose of DTP and the following doses, attributed to lack of access (ScienceDaily, 2019).

Global goals such as sustainable development goals (SDGs), reducing vaccine preventable morbidities and mortality, addressing antimicrobial resistance (AMR) and attainment of Universal Health Coverage (UHC), are unlikely to be achieved in sub-Saharan Africa due to many reasons and factors that include health systems related factors (McLeod, 2019). Health system related factors such as lack of vaccines, weak governance and human resources, have a major effect on access to immunization and often damage many immunization programs in Africa (Mihigo, Okeibunor, Anya., Mkanda, & Zawaira (2017).

In order to reach vulnerable populations, increase access to vaccinations, strong effective health systems are key. WHO defines a health system as having 6 building blocks – service delivery, governance, health information systems, financing, medical products and human resources (WHO, 2018). When these are effectively working and maximized, they lead to improved health outcomes, responsiveness, reduction in healthcare related costs, social and financial risk protection and improved efficiency through improved coverage, quality and safety (Lazarus & France, 2014). They also contribute to the rise and spread of antimicrobial resistance by reducing the selection pressure.

Access to vaccines improves health and maximizes health outcomes, it results in healthy children, health communities and prosperous nations. In order to increase immunizations in SSA and reduce preventable deaths understanding predictors of key building blocks, how they work and complement each other and where in the value chain interventions can best be made with a higher impact is necessary. Without increasing immunization rates, set targets and goals, will not

be attained leading to morbidities and mortalities and affecting the economic wellbeing of countries.

This study could contribute to better understanding of the relationships between building blocks, their predictors and vaccinations and contribute to policies at country and regional level that would lead to improved access to immunizations resulting in the positive health outcomes.

Purpose of the Study

The purpose of this ecological quantitative study was to look at how health systems blocks - service delivery, human resources, health information systems, financing and medical products – vaccines and other medical products and governance affect access to immunization in 9- sub-Saharan African (SSA) countries. These countries fall in the categories of being Low- and Middle- Income Countries. The predictors and relationships between the building blocks and access to immunizations were examined and whether certain building blocks as defined by WHO in the health systems approach and definition that should be emphasized more with more strategic investments given to them than others? With most SSA countries challenged with financial and human resources and other competing priorities, African countries need to prioritize resource investment into health system blocks that will increase access and uptake of immunizations to prevent, preventable morbidities and mortalities, these however should be evidence-based.

Research Question(s) and Hypotheses

The study had 5- research questions with corresponding hypotheses:

1. Is there a significant association between the quality of service delivery and access to immunizations in nine sub-Saharan African countries?

H1₀: There is no significant association between the quality of service delivery and access to immunizations in nine sub-Saharan African countries.

H1_A: There is a significant association between the quality of service delivery and access to immunizations in nine sub-Saharan African countries.

2. Is there a significant association between governance and access to immunizations in nine sub-Saharan African countries?

H2₀: There is no significant association between governance and access to immunizations.

H2_A: There is a significant association between governance and access to immunizations.

3. Is there a significant association between vaccine supply and access to immunizations?

H3₀: There is no significant association between vaccine supply and access to immunizations.

H3_A: There is significant association between vaccine supply and access to immunizations.

4. Is there a significant association between health financing and access to immunizations in nine sub-Saharan African countries?

H4₀: There is no significant association between health financing and access to immunization in nine sub-Saharan African countries.

H4_A: There is a significant association between health financing and access to immunization in nine sub-Saharan African countries.

5. Is there significant association between socioeconomic factors and access to immunizations in nine sub-Saharan African countries?

H5₀: There is no significant association between different socioeconomic factors and access to immunizations in nine sub-Saharan African countries.

H5_A: There is a significant association between socioeconomic factors and access to immunizations in nine sub-Saharan African countries

Theoretical Foundation of Study

Choice of Theory. This study used the systems theoretical framework as its foundation.

This is a theory that posits that within a system there are small units or variables that are interconnected, interact and work together to get the desired outcome (McCoverly & Matusitz, 2014). It acknowledges the complexities involved to successfully deliver services. The systems approach has found its use in studying health models and to further explore barriers to system changes such as human behavior (Steenrod, 2014). The systems theory approach found its beginnings in the 1940's through Ludwig von Bertalanffy, who described it as a science of wholeness (Mutale, 2016). He expressed and espoused that systems do not consist of parts that are autonomous working independently or in isolation, but that they are interconnected functioning as one unit, as a whole to achieve the desired end (Anderson, 2016). Thus, though the health system has several building blocks they need to function as one with the different building blocks operating in a cohesive way.

Mutale et al (2016) used the systems thinking in evaluating a program, Better Health Outcome through Mentorship and Assessment (BHOMA), looking at interactions, intended and unintended consequences of different system blocks in Zambia. Bielecki & Stocki (2010) observed that several national health systems were failing because of they looked at subsystems to be autonomous and how working as a whole. Lee, Mueller & Tilchin (2017) used the systems

theory to understand vaccine decision making by looking at the relationships of biological, clinical, operational, social and economic factors.

Using the systems theory in this study, interactions of health systems, building blocks where explored and examined in relation to access to immunizations: health information, service delivery, governance, finance, medical supplies (vaccines) and human resources. Using the health systems approach, will lead to a deeper understanding of how system components behave and provide insights in the design and selection of appropriate interventions (WHO, 2009).

All the components of the health system are very important to optimization of a health system. For example, financial resources are essential to procure and distribute vaccines just as good governance that creates a conducive atmosphere for operations, information systems that provide timely and accurate data to act upon, availability of vaccines, trained human resources and knowledgeable leadership that can make decisions addressing access issues and smart investments in health systems building blocks. Policy and programs decisions made are based on the information available, this information has to be accurate and reliable to promote sustainable access, inaccurate information or data would contribute to the unmet needs (Iyer, Chukwuma, Mugunga, C., Manzi, Ndayizigiye & Anand, 2018).

Having trained human resources leads to increased efficiencies and effectiveness in decision making and health service delivery for example training in supply chain functions such as selection, forecasting, quantification and delivery of immunizations (Prosser et al, 2017). Additionally, certain sociodemographic and economic index factors affect how people access health systems and comply to immunizations such as the level of education of mothers, poverty head count and human development index, costs of immunizations including religious factors.

Some of these factors were assessed for any association to immunization access. Unfortunately, the dataset used did not have data on information technology however, this was reviewed from secondary data though not discussed extensively.

The Rationale for the Choice of Framework

Firstly, access to medicines is one of the major challenges in LMICs, contributing to more morbidity and mortality with many factors attributed to it. Access to immunization is particularly challenging as it involves different components and many complex factors that include procurement functions such as selection, forecasting, procurement, distribution, administration and finances among others. Immunizations are administered in the context of health systems, which calls for better understanding of the architecture of health systems and predictors. Understanding these would help policy makers and program managers maximize intervention for better outcomes. Using the systems approach is an effective way of exploring the different elements or health systems building blocks, how they interact and reveals where strengthening should occur to improve access to immunizations to meet national and global targets.

Secondly, provision of healthcare and services such as immunization relies on complex factors at play working in unison. It requires a broader perspective view which the systems framework approach provides. Understanding these complex factors and their interplay is critical in the realization of the maximum benefits at the same time strengthening health systems. The health systems theoretical provides this level of understanding. Knowledge from using this approach can be used for the other health commodities.

Thirdly is that the health systems approach has been successfully used to improve access to newborn immunizations in 6- states in India as an implementation strategy(Gera et al, 2019). Low vaccination uptake was related to challenges in stewardship, poor service delivery, stock-outs and human resources. Using the systems approach they developed intervention strategies that led to improvement in vaccination of newborns from 55% - 88% in their programs (Gera & et al, 2019). This shows that the systems approach can be used to explore and understand predictors of immunizations to guide developing interventions to increase immunizations.

Logical Connection

Mutale et al (2016) used the systems thinking theory to strengthen the health system riddled with many barriers to increase demand and access to healthcare services, by evaluating stages of a complex program. They sought to take a broader look and analysis, rather than a narrow vertical approach. In doing so they used the systems building blocks to show the interactions between them and determine the cause and effect factors. Largeron, Lévy, Wasem, & Bresse, (2015) noted that immunizations are key to strengthening health systems by making contributions to building blocks such as making finances available, human resources and products, also by reducing costs associated with them through diseases in their study.

Gera et al (2019) used the health systems approach as an implementation strategy aimed at increasing vaccination rates at birth in 6- states in India. They examined the various building blocks and bottlenecks to immunizations at birth.

Building on these previous studies and taking a holistic approach which was ideal for this study, I used the systems theoretical framework, to examine relationships between the building blocks and access to immunization and their determinants. Since immunizations occur in health

systems this theoretical framework is ideal to provide insight into factors that lowers immunization rates and provide points in the value chain of immunization to focus for a high value in return on investment. This approach is useful in explaining the cause and effect relationship and how interconnected the building blocks are their predictors.

Thus, understanding the predictors of immunizations by examining the building blocks and their roles and how they interact, will allow us to further understand where to intervene to maximize returns as evidenced by increase in immunizations. There is a cause and effect relationship and a high degree of dependency and interconnectedness building the health systems building blocks. Provision of vaccines to untrained staff would not support access to immunizations at all, just like poor forecasting or lack of funds to ensure availability of vaccines when patients need them. However, understanding the gaps, the influences, characteristics and behaviors would lead to increased access and uptake of immunizations.

Nature of the Study

An ecological quantitative study method was used for this doctoral study using country level data from 9- sub-Saharan African countries. Secondary data analysis was done using secondary datasets from WHO and UNICEF. Quantitative methods are often used to look at relationships among variables using statistical analysis (CIRT, 2019). The study looked at the relationship between the dependent and independent variables.

The independent variables used were the 6- building blocks of a health system as defined by the WHO: human resources, service delivery, medical products, health information, finance, governance (WHO, 2019). In addition, a select sociodemographic factors where considered in the study. The dependent variable was access to immunization.

Literature Search Strategy

Search Strategy

The literature reviewed for this study included peer reviewed articles from the following academic databases, CINAHL Plus with Full Text, EBSCOhost, NCBI, ProQuest Health, the Walden Library, ProQuest Central, SAGE Journals, MEDLINE Full Text and PubMed. Other databases used were ResearchNow, InfoSci journals, Taylor Francis Online, BMJ, Lancet, google scholar, GAVI, and Science Direct. Additional databases included the WHO, UNICEF, CDC, CIA, DHIS2 for 8- sub-Saharan African countries. Literature search done was from 2010 to 2020.

Search terms

The following search terms were used for this study, health systems, health systems strengthening, vaccinations, immunizations, sub-Saharan Africa, access to medicines, access to vaccines, vaccines and vaccine coverage, pharmaceuticals and National Essential Medicines List. Other terms included names of vaccines BCG, DPT1, DPT3, OPV3, HBV3, HIB and Measles included in the study.

Scope of Literature Review

Literature reviewed for this study included peer reviewed articles from scientific journals including systematic reviews, meta-analysis, reports from organizations involved in immunizations such as GAVI, UNICEF, WHO including country reports. Others included USAID articles, African Union, Africa CDC and regional economic groups.

Literature Related to Key Variables and or Concepts

There is paucity of data for immunizations in sub-Saharan Africa, which posed challenges, however there is enough evidence and statistics that show that rates of immunizations in sub-Saharan Africa are far behind many global set targets. Data is often missing in country datasets and some districts are missed out. There is still enough data for analysis. In 2017, 19.9 million children did not receive immunizations with the larger percentage of these children being in sub-Saharan African countries. DTP3 coverage for example, remained at 72% in African countries for almost 10 years despite the increase in infant births, below the Global Vaccine Action Plan (GVAP) of 90% or more target (WHO, 2019). WHO (2019) reported that 20.8 million people under 1 year did not receive a single dose of measles vaccine in 2017. Access to vaccines remains to be a challenge in this region.

Global statistics on global and sub-Saharan Africa statistics

There is paucity of data in most LMICs compared to developed countries regarding access to immunizations and immunization rates, which has improved over the last few years. Data is often incomplete for certain variables and often incomplete. Despite this challenge, there is enough evidence and data that show that rates of immunizations in sub-Saharan Africa are far behind many global set targets. In 2017, for example, 19.9 million children did not receive immunizations with the larger percentage being in sub-Saharan African countries (WHO, 2019). Diphtheria, Tetanus and Pertussis 3rd vaccine (DTP3) coverage, remained at 72% in African countries for almost 10 years despite the increase in infant births below the Global Vaccine Action Plan (GVAP) target of 90% or more (WHO, 2019). 20,8 million people under 1 year did not receive a single dose of measles vaccine the same year, 2017 (WHO, 2019).

Globally there has been an improvement in reducing mortality rates for children with the UN, reporting a decline of 58% since 1990 and a remarkable drop in the number of deaths of children under the age of 5 years from 12.6 million in 1990 to 5.4 million in 2017 (UN, 2019). Despite this progress the report noted that still most children under the age of 5 years die from preventable diseases such as pneumonia, diarrhea, and neonatal sepsis, where effective interventions like immunizations would have prevented the deaths (UN, 2019). In the US another key constituent who die from vaccine preventable diseases are the elderly, contributing 50,000 to 90,000 deaths a year (IDPV, 2020).

Through the use of vaccines some diseases such as polio and smallpox have been eradicated. Major progress has equally been made in eliminating maternal and neonatal tetanus, a high child killer with a fatality rate of 70 to 100%, globally, with only 13 countries remaining since 2019 (UNICEF, 2019). This shows how effective immunizations are in preventing diseases.

The case for immunizations: Immunizations are the cornerstone of modern medicine and one of the most effective public health interventions in modern history. Through immunizations, many diseases, disabilities and mortality can be prevented. Examples of these diseases with a high toll on morbidity and mortality, include yellow fever, diphtheria, tetanus, mumps, hepatitis B, pneumococcal infections, pertussis, polio and *haemophilus influenza type B* infections (UNICEF, 2019). Other diseases are TB, hepatitis A, rotavirus rabies and yellow fever (UNICEF, 2020).

The impact and success of immunizations can be seen from mortalities they prevent and the decline that has been seen for some highly infectious diseases. Immunizations saves lives and

have contributed in the decline of under 5 years mortality rate by 24% from 2010 to 2017 and prevent 2 – 3 million deaths every year (IHME, 2020, WHO, 2020). Measles a highly contagious infectious disease and killer for children declined by 80% within a 17-year period from 2000 to 2017 averting 21.1 million deaths due to increase in immunization coverage (UNICEF, 2019). sub-Saharan Africa has the highest burden of infectious diseases, home of half of the world's poorest and deals with a triple burden of HIV and AIDS, TB and malaria. Most of these infectious diseases can be prevented through immunizations. However, gaps still exists and understanding them through a health systems lens would enable this region to enjoy the success that most western countries enjoy. DTP3 is a vaccination that is used as good indicator for immunization programs, in 2018, 19.4 million infants globally did not receive DTP3 vaccine, with 60% of those coming from LMICs including sub-Saharan African countries (WHO, 2020).

Vaccinations also contribute to reduction in the spread of infections in communities where more people have been vaccinated and have developed herd immunity. Other benefits of immunizations are that they are a very cost effective intervention, saving millions of dollars that can be invested in other health programs and directly in health systems strengthening. For every dollar spent on measles vaccinations in 94- LMICs, there is a return on investment of USD 58, this averts disabilities including death but also cuts healthcare associated costs (Ozawa et al, 2016).

Immunizations also lead to prosperity in countries and is a good economic indicator. They lead to healthier and prosperous communities as fewer people get sick, children do not miss school, parents do not miss work, healthcare expenditures are low, the stress on health systems is reduced allowing saving of funds that can be directed health systems strengthening and other

country progressive agendas. Immunizations will prevent 24 million people being pushed in extreme poverty by 2030 (Chang et al, 2018).

Immunizations also are a sensitive intervention for a major public health crisis of emerging and re-emerging infections including antimicrobial resistance. They reduce the demand for the use of antibiotics and emergency of resistant pathogens. Ramanan et al (2018) estimate that antibiotic use for PCV can be reduced by 47% in pneumonia patients, an equivalent of 11.4 million antibiotic days, which is very significant.

Immunizations also contribute to global goals and key to the attainment of SDG 3, whose goal is to ensure healthy lives for all and promote well-being and affects some SDGs directly and others indirectly (WHO, 2020). Sub-Saharan African countries made commitments to global goals such as the SDGs, International Health Regulations (IHR) and the Immunization Agenda 2030. The Immunization Agenda 2030 theme is that of leaving no one behind by committing to ensuring that everyone, everywhere has access to immunization and attain the goals of health (WHO, 2020) The impact will be equitable access to vaccines for all, attainment of the highest level of health through strong immunization in primary health care and contributing to the reduction in morbidity and mortality from preventable diseases (WHO, 2020).

Vaccine Supply: Access to life-saving vaccines is still one of the major challenges for a number of countries that include sub-Saharan African countries and most fragile nations. This largely depends on vaccine supply factors, that include supply chain. Popova & Palacios (2015) noted that children under the age of 5, are 15 times more likely to die in sub-Saharan Africa compared to the same age group in developed countries due to lack of access to life-saving vaccines. UNICEF (2019) reported that approximately 1.5 million children died from

preventable infectious diseases, citing lack of access to vaccines as one of the major factors, 50% of those deaths could have been prevented. Weak immunization supply chain systems impede access to immunizations in sub-Saharan Africa and remains one of the major barriers (Vouking et al, 2019).

Financing and cost of vaccines – Lack of affordability of vaccines due to lack of funding, is another issue some countries have to deal with that lead to lower uptake of immunizations. This will become a major challenge as countries graduate from the Global Alliance for Vaccines and Immunization (GAVI) and are expected to take up most of the costs of procurement and supply chain. Ethiopia for example gets 100 million USD from donors of the 150 million USD it spends every year on vaccines procurement, once it graduates it will have to finance the entire 150 million USD, which will be an onerous task (WHO, 2019).

Health information systems: Information about vaccines and immunization is critical for developing and managing immunization programs. This information feeds into the procurement systems guiding forecasting, procurement and distribution of vaccines in a country. WHO (2020) determines 4- essential functions of health information systems as generation of data, collating and compilation, analysis and communicating to key policy and decision makers for decision making (WHO, 2020). Health systems need to ensure adequate steady supplies of vaccines to avoid stockouts and vaccines expiring on the shelves. Unfortunately, in most sub-Saharan African countries, health information keeping is still paper-based, making it very difficult for transmission of data on time and analysis to allow for evidence-based decision making. Electronic information systems have been found to be improve immunization coverage. They have many benefits that include accurate record keeping, allows individuals to be followed

up easily, helps with immunization surveillance, tracking of defaulters and support clinical decision making (Danovaro-Holliday et al, 2019).

Governance: Immunization programs are run by governments. They are critical in setting country priorities, developing policies, providing technical and financial resources and strengthening health systems. Other functions include creating enabling environments that promote and support immunizations, regulation frameworks, developing and dissemination of information and accountability (WHO, 2019). Governance and leadership are also key in performing procurement and supply chain activities for vaccines in most LMICs. Leadership and governance functions that determines access to immunizations include .

Human Resources: Having adequate human resources that are trained is key for achieving immunization goals. Staff should have proficiencies in data management in addition to documenting, analyzing and feeding data into health systems and channels that can us it is important (Nicol, Turawa & Bonsu, 2019). Unfortunately, most health facilities in LMICs are under-staffed and most staff do not have adequate training on vaccines, and lack skills in handling immunization data and how to efficiently use it in healthcare delivery (Nicol, Turawa & Bonsu, 2019). This is often expressed in poor quality and incomplete data that makes planning, monitoring and evaluating interventions extremely challenging. Human resources are thus a key component of a health system.

Studies Related to Key Constructs and Methods

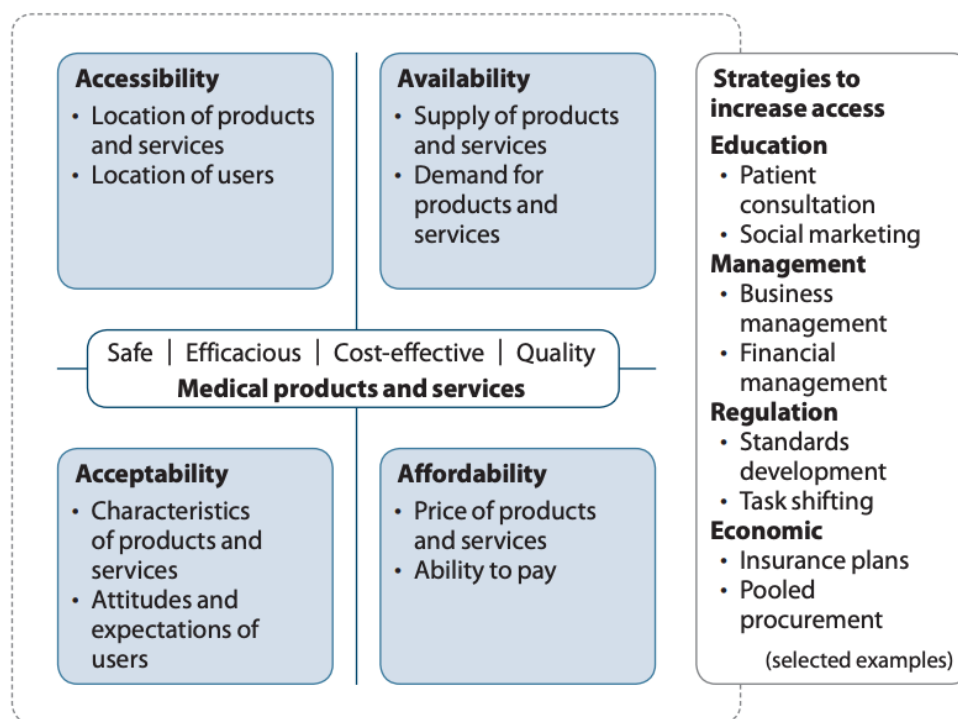
Literature on determinants of access

One of the definitions of Access to medicines (ATM) looks at it as having 4- dimensions, accessibility, availability, affordability and acceptability of medicines (Costa & e tal, 2017).

Improving access to medicines requires an understanding and appreciation of these 4 key elements. Management Sciences for Health (MSH) promoted this model showing the interactions and relationships including the strategies to include access through education, strengthening management, instituting regulations and economic such as using procurement strategies as pooled procurement to leverage on economies of scale and getting better pricing (MSH/CPM, 2011).

Figure 1

Access Framework



Note. From CPM/MSH 2011

Accessibility refers to ensuring that the medicines are located where patients can get them, availability refers to the trait that medicines are available in the right quantities and when they are needed, affordability means that medicines are affordable to patients and not prohibitive in pricing while acceptability refers to medicines being able to be used, having characteristics that do not hinder patients using them (WHO, 2020). Bridgeli et al (2003) discussed the ATM framework by incorporating the components of supply and demand and the dynamic relationship between the two.

Table 1

Domains and determinants covered in existing frameworks of ATM

ATM Framework	Domains	Specific Determinants	Cross-cutting Determinants
WHO-MSH 2000 (Centre for Pharmaceutical Management 2003)	Availability	Medicines' supply— type and quantity Medicines' demand—type and quantity	Quality of products and services
	Affordability	Prices of drug products and services User's income and ability to pay	
	Acceptability	Characteristics of products and services User's attitudes, expectations of products and services	
	Accessibility	Medicines' supply location User location	
WHO 2004c	Rational use	Rational therapeutic choices	Quality of medicines

		Improved medicines' use by consumers	
	Affordable prices	Medicines' pricing policies	
	Sustainable Financing	Resource mobilization Pooling Reduction of out-of-pocket expenditure	
	Reliable health and supply systems	Medicines procurement and supply Regulation Human resources	
Frost and Reich (2010).	Availability	Manufacturing Forecasting Procurement Distribution Delivery	Architecture: organization relationships at national and international level
	Affordability	Government affordability Non-governmental agency affordability End-user affordability	
	Adoption	Global adoption National adoption Provider adoption End-user adoption and appropriate use	

Note. From *Bigdelo et al., (2013)*

The UN define access as the continuous availability and affordability of medicines at health facilities including drug outlets that can be accessed within one hours walk from patient's residences to a health service facility (UN, 2019). Emphasizing similar characteristics as MSH.

The 4 As, availability, affordability, accessibility and acceptability are systems characteristics and one can look at the predictors of each and how they affect overall access to immunizations.

Philips, Dieleman, Lim & Shearer (2017) proposed a framework for determinants to vaccine utilization as intent to vaccinate, facility readiness and community access. Intent to vaccinate looks at the demand side for vaccines while facility readiness looks at the supply side including supply chain factors and community access, response of communities for uptake or not. The study however did not look at the predictors to access for these elements. One of the key elements in raising the demand for immunizations is having a strong and efficient health system that utilizes primary health care and outreach programs in the community that raise awareness.

Financing: One of the major challenges to access is financing both at the individual and national level. When vaccines are expensive patients cannot afford them limiting access and countries do not procure to distribute in the country. Inadequate financing and budgeting thus affect's availability and affordability of vaccines. Most LMICs do not use their own resources to procure vaccines but depend on donor funding. Access to immunization is still a challenge with many countries progress stalled in the last few years, showing 1 in 5 children not receiving all vaccines required in LMICs (GAVI, 2020). Ozawa et al (2016) analyzed the funding gap in their study for 94- LMICs over 5 a period of 5 years from 2016 – 2020 for full immunization costs. The result of their study underscored the importance of the need for more financial resources that would result from multiple stakeholders including governments working together to ensure comprehensive support of the value chain of immunization programs that includes the procurement cycle: forecasting, procurement, delivery and administration as they showed a gap of \$7.6 billion (Ozawa et al, 2016). 98% of that of the gap was for routine immunizations,

running immunization programs is costly and most LMICs cannot meet the costs within their budgets (Ozawa et al, 2016).

Sociodemographic factors - Other factors include sociodemographic factors such as level of education of mothers and distance from health facilities. A strong association has been observed between vaccination rates and maternal level of education, higher vaccination rates are seen in children with mothers that have higher levels of education (Cao, Zheng Cao, Cui, Duan, & Xiao (2018). The distance to health facilities and time it takes to the health facility are other determinants, the further the health facilities are or vaccination sites, the more unlikely that patients would travel for vaccinations or mothers will take their children (Cao, Zheng, Cao, Duan & Xia, 2018). The closer the health facilities are to the communities the more likely that high immunization rates will be observed.

At the industry level, The Access to Medicines Foundation uses 2 models to measure performance of pharmaceutical companies' efforts to improve access to medicines and vaccines and to stimulate them to increase access efforts (ATM, 2029). The indexes used are, Access to Medicines Index (AMI) and Access to Vaccines Index (AVI). Indicators used to rank companies include investments in R&D, pricing, donations and licensing, measuring how industries have performed in each of these areas and giving them a score that is published every year. This acknowledges that access is not only affected by the demand factors but supply factors.

Indicators that can be used to assess access to immunization using the systems approach are summarized in the table below with necessary indicators.

Table 2

Proposed Indicators to be used from WHO/UNICEF Estimates of National Immunization Coverage (WUENIC) and the Joint Reporting Form (JRF) estimates Adapted from WHO

Variable Dimension of system	Indicators
Finance	<p>Health Expenditure (% of GDP) Govt. Health Expenditure (% of GDP) Per capita Gross National Income Official Development Assistance (% GDP) Received Percentage of total expenditure on routine immunization financed by government funds? Are there line items in the national budget specifically for the purchase of vaccines used in routine immunizations? What amount of government funds are spent on vaccines? What is the total expenditure (from all sources) on vaccines used in routine immunization Percentage of total expenditure on vaccines financed by government funds What is the total expenditure (from all sources) on routine immunization? Percentage of total expenditure on routine immunization financed by government funds?</p>
Service Delivery	<p>Physicians per 1000 population Community Health Workers per 1000 population Health care workers aware of vaccination schedules Is there a stock-out at national level for BCG Is there a stock-out at national level for DTP</p>
Medical products - Vaccine Supply	<p>Is there a stock-out at national level for BCG, Hep1, Hep2 Hep3 and PCV If yes, specify duration in months – BCG, Hep1, Hep2 Hep3 and PCV Main cause for BCG stock-out, Hep1, Hep2 Hep3 and PCV Is there a stock-out in any district for BCG, Hep1, Hep2 Hep3 and PCV Was the district level stockout linked to a national one for BCG, Hep1, Hep2 Hep3 and PCV Vaccination services interrupted because of lack of vaccine for BCG, Hep1, Hep2 Hep3 and PCV</p>

Systems	Number of districts with DTP3 coverage categorized (<50%, 50-79%, 80-89%, > 90%) % of districts with DTP3 coverage categorized <50%, 50-79%, 80-89%, > 90%, >=95% % of districts with DTP3 coverage categorized <50%, Drop-out rate between DTP1 and DTP3 coverage % of districts with MCV2 coverage <50%, 50-79%, 80-89%, > 90%) Drop-out rate between MCV1 and MCV2 coverage
Governance and Regulation	Has the country a Multi-Year Plan (MYP) for immunization? Has the country an annual workplan for immunization activities? % of districts with micro plans including activities to raise immunization coverage Has the immunization programme a CMYP supply chain improvement plan? Is there a national system to monitor adverse events following immunization? Does the immunization programme have a dedicated immunization supply chain manager at national level?

Note Proposed variables and indicators

Health systems

Indicators of strong health systems can be evaluated by using both the process and outcomes indicators. Strong health systems have a higher chance to deliver immunizations, reduce stockouts, meet national and global targets and lead to reduced morbidity and mortality and better outcomes. There is also a positive result from immunizations of children and the elderly that leads to reduced strain on health systems, such as hospitalization, length of hospital stay, increased costs of diagnostics, human resource demand and treatments and other related health care costs (Largeron, Levy, Wasem & Bresse, 2019). Strong supply chain systems also contribute to lower nosocomial infections and antimicrobial resistance that leads to increased health care costs, morbidity and mortality.

Kamadjeu (2018) looking at the future of immunization programs in Africa reviewed the Expanded Program on Immunization (EPI) and observed that the success of immunization programs are coupled with strong delivery health systems components both structural and

financial. Reaching more people for immunization through the EPN remain the greatest challenge (Kamadjeu (2018). The strength of a health system can be determined by the effectiveness of programs like the EPI programs as they cannot be decoupled from the performance of a health system they operate under (Kamadjeu, 2018). immunization programs are run by the national government and thus make them as key stakeholders. The EPI program involves complex processes and elements working together and thus are a good mirror image of a health system.

Information System

Effective information systems are important for many reasons that include ensuring accurate documentation, ease of collecting and collating information, analysis of data and transmission of data to the district provincial and country level. However most Extended Immunization Programs (EPI) face challenges with data due to poor documentation, collation and effective utilization of information as they remain paper-based. Namageyo-Funa, Samuel, Bloland, & Macneil (2018) recommended that moving away from paper-based immunization records to electronic-based immunization records would lead to increased effectiveness and efficiencies in immunization programs in African countries. Information on consumption, utilization and forecasting including procurement would easily be accessible and strengthen decision making processes. It would also reduce the time that paper-based reporting takes. Clearly better documentation, sharing and utilization of this data would have a high impact on access to immunizations. Information transmitted inform many decisions made such as procurement and supply chain decisions, new improvements interventions, budgetary, education and staff competencies, policies and standards.

Yawson & et al (2017) observed several factors in their study, that affected failure to reach child immunization goals in Nigeria, these included inadequate vaccines, lack of access to health facilities, gaps in human resources capacity on immunizations and weak health delivery systems such as information. systems. All the factors identified and stated are components of the health system as defined by WHO.

Findings from past research

Mihigo, Okeibunor, Anya, Mkanda and Zawaira (2016), looking broadly at the challenges of immunization in Africa made a number of observations that included the challenges in logistical capacity of many countries, especially the cold chain needs for new immunizations and lack of funding. Funding immunization programs remain a major challenge for most SSA countries. Only a few countries allocate funds in their budgets for vaccine procurement, a major contributor to frequent stockouts of vaccines resulting in poor access and reduction of confidence in health systems.

Most African countries depend on funding from GAVI for their immunization programs, only 5 countries fund immunizations at 100% with more than half of the countries funding less than 50% and 10 countries funding at <20% (Mihigo, Okeibunor, Anya, Mkanda & Zawaira, 2017). With the disruption to African economies COVID-19 has done, this will even be a major problem leading to disruptions of many country programs, loss of revenue for countries, increased costs of healthcare and health outcomes.

Weak laboratory infrastructure and laboratory capacity contributes to the challenges of identifying causative organisms for certain diseases. This is even more important now when we have emerging and re-emerging infectious diseases. In Africa most immunization programs

depend on the laboratory infrastructure for polio eradication, which is now a problem as funding for polio eradication goes down (Mihigo, Okeibunor, Anya, Mkanda & Zawaira, 2017).

Current supply chain systems are stressed meeting requirements of newer vaccines that may require special handling and storage on top of the requirements of cold chain and have to reach communities in the last mile.

Most immunization programs in LMICs are funded by partners, GAVI the vaccine Alliance being one of them and developmental partners. LMICs require a paradigm shift in immunization financing as funding channels shrink and some countries graduate into the middle income category which will remove them from countries supported by GAVI. The funding gap for African countries between 2016 – 2020 was projected to be \$5 billion, this would prove to be a challenge for most countries due to competing priorities and their response to emerging and reemerging infectious diseases (Mihigo, Okeibunor, Anya, Mkanda and Zawaira, 2016),

Adedokun, Uthman, Adekambi and Wiysonge (2017) used the cross-sectional study and secondary data to explore and examine factors that lead to incomplete childhood immunizations by looking at individual, community and state factors in Nigeria. Their findings showed an alarming high percentage of children had not completed their recommended immunizations, $\frac{3}{4}$ of children (76.3%) with major determinants being illiteracy of parents and those who lived in low socio-economic settings. These settings have weak health systems that could contribute largely to low immunization rates and most parents are unable to afford user fees.

Nnorom (2017) used secondary data for a cross-sectional study that looked at health predictors of access to maternal health medicines. She used the health systems approach and access to misoprostol, oxytocin and magnesium sulfate used for post-partum hemorrhage. Using

the systems approach her conclusions included the observation of the disproportionate of distribution of post-partum hemorrhage in LMICs, the need to expand the way certain health systems components are looked at like finance to include accountability and need for strengthening the supply chain. Nnorom (2017) also concluded that access to essential maternal medicines was significantly predicted by the strength of the health system, procurement practices, distribution and financing.

Cooper, Betsch, Sambala, Mchiza and Wiysonge (2018) did not use the systems approach in their study but looked at vaccine hesitancy as a threat to achieving vaccination goals and benefits in African countries. They argued that while many studies have been conducted in high-income countries few studies if any had been done in Africa, more studies needed to be done that would take into consideration unique factors in the African context and lead to developing context specific interventions that could increase access and uptake of immunizations (Cooper, Betsch, Sambala, Mchiza and Wiysonge (2018). A strong health system that meets the needs of communities needs to be built taking the local situation into context.

Boyce et al, (2019) observed how challenging data for immunizations in African countries is and proposed to develop and pilot tools that would be used to identify areas with limited access to immunization services and use that as proxy for immunizations. Data is crucial to successfully run immunization programs especially accurate data that can be used for correct forecasting, determining the unmet need, inform procurement and other policies that would increase access to immunizations. The areas that are the most challenged are rural areas, they often have unstructured methods to collect data, new tools thus would increase the ease and strengthen data collection (Boyce et al, 2019).

The success of immunization programs depend on supply chain in particular – vaccine delivery proposed Utazi et al (2019). Using DHS data, they mapped predicted coverage at 1X1Km spatial resolution in 5- LMICs and determined under vaccinated areas resulting from gaps in the delivery systems (Utazi et al, 2019).

Operational Definition of Terms

Access to immunizations: Access to immunization refers to the concept of having vaccinations available at all times, the right quantities, affordable, acceptable and acceptable (WHO, 2020). This is measured by rates of immunizations, policies in place to promote immunizations such as the country having a Multi-Year Plan (MYP) and percent of districts with coverage of a particular immunization. Access is referred to as the 4 A's:

Availability: vaccines that are in stock all the time in healthcare facilities.

Affordability: Vaccines that all population members can afford to purchase or access even when they have to pay user fees.

Accessibility: vaccines that all population can get to with no limitations of distance, time nor other hindrances.

Acceptability: vaccines that are acceptable in communities in consideration of their cultural, religious or side effects.

Building blocks of health systems: Health systems building blocks refer to service delivery, health workforce, information, medical products, vaccines and technologies, financing, and leadership/governance as defined by WHO (Manyazewal, 2017). The health building blocks are critical to the delivery of health services and achievement of optimal health outcomes.

Health system: is a system whose primary purpose is to achieve health, the maximum status of health possible, promote, restore and maintain health and involves the interaction between institutions, people and resources (WHO, 2020). Almost all the countries in the world are committed to the provision of health services to their citizens as one of their fundamental roles.

Essential medicines: these are medicines that the population cannot afford to not to have to meet their health needs. These are medicines that should be available all the time and achieve the 4 elements of access, affordable, accessible, accessible, are available all the time with assured quality (WHO, 2020). These include vaccines.

Analytic Strategies

The statistical Package for Social Sciences, IBM SPSS Statistics 25 software was used to perform both descriptive and inferential statistics. Both univariate and multivariate analysis were performed. Using select variables from the data, Chi square and logistic regression was performed to show relationships between variables and their statistical significance to answer the research questions. The p value of 0.05 was used to determine significance..

Assumptions

Assumption 1

The WHO/UNICEF dataset that was used in this study were assumed to be representative of a country and complete. The methodology and tools used for joint reporting by countries were reviewed in order to ensure that they were similar across countries so that the data on immunizations, access, human resources or financing were comparable between countries.

Assumption 2

The assumption was made that all the data collectors were trained, did due diligence in collecting data using the same methodology and that the data is truthful.

Assumption 3

My other assumption was that the data submitted to WHO and entered into the system was complete, verified and accurate and captured information on all the vaccines. Also, that quality assurance was ensured

Scope and Delimitations

The aim of this study was to examine how health systems building blocks pertaining to vaccines, affect access to immunization in sub-Saharan African (SSA) countries. This was done by using the ecological study design. Select variables for each building block most relevant to the study and where sufficient data was available was selected using the secondary dataset.

What this study did not look at was to determine causation. Cause and effect cannot be determined by using an ecological study design. One of the characteristics of ecological studies is based on the intent, the intent is to study relationships at the population level involving exposure risk and the contextual effects on the population study and not the causal relationships (Nature, 2020).

This study was based on population data that WHO and UNICEF collect from member countries using standardized tools for immunizations and indicators they use for measuring access. This data is collected every year and is dependent on countries self-reporting. Countries have been taught on data collection.

Limitations, Challenges, and/or Barriers

The challenges I faced in this study was the lack of availability and insufficiency of some data on certain immunizations used as proxies. For some countries not all district had reported immunization data contributing to data insufficiency and completeness. Most LMICs face the challenge of lack of good data, insufficient and complete data and good repositories. This is coupled with the lack of electronic reporting systems leaving them dependent on paper-based information systems. Data on information systems was scant and mostly qualitative in different data sets.

Using secondary data is a challenge most times due to the fact that the primary reason for which data was collected may be different from the research question or reason the user of the data might have. It might also be a challenge to have an adequate sample size that would allow statistical analysis.

In this study, the percentage of missing data varied from measure to measure. A minimum of 7.6% missing cases was found in the case of the dependent variable, with a maximum of 42.4% in the case of the question asking "Is there a stock-out in any district for Measles?" In the logistic regression analyses conducted, valid sample sizes ranged from a minimum of 114 to a maximum of 178. With regard to the categorical measures included in this study, the dependent variable had data points of zero with respect to only six cases (3.3%). 05160 was found to have 31 cases (17.3%) of cases which had data points of zero, with 13198 having 30 cases (21.6%) with entries of one. Next, 13204 had 19 cases (15.0%) with values of one, with 13249 having 22 cases (19.3%) with values of one. 13246 was found to have 16 cases (11.8%) with values of one, and with 06167 having 18 cases (10.1%) with values of zero

The other limitation is that the study did not look at all the immunizations but selected a few immunizations that all the countries have on their mandatory list which had sufficient data. The immunizations used as proxies were BCG, DPT1, DPT3, OPV3, HBV3, HIB3 and Yellow Fever. These provided a good sample for analyzing access to immunizations.

Summary, Significance and Conclusion

The national and global goals on health, promote well-being and enjoyment of health to the full extent possible. The third- sustainable development goal (SDG), focuses on health and has indicators that include reduction of mortality rates for infants and mothers by 2030, provision of universal health coverage including health services, medicines and vaccines (WHO, 2019). SDG 3- also focuses on the reduction of premature mortality by a third (1/3) from non-communicable diseases (NCDs). The Immunization Agenda 2030's vision is to have sustainable access to vaccines for everyone with the impact goals of reducing vaccine-preventable morbidity and mortality, and ensuring the highest level of health for everyone by strengthening health systems including primary health (WHO, 2020). Achieving these immunization goals could reverse and prevent the high morbidity and mortality in sub-Saharan Africa, a region with the highest maternal and infant mortality rates, most of which are preventable through immunizations (Doctor, Nkhana-Salimu & Abdulsalam-Anibilowo, 2018).

Rates of immunizations are a very good indicator and determinant of healthy communities and economies. It is very unlikely that national goals and global goals on any economic indicator whether it be on education, energy, employment, disease containment and creation of healthy communities can be attained without healthy people and health interventions such as vaccinations. Immunizations are very cost effective with a high return on investment,

showing high numbers of lives saved, economic savings and reduction in the demand and stress on health systems. For example, in the US the Hemophilus influenzae type B vaccine has 12 billion USD attributed to indirect costs and 5 billion USD to direct costs, for smallpox the estimates are at 300 million USD in direct costs yearly while for DTAP, USD 24 is saved for every USD spent in investment (Rémy, Zöllner, & Heckmann, 2015). Failure for SSA countries to provide immunizations to the last mile, will result in continued economic losses, weakened health systems, increased morbidity, increased infant and maternal mortality rates, non-communicable diseases (NCDs) and failure to achieve global goals such as the Immunization 2030 Agenda and SDGs.

Debilitating diseases such as polio have been eradicated through effective vaccination programs, failure to continue providing vaccinations could see these diseases coming back. While there are many factors that contribute to rates of immunization from personal, cultural, economic, structural, to state of health systems, countries with strong health systems tend to have higher immunization rates than those with weak health systems. One can attribute immunizations rates as being a health systems issue as they occur within health systems.

Lack of immunizations have several secondary impacts apart from preventing diseases, these include causing severe diseases which lead to hospitalizations, increased hospital stays, increased costs associated with that, increased secondary infections, that may lead to the use of expensive antibiotics, increased morbidity, increased costs of treatment and deaths.

Immunizations contribute to strengthened health systems by lowering the stress on them, costs, reducing utilization of health care and by preventing hospital acquired infections and infections

that might lead to additional hospital days by 4 – 12 days (Largeron, Lévy, Wasem, & Bresse, 2015). They are a very good preventive intervention to diseases.

While there are studies that have looked at access in terms of solid formulations, there are very few studies if any I came across, that have looked at vaccines, which are specialized products with peculiar challenges such as maintaining the cold chain patency from procurement, transportation, storage to administration and other complex factors including financing. Immunizations are often administered to healthy people that might delay the urgency of receiving them.

The study will contribute to social change by generating knowledge and showing the predictors of building blocks and their association to access of immunizations, show where countries can focus in strengthening health systems by using the health systems approach and best leveraging them to increase immunization access in SSA countries. The study could also inform and influence policies aimed at improving interventions to address the current challenges of access to vaccines and meeting the unmet needs. Equally through strengthened health system with improved access, members of the communities will develop more trust in health systems that might result in increased uptake of vaccinations.

Immunizations are one of the most effective public health interventions. They offer protection from so many infectious diseases such as polio, malaria, measles, pneumonia, hepatitis and non-communicable diseases like cervical cancer. Globally 2-3 million deaths are prevented due to immunizations every year (WHO, 2019). Despite the evidence of success in immunizations, immunizations rates in sub-Saharan Africa still fall short of global targets. According to the WHO (2019), the estimates for 2018 show that 19.4 million children less than 1

year old did not receive basic vaccines. The average rate of immunization in sub-Saharan Africa is 72% which unfortunately exposes many in the population to vaccine preventable diseases (VPDs), (WHO, 2019). Estimates from WHO Africa region, show that 19.4 million infants globally were unreached for immunizations in 2018 (WHO, 2019).

Lack of access to immunization services and vaccines, is one major reason that has led to lower immunizations in the region. Increasing access to vaccines would lead to increased access to vaccines that would prevent vaccine preventable diseases. Vaccine preventable diseases affect 31 million children under 5 years, with over 500,000 dying from lack of access to vaccines every year, majority of these being in sub-Saharan Africa (WHO, 2020).

Immunizations occur within health systems, through the Expanded Programme on Immunization (EPI). A health system consist of 6 building blocks as defined by the WHO. These include finance, service delivery, information, medicines (such as vaccines), health workforce, and governance (WHO, 2019). Gaining an understanding of the building blocks and their predictors would lead to targeted interventions that lead to increased access to immunizations. They would lead to evidence-based decision making, policy development, well-resourced health system, better forecasting and procurement and improved service delivery. These systems building blocks need to work in unison and in sync to maximize their effect and achieve the health outcomes of a health system.

Ensuing equitable access to immunizations has been one of the major global goals. The UN sustainable development goal number 3 is on health, to ensure heathy lives and on health, and promoting well-being for all (UN, 2019). Some of the key targets include achieving equitable access to universal health coverage, health care services and to quality, affordable

vaccines and to prevent infant and children under 5 deaths which are preventable through vaccinations and access to healthcare services (UN, 2019).

The Africa Union realizing the need to increase access to immunizations had the Head of States sign and endorse the Addis Declaration on immunization whose goal was to ensure equitable immunization for all children regardless of their economic social circumstances (WHO, 2019). In 2016 African countries committed to the Universal Access to Immunization declaration and reaffirmed their declaration to achieve immunization rates of 90% by 2020 and committed to the Regional Strategic Plan for Immunization (RSPI) for Africa that included targets such as elimination of polio, measles and maternal and neonatal tetanus. (WHO, 2020).

I chose to use the ecological study design for this study, a study design that has been used and suitable to study populations and not individuals and allows for comparisons between countries. The study did not look at the cause and effect but the association between the dependent and independent variables: access to immunizations and health systems building blocks respectively. The WHO/UNICEF dataset was the primary dataset used for this study.

Section 2: Research Design and Data Collection

Introduction

In this section, an elaborate explanation was provided on the proposed statistical approach to be employed to study the relationship between the variables of interest. The main topics that were addressed in this section included the research design and the rationale of choosing it, the study variables and the methodology. In the methodology segment, detailed explanations of the target population, sampling and sampling procedures, instruments of measure and the data analysis plan were provided. The chapter also provides the threats to the internal,

external, construct and statistical conclusion, and ethical procedures that were used to achieve validity. The section also includes how data was handled with confidentiality and the IRB approval process and any ethical considerations.

Research Design and Rationale

This study was an ecological study using secondary data on immunizations in sub-Saharan African countries. The study examined the predictors of access to immunizations in sub-Saharan Africa, by looking at the health systems building blocks and their relationships to access. Setia (2016) defined cross-sectional study design as a type of observational study whereby the exposure is not altered and the researcher measures outcomes and relationships in the population. Ecological studies are observational studies where one of the characteristics is that data is analyzed at the population and not individual level, for example, comparing groups of people like countries (Neumark, 2017). Relationships are examined by looking at rates and exposures in the population (Neumark, 2017).

Limitations of ecological studies include the fact that casual relationships are difficult to derive (David, Geier, Kern, & Geier, 2018). Despite this weakness and that of biases, ecological studies are widely used in public health for health planning, monitoring and evaluation, they are less expensive and easier to conduct which my study benefited from (Setia, 2016).

This study looked at data between 2010 and 2016 and examined predictors of access to immunizations using the systems-based approach. The relationship between the health system indicators and vaccination coverage was assessed in this study. The exposure variables were determined from standard sources like studies published in peer reviewed journals reports from government/international agencies, UN reports, World Bank reports, etc.

The study proposed to examine the trends of demographic factors indirectly linked to health systems such as the region Human Development Index, Per capita Gross National Income, GINI Index, Poverty Head Count Ratio at 1.9\$ per day (2011 PPP), Total Fertility Rate, Education Index, Adult Literacy Rate, Adult Female Literacy Rate, Official Development Assistance(% GDP) Received. The outcome variables used were vaccination coverage over the years in those respective countries, for BCG, DPT1, DPT3, OPV3, HBV3, HIB3 and Yellow Fever. The relationship between the health system indicators and vaccination coverage was assessed through the study. The exposure variables will be found out from standard sources like studies published in peer-reviewed journals, reports from government/international agencies, UN reports, World Bank reports etc-. The vaccination coverage data used were taken from WHO & UNICEF.

Study Variables

The study aimed to investigate associations between the independent variables, health systems building blocks characteristics and access to immunizations, the dependent variable. Franfort-Nachmias (2018) defines the dependent variable as the variable investigators are seeking to explain, the object of the research while the independent variable is the variable expected to account for the dependent variable. The independent variables that this study focused on were governance, finance, information systems, health service delivery, vaccines and socioeconomic indicators.

Three to four indicators under each of these building blocks were analyzed for association to the outcome variable of this study, access to immunizations. The reason for limiting the number of independent variables within each category was in order to avoid the

possibility of there being too many variables to be analyzed under each building block, and due to missing and insufficient data available in the dataset. The smaller number of variables selected for analysis then formed the basis for generalization. The following immunizations were proposed to be used as markers and proxies for immunizations BCG, DPT1, DPT3, OPV3, HBV3, HIB3 and Yellow Fever.

Table 3

Total Variables Considered

Variables:	<ul style="list-style-type: none"> • Health Expenditure (% of GDP) • Govt. Health Expenditure (% of GDP) • Per capita Gross National Income • Official Development Assistance (% GDP) Received • Percentage of total expenditure on routine immunization financed by government funds? • Physicians per 1000 population • Community Health Workers per 1000 population • Health care workers aware of vaccination schedules • Is there a stock-out at national level for BCG, DPT1, DPT3, OPV3, HBV3, HIB3 and Yellow Fever • If yes, specify duration in months – BCG, DPT1, DPT3, OPV3, HBV3, HIB3 and Yellow Fever Main cause for BCG stock-out, Hep1, Hep2 Hep3 and PCV • Was the district level stockout linked to a national one for BCG, DPT1, DPT3, OPV3, HBV3, HIB3 and Yellow Fever • Is there a stock-out in any district for BCG, DPT1, DPT3, OPV3, HBV3, HIB3 and Yellow Fever • Vaccination services interrupted because of lack of vaccine for BCG, DPT1, DPT3, OPV3, HBV3, HIB3 and Yellow Fever • Number of districts with DTP3 coverage categorized (<50%, 50-79%, 80-89%, > 90%) • % of districts with DTP3 coverage categorized <50%, 50-79%, 80-89%, > 90%, >=95% • % of districts with DTP3 coverage categorized <50%, • Drop-out rate between DTP1 and DTP3 coverage • % of districts with MCV2 coverage <50%, 50-79%, 80-89%, > 90%) • Has the country a Multi-Year Plan (MYP) for immunization?
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	<ul style="list-style-type: none"> • Has the country an annual workplan for immunization activities? • % of districts with micro plans including activities to raise immunization coverage
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Note. These are the total variables in all the domains of access considered

Research Design Connection to the Questions and Scientific Knowledge

This study was an ecological quantitative study that investigated the relationship between access to immunization and health systems blocks using population data from 9 sub-Saharan African countries. Past research has successfully used ecological studies for population studies for examining and investigating relationships between variables. Using population data for immunizations and not individual data and looking at trends, this research design was better fitted to answer the research questions. This research design would lead to new evidence and findings that can be used to strengthen immunization programs and inform policy. Ecological studies are best tailored for such studies that support strengthening programs and policy work (Setia, 2016).

As noted earlier in this chapter, there are few studies that I came across that had investigated the relationship of access to immunizations using the health systems building blocks, governance, human resources, information systems, service delivery and products. Using secondary data is also a cheaper way of conducting such studies and also cuts on time (Setia, 2016).

Methodology

Target Population

The target population used in this study, were 9- sub-Saharan countries, with data derived from using data from the WHO/UNICEF Joint Reporting Form (JRF). These are global surveys conducted by WHO and UNICEF using standard questionnaires that have been developed. One characteristic is that the WUENIC data allows for comparison between countries and regions. The JRF data is submitted to countries to collect data on systems performance every calendar year, both WHO and UNICEF review this data for completeness and consistency, this provides them to check the quality of the data and ask for any clarifications (WHO, 2020)

This study focused on data from 9- sub-Saharan African countries. The Multiple Indicator Cluster Surveys (MICS) are surveys done by USAID that allow for international comparisons by using more than 100 indicators that cover children and women in several areas including health, education and gender (USAID, 2019).

A total of 9- countries were selected for the study, based on the consensus opinion of public health experts consulted, who have extensive experience working in Africa and in terms of the availability of data. The selection was made in order to provide the highest degree of representativeness possible as it relates to this study's sample and the results obtained, and to ensure maximum external validity. The countries selected for the study are at various stages of socio-economic development and represent the various kinds of political systems on the continent.

A single large data WHO/UNICEF dataset was used for the study. The dataset did not have some exposure variables and therefore was complemented by health systems data from

standard sources. The study covered multiple vaccines- BCG, DPT1, DPT3, OPV3, HBV3, HIB3 and Yellow Fever

Settings

WHO- UNICEF has been providing support to countries to collect data on children and women that countries can use to develop policies and intervention programs addressing health (UNICEF, 2019). These surveys are developed by WHO/UNICEF in collaboration with countries and are administered through face to face interviews. Country Ministries of Health collect the data and are supported by WHO and UNICEF country offices if they need it. Through joint collaboration WHO and UNICEF, both use a joint reporting form (JRF) and aggregate the data that reduces the reporting burden of country members to fulfil their mandate of using the data collected for monitoring health situations and trends (WHO, 2019). This data is collected every year for the period January through December, which after aggregation and evaluation is reported by WHO and made available on their website. This collaboration is the basis of the WHO/UNICEF Estimates of National Immunization Coverage (WUENIC). Information collected is also used in tracking and monitoring of global plans on immunizations in particular the Global Vaccine Action Plan (GVAP) and the Regional Vaccine Action Plans (RVAPs). Countries can also use this data to monitor their progress and for planning purposes. It has key indicators that are very useful. This data is open source and is available on the WHO website.

Sampling and Sampling Procedures

Sampling is the selection of a number of sampling units from a population of interest. Using the purposive sampling technique, a total of 9 sub-Saharan African countries were selected

for inclusion in this study, the Democratic Republic of Congo, Ethiopia, Ghana, Kenya, Malawi, Rwanda, United Republic of Tanzania, Zambia, and Zimbabwe. This selection of countries was chosen in order to allow for a sample that was as representative as possible and in order to ensure maximum validity. The countries selected for this study are at various stages of socio-economic development and represent the various kinds of political systems on the continent.

Procedures for Data Archival

The WHO/UNICEF dataset was used for this study, it included immunization coverage by vaccine, access, financing, global immunization profiles, immunization schedules and estimates based on quantitative data (WHO, 2019). Some exposure variables not in this dataset were complemented by health systems data from standard sources. Additionally, some socio-economic variables from sub-Saharan African countries were obtained from publicly available sources such as the CIA website. Latest available data was harvested from these sources and used for analysis. The project covered multiple vaccines- BCG, DPT1, DPT3, OPV3, HBV3, HIB3 and Yellow Fever.

As indicated above, countries collect yearly data on public health indicators that are reported to WHO and UNICEF. WHO and UNICEF have a collaboration that allows countries to collect data using a joint reporting form (JRF) and aggregate the data that reduces the reporting burden of country members to fulfil their mandate of using the data collected for monitoring health situations and trends (WHO, 2019). Country offices for WHO and UNICEF help countries with methodology or any challenges encountered if needed.

The DHS-USAID also collects data on countries and have datasets. They use questionnaires with modeled questions which have been developed with countries having the

options of adding their own questions across the fields that include demographics, child health, anemia, service provider assessments, Malaria and HIV and AIDS (USAID, 2019).

Access to Datasets and Permissions

All 3 organizations UNICEF, WHO and USAID granted permission to use their datasets after formally applying to them for permission. The application involved stating the reasons the data going to be used for, the name of the institution I affiliate with and if there were collaborating researchers. The application was made despite the datasets being available as open access. This also provided the opportunity of asking for more data in case I needed it.

Instrumentation and operationalization of constructs

Despite the paucity of data the WHO/UNICEF dataset were used for this study with complimentary data on health systems exposure variables from standard sources. The WHO/UNICEF datasets have health systems building block indicators as defined by WHO. The indicators are coded and point to health systems building blocks, governance, human resources, finance, access to immunizations and service delivery. Seven vaccines were used as proxies for some research questions, BCG, DPT1, DPT3, OPV3, HBV3, HIB3 and Yellow Fever.

Instrumentation and Operationalization of Constructs

The main source of the data used and reported to WHO and UNICEF is country data that is collected by countries through a tool developed by WHO and UNICEF. All the 9- countries included in this study report on common indicators that include vaccination coverage and health systems indicators such as governance, financing, service delivery, supply chain factors such as stock levels and stockouts. WHO and UNICEF report this yearly data on the WHO website and

is archived with countries and institutions including individuals being able to use the data for various causes. The data is reported under domains that include health systems building blocks.

Operationalization of Variables

Dependent Variable

The dependent variable for this study was access to immunization. Access has 4 dimensions namely accessibility, availability, affordability and acceptability. Access was determined through information from the dataset on the rates of immunizations, stockouts, whether the country had a Multi-Year Plan (MYP) for immunizations, coverage information for each vaccine in percentages and % of districts with a specific vaccine coverage between defined percentage points.

Independent Variables

The study used systems building blocks as independent variables: governance, finance, information systems, health service delivery and vaccines. These variables were in the dataset that was used.

Table 4

Health systems determinants of access to immunizations used for evaluating the study hypotheses

Indicators	Variables
Access to immunizations	Is there a national system to monitor adverse events following immunization?
Quality of Service Delivery	Is there a national system to monitor adverse events following immunization? Is there a stock-out at national level for BCG Is there a stock-out in any district for Measles Physicians per 1000 population Community Health Workers per 1000 population

Governance	Has the country a Multi-Year Plan (MYP) for immunization? Is there a national system to monitor adverse events following immunization?
Vaccine supply	Is there a stock-out at national level for BCG Is there a stock-out at national level for DTP Is there a stock-out at national level for Measles
Health Financing	Are there line items in the national budget specifically for the purchase of vaccines used in routine immunizations? Percentage of total expenditure on vaccines financed by government funds
Select socioeconomic Factors	Overseas Development Assistance as % of GNI , Health Expenditure as % of GDP, Government Health Expenditure as % GDP, GNI per capita % of government funding of GDP

Note. The dependent and independent variables selected for the study

I proposed to use two options, the using the Mean- 1 Standard Deviation as cut-off. These formed components of an indicator. If a country has all the variables (of the indicator) above the cut-off values, we can classify it accordingly. For example, if Kenya had Physicians per 1000 population and Community Health workers per 1000 population above the cut-off values, we can classify it as having adequate quality of healthcare delivery.

The 5 indicators were categorized as mentioned in the hypotheses below. The indicators will not be assessed independently but a score will be created as mentioned above. A total score will be computed of all the variables for each category and each variable will be converted into dichotomous variables using descriptive statistics. For example, for assessing access using the four dimensions I will use highly available or poorly available, poorly accessed or highly accessible and highly affordable and poorly affordable.

A change was made to these steps due to insufficient and incomplete data as discussed in section 3. I did not use either Mean-1SD or Median Absolute Deviation for the final analysis, as vaccination coverage was taken as a continuous variable for all the statistical aspects. Since there is a large temporal difference (over 10 years) in the data, artificial cut-offs may not be representative or valid. The initial idea was to convert vaccination coverage into categorical variables (using cut-offs) and then do the analysis.

The selected indicators were representative of assessing access to immunizations using the health systems blocks. IBM SPSS Statistics 25 software was used for both descriptive and inferential analysis.

The variables that were finally used are in the table below. Most variables had insignificant results to be included in the analysis.

Descriptive analysis proposed was to be done by converting dichotomous variables. These variables were to be grouped into the building blocks and other health and developmental indicators and were tested for association. In doing so initial diagnostic were conducted on these data in order to check for accuracy, as well as any errors or duplicity of data. These data were further analyzed through inferential statistics, which took the form of logistical regression analyses.

Data Analysis Plan

Statistical Software

Data was analyzed by using the IBM SPSS Statistics 25 software package. The analyses included both descriptive and inferential statistics.

Data cleaning and screening procedures

Indicators were selected and narrowed down into the main health systems building blocks. The following steps were executed, cleaning, coding of data and inputting into SPSS software, production of frequency tables and exclusion of missing data and data deemed to be outliers. Only data from the following countries were used Democratic People's Republic of Congo, Ethiopia, Ghana, Kenya, Rwanda, Uganda, Tanzania, Zambia and Zimbabwe.

Research Question(s) and Hypotheses

The following are the research questions and hypotheses where used to determine predictors of access to immunizations.

1. Is there a significant association between the quality of service delivery and access to immunizations in nine sub-Saharan African countries?

H₁₀: There is no significant association between the quality of service delivery and access to immunizations in nine sub-Saharan African countries.

H_{1A}: There is a significant association between the quality of service delivery and access to immunizations in nine sub-Saharan African countries.

2. Is there a significant association between governance and access to immunizations in nine sub-Saharan African countries?

H₂₀: There is no significant association between governance and access to immunizations.

H_{2A}: There is a significant association between governance and access to immunizations.

3. Is there a significant association between vaccine supply and access to immunizations?

H3₀: There is no significant association between vaccine supply and access to immunizations.

H3_A: There is significant association between vaccine supply and access to immunizations.

4. Is there a significant association between health financing and access to immunizations in nine sub-Saharan African countries?

H4₀: There is no significant association between health financing and access to immunization in nine sub-Saharan African countries.

H4_A: There is a significant association between health financing and access to immunization in nine sub-Saharan African countries.

5. Is there significant association between socioeconomic factors and access to immunizations in nine sub-Saharan African countries?

H5₀: There is no significant association between different socioeconomic factors and access to immunizations in nine sub-Saharan African countries.

H5_A: There is a significant association between socioeconomic factors and access to immunizations in nine sub-Saharan African countries.

Statistical Analysis

Testing for Multicollinearity

Multicollinearity occurs when two or more independent variables have a high linear correlation. The presence of multicollinearity in a regression analysis will result in the violation of the basic assumptions of regression. In order to avoid this problem, it was proposed that variance inflation factors (VIFs) be calculated in any cases where multiple independent variables

were included in a single analysis. A VIF below five was deemed indicative of the absence of high multicollinearity. However, as only a single predictor was found to achieve statistical significance in these analyses, the calculation of VIFs was not necessary.

While the lack of high multicollinearity is an assumption of regression analysis, this was not examined as part of the logistic regression analyses conducted in this study as these analyses only include individual predictors. Multicollinearity can only be present with multiple regression.

Checking for Outliers

I did check for outliers, these are values that differ significantly from other values and may affect the statistical inference (NIST, 2020). Both the mean and trimmed mean using SPSS was used including plotting on box plot.

Descriptive Analysis

Descriptive analysis of data is performed to provide insights about the distribution and the basic features of the various variables in a dataset. Essentially, descriptive analysis is the generation of descriptive statistics which consists of measures of central tendency and variability. The study variables that were used in this research were quantitative data. Some data in the datasets were qualitative data that were converted into quantitative data. Frequency tables, histograms and bar graphs were the outputs that were generated for these variables. The use of frequencies allowed for the determination of the mode and also showed how the data are distributed throughout the various categories of each variable.

Inferential Analysis

Just as its name suggests, inferential analysis in research is performed to aid in providing inferences on various phenomena. The most important inferential analysis proposed to be done on the data was logistic regression. Logistic regression was used and the significant association of variables was determined through a *p*-value of less than 0.05.

Binary logistic regressions were conducted for the dependent variable against the independent variables. The dependent variable, access to immunization, is a dichotomous variable that indicates whether a country has access to immunization or not. The independent variable in this regression model were the components of the health system building blocks, which included governance, service delivery, finance, quality of service delivery and human resources. The analysis was conducted in two stages. In the first stage, each independent variable was regressed against the dependent variable with all independent variables with significant relationships selected. In the second stage, all the significant variables from the first stage were planned to be included in a single multivariate logistic regression analysis alongside the dependent variable. However, this second planned stage was not executed as only a single independent variable was found to achieve statistical significance in the simple logistic regression analyses conducted, obviating the need for a multivariate analysis.

Threats to Validity

External validity

This study involved the use of a sample to make a generalization to the population in question, which provided external validity to the study. The sampling units that were used in this study were selected using the purposive sampling technique. This procedure can lead to selection bias, which consists of a threat to the study's external validity. Selection bias can be encountered during the selection of the sampling units. In research, the sampling units should have an

attribute of interest that can be used to make generalization to the entire population. If a unit is selected and does not possess this attribute, selection bias is introduced.

This study has some probability of selection bias due to a limited number of countries being included in the final data sets. This was reduced by including 9 countries in the study and making the country selection as representative as possible. The probability of information bias was felt to be low as the data were taken from standard sources. Also, multiple estimates of vaccination coverage were used in the final analysis in order to reduce biased information. The possibility of confounding was planned to be reduced by the use of multivariable regression modeling, while due to only a single independent variable achieving statistical significance in these analyses, this final planned model was not run. Additionally, an examination of the literature did not reveal any other confounders or control variables, and so no other potential confounding or control variables were included in this study.

Internal validity

In order to make reasonable conclusions, sound research has to be conducted. Internal validity is concerned with the number of confounding variables that are found in a study. A high number of confounding factors greatly compromises the meaning and sense that can be derived from a particular research. Therefore, it is vital to ensure that the confounding effect has been reduced to the lowest level possible. Having high internal validity is essential as it leads to results that are consistent if the study is repeated. To increase the internal validity in this study, factors that can cause confounding were also included in the study.

Statistical conclusion validity

Achieving statistical validity is important to reach conclusions in a study, a failure to achieve statistical validity can occur when statistical significance is not reached due to

insufficient data or deviations from (Creswell, 2013). In order to have sufficient data, 9-countries were selected and the number of years of focus increased for this reason.

Ethical Considerations

An application was made to the Walden Institutional Review Board before data was reviewed and used. To fulfil one of the requirements, I completed the training offered by the National Institute of Health Office of Extramural Research that helps researchers working with human subjects to learn how to handle human subject data and ensure confidentiality. The certificate of completion was submitted to the Walden Institutional Review Board as part of the application process. The data used had no individual identifiers as it was country data used.

Protection of Participants Rights

The data that was used was country level data that had no individual identifiers at all. This data was country level aggregated data collected by the Ministry of Health with no individual identifiers that would identify individuals and violate any human rights. Both descriptive and inferential statistics were proposed to be used.

Data Protection

Data will be saved with security code protection both on my laptop and an external hard drive. The data will be kept for 5 years after graduating and will be destroyed using the recommended procedures.

Summary

This quantitative ecological study used the health systems building blocks to examine the strength of their association to access to immunizations in nine sub-Saharan African countries.

The dependent variable was access to immunizations while the independent variables were financing, governance, human resources, vaccines, service delivery and some socioeconomic factors based on country indices such as GNI, GDP. The study was approved by the IRB of Walden University after meeting all the requirements.

Section 3: Presentation of Results and Findings.

Introduction

As stated in Section 1, the purpose of this study was to examine the association of health systems building blocks as predictors of access to immunization in 9 sub-Saharan African (SSA) countries. The research questions and hypotheses included in this study consisted of the following:

1. Is there a significant association between the quality of service delivery and access to immunizations in nine sub-Saharan African countries?

H1₀: There is no significant association between the quality of service delivery and access to immunizations in nine sub-Saharan African countries.

H1_A: There is a significant association between the quality of service delivery and access to immunizations in nine sub-Saharan African countries.

2. Is there a significant association between governance and access to immunizations in nine sub-Saharan African countries?

H2₀: There is no significant association between governance and access to immunizations.

H2_A: There is a significant association between governance and access to immunizations.

3. Is there a significant association between vaccine supply and access to immunizations?

H3₀: There is no significant association between vaccine supply and access to immunizations.

H3_A: There is a significant association between vaccine supply and access to immunizations.

4. Is there a significant association between health financing and access to immunizations in nine sub-Saharan African countries?

H₄₀: There is no significant association between health financing and access to immunization in nine sub-Saharan African countries.

H_{4A}: There is a significant association between health financing and access to immunization in nine sub-Saharan African countries.

5. Is there a significant association between socioeconomic factors and health financing access to immunizations in nine sub-Saharan African countries?

H₅₀: There is no significant association between socioeconomic factors and access to immunization in nine sub-Saharan African countries.

H_{5A}: There is a significant association between socioeconomic factors and access to immunization in nine sub-Saharan African countries.

In this chapter, the results of the analyses conducted for this study are presented and discussed. This consists of a set of descriptive statistics conducted on the dependent and independent variables included in this study, followed by a series of logistic regression analyses. The dependent variable was access to immunizations while the independent variables included health systems building blocks, health service delivery, governance, vaccine supply and health financing. The descriptive statistics conducted consisted of frequencies and percentages associated with each response category in relation to all categorical variables of interest, with measures of central tendency and variability calculated and reported for the one continuous measure included in this study.

These analyses are followed by simple logistic regression analyses, with one analysis conducted in relation to each independent variable. A multiple logistic regression analysis was also planned, but was not run as only a single independent variable was found to achieve statistical significance in the simple logistic regression analyses conducted for most variables except socioeconomic variables. Finally, a summary is presented, which briefly summarizes this study's results, and also discusses these findings in relation to this study's research questions and hypotheses.

Data Collection of Secondary Data Set

The source of data used in this study consisted of data derived from the annual WHO/UNICEF Joint Reporting Form. The time frame for data collection was 1997 to 2018. This is a population-based survey, with sampling suggested at one or more stages such that a representative sample of the population is achieved. WHO's member states report data every year following a designed methodology and questionnaire by both WHO and UNICEF. WHO and UNICEF request for data from January to December each year through written communication with Member States, which they extract, reviews to assure completeness and accuracy (WHO, 2020). Although the WHO provides sampling recommendations and guidelines, actual recruitment and response rates varied from country to country. The data tools used are standardized while countries can make adjustments by adding extra data they might need.

A number of discrepancies were present between the use of the secondary dataset as proposed, and what was actually done. First, regarding the range in years used in these analyses, due to the small sample size included in these data, this was expanded from 2010 to 2016 to 1997 to 2018. The number of indicators examined under each independent variable, varied but

were not three to four in all cases as planned. Additionally, the full list of immunizations proposed, which consisted of BCG, DPT1, DPT3, OPV3, HBV3, HIB3 and Yellow Fever, were not all incorporated into these analyses, including some socio-economic variables also incorporated into these analyses. Some of these vaccines data was insufficient not to provide any statistical significance.

The dependent variable chosen specifically related to whether the country has a Multi-Year Plan (MYP) for immunization. The final set of independent variables analyzed differed significantly from the list of those included in the tables in Section 2. This was due to lack and minimal data for analysis. Finally, variables were not dichotomized for the purposed of these analyses so that statistical power would not be reduced.

Data used for human resources related to BCG and DPT1 immunizations obtained from the WUNEIC dataset for the same years.

Regarding the representativeness of this sample, methods used varied from country to country, with the WHO and UNICEF only providing recommendations with regard to the sampling used. Similarly, response rates also varied from country to country. Implementation of the WHO's recommendations would provide for representative samples.

Inclusion and Exclusion Criteria

This study focused on sub-Saharan Africa due to the large incidence of disease in this portion of Africa that is preventable by vaccines. This portion of the continent was also focused upon as a delimitation determined by the researcher due to the current gaps in knowledge present in this area when focusing on sub-Saharan Africa. Purposive sampling was used in order to select a total of nine sub-Saharan African countries, with this sampling method chosen in order to

produce a sample that was representative of sub-Saharan Africa and with the sample being valid. All countries outside of the researcher's area of interest was excluded from this study. All the data in the WHO/UNICEF dataset was included in the study.

Review of Statistical Assumptions.

The statistical analysis included the dependent variable access to immunizations and the independent variables governance, quality of service delivery, financing, vaccine supply and socioeconomic factors. A review was conducted of the missing data, multicollinearity and any outliers. This review did not show any outliers.

Descriptive Statistics

Initially, a series of descriptive statistics were conducted on the dependent and independent variables of interest included in this study. Access to immunizations consisted of the dependent variable included in this study, while independent variables fell under the categories of Quality of Service Delivery, Governance, Vaccine Supply, and Health Financing. Table 4 reports the frequencies and percentages of response associated with all categorical measures of interest, which included all measures with the exception of GSA_06172, which was continuous. First, with respect to whether the country has a Multi-Year Plan (MYP) for immunization (GSA_01001), slightly over 3% of the sample had a response of "No," with close to 97% having a response of "Yes."

Regarding Quality of Service Delivery, these measures consisted of the following: Is there a national system to monitor adverse events following immunization? (GSA_05160), Is there a stock-out at national level for BCG? (GSA_13198), Is there a stock-out at national level for DTP? (GSA_13204), and Is there a stock-out in any district for Measles? (GSA_13249).

First, with respect to whether there is a national system to monitor adverse events following immunization, this was "No" in slightly above 17% of cases and was "Yes" in close to 83% of cases. Next, regarding whether there is a stock-out at national level for BCG, this was "No" in slightly above 78% of cases, and was "Yes" in close to 22% of cases. Next, with respect to whether there was a stock-out at national level for DTP, responses were "No" in slightly above 85% of cases, and "Yes" in close to 15% of cases. Finally, with respect to whether there was a stock-out in any district for Measles, this was "No" in close to 81% of cases and was "Yes" in slightly above 19% of cases.

Next, with respect to Governance, the measures of GSA_01001 (Has the country a Multi-Year Plan (MYP) for immunization?) and GSA_05160 (Is there a national system to monitor adverse events following immunization?) were included. However, GSA_01001 consisted of the dependent variable in these analyses and so was not duplicated in Table 4. In addition, GSA_05160 was already categorized under Quality of Service Delivery and is also not duplicated in Table 4.

Regarding Vaccine Supply, these measures consisted of GSA_13198 (Is there a stock-out at national level for BCG?), GSA_13204 (Is there a stock-out at national level for DTP?), and GSA_13246 (Is there a stock-out at national level for Measles?). As GSA_13198 and GSA_13204 were already categorized under Quality of Service Delivery, these results will not be duplicated here. Regarding whether there was a stock-out at national level for Measles, this was "No" in slightly over 88% of cases, and "Yes" in close to 12% of cases.

Finally, regarding Health Financing, these measures consisted of GSA_06167 (Are there line items in the national budget specifically for the purchase of vaccines used in routine

immunizations?) and GSA_06172 (Percentage of total expenditure on vaccines financed by government funds). Regarding whether there were items in the national budget specifically for the purchase of vaccines used in routine immunizations, this was "No" in slightly above 10% of cases, and "Yes" in close to 90% of cases. Measures of central tendency and variability were instead conducted in relation to GSA_06172, the only continuous measure included in this study's logistic regression analyses. This measure was found to have a mean of 21.092% ($SD = 26.509\%$), with a median of 11.500%, and a mode of 0%. A range of 100% was found, with a minimum of 0% and a maximum of 100%.

The descriptive statistics included in this table include all dependent and independent variables included in this study's analyses. As they were all dichotomous, there is no additional descriptive data to report.

Table 5

Descriptive Statistics: Frequencies

<u>Measure</u>	<u>No</u>		<u>Yes</u>	
	<u>N</u>	<u>Valid %</u>	<u>N</u>	<u>Valid %</u>
<i>Dependent Variable</i>				
GSA_01001	6	3.279%	177	96.721%
<i>Quality of Service Delivery</i>				
GSA_05160	31	17.318%	148	82.682%
GSA_13198	109	78.417%	30	21.583%
GSA_13204	108	85.039%	19	14.961%
GSA_13249	92	80.702%	22	19.298%
<i>Vaccine Supply</i>				
GSA_13246	120	88.235%	16	11.765%
<i>Health Financing</i>				
GSA_06167	18	10.112%	160	89.888%

<u>Measure</u>	<u>Indicators</u>
Dependent Variable GSA_01001	Has the country a Multi-Year Plan (MYP) for immunization?
Independent Variable	
Quality of Service Delivery	
GSA_05160	Is there a national system to monitor adverse events following immunization?
GSA_13198	Is there a stock-out at national level for BCG
GSA_13204	Is there a stock-out at national level for DTP
GSA_13249	Is there a stock-out at national level for Measles
Vaccine Supply	
GSA_13246	Is there a stock-out at national level for Measles
Health Financing GSA_06167	Are there line items in the national budget specifically for the purchase of vaccines used in routine immunizations?

Logistic Regression Analyses: Introduction

A series of simple logistic regression analyses were conducted with access to immunizations as the dependent variable, and with each independent variable of interest included individually in each logistic regression model. While a multiple logistic regression analysis was planned following these analyses, only a single predictor was found to achieve statistical significance out of all predictors analyzed, which made this final analysis unnecessary.

Research Question 1

Is there a significant association between the quality of service delivery and access to immunizations in nine sub-Saharan African countries?

H1₀: There is no significant association between the quality of service delivery and access to immunizations in nine sub-Saharan African countries.

H1_A: There is a significant association between the quality of service delivery and access to immunizations in nine sub-Saharan African countries.

The first set of simple logistic regression analyses were conducted with the measures of interest associated with Quality of Service Delivery. These consisted of the following: Is there a national system to monitor adverse events following immunization? (GSA_05160), Is there a stock-out at national level for BCG? (GSA_13198), Is there a stock-out at national level for DTP? (GSA_13204), and Is there a stock-out in any district for Measles? (GSA_13249).

Table 6 presents the results of these analyses. As shown, statistical significance was only found with respect to the effect of GSA_05160, Is there a national system to monitor adverse events following immunization? An odds ratio of 21.630 was found, indicating that the presence of a national system to monitor adverse events following immunization was associated with an odd of the country having a Multi-Year Plan (MYP) for immunization that were increased by a factor of 21.630. The 95% confidence interval for this predictor's odds ratio was found to be very wide, ranging from 2.327 to 201.040. This reflects a higher degree of variability and reduced precision with respect to the point estimate of this particular odds ratio. In terms of predictors that were found to achieve statistical significance, only in this case was the 95% confidence interval found to be very wide. As indicated in the notes of this table, this logistic regression

model was found to achieve statistical significance, with a Cox & Snell R^2 of .053 being found, along with a Nagelkerke R^2 of .236.

Table 6

Logistic Regression Analyses With Quality of Service Delivery

<u>Measure</u>	<u>B (SE)</u>	<u>Wald χ^2 (df)</u>	<u>OR</u>	<u>95% CI for OR</u>	
				<u>Lower</u>	<u>Upper</u>
GSA_05160 ^a	3.074 (1.137)	7.303** (1)	21.630	2.327	201.040
GSA_13198 ^b	-.612 (1.243)	.243 (1)	.542	.047	6.190
GSA_13204 ^c	17.648 (9220.900)	.000 (1)	46156424.081	0.000	—
GSA_13249 ^d	-1.466 (1.435)	1.044 (1)	.231	.014	3.841

Note. * $p < .05$, ** $p < .01$, *** $p < .001$. GSA_05160 = National Adverse Event Monitoring System, GSA_13198 = Stockout at National Level for BCG, GSA_13204 Stockout of DPT at National Level, GSA_13249 = Stock-out at National Level for Measles,

Research Question 2

Is there a significant association between governance and access to immunizations in nine sub-Saharan African countries?

H₂₀: There is no significant association between governance and access to immunizations.

H_{2A}: There is a significant association between governance and access to immunizations

Next, with respect to Governance, after filtering and removing unusable variables from those proposed, the measures of GSA_01001 (Has the country a Multi-Year Plan (MYP) for immunization?) and GSA_05160 (Is there a national system to monitor adverse events following immunization?) were retained. However, GSA_01001 consisted of the dependent variable in these analyses and so could not also be included in these analyses as an independent variable,

while GSA_05160 was previously examined as an independent variable with respect to Quality of Service Delivery. Therefore, no new results are presented here.

Research Question 3

Is there a significant association between vaccine supply and access to immunizations?

H3₀: There is no significant association between vaccine supply and access to immunizations.

H3_A: There is a significant association between vaccine supply and access to immunizations.

The following analyses focused upon Vaccine Supply. The independent variables associated with Vaccine Supply consisted of GSA_13198 (Is there a stock-out at national level for BCG?), GSA_13204 (Is there a stock-out at national level for DTP?), and GSA_13246 (Is there a stock-out at national level for Measles?). As GSA_13198 and GSA_13204 were previously examined, these results will not be repeated here, with the results of the remaining model presented in Table 7. As shown, this measure was not found to achieve statistical significance, with this logistic regression model also not found to achieve statistical significance.

Table 7

Logistic Regression Analysis With Vaccine Supply

<u>Measure</u>	<u>B (SE)</u>	<u>Wald χ^2 (df)</u>	<u>OR</u>	<u>95% CI for OR</u>	
				<u>Lower</u>	<u>Upper</u>
GSA_13246	-1.369 (1.255)	1.191 (1)	.254	.022	2.975

GSA_13246 Stockout at National Level for Measles

Research Question 4

Is there a significant association between health financing and access to immunizations in nine sub-Saharan African countries?

H₄₀: There is no significant association between health financing and access to immunization in nine sub-Saharan African countries.

H_{4A}: There is a significant association between health financing and access to immunization in nine sub-Saharan African countries.

The other set of logistic regression analyses conducted focused upon Health Financing, with the independent variables of interest analyzed consisting of GSA_06167 (Are there line items in the national budget specifically for the purchase of vaccines used in routine immunizations?) and GSA_06172 (Percentage of total expenditure on vaccines financed by government funds). As shown in Table 8, neither of these independent variables were found to achieve statistical significance, with neither of these logistic regression models found to achieve statistical significance.

Table 8

Logistic Regression Analyses With Health Financing

<u>Measure</u>	<u>B (SE)</u>	<u>Wald χ^2 (df)</u>	<u>OR</u>	<u>95% CI for OR</u>	
				<u>Lower</u>	<u>Upper</u>
GSA_06167 ^a	.661 (1.126)	.345 (1)	1.937	.213	17.624
GSA_06172 ^b	.014 (.031)	.212 (1)	1.015	.954	1.079

GSA_06167 = National Budget line for Vaccine Purchase, GSA_06172 = Percentage of Total Expenditure on Vaccines financed by government funds

Research Question 5

Is there a significant association between socioeconomic factors and health access to immunizations in nine sub-Saharan African countries?

H5₀: There is no significant association between socioeconomic factors and access to immunization in nine sub-Saharan African countries.

H5_A: There is a significant association between socioeconomic factors and access to immunization in nine sub-Saharan African countries.

A multiple regression analysis was conducted for the socioeconomic variables using BCG vaccine as the proxy Overseas Development Assistance as % of GNI , Health Expenditure as % of GDP, Government Health Expenditure as % GDP, GNI per capita and % of government funding of GDP. The Overseas Development Assistance as % of GNI has a p-value <0.05 just as the GNI per capita and % Government funding for vaccination showing strong evidence against the null hypothesis. This shows that there is a significant association between ODA% of GNI, GNI per capita, % Government funding for vaccination and access to immunization. These are good predictors of immunization coverage.

Health Expenditure as % of GDP and Government Health Expenditure as % of GDP had the p-value greater than 0.05 showing that we accept the null hypothesis. There was significant association between Health Expenditure as % of GDP, Government Expenditure and access to immunization. BCG coverage and Health Care Worker per 1000 population and BCG Coverage and Doctor per 1000 population were strongly associated with access to immunization leading to the rejection of the null hypothesis just as the similar indicators for DPT1, DPT1 Coverage and

Health worker per 1000 population and BCG Coverage and Doctor per 1000 population. These results shown a strong association between socioeconomic factors and access to immunizations.

Table 9

Multiple Linear Regression models to predict vaccine coverage

BCG coverage

Variables in the model	Unstandardized Beta Coefficient	Standardized Beta coefficient	t-test value	P value
Year	1.432	0.668	3.022	0.006
Overseas Development Assistance as % of GNI	0.725	0.402	2.223	0.036
Health Expenditure as % of GDP	0.344	0.092	0.398	0.694
Government Health Expenditure as % of GDP	-1.312	-0.136	-0.628	0.536
GNI per capita	0.017	0.714	3.670	0.001
% Government funding for vaccination	0.259	0.746	3.716	0.001
BCG Stockouts	-2.376	-0.127	-0.886	0.385
Constant	-2815.551		-2.995	0.007

R square- 0.681, Durbin Watson- 1.648, ANOVA: F-7.319 p value <0.001

The table shows significant results for overseas development assistance as a percentage of GNI, GNI per capita, and the percentage of government funding for vaccination

Table 10*Correlation between Vaccination Coverage and Baseline Variables**BCG*

Variables	Correlation Coefficient	P value
BCG Coverage and Health worker per 1000 population	0.667	0.009
BCG Coverage and Doctor per 1000 population	0.928	<0.001

Table 11*DPT1*

Variables	Correlation Coefficient	P value
DPT1 Coverage and Health worker per 1000 population	0.597	0.024
DPT1 Coverage and Doctor per 1000 population	0.892	<0.001

Summary

The results of the logistic regression analyses indicate that the null hypotheses relating to the Quality of Service Delivery and Governance, which relate to Hypotheses 1 and 2, respectively, were rejected as the predictor "Is there a national system to monitor adverse events following immunization?," which was included in both of these categories, achieved statistical significance. Hypothesis 5 also indicated that the null hypothesis relating to socioeconomic factors was rejected as predictors, DPT1 Coverage and % district vaccination, DPT1 Coverage and Doctor per 1000 population, and ODA as % of GNI showed strong association to access to immunization.

As no other predictors were found to achieve statistical significance, null hypotheses three and four were not rejected. With respect to this study's research questions, these results did indicate a significant association between the quality of service delivery and access to immunizations in nine sub-Saharan African countries, as well as a significant association between governance and access to immunizations in the nine sub-Saharan African countries.

The results of the logistic regression analyses conducted for this study only found statistical significance with respect to the effect of whether there is a national system to monitor adverse events following immunization, with this having a strong and positive impact upon whether the country has a Multi-Year Plan (MYP) for immunization. The following chapter will discuss these results in relation to previous literature and theory, as well as the limitations of the study and possibilities for future research.

The results also showed statistical significance with some socioeconomic factors significant, the Overseas Development Assistance as % of GNI, GNI per capita and % Government funding as predictors for vaccination coverage. Some socioeconomic factors thus showed significance in this study while others did not. Additionally, this following chapter will also discuss implications and conclusions associated with this study's results. The following chapter will discuss these results in relation to previous literature and theory, as well as the limitations of the study and possibilities for future research.

Section 4: Application to Professional Practice and Implications for Social Change Introduction

Interpretation of the Findings

This study was an ecological quantitative study that used secondary data from WHO and UNICEF. It examined the association between health systems building blocks and access to immunization. Immunizations are one of the most successful public health interventions but unfortunately sub-Saharan African countries remain below the global targets. This contributes to the high morbidity and mortality especially for children under the age of 5.

Interpretations of findings

Study Findings and Past Research

Quality of service delivery. The study examined the strength of association between the quality of service delivery and access to immunizations in nine sub-Saharan African countries. The variables that were investigated include: Is there a national system to monitor adverse events following immunization? Is there a stock-out at national level for BCG? , Is there a stock-out at national level for DTP? and Is there a stock-out in any district for Measles?

The logistic regression analysis showed a predictive relationship between the quality of service delivery and access to immunizations in sub-Saharan African countries. With increased quality of service delivery access to immunizations goes up. This study supports findings from other studies that have looked at this. Lahariya (2015), showed that states with improved service delivery had improved access to immunizations than states who did not. Malande et al (2019) identified service delivery as one of the determinants to access to immunizations in a rural district in Uganda. Service delivery focusing on stock levels and community reach out was one

component of the strategy to increase access and uptake at community level where uptake is low (Shikuku et al, 2019).

Amponsa-Dacosta supported the findings of this study by reporting a number of factors that affected the quality of service thus affecting access to immunizations. Among the constraints in sub-Saharan Africa to access to immunizations, health resources constraints, supply chain functions, how far health facilities that had the HPV vaccine, the focus of the study and programs that targeted communities (Amponsah-Dacosta, Kagina & Olivier, 2020). Peck et al (2018) looking at global vaccination coverage had findings that support my study findings, barriers to access to immunizations include hard to reach populations, supply factors such as service delivery and stock levels of vaccines. They gave an example of the dropout rate of DPT1 to DPT3 in 2018 where the dropout rate was highest in the African region 10% compared to the West Pacific Region at 1% (Peck, et al, 2018).

Ako et al (2016) is another study that supports my findings how the quality of service delivery is a predictor for access to immunization. The study was conducted in one of the largest districts in west Cameroon and looked at human resources, availability of vaccine essential resources and the knowledge of health personnel on vaccines and cold chain development. Their results showed major gaps in all these areas and concluded that in order to improve access strengthening was required in knowledge, availability of vaccines, cold chain and outreach programs.

Ankrah, Darko, Sabblah, Mantel-Teeuwisse & Leufkens (2018) study supports the findings of this study regarding the strong association of reporting adverse events following vaccines through a study they conducted in Ghana on reporting of adverse events following

immunization. Following adverse events after immunizations especially within the week is important in assuring patient safety, monitoring any adverse events and assuring confidence to the patient and community. Immunizations are a very sensitive subject in most communities and any report of adverse events can derail an immunization program.

Findings from the study that looked at the relationship between facility-Based delivery and infant immunization in sub-Saharan Africa showed a strong relationship between facility delivery and immunization (Moyer, Benyas & Rominski, 2016). They also showed social factors related to facility delivery as service delivery and immunization. Additional findings are quite critical in supporting the systems approach of this study where they looked at governance and its holistic role of touching on other health systems building blocks, human resources and capacity, health and employment and the ability to draw knowledge and values that would lead to health service delivery (Moyer, Benyas & Rominski, 2016).

Some studies included human resources under the quality delivery of services,. There was a strong association for the number of health care workers and doctors per 1000 population. Having more health workers and doctors increased access to immunizations. Malande et al (2019), showed lower immunization rates with overwhelmed staff due to understaffing and recommended increasing health care workers to increase access to immunizations. Brandy & Biggs (2019) also complement my findings with their results that showed lower immunization rates with low staffing levels and that high staff levels would lead to increased access. Amponsah-Dacosta, Kagina & Olivier (2020) showed that the size and knowledge of health workers was one of the keys to increasing access, areas with staff who were not knowledgeable

about the HPV, which was the focus of the study, had low access compared to those with more staff and knowledge about the vaccine. This is another study that supports my findings.

Governance and access to immunization. The study showed governance as a strong predictor to access to immunization. Countries with strong governance structures are more likely to have increased access to immunization than those without. Countries with Multi-Year Plans (MYPs), one governance function, were more likely to have higher access to immunizations than the ones without. Countries use MYPs as their strategies for immunizations in the country, for planning to increase immunizations, inform supply chain functions, budgetary allocation, resource mobilization and other resources. Mihigo, Okeibunar, Anya, Mkanda & Zawaira (2018) had similar findings to this study, attributing increased access to immunization in African countries over the last few years to strengthened Multi-Year Plans (MYP) and the presence of the National Immunization Technical Advisory Groups (NITAG) that advise policy. Petu (2018) had similar findings showing increasing trends of access for countries with cMYPs that led to better management functions such as procurement and distribution of immunizations.

In India, Gurnani et al (2018), reported an increase in immunization rates of 6.7% through the Intensified Mission Indradhanush (IMI) program instituted by the Ministry of Health and Welfare. This supports the importance of planning and having MYPs in place down to the region and district levels. These findings support efforts in African countries by donor communities to encourage MYPs and the formation of the National Immunization Technical Advisory Group (NITAG), that would support policies, planning and implementation of immunization programs (Mihigo, Okeibunar, Anya, Mkanda & Zawaira, 2018). Amponsah-Dacosta, Kagina & Olivier (2020) also support these findings as they noted in their study clear

governance structures that include the National Immunization Programs to increase access to immunizations. Anya, Okeibunor, Mihigo, Poy, Zawaira (2018) equally attributed poor governance to affecting immunizations in African countries in their study.

Part of the governance functions is to put in place policies that assure quality and safety of immunizations of which adverse events are one. One way to increase access to immunizations is through mandatory provisions through legislation, even in this case, governance functions that support procurement functions, access, planning are still critical (MacDonald et al, 2018).

Additionally, the findings also would support the use of MYPs as instruments for resource mobilization for both GAVI and non-GAVI countries. The MYPs also show the various contributions of funders including government that provide valuable information for planning purposes and resource mobilization. Clearly addressing governance key functions such as policy setting, planning, supply chain functions and human resources would promote access to immunizations (Songane, 2017).

Vaccine Supply. Vaccine supply was not found to be statistically significant as a predictor for immunizations. There are reasons that might explain this that include vaccination hesitancy, where religious, social and personal beliefs towards immunizations might play a part. It could also be the fact that immunizations are supplied through national programs that might impact availability of vaccines. The result could also support the belief that there are several other predictors for immunization which are complex and a combination of them might play a part in explaining this finding including the health systems building blocks.

These findings however differ from some studies, Bangura, Xiao, Qiu, Feiyun & Chen (2020) in their study noted that among the barriers to immunizations were parent factors and

vaccine supply factors. van den Ent et al (2017) in their study, equally attributed the low immunization rates in Madagascar to several factors that included supply chain factors such as stockouts. Grandy & Biggs (2019) had similar findings in their study that weak policies, vaccine supply systems, stockouts affected access to immunizations especially in countries affected by violence and displaced communities. This was a similar observation in a study that looked at barriers to uptake and provision of immunization in a rural district in Uganda, low stocks and stockouts led to low immunization rates, for measles the uptake for was only 65.5% (Malande et al, 2019). Another study conducted in Cameroon reached the same conclusions around vaccine supplies, availability of immunizations being a predictor to access to immunization among other factors (Akoh et al, 2016).

Costa, Weber, Darmstadt, Abdalla, & Victora (2020) in their study found religious factors to have influenced access to immunizations with lower uptake among Muslims than Christians and not availability of vaccines. This supports the findings of this study that vaccine supply alone is not a predictor to immunizations even when vaccines are available uptake can be low due to other factors such as religious affiliation and beliefs. While some studies and surveys have shown availability of immunizations such as the Multiple Indicator Cluster for Nigeria 2016-2017 in 14% of children were not fully vaccinated due supply factors such as lack of vaccines, Sato (2020), showed in his study that in some regions of Nigeria stockouts were predictors of immunization while some regions similar findings to this study were observed.

My findings show while vaccine supply was not a significant predictor to access, there many reasons and factors that need to be looked in to understand this and increase immunization rates.

Financing. The study examined the association between Health Financing and access to immunization. The study showed that there was no significant association between health financing by countries and access to immunization ($p>0.05$). Countries that had a budget line for procurement of vaccines and also the percentage of total expenditure. This finding is supported by Michingaindze, Wiysonge & Hussey (2013) study that showed similar findings and attributed this to the lack of financing by governments despite having a budget line for vaccines in their budgets. The reason is that while the budget lines were provided for, the funds were not released. Giffiths et al (2020) looked at immunization budget lines in 33 African countries and some of their findings included disparities in the budget lines and actual execution reported to WHO this was $>50\%$ in 84% of the countries. They also observed that 44% of the countries did not have a budget line despite reporting to WHO its existence and budgeted and executed figures were different with executed figures being lower (Giffiths et al, 2020). This could explain and supports the finding of this study that did not show significance association between financing and access to immunizations.

GAVI support to African countries could be one reason that could explain this finding as most are still recipients and having budget lines may not significantly improve procurement of vaccines and access by extension. Sambala & et al (2019) tested whether GAVI eligible countries were more likely to introduce new and underutilized vaccines (NUVs) between 2010 and 2017 than non-GAVI countries. They found that there was no statistical significance relationship, similar to what my study found. Peck et al (2019) also showed the difference that GAVI funding made in increasing immunization rates of PCV and DPT3 in 79% of African countries.

However, Onishchenko et al (2018) in their study looking at trends in vaccines in different countries reached a different conclusion by showing a correlation between increased sustainable funding for vaccines with immunization access and availability. They found though lower access for newer vaccines attributing that to increased costs (Onishchenko, 2018). This could support that GAVI and ODA funding skews and may lead to different conclusions regarding financing and access to immunizations in LIMCs.

Socioeconomic Factors. The study showed that there was a significant association between certain determinants of health and access to immunizations that relate to financing. These social determinants are Overseas Development Assistance as % of GNI, GNI per capita and % Government funding for vaccination. This finding is supported by a study by Onishchenko et al (2019) showed a strong positive association the scope of immunization and funding for vaccination between 2006 and 2016. The same finding applied to the GNI per capita and % Government funding for vaccines in middle-income countries that are not GAVI recipients (Onishchenko, 2019). Where the governments had higher income they were more likely to earmark more funds to vaccine procurement and immunization programs.

While there weren't studies I came across that showed direct expenditure on immunizations from ODA, the association could probably be explained as funds that are included in the total health expenditure which in most countries has gone up in African countries. Shajalal et al (2017) showed how China's contribution has grown over the years in its assistance to African countries with the health sector being one of the benefiting areas with Mother and Child Health among the main beneficiaries. In their study Ikilezi, Augusto, Dieleman, Sherr, & Lim. (2020) in their study showed how donor assistance for health (DAH) had grown between 1990 and 2016 totaling \$34.5 billion for African countries of which \$22.1 billion was channeled directly to

DAH. This could explain partly the result of my study. Ikilezi et al (2020) finds support a strong association between higher amounts of developmental aid towards immunizations and improved DPT3 vaccine coverage in Africa.

Limitations

The use of secondary data pauses the limitation that the data's objective for which it was collected may be different from the objective of the researcher who wants to use it. This was one of my limitation. The other limitation was the missing data for certain variables and insufficiency that made me drop certain variables that would have been used. This paused a limitation in using more valuables that would have been used for statistical analysis and contributed to the adjustments in methodology.

The use of country data also paused the limitation that it did not provide individual data and factors that would have been important in understanding predictors to immunization at the individual level and how that feeds into the national data. Part of understanding and strengthening health systems is to increase access to immunization taking into consideration individual factors as some studies have shown (Bangura & Xiao, 2019).

The other limitation of the study is that access to immunization in a country may be different between regions and districts. The secondary data used for this study by WHO and UNICEFF, only looks at national data and does not take into consideration the differences between regions or districts and provide for better understanding or predictors in different districts and regions. Eboime, Abimbola & Bozzani (2015) showed disparities in access to immunizations and rates by looking at 2 regions in Nigeria. Different factors can predict access to immunizations in the different regions of the same countries.

Recommendations for Further Research

The study examined the strength of association of health systems building blocks and access to immunizations in 9 sub-Saharan African countries. The study highlighted the importance of governance, service delivery, human resources and some economic indicators in increasing access to immunizations to reach national and global targets. The importance of having national yearly plans that takes into consideration the resources and different characteristics of the country and its region. The study also highlighted the need for a plan that takes into consideration safety by monitoring adverse events of immunizations.

Service delivery was another predictor the study highlighted that is a predictor of access to immunizations. The study did not however look at the individual countries and individual predictors. This is one area that future studies should look at. Future studies should also look into incorporating more variables into the study. Human resources- health workers and doctors are critical and essential to access to immunizations. Beyond looking at each individual building blocks the study showed how they all need to work together to increase immunizations in sub-Saharan African countries. While some might show strong association to access it nevertheless doesn't discount the others.

The ecological nature of the study did not provide for studying the cause and effect relationship. This is an area that I recommend for further study as it would complete the knowledge this study has highlighted and provide policy makers and implementers knowledge to use for policy, investments and implementation.

Implications for Positive Social Change

While immunizations are one of the most successful public health interventions, unfortunately access to immunizations in sub-Saharan Africa remains a challenge. Immunization rates are below the global goals, posing a challenge for increased morbidity and mortality to vaccine preventable diseases. Immunizations are managed and administered in health systems and the success is dependent on how strong and effective the health system is. Understanding the predictors to access would contribute to increasing access to immunizations and benefits that come with this.

This study took the systems approach by looking at the health systems building blocks and examining them as predictors of access to immunizations. Understanding building blocks and key variables that would help program managers with program and policy development. This study did show a strong association between quality of service delivery, governance to access to immunization, human resources and some socioeconomic factors.

This study highlights the importance and relevance of governance, service delivery, human resources and socioeconomic factors in increasing access to immunization towards achieving national but global goals. It highlights how important it is to understand the predictors and how they work in a system to affect immunization access. It shows how important it is to look at all the health systems blocks and invest in them to maximize the value of health systems towards access to immunizations.

Having Micro Yearly Plans (MYP) that are comprehensive and using them as planning and management tools that include finance, supply chain functions, staffing and ensuring steady vaccines flow, no stockouts, looking at both the supply and demand side of immunizations would

lead to a positive change. This study will contribute to national governments planning and focusing on how best to plan for immunizations through the year, increasing and investing in health systems blocks that might make a huge difference. This includes focusing on governance, service delivery, human resources, planning, setting of targets and strengthening selection, forecasting, procurement distribution functions of their supply chain to increase stock levels of vaccines and avoid stockouts.

The study also shows the need to look at those determinants that did not show a strong association and the reasons behind those results that would be informative in the immunization agenda.

The results of this study will be disseminated by sharing with the Ministries of Health in the nine countries, through conferences, workshops and publications in both peer reviewed journals and open access journals.

Implications for Practice

The success of public health programs depend on good planning driven by data. This includes immunization programs. This study has highlighted 4 main areas that can lead to improved access to immunizations in sub-Saharan African countries and other LMICs. Firstly, the importance of strong governance that invests in planning, having a comprehensive MYPs, that can be used as a management tool and strategy to increase access to immunizations including through action plans informed by evidence (Petu, 2018). This should take into consideration the unique and peculiar characteristics of the country and its regions. It should also contain indicators, resources such as financial and human and targets.

The second is the importance of taking the systems approach in improving access to immunizations by looking at the health systems building blocks and understanding how they influence and contribute the desired goal of the system, increased service delivery and access to immunization by working in unison as a unit. Each health system building block has its predictors some of which affect more than one health systems building blocks. By looking at each building block and how it influences other building blocks is a critical element in maximizing each buildings blocks contribution. Such an approach would address the inherent challenges to immunizations such as human resources, sustainable funding, servive delivery vaccine stockouts and supply chain functions such as logistics (Mihigo, Okeibunor, Anya, Mkanda & Zawaira, 2017).

The third area is that of financing, ensuing vaccines are available and immunization supplies on the supply side. This is one of the major challenges for most sub-Saharan African countries, that requires these governments to increase funding especially with the competition with donor funding and as most will be graduating from GAVI support for vaccine support and immunization (Mihigo, Okeibunor, Anya, Mkanda & Zawaira, 2017).

Strengthening functions of the supply chain to increase vaccine supply is critical to improving access. Availability, accessibility and affordability are critical elements. Fourthly the key role and need for trained human doctors and health workers as essential to improving access. Trained health care workers provide many functions that include information dissemination, service delivery and manage EPI programs. Investing in health systems building blocks would lead to increased access in countries.

Public health planners need to take this into consideration and countries. Countries can use findings from this study when making proposals for funding for immunizations to partners and foreign agencies. Funders can also use this evidence to justify why they should fund immunization programs and contribute to access to vaccines especially the newer vaccines that are generally expensive.

Conclusion

Immunizations are effective in preventing many vaccine preventable infectious diseases. They are a major success in public health and a cornerstone to universal health coverage. Unfortunately access to immunizations remains a major problem in most sub-Saharan African countries. The study is the first to use the systems approach in looking at the association of health systems building blocks to access to immunization. The study supports the hypothesis that health systems building blocks are predictors of access to immunizations. Health systems building blocks, governance, service delivery, human resources and socioeconomic factors are predictors of access to immunizations in sub-Saharan African countries.

The new knowledge derived in this study will be useful for country immunization program planners, for policy makers to develop and implement evidence-based policies targeted at increasing immunization. Strengthening governance and service delivery in the context of the health system will be important. The results are also useful for funders in making decisions concerning funding immunization programs by supporting investments and strengthening of certain building blocks that have stronger association to immunizations.

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