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ANALYSIS OF THE EFFECTIVENESS OF UTILIZATION OF HEALTH INFORMATION TECHNOLOGIES IN COVID-19 MANAGEMENT IN KENYA

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MBA/133924

A RESEARCH DISSERTATION SUBMITTED TO THE STRATHMORE UNIVERSITY BUSINESS SCHOOL IN PARTIAL FULFILMENT FOR THE DEGREE OF MASTER OF BUSINESS ADMINISTRATION OF STRATHMORE UNIVERSITY

MARCH 2023

DECLARATION

This dissertation my original work and has not been submitted for examination in any other institution. Previously published or written material by another person that has been used, due reference was made.

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Supervisor Approval

This research dissertation has been submitted for examination with my approval as the university supervisor

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ABSTRACT

Locally, the country has struggled to manage the COVID-19 pandemic due to the weak healthcare systems and the limited number of specialized health facilities. Further, insufficient testing capacity and public sensitization have resulted in the increasing spread of infections in the country. However, evidence from developed countries has shown that extensive application of health information technologies has been critical in the management of COVID-19 pandemic. There has minimal investigation of how these health information technologies were adopted in the country over the last two years of the pandemic. And more so, if they had an influence on COVID-19 management. The current research sought to fill this gap and establish how health information technologies; health information exchange, electronic surveillance and digital connectivity influenced COVID-19 management. The research was informed by the Unified Theory of Acceptance and Use of Technology. A positivism study philosophy was used in the survey with a descriptive research approach being considered. The study population was the health facilities in the country that utilized health information technologies since the pandemic began in the country. The study applied purposive sampling to target 86 senior hospital personnel drawn from Kenyatta National Hospital, Ministry of Health, ICT Authority Kenya, County Referral Hospitals, Private Referral Hospitals (Nairobi), and Research Institutions (KEMRI & KHF). This was followed by stratified sampling for Kenyatta National Hospital. The study applied a structured questionnaire in the data collection. The collected study data was analysed using statistics such as frequencies, percentages, means, standard deviation, correlation coefficient and regression tests. The analysed data was presented using figures, charts and tables. Correlation tests established that the independent variables; adoption of health information exchange, adoption of electronic surveillance and digital connectivity had a positive relation with COVID-19 Management in Kenya. The regression findings revealed that 52.2% of the variations in COVID-19 management in the country are determined by the adoption of health information technologies in the health sector in Kenya. The analysis conclusions were that the three independent variables have been employed in Kenya and have improved their ability to effectively manage the COVID-19 pandemic. Healthcare centres used health information exchange technologies, electronic surveillance technologies and digital connectivity in reducing the spread of the corona virus. The study recommends that regular staff training be carried out to make them capable of utilizing new technologies and improvising existing ones to serve current needs. The study recommends that data security and surveillance laws be regularly updated to address the loopholes that emerge when new technologies are introduced. The study also recommends better legislation around cyber security to ensure protection of user data and guide on best practices to protect patient data.

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LIST OF ABBREVIATIONS

AI	Artificial Intelligence
COVID-19	Corona Virus Pandemic
HIT	Health Information Technologies
ICT	Information Communication Technology
WHO	World Health Organization

DEFINITION OF TERMS

COVID-19 Management — The management of COVID-19 is centred on the development of robust programs for prevention, rehabilitative approaches and promotive practices to reduce the spread of infections (Mbunge, Akinnuwesi, Fashoto, Metfula, & Mashwama, 2021).

Electronic surveillance — The use of electronic systems to observe, record and act upon available data in delivery of healthcare services. Electronic surveillance in healthcare has been associated with improved patient-tracing, movement screening and pattern analysis, improving decision making and policy formulation (Calvo, Deterding, & Ryan, 2020).

Digital connectivity — The degree of interconnectedness and interoperabilityof digital data between departments, organizations and healthcare facilities (Chitungo, et al., 2021).

Effectiveness — The degree of success towards achieving a certain goal (Ienca & Vayena, 2020).

Health information exchange — Health information exchange is the use of digital technologies to share information between interconnected systems, health facilities, providers, and patients (Lenert & McSwain, 2020).

Health information technologies — The electronic systems used by health care professionals and patients to collect, processing, storage, and exchange of health information in an electronic environment (Rab, Javaid, Haleem, & Vaishya, 2020).

Telemedicine — Telemedicine involves the practices of relying on HIT to deliver services through remote services technologies that support consultations,

diagnostics, guidance, and preventative measures (Ohannessian, Duong, & Odone, 2020).

CHAPTER ONE

INTRODUCTION

1.1 Introduction

The COVID-19 pandemic has had a significant negative effect on hospital systems, businesses, schools, and the economy in general and amid this upheaval, new technologies have become key in helping the society slow down the spread of the virus. The pandemic has also increased the need for the adoption of innovative technologies, despite little empirical evidence on their effectiveness in reducing the spread of the disease. This study sought to analyse the effectiveness of health information technologies in the management of COVID-19 in Kenya. This chapter presented the background of the study, the conceptualization of the research variables, the statement of the problem, and the objectives that guided this study.

1.2 Background to the Study

The world has faced the COVID-19 pandemic for at least two years now resulting in unprecedented challenges in healthcare systems. Accordingly, Lal, Erondu, Heymann, Gitahi and Yates (2021) are assertive that within the first year of the viruses' emergence, many health systems in developed as well as developing countries were unprepared and had become overwhelmed. Miyawaki and Tsugawa (2022) opine that such an emergency required quick organizational reorganization and supply of resources to enable healthcare facilities rapidly adapt to identify, collect, store, manage, and transmit accurate and timely COVID-19 related data. However, Negro-Calduch, et al. (2021) reports that many health systems were under-resourced, had obsolete health information technologies, and lacked integrated systems. The brunt of this was in middle- and low-income nations with limited technical capacity and operational flexibility. The pandemic highlighted the weaknesses of health systems and brought to question their ability to effectively respond to and manage emerging epidemics.

In an Oxfam (2020) report, weak healthcare systems in developing nations contributed to a higher rate of COVID-19 related deaths, where three in every four deaths are estimated to have occurred. Latin America accounted for at least 40% of all deaths, with many more being unreported where reporting mechanisms were low (World Health Organization, 2021). An examination on healthcare professionals with a background in informatics from

6 international hospitals reveals that health information technologies (HIT) were used to enhance patient, time and resource management, improve effectiveness of diagnoses treatment, and in negating risk infection in health centres. In New York, (Salway, Silvestri, Wei, & Bouton, 2020) report the use of HITs to improve staff efficiency, standardize clinical workup, informatics, bridge information system, and to improve patient experience. Asadzadeh, Pakkhoo, Saeidabad, Khezri and Ferdousi (2020) identified a host of technologies that were used to facilitate the viruses' detection and diagnosis, treatment, prevention and management.

In Italy, Bioinformatics systems were used to enhance COVID-19 detection, classification and tracing of the viruses' genomic sequence and in the discovery of COVID-19 antivirals and potential protein targets while the Chinese utilized artificial intelligence and machine learning to enhance surveillance, detection and infection prediction, information sharing, spread forecasting (Salway, Silvestri, Wei, & Bouton, 2020; Zhou, Dzingirai, Hove, Chitata, & Mugandani, 2022). Further, decision making systems were used in risk assessment, GPS tracing, web-based mapping and risk assessment among others. Robotics were also used to facilitate remote disease management by carrying out disinfections, information sharing, disease diagnosis and to ease professional workload by performing sterilization and temperature monitoring (Asadzadeh, et, al., 2020). The use of a wider range of HITs was linked to better community knowledge, real-time diagnosis, reporting, recording and sharing, saved cost, reduced disease spread, improved disease forecasting and decision making, information sharing, among others. WHO's (2022) Joint External Evaluation (JEE) of IHR core capacities asserts that HITs should be able to improve a country's ability to prevent, detect and respond to emerging health risks.

While developed countries were able to deploy sophisticated technologies to enhance the management of the disease, (Nachega, et al., 2021) shows minimal use of such technologies. The research which sought after best practices shows use of mobile phone facilitated digital contact tracing in South Africa and Rwanda, the leveraging of multi-platform public communications to spread accurate COVID-19 self-management information in Nigeria and Uganda. In Kenya, HITs have been deployed to assist in the prevention, testing and tracing of the disease, Edejer, et al. (2020) aver that HITs are considered core to the country's response strategy. Maruta and Moyo (2022) show extensive use of telehealth technologies to inform the population best practices and mobile phone technology to help in contact tracing. However, these studies aver that the

technologies are not easily accessible outside urban settings and in resource-scarce settings, significantly impacting the country's ability to effectively manage the diseases' spread.

An assessment of Kenya's health systems capacity asserts that the country's hospitals lack the capacity to absorb increased caseload of the virus (Chitungo, et al., 2021). The study noted that the country lacks the ability to adequately forecast and predict the diseases' patterns which impacts resource allocation and management. Barasa, Kairu, Maritim, Were and Akech (2021) report shortfalls in developing cost-effective interventions, mobilizing adequate resources, and sustaining an effective health system while according to Jalabneh, et al. (2021), the country's inability to distribute testing kits and vaccines has resulted in a low vaccination turnout, with only 18 percent of the population being estimated to have been vaccinated. This puts the country at risk of overload should a surge in infections occur in the future.

Digital technologies promise to increase the effectiveness of health systems in managing emerging epidemics. For instance, the Internet of Things (IoT) provides opportunities for health agencies to share and access data on the pandemic, big data provides opportunities to model virus activity and enhance forecasting and resource allocation for individual countries, while digital technologies have been used to enhance public-health education (Thaiya, et, al., 2021). The MOH (2022) is assertive that Kenya still has low preparedness score to effectively prevent, detect and respond to pandemics. Geissler and Prince (2020) even report that the country's ministry of health does not have the true number of deaths and infections that occurred in Kenya. HITs have enhanced developed countries' ability to detect, share information and develop strategies to minimize the diseases' impact on their populations and health systems. This study seeks to determine the degree to which HITs helped health care centres in Kenya manage the pandemic.

1.2.1 Health Information Technologies

Health information technologies (HIT) are concerned with applying information-based technologies and applications in the provision of healthcare-related (Rab, Javaid, Haleem, & Vaishya, 2020). HITs are heralded as transformative change in extending and offering services to physicians, healthcare staff, and patients that support better health control and monitoring of the quality of health services provided (Khan & Javaid, 2020). Through the utilization of the vast cloud-based solutions in the maintenance of records, information

sharing, handling of medical issues, creation of electronic records, testing, analysis of data, and management of health personnel, HIT ensures there is the enhancement of patient care and satisfaction (Park, Choi, & Ko, 2020; Kogan, Klein, Hannon, & Nolte, 2020).

An, You, Park and Lee (2021) report the use of the IoT, big-data analytics, AI and blockchain in monitoring, surveillance, detection and prevention of COVID-19, while according to Asadzadeh, Pakkhoo, Saeidabad, Khezri and Ferdousi (2020), HITs such as surveillance systems, bio-informatics, robotics and telemedicine have been extensively applied in disease management. The research shows the use of HITs in information sharing, detection and diagnosis, treatment and management. Adler-Milstein, Garg, Zhao and Patel (2021) opines that surveillance, information sharing and system-wide integration HITs are the most prominent technologies applied in the management of the pandemic. With Sittig and Singh (2020) affirming that health institutions in developing countries are under-resourced, characterized with obsolete technologies and with little interoperability capabilities, this research investigated the effectiveness of information exchange, surveillance and digital connectivity technologies in the management of COVID-19. A variation of these technologies was used in the study by Adler-Milstein, Garg, Zhao and Patel (2021). Theoretically, effective use of these technologies should improve health systems' ability to prevent, test, trace and treat infectious diseases.

Health information exchange involves the electronic transmission of health-related data between facilities, providers, and patients in a timely and uniform fashion (Lenert & McSwain, 2020), which helps supports the digital sharing of critical patient records and support decision making (Webster, 2020). They encompass platforms such as national patient portals, telemedicine infrastructure, and digital networks. Computerized vision, smartphone apps, machine learning, SMS and instant messaging, wearables and sensors, and data analytics have all been used to accomplish various tasks at various stages of COVID-19 management (Budd, et al., 2020). The Internet of Things (IoT) was key in provision of new forms of data and big data offered location-based and contact tracing after integration into health systems (Whitelaw, Mamas, Topol, & Van Spall, 2020).

Jiancheng (2020) shows the use of HIE to enhance data sharing, information delivery, remote consultation, and intelligent diagnostics while Turer, Jones, Rosenbloom, Slovis, and Ward (2020) refer to the use of information exchange platforms to securely share data on the virus and to aid in the identification of patterns of spread. On the other hand,

telehealth technologies facilitated follow-up of hospitalized patients, consultations, diagnostics, guidance (Ohannessian, Duong, & Odone, 2020), while video conferencing facilitated virtual homecare for asymptomatic patients (Colbert, Venegas-Vera, & Lerma, 2020). Yaraghi and Peter (2021) aver that health systems in New York leveraged HIEs to identify, promote, record, and track immunization, improving vaccination outcomes by reporting and associating causes for potential side effects. Accordingly, HIE technologies enable doctors to provide safer, more effective care tailored to patients' unique medical needs (Ienca & Vayena, 2020). This study reviewed the effectiveness of HIE technologies in the management of COVID-19 in Kenya.

UNICEF (2020) confirms the importance of monitoring and control when managing pandemics. According to the WHO's (2022) COVID-19 management report, health systems are required to monitor, collect, analyse and interpret health-related data to determine the best practices. It is essential that public health surveillance systems are effective to enhance early detection and response to outbreaks. COVID-19 surveillance was essential in monitoring of SARS-COV-2 incidences, tracking of potential epidemiological changes over time, and in developing health sectors' understanding of the co-circulation of SARS-CoV-2 (Martin, et al., 2020). Kumar, et al. (2021) document the use of drones in controlling movement, surveillance and in crowd control while Calvo, Deterding and Ryan (2020) are assertive that surveillance systems expand tracing capabilities which is key to control of the disease across populations. Rai et al., (2021) affirm the importance of surveillance tools in policy decision making. This study sought after the impact of different surveillance technologies in the management of the COVID-19 pandemic.

Connectivity refers to the degree of interconnectedness and digital connectedness shows the degree with which digital technologies within a system are integrated and interconnected (Bayram, Springer, Garvey, & Özdemir, 2020). Digital connectivity is increasingly important in the modern economy where IT technologies have revolutionized the way people exchange and acquire information. In healthcare settings, digital connectivity (DC) refers to the degree to which digital technologies are able to communicate and use data to advance health goals (Chitungo, et al., 2021). Digital connectivity incorporates all the wireless, wired, and satellite technologies that influence data sharing and utilization and entails standardized data and its interoperability (Bayram,

Springer, Garvey, & Özdemir, 2020), which is key to improved service delivery among healthcare professionals (Ienca & Vayena).

Digital connectivity encompasses Mobile health (mHealth), (eHealth) and other interconnected systems that facilitate real time data sharing and analysis (Park, Choi, & Ko, 2020). Hannemann, Götz, Schmidt, Hübner and Babitsch (2021) showed the use of digital technologies to facilitate work from home amid limited access to inpatient diagnosis. Social media channels have been used extensively in Rwanda to keep communities informed on preventative measures and the importance of vaccination (Karim, et al., 2021). Wearable technologies and digital diagnostics tools have been utilized to identify risky travel patterns and develop better restrictions and isolations for persons that have come into contact with the virus (Channa, Popescu, Skibinska, & Burget, 2021). This study will examine the impact of connectivity systems on COVID-19 management in Kenya.

1.2.2 COVID-19 Management

In Kenya, the management of COVID-19 was tasked to the COVID-19 Taskforce under the Kenyan Ministry of Health (MOH) (Ogweno, Oduor, & Mutisya, 2021). The task force was, among other things, expected to prevent the virus from devastating the health, social and economic facets of the country. The task force's first step focused on was containment of the virus through early detection of cases. Further, the task force was expected to involve health officials in creating actionable data that can be applied in developing policies and interventions that are evidence-based (Ogweno, et al., 2021). The task force was also expected to create awareness, improve control measures, curb misinformation in public and evaluate the effectiveness of the various public regulation measures adopted through Presidential addresses (Executive Office of the President, 2020).

The National Emergency Response Committee on Coronavirus was set up early before the first case was identified on March 12, 2020. Since then, the country has identified 336,445 infections and recorded 5,668 coronavirus-related deaths (MOH, 2022). Upon identification of the first case, Kenya took stringent measures to control the diseases' spread. International flights, meetings and events were cancelled on March 6 2020, and the country's borders were closed and strict internal curfews and social distancing measures were among the first actions against the virus (MOH, 2022). Testing was prioritized, despite a low supply of testing kits and there were mandated increases in

capacity, supplies, and human resources, with all counties being directed to identify and designate at least one COVID-19 hospital and recruit additional healthcare workers. Globally, empirical studies have shown that the management of the COVID-19 has focussed on control and prevention of spread of the virus and restricting movements to limit its spread (Kumar, Kumar, & Shah, 2020).

Health system's response to the virus has been multi-faceted and digital technologies have been essential in the management of the disease through facilitating the dissemination of health information to the public, inter-organizational coordination, rapid response, monitoring, treatment of the disease. Mobile applications and chatbots have been utilized to facilitate communication between stakeholders, tracing, and surveillance (Bardhan, Chen, & Karahanna, 2020). These have also been used to facilitate video-conferencing, telemedicine and to support work from home policies which helped reduce the spread of the disease (Marr, 2020). Further, countries have invested in increasing awareness and knowledge regarding the disease, which has been critical to changing the attitude of the citizens (Goniewicz, et al., 2020).

The management of COVID-19 is centred on developing robust programs for prevention, rehabilitative approaches, and promotive practices to reduce the spread of infections' (Mbunge, et al., 2021). Accordingly, Watkins (2020) affirms that health information technologies have been utilized in all jurisdictions to some extent as the pandemic has highlighted the importance of digital connectivity and emerging technologies as a strategic disease management tool. Currently, the pandemic is under control and most of the measures instituted to control the pandemic's spread have been relaxed (Barasa, et al., 2021). However, the Africa CDC (2020) reports that new, less deadly but highly transmissible variants have seeped into the population, and more than 65 percent of the Kenyan population may have been exposed. Such a penetration rate would devastate health systems if the variants were more virulent (Iwuoha, Ezeibe, & Ezeibe, 2020).

Kebede, Yitayih, Birhanu, Mekonen, and Ambelu's (2020) study showed that knowledge of the clinical symptoms and the transmission of COVID-19 was critical to managing the disease in Ethiopia. Despite government efforts, a WHO report shows that most Sub-Sharan Africa residents did not comply with health and safety measures, resulting in poor COVID-19 management. This can be highlighted by the low uptake of vaccines across the continent, with approximately 16 percent of the population receiving at least two doses

of the vaccines. Misinformation and limited capacity in health departments have exacerbated the situation (Molla & Abegaz, 2021).

Despite this being the second year since the pandemic curtailed normal operations in the country, minimal scientific studies have been conducted focusing on the pandemic's management. This study focused on available evidence and review how health information technologies have impacted the management of COVID-19 in Kenya. The management of COVID-19 was assessed by the effectiveness of containment, detection, prevention, and control measures advanced across health institutions in the country.

1.3 Statement of the Problem

The year 2019 saw the emergence of new strain of coronavirus, SARS-CoV-2, the virus which causes COVID-19, and it has since decimated health systems across the globe (World Health Organization, 2021). As of August 2022, more than 544 million people have been infected by the virus, with 6.43 million succumbing COVID-19 globally. Digital systems have become synonymous with management of the pandemic and Bright, et al. (2021) recognize the impact of information systems in management of the spread of the virus. Digital technologies have enhanced disease diagnosis, detection and management, enhancing the healthcare sector's ability to control the diseases' spread. However, Adler-Milstein, Garg, Zhao and Patel (2021) opine that the application of information systems in COVID-19 management has been varied, with some being more effective than others. Muinga, et al. (2020) highlight hospitals' focus on purchasing digital health system primarily to support administrative functions, lack of interoperability within facilities that have multiple systems, and inadequate training, infrastructure and system support as the main factors impacting Kenyan hospitals' ability to effectively manage the COVID-19 pandemic.

According to the WHO, effective healthcare systems should drive health institutions to a better level of healthcare delivery (Wadekar, 2020). Jiancheng (2020), for instance, showed the use of telemedicine, AI, Big Data analysis, health information exchange, digital surveillance, and contact tracing in controlling disease spread in the USA while Khan and Javaid's (2020) results showed the application of big data, AI, and machine learning in data assessment which improved decision making. In China, Ye, Zhou, and Wu (2020) aver that clinical information systems and digital contact tracing played a significant role in surveillance, enforcement and control of movement. In Sub-Saharan

Africa, Bakibinga-Gaswaga et al. (2020) acknowledge that limited investment in technological infrastructure has negatively affected the region's handling of the COVID-19 pandemic as countries used basic technologies with little innovativeness. In Rwanda and Uganda, WelTel virtual care systems were used to monitor patients and to minimize inpatient meeting while in Senegal and Ghana, USSD messaging systems were used by patients as well as healthcare stakeholders to disseminate educative information and facilitate symptoms reporting, enhancing management of the disease (Nachega, et al., 2020).

The above studies highlight several uses of digital technologies in healthcare delivery. However, Farrer (2020) asserts that healthcare systems in developing countries have weak healthcare systems with limited resources, poor technical capacity and insufficient coordination mechanisms. In Kenya, Muinga (2020) shows lack of integration and data interoperability which forced some health facilities to use independent systems within a department. Shahid, et al. (2021) assert that effective HITs should improve testing capacity, contact tracing and strengthen inter-facility data exchange, coordination and decision making. Despite the limited capacity of Kenyan health systems', the virality of the virus has reduced significantly in recent months and the pressure on healthcare centres has fallen substantially. Improving disease management necessitates determination of factors that contributed to enhanced management of the COVID-19 pandemic. This study thus investigated the effectiveness of health information technologies in COVID-19 Management in Kenya in an attempt to determine whether future disease management can be improved.

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1.4 Objective of the Study

The study's main purpose is to analyse the effectiveness of health information technologies utilization in COVID-19 Management in Kenya.

1.4.1 Specific Objectives

i. To examine the effect of adoption of health information exchange on COVID-19 Management in Kenya.
ii. To establish the effect of adoption of electronic surveillance on COVID-19 Management in Kenya.
iii. To evaluate the influence of digital connectivity on COVID-19 Management in Kenya.

1.5 Research Questions

i. How does the adoption of health information exchange affect the COVID-19 Management in Kenya?
ii. What is the effect of the adoption of electronic surveillance on COVID-19 Management in Kenya?
iii. To what extent has digital connectivity influenced COVID-19 management in Kenya?

1.6 Scope of the Study

This research contextual scope examines how the various health information technologies available in the country have been applied in the management of COVID-9. The study examined how adoption of electronic surveillance, digital connectivity and health information exchange influences the management of COVID-19. The study theoretical scope was anchored on the unified theory of acceptance and use of technology. The research data was collected between March and April of 2022 and focused on six (6) healthcare facilities/institutions that were designated for the management of COVID-19 in Kenya. These facilities/institutions were the most active during the pandemic and handled the most severe of the cases, as well as were provided with the best technologies by the government. They are therefore best placed to respond with the regards to effectiveness of the technologies deployed.

1.7 Significance of the Study

The findings of this study will help inform policymakers at the national and county-level on how best they can promote better awareness and knowledge on how COVID-19 spreads and how the public can cushion themselves. The health officials will also be at a position to utilize the findings of this study in decision making on how best to alleviate future spikes in infection rates. The research results will help the Ministry of Health in formulating new policies that can help guide development of new protocols for the management of COVID-19 pandemic. The findings will provide insights on how various technologies can be leveraged across the country to extend the capacity of health facilities in the management of the pandemic. The study is also expected to immensely contribute to the body of knowledge by providing information for future academicians on how health information technology can be applied in managing health crisis in Kenya and beyond.

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CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This section presents a review of the theoretical and empirical literature. The study was bound by the unified theory of acceptance and use of technology (UTAUT) which asserts that the perceived usefulness, reliability, social pressure associated with a new technology, and the user's perceived capability greatly influenced adoption and continued use, and the Technology Acceptance Model (TAM) which was essential in guiding the researcher towards determining the factors that influence acceptance and utilization of different technologies. The empirical section is presented in line with the study objectives and presented previous researchers' findings on how the various components of health information technologies influence their usage in managing the COVID-19 pandemic.

2.1 Theoretical Framework

2.2.1 The Unified Theory of Acceptance and Use of Technology

The unified theory of acceptance and use of technology (UTAUT) is framework for technology acceptance that was formulated in 2003 by Venkatesh et al. (2003). The model was developed to direct towards unified view of technology adoption and aims to explain the factors that drive user intentions to use an information system and the subsequent behavioural tendency to make continued use of the systems. Venkatesh et al., (2003) identifies performance expectancy, effort expectancy, social influence, and enabling conditions as the four key determinants of technology adoption. Performance expectancy, effort expectancy and social influence are direct determinants of usage intention and behaviour, while enabling conditions are a direct determinant of user behaviour (Alowayr, 2021). The user's gender, age, experience, and attitude towards usage, on the other hand moderate the impact of the key constructs of usage intention and behaviour (Chang, Liu, Huang, & Hsieh, 2019).

Performance expectancy refers to the degree to which an individual believes that using the system would improve their job performance (Venkatesh et al., 2003). Effort expectancy refers to the degree of ease associated with the use of the system, while facilitating conditions refer to the degree to which an individual believes that they are supported with technical infrastructure to support the use of the system (Venkatesh et al., 2003). Social influence, on the other hand refers to the degree to which an individual

perceives important figureheads support the new system (Venkatesh et al., 2012). A high degree of these constructs would guarantee continued use of an emerging technology. The theory reviewed and consolidated constructs in previous models explaining behavioural intentions such as the theory of reasoned action, technology acceptance model and the theory of planned behaviour, and has been utilized previously to explain usage of mobile commerce (Asastani, Kusumawardhana, & Warnars, 2018), electronic banking (Chiroma, 2021), cloud computing (Saini, 2021), and medical record system usage (Shiferaw & Mehari, 2019).

The theory has been used extensively to review and test the factors that drive users towards accepting ICT solutions. It explains the degree of acceptance and use of information systems and has been essential in determining whether a user will accept and be able to utilize new technologies to solve emerging complications. Recently, Barua and Barua (2021) used the theory to examine the acceptance and usage of mHealth technologies during the COVID-19 pandemic. Zhou, et al., (2022) determined that technologies that are easy to use, reliable, usable and similar to existing technologies are usually adapted at a faster rate. Walrave, Waeterloos and Ponnet (2021) sued the theory to explain the adoption of COVID-19 contact-tracing technology and Békés, Doorn and Bőthe (2022) used the theory to explain patients' attitudes towards tele-psychotherapy utilization and the determinants of its integration effectiveness. Chuenyindee, et al. (2022) utilized the theory in explaining the use of mobile technologies in contact tracing in Thailand.

In COVID-19 management, the degree of connectivity of health information technologies, their usability and effectiveness in addressing surveillance and information exchange will have a positive influence on users' (patients, medical providers and stakeholders) intention to adopt health information technologies. Previous empirical evidence shows that the theory effectively explains consumer behaviours and intentions (Dwivedi, Rana, Tamilmani, & Raman, 2020). This theory was utilized to identify the reason for different degrees of utilization of different technologies to facilitate health information exchange, surveillance and connectivity facilitates in managing the COVID-19 pandemic.

2.2.2 Technology Acceptance Model

The Technology Acceptance Model (TAM) was postulated by Davis (1989) and it has emerged as one of the most influential models explaining acceptance of emerging technologies in different contexts. Davis developed the TAM model to predict user's

acceptance and degree of usage of information technologies in an organizational and personal context. Empirical evidence points to two main determinants that influence an individual's intention to use new technology; perceived ease of use and perceived usefulness. Davis (1989) defined perceived usefulness as the degree to which an individual believes that using a particular technology would enhance his or her job performance and the perceived ease-of-use as the degree to which an individual believes that using a particular technology would be easy to use. TAM helps managers and decision makers to assess the likelihood of successfully introducing new technologies into an organization, and motivate users to accept the systems (Joo, Park, & Lim, 2018).

TAM has been criticized on a number of grounds, with Ajibade (2018) arguing that it is designed to explain acceptance within an organization rather than individual acceptance. Despite this criticism, Tsai, et al. (2021) assert that it can also reliably explain individual's intention to use internet technologies since factors such as internet cost and divide affordability influence users' perceived ease of use. An, You, Park and Lee (2021) used the theory to explain South Korea's usage of telehealth services in flattening the COVID-19 curve. In China, the theory was used by Zhang, Zhou and Yoruk (2020) used the model in explaining the adoption of health self-monitoring devices while Shemesh and Barnoy (2020) avers that the model is a useful tool in explaining the usage of mobile health applications for COVID-19 surveillance among the Israeli adult population.

The TAM serves as a useful and consistent framework that has been applied in a wide variety of scenarios in examining the factors that influence individual's intention to use new technologies. TAM has been utilized to explore three application areas of HIE in the medical service industry: telemedicine, electronic health records, and mobile applications. This study applied it in examining the factors that drive users towards adopting Health Information Technologies in the management of COVID-19 in Kenya.

2.2 Health Information technologies and COVID-19 Management

Digital technologies have emerged as effective tools in disease management. Empirical evidence confirms the use of information technologies in various phases of disease management, from detection, analysis, information awareness to treatment diagnosis and policy setting (Vaishya, Haleem, Vaish, & Javaid, 2020). Health information technologies concepts include various electronic supported services that enable healthcare professionals and patients to come together to foster the delivery of services (Park, Choi,

& Ko, 2020). Sayeed, Gottlieb, and Mandl (2020) contend that HIT has facilitated patient data handling, patient prescription, electronic-based medicine dispensing, records handling, and medical care administration. Aceto, Persico, and Pescapé (2020) showed HIT could be deployed in hospitals through health information exchange, electronic health records, telemedicine, and information-based smart applications.

In China, HIT has been applied in early warnings, monitoring, detection, control, and prevention of the disease. HIT has been deployed through the utilization of web-based services, artificial intelligence (AI), telemedicine, clinical information systems, and digital contact tracing in the clinical management of COVID-19 (Ye, Zhou, & Wu, 2020). In the United Kingdom and the United States, Malden, et al., (2021) results showed that utilization of health information technologies such as electronic health records, remote working, telehealth services, and specialized alerts have expanded the quality of care provided in the COVID-19 pandemic. HITs have been critical to reducing infection rates, developing hospital capacity tracking, and supplying treatments.

Artificial Intelligence technologies such as machine learning, image recognition, and deep learning algorithms have been used to help in early detection and diagnosis of the infection, and fasten the drug discovery process (Brohi, Jhanjhi, Brohi, & Brohi, 2020). These technologies have also been deployed to assist in the enforcement of social distancing and contact tracing (Sipior, 2020). Data analytics have been key in the prediction of risk exposure of travellers and speed up the development of antiviral drugs (Wang, Ng, & H., 2020). High-performance computing (HPC) technologies that utilize networks have also been deployed to assist in the breakdown and analysis of big data to assist in drug development (Woo, 2020). Block chain have also been essential as online ledgers and patient identification tools that have helped in the verification of vaccinated people; alongside preserving patient records' integrity and claims processing (News Staff, 2020). These are some of the technologies deployed in developed countries.

In Sub-Saharan Africa, Bakibinga-Gaswaga, et al. (2020) highlighted increased investments in Information Communication Technology (ICT) infrastructure and digital technologies have played a key role in advancing country's capacity to manage the pandemic. Mbunge, at al. (2021) noted that the adoption of emerging technologies such as AI, blockchain technology, smart applications, telemedicine, and the Internet of Medical Things (IoMT) had been key to detection, monitoring, diagnosis, screening, tracking and creating awareness of COVID-19. Webster (2020) asserts the use of mobile

telephony and virtual tools in the management of COVID-19 in South Africa. Studies on the impact of HITs in COVID-19 management is are reviewed in the section below.

2.3 Empirical Review

2.4.1 Adoption of Health Information Exchange for COVID-19 Management

Ye, Zhou and Wu (2020) sought to develop a technical framework for increasing the effectiveness of response to the COVID-19 epidemic from a health informatics perspective. The study collected health technology–related information from Chinese health centers, government departments and management agencies, health care industry associations, and public enterprises. The analysis of the data collected showed that different information exchange technologies had been utilized at different times for different purposes resulting in improved detection, early response, intervention and post-intervention disease management. Information communication technologies were essential in tracing, tracking and risk assessment, while big data facilitated diagnosis, risk assessment and information security. Cloud computing and mobile technologies were also used to transmit real-time information and data between patients and care providers. This study collected secondary data while the current used primary data to measure the extent of the relationship between the study variables.

Wood, et al. (2019) sought to investigate the effect of connected mobile health diagnostics of infectious diseases on quality health assurance during the COVID-19 pandemic. The researchers reviewed published literature towards this end and determined that the application of mobile devices, their components and related technologies to healthcare has significantly improved the ability of patients to access treatment and advice. Phone-based decision trees have emerged as useful tools that healthcare professionals can utilize in making informed decisions through efficient data gathering, diagnosis and monitoring. Integrating these technologies has provided novel ways for medical personnel to diagnose, track and control infectious diseases and improve healthcare delivery, ensuring public health authorities can monitor outbreaks, implement response strategies and assess the impact of interventions more effectively.

On the other hand, Dwivedi, et al. (2021) investigated Tanzania's journey towards implementing a national healthcare information exchange (HIE) system and its impact on healthcare delivery. The study sought data from the country's records on the partnership between its Ministry of Health and the U.S. Agency for International Development's

(USAID) flagship Maternal and Child Survival Program (MCSP). The data exchange systems collected varied types of data regarding the health workforce, financial capability of healthcare centres, patient traffic, disease surveillance and containment capacity and other health-related information from consumers. This data was utilized to facilitate planning, identify gaps, support decision-making, and prioritize resources. The analysis determined that the degree of interoperability of the collected data, its timeliness and relevance were essential to effective utilization of HIE. Additionally, the interoperability dimension ensured sustained quality of data collected. This study investigated information exchange between two organizations with a specific goal rather than the whole system which collects more patient data.

Tortolero, et al. (2021) investigated the importance of having a clear understanding of a population's socio-demographic characteristics on healthcare delivery. The research specified the effect of the Southeast Texas Greater Houston Health connect (GHH), which is a large health information exchange system, on predicting risk factors. The review ascertained that the system had been successfully leveraged to identify at risk COVID-19 patients, and the factors associated with favourable and unfavourable outcomes. The analysis determined that through having access to patients' lifestyle, laboratory, and clinical data, the HIE system had been used to predict at risk behaviours such as smoking and ascertained the existence of a smoking, age—mortality relationship. A HIE system was determined to be key to identifying a cohort, aggregate sociodemographic, behavioural, clinical and laboratory data across disparate healthcare providers systems, follow the cohort over time and utilize it to facilitate data-driven decisions.

Mekuria, et al. (2021) carried out an explanatory sequential mixed-methods study collecting data from 4 private not-for-profit outreach clinics in Kenya to assess the degree of prescription of antibiotics for the treatment of acute respiratory tract infections (ARIs). Real-time data was sourced from mobile telephone-based healthcare data and a mobile payment system. The research also carried out in-depth interviews with 12 clinicians and 17 patients. The analysis showed a tendency of healthcare providers to prescribe antibiotics for ARIs. The interconnectivity of digital platforms in healthcare would improve how hospitals monitor prescription patterns using real-world data and potentially integrate algorithms that represent national treatment guidelines and help clinician operations by reminding them of guideline recommendations. Such features were also determined to provide real-time feedback and help clinicians provide high quality services

to patients. This study focused on the effectiveness of doctor prescriptions and not on COVID-19 control and monitoring.

Elsewhere, Alam, Reegu, Daud and Shuaib (2021) analysed the role of blockchain in electronic health records management by reviewed the various EHR requirements, challenges faced in EHR implementation and how blockchain technologies can be used to address these issues. EHR challenges identified included protection of data being exchanged, access and usage privileges, confidentiality, integrity and the need for interoperability. The research showed that blockchain offers data immutability, confidentiality, user access properties, and a distributed storage system which facilitates access and usability. With blockchains, there was early detection of spread patterns, refined contact tracing, monitoring and prediction of disease clusters. Blockchain also has the potential for use in Clinical Trial Data Management, vaccine and essential medicine supply chain management, contact tracing, and data analysis while preserving privacy and confidentiality guarantees.

Morgan, et al. (2021) sought after the effect of digital technologies in disease monitoring and spread management by assessing "COVID Watch," a Short Message Service (SMS)-based automated remote monitoring program designed to supplement existing lines of care. The messaging system was theorized to improve patient-healthcare provider communication and was designed to trigger telemedicine clinicians when they were needed. The research incorporated a healthcare web-based dashboard which monitored patient reviews to identify escalations and record shifts in patient needs. The analysis showed a high degree of acceptance and determined that electronic communication devices can play an essential role in facilitating information sharing and providing up-to date and relevant information on the health conditions of patients. The technologies also provided disease spread patterns and regional demographics which were essential for contact tracing, risk analysis, resource needs prediction and allocation, thus improving patient care, while increasing efficiency. This study focused on one technology and impact on COVID disease management while the current examined how multiple technologies can enhance COVID disease management.

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2.4.2 Adoption of Electronic Surveillance for COVID-19 Management

Fu, Zhang, and Zhang (2021) carried out an exploration into the functions and concepts of public health monitoring to determine the role of public health surveillance in prevention and control of COVID-19 in China. The researchers carried out a literature review towards this end. The analysis showed that the government was leveraging emerging technologies in monitoring and early warning systems. Data on a population's size, age, gender distribution, resource capacity and response capability and other essential information was key threat determination and policy development. Civil Registration Data provided data on the population's experiences with the healthcare system, while population survey data provided information on the population's health risk factors. With these data, healthcare officials were able to improve the management system, determine the degree of training needed and resources to be distributed in various regions depending on its capacity to handle the population demographics and risk factors. This study was based on a developed economy where public health information is highly integrated.

Ibrahim, et al. (2021) carried out a cross-sectional exploration into the effect of the electronic Reporting of Integrated Disease Surveillance and Response (eIDSR) project implemented in North-eastern Nigeria on the timeliness and completeness of disease reporting and public health action. The researchers contacted medical professionals and carried out online interviews using structured questionnaires. From thematic analysis employed, the analysis showed that the eIDSR system had improved the timeliness of disease outbreak alerts the completeness of reporting, and supervision. The system was more effective when adopted by multiple interconnected health facilities as the data collected was more comprehensive and provided a clearer means for analysis. Conclusions were that proper harnessing of the system would revolutionize Nigeria's public health surveillance capability.

Fall, et al. (2020) carried out an investigation into the current state, challenges and perspectives of an integrated disease surveillance and response (IDSR) strategy in Africa. A pretested rapid assessment questionnaire and quarterly compilation of data for two IDSR key performance indicators (KPI) were used to determine the state of the IDSR strategy implementation. The analysis showed high adoption, albeit low implementation of IDSR recommendations, with only 12 countries meeting the desired target. The analysis determined that a host of technologies such as mHealth approaches, eLearning and

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eTeaching, and web-based approaches had been key to the adoption of the strategy. The disease surveillance system requirements had resulted in improved and timely events' reporting which supported the implementation of proactive interventions. By focusing on reporting mechanisms, the system improved medical providers' ability to adequately monitor patient movement and track medications. This was a multi-country exploration while the current focused on technologies available in Kenya.

Golinelli, et al. (2020) carried out a literature review to identify the digital technologies utilized to mitigate the impact of COVID-19 on individuals and health systems. A rubric was built to cross-classify patient needs against the type of technologies utilized. Artificial Intelligence-powered technologies were effective in diagnosis and screening of COVID-19. Contact tracing applications and technologies facilitating internet search and social media usage monitoring were key prevention and surveillance measures, while other publications identified telemedicine and telehealth technologies as important technologies that facilitate lifestyle empowerment and sustainable patient engagement, especially when movement restrictions are enforced and in-patient visits impossible.

Gansel, et.al., (2019) sought after the effect of data interoperability on e-health effectiveness in infectious disease management in European states. The review introduced the concept of semantic data interoperability, its added value and application in the standard healthcare system. The review asserts that in the modern world, disease management is international and involves sharing data in multiple languages, across multiple devices, with different codes and standards of operation in matters regarding etiology, diagnosis, treatment, and follow-up. The researchers affirmed that it is essential for associated organizations to adopt a uniform and clear data management system that would adhere to the principles of predictability, preventive, personalization and participatory. Semantic data interoperability was singled out as a technical building block supporting digital healthcare provision by infectious disease-related actors.

Choi, et.al, (2016) applied a systematic review framework in searching, screening, identifying and analysing the effect of web-based infectious disease surveillance systems on public health provision. The research reviewed 11 web-based infectious disease surveillance systems to determine their strengths and weaknesses and concluded that web-based systems played a key role complementing traditional systems. The analysis determined that the new systems were more integrated, adaptable, low-cost, easy to use and provided real-time data which enhances the reliability and quality of collected data,

thus meeting the requirements of an effective public health surveillance tool. However, web-based healthcare systems were vulnerable to inaccurate data collection which impedes the interpretation and prediction of health status. Further, since the devices are localized and working within public networks, privacy issues and questions regarding data security had impacted consumer trust in the systems.

Ruiz Estrada (2020) evaluated the crucial role of drones in public health delivery to people in quarantine in China. Carrying out a review of previous literature and published reports, the researchers were able to identify three main ways through which drones had been used to control massive epidemics, halt the spread of contagious diseases and provide relief humanitarian aid. The analysis showed that quadcopters, drones and smart platforms were only as effective as the human capital available, technological development and software integration. Drones facilitated aerial monitoring to calculate the impact of epidemic containment measures, aided in the distribution and logistics of light cargo, and assisted in identifying problematic regions where most people were most likely to break COVID-19 protocols.

Mwongela (2018) aimed to come up with a mobile-based system that would enhance TB contact tracing and screening using both Android and USSD technologies. The study adopted the Agile methodology as the methodology for developing the system. The research asserts that covering a vast geographical location with a limited number of health workers had limited the healthcare system's ability to collect, store and retrieve quality data. Through the USSD application, patients were able to remotely select their symptoms and report risk factors, while also checking their screening results. These applications were then integrated with analytical backend that enabled the presentation of a summary of contact tracing and screening activities. Conclusions were that the system improves decision making by TB policy officials by providing them with relevant surveillance reports, analytics and statistics. This study investigated TB surveillance and control while the current examined the Kenyan situation.

2.4.3 Digital Connectivity for COVID-19 Management

Dey and Chatterjee (2022) investigated the impact of the use of Internet of Things on COVID-19 waste management, seeking to develop an Internet of Things (IoT)-based smart framework for COVID waste management and proposed smart COVID waste bins for collecting home and COVID medical wastes generated from hospitals and other

healthcare centres. The review asserted that the IoT can be harnessed to meet automatic capture of waste components through attached sensors and send the collected data wirelessly to a remote municipality server for analysis. Through analysis and determination of risk factors associated with waste, the IoT framework would reduce exposure and interaction with infected waste, thus, reduce spread of the virus. Further, it enhances the ability of the municipality to make decisions on the number of bins to be deployed and intervals for waste clearance. This study is based on a developed economy where high-quality internet infrastructure and connectivity enables application of smart systems.

Heinemann, et al. (2021) carried out a literature review on the effects of smart insulin pens on diabetes management. The research evaluated publications containing insulin pens with Bluetooth/Near Field Communication connectivity. Primarily, the studies focused on assessing the patient's preference, usability, and technical accuracy. The review showed increase in use of smart insulin pens was associated with improved and simplified diabetes self-management which led to better health outcomes for diabetes patients. Continuous glucose monitoring (CGM) and insulin pumps were key resources that complemented the effectiveness of smart insulin pens.

Muyingo, et.al., (2020) investigated the relationship between digital connectedness and control of the COVID-19 pandemic to determine the opportunities and challenges that exist in the fight against epidemics. The review determined that a high degree of digital connectedness between of individuals and organizations facilitated information sharing on the causes and measures aimed at controlling the pandemic with developing economies of Africa. Digital connectedness enabled African countries to access, share and implement globally suggested mechanisms and measures that controlled the spread of the COVID-19 epidemic. These populations were able to get first-time information from shared digital sources which increased their awareness and participation in initiatives aimed at curbing the COVID-19 epidemic. Digital platforms fostered a global coordinated message transmission.

Wang, et.al., (2021) carried out a systematic and comprehensive review of the effect of digital healthcare on combatting the COVID-19 pandemic. Bibliometric techniques were used in analysis of the research data, geographic distribution, discipline distribution, collaboration network, and hot topics of digital healthcare before and after COVID-19 pandemic. Analysis revealed that COVID-19 had accelerated research on the integration

of digital technologies and healthcare. Big data, artificial intelligence, cloud computing and 5G were the most effective tools in developed countries such as USA, China and Germany. However, challenges in data sharing, data fragmentation, privacy security, and data security concerns had impacted the effectiveness of digital healthcare.

Budd, et al. (2020) aimed to capture the breadth of digital innovation usage on response to COVID-19 in the public-health sector. The literature review determined that digital technologies have been utilized extensively to support the response to COVID-19 worldwide. Digital technologies that leverage billions of mobile phones, large online databases, connected devices, and advances in machine learning and natural language processing were used in surveillance of the population, case identification, contact tracing and evaluation of interventions. Data dashboards were used extensively to collate real-time public-health data, confirm cases, testing figures, and to keep up with the death figures. Digital technologies also supplemented clinical and laboratory notification, facilitated widespread access to community and self-testing, and acceleration of incidence reporting to public-health officials. Cellular network and GPS also improved disease surveillance while digital contact-tracing apps significantly improved the speed and scale of tracing for both individual and hotspot tracing.

2.5 Research Gaps

The studies above point to the existence of a significant relationship between digital health information technologies and management of infectious diseases. However, from the review, certain gaps were identified. First, most of the studies were carried out in developed economies such as Wang, et.al., (2021), Budd, et al. (2020) and Ruiz Estrada (2020), where technologies are more interconnected and standards of inter-operability more standardized. Methodological gaps were also present, with Choi, Cho, Shim and Woo (2016) carrying out a systematic review and Golinelli, et al. (2020) carrying out a literature review. Additionally, Ibrahim, et al.'s (2021) study was cross-sectional in nature while our study is descriptive in nature. Fall, et al. (2020) focused on the application of a large integrated continental disease surveillance and response database and its impact on disease management, while the current study focused on various health information technologies, not just integrated databases.

A similar gap was identified in the study by Morgan, et al. (2021) whose knowledge gap was due to its focus on a surveillance application known as 'COVID WATCH', the current

examined the application of multiple technologies such as drones and blockchain technologies and their impact on disease management. Mekuria, et al. (2021) carried out a mixed methodologies study while the current focused on descriptive methodologies in analysis. The studies by Heinemann, et al. (2021) and Mwongela (2018) based their findings on the management of infections not caused by the current COVID-19 pandemic. Table 2.1 presents a summary of the research gaps.

Table 2.1: Summary of Research Gaps

Author	Title	Methodology	Findings	Gaps
Ye, Zhou and Wu (2020)	Using information technology to manage the COVID-19 pandemic: development of a technical framework based on practical experience in China.	Explorative methodology using literature analysis methods	ICTs are essential in tracing, tracking and risk assessment, while big data facilitated diagnosis, risk assessment and information security.	The study sourced COVID-19 management data from a developed economy where the data collection is more streamlined while the current study examined disease management in a country with less developed collection techniques
Wood, et al. (2019)	Taking connected mobile-health diagnostics of infectious diseases to the field.	The exploratory study used literature analysis methods	Phone-based decision trees are useful tools that facilitates information collection and patient monitoring, producing real-time data that analytics tools can utilize to prescribe policies and practices made	This study focused on the use of mobile technologies; the current analysed how more interconnected devices can be used to advance health goals

			from efficient data gathering, diagnosis and monitoring	
Gansel, et.al., (2019)	Semantic data interoperability, digital medicine, and e-health in infectious disease management: a review.	The study was a systematic review	The review introduced the concept of semantic data interoperability, its added value and application in the standard healthcare system	This study focussed on how interoperability of digital data affects decision making while the current focused on how multiple data sources can advance health management goals.
Tortolero, et al. (2021)	Leveraging a health information exchange for analyses of COVID-19 outcomes including an example application using smoking history and mortality.	Descriptive analysis using Multivariable logistic regressions	Digital technologies are essential when determining the relationships between lifestyles and disease outcomes.	The study aimed to develop a framework for analysing COVID outcomes while the current study addresses how technologies can be used to detect and minimize the spread of the COVID-19 pandemic
Mekuria, et al. (2021)	Analyzing data from the digital healthcare exchange platform for surveillance of antibiotic prescriptions in primary care in urban Kenya: A	The study used mixed methodologies	Interconnectedness enables tracking of prescription patterns and suggest how to monitor and improve	This study was based on private not-for-profit outreach clinics and investigated prescription of antibiotics.

	mixed-methods study.		physician practices	
Ibrahim, et al. (2021)	Electronic reporting of integrated disease surveillance and response: lessons learned from northeast, Nigeria.	The study used thematic analysis	eIDSR system adoption resulted in improved timeliness of disease outbreak alerts the completeness of reporting, and also facilitated supervision.	This study was a cross-sectional exploration while the current study was descriptive in nature
Mwongela (2018)	A Mobile based Tuberculosis contact tracing and screening system.	Literature analysis	Mobile-based systems improve decision making by TB policy officials by providing them with relevant surveillance reports, analytics and statistics	The current study addresses the COVID-19 pandemic and not the Tuberculosis disease.

2.6 Conceptual Framework

The conceptual framework sought to identify the interaction between the selected health information technologies and the management of COVID-19 in Kenya. The independent variables and dependent variable of the study are also shown in Figure 2.1.

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Independent variables **Dependent Variable**

Health Information Exchange

- Sharing medical information
- Remote consultation
- Intelligent diagnostics

Electronic Surveillance

- Contact tracing
- Risk screening & visualization
- Temperature detection

Digital Connectivity

- mHealth
- Health monitoring
- Regional surveillance

Covid-19 management

- Containment
- Detection
- Prevention
- Control measures

Figure 2.1: Conceptual Framework

The study conceptualizes the health information technologies into; health information exchange, electronic surveillance and digital connectivity and how they influence COVID-19 management in the country. The variables were operationalized as shown in Table 2.2;

Table 2.2: Operationalization of Variables

Variable	Constructs	Measurement	Type	Literature
Health information exchange	• Sharing medical information • Remote consultation • Intelligent diagnostics	Descriptive and Inferential measures	5-point Likert Scale Ordinal variable	(Lenert & McSwain, 2020); (Webster, 2020).
Electronic surveillance	• Contact tracing • Risk screening & visualization • Temperature detection	Descriptive and Inferential measures	5-point Likert Scale Ordinal variable	(Jiancheng, 2020); (Calvo, Deterding, & Ryan, 2020).
Digital connectivity	• mHealth • Health monitoring • Internet of Things	Descriptive and Inferential measures	5-point Likert Scale Ordinal variable	(Jiancheng, 2020); (Park, Choi, & Ko, 2020).
COVID-19 management	• Containment • Detection • Prevention • Control measures	Descriptive and Inferential measures	5-point Likert Scale Ordinal variable	(Mbunge, Akinnuwesi, Fashoto, Metfula, & Mashwama, 2021); (Molla & Abegaz, 2021).

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CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter of the proposal focused on presenting the methodological plan that was employed in guiding the conduct of the research. The chapter presented the philosophical paradigm, the research design, population and sampling procedures that was applied. Further, data collection instruments, procedures, quality of instrument and data analysis approaches are shown in this chapter.

3.2 Research Philosophy

Research philosophy can simply be defined as a belief about the way in which data about a phenomenon should be gathered, analyzed and used (Crano, Brewer, & Lac, 2014). This study relied on a positivism research philosophy. This paradigm is based on quantifiable observations that lead themselves to statistical analysis. It is noted that positivism is in accordance with the empiricist view that knowledge stems from human experience (Kothari, 2019). The paradigm is appropriate for this study as it supported the adoption of quantitative methods that rely on the researchers' ability to amass numerical evidence of the phenomena under investigation and analyze it to answer the research questions. Thus, it helped in quantitatively analysing the effect of health information technologies in COVID-19 Management in Kenya.

3.3 Research Design

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Kothari (2019) asserts that research design is an illustration of the plan that the study utilizes in an endeavour to find answers to the study problem. Descriptive research entails the process of obtaining information concerning the current phenomena to describe the study variables (Crano, Brewer, & Lac, 2014). Bryman (2016) asserts that descriptive survey design sought to obtain information from a sample and present finding that bear the characteristics of the entire population. As such, this study relied on this design in conducting a quantitative analysis that helped in describing how various health information technologies impacts the COVID-19 management. This was key to determining how the variables interact and develop inferences based on the results.

3.4 Target Population

Kothari (2019) refers to a population as a larger group from which the sample is taken. According to Walliman (2015) the population is a complete set of individual cases with some common observable attributes. Based on the Ministry of Health, Kenya (2022) there were six (6) healthcare facilities/institutions that were designated for the management of COVID-19 in Kenya. These six facilities/institutions were: Kenyatta National Hospital, Ministry of Health, ICT Authority Kenya, County Referral Hospitals, Private Referral Hospitals (Nairobi), and Research Institutions (KEMRI & KHF). The population of the study comprised of key executive personnel, namely, Senior Doctors, Managers, and Directors from the six healthcare facilities/institutions.

3.5 Sampling Design and Sample Size

According to Walliman (2015), a sampling frame is a directory from which a sample is collected. The sampling frame comprised of a purposively defined/selected set of key executive personnel: Senior Doctors, Managers, and Directors drawn from the six healthcare facilities/institutions outlined. Various smaller hospitals in the population were not included in the sample due to limited adoption of HIT. This ensured that the researcher collects more relevant and reliable data that focused on the study objectives and helped the researcher answer the study questions. Stratified sampling was also used for Kenyatta National Hospital in which certain subgroups were selected from the sample. This was in respect to their positions in the organization, for instance, Doctors, and Managers. The sample frame was composed of the 86 key executive personnel from the six healthcare facilities/institutions. A total of 86 respondents was considered as the main respondents in this research as shown in Table 3.1.

Table 3.1: Sample Size by Facility/Institution

Facility/Institution	Target Employees	Population	Sample Size
Kenyatta National Hospital	Senior Doctors	6	6
Kenyatta National Hospital	ICT Managers	4	4
Ministry of Health	Director and ICT Managers	10	10
ICT Authority Kenya	Directors and Managers	10	10
County Referral Hospitals	Director/CEO	49	49

Private Referral Hospitals (Nairobi)		5	5
Research Institutions (KEMRI & KHF)	Directors	2	2
Total		**86**	**86**

Source: (Hosi Kenya, 2022; Executive Office of the President, 2020; MOH Kenya, 2022)

3.6 Data Collection Instruments

Data collection instruments are tools used to collect data from the selected sample size based on the type of data the researcher is interested in to solve the stated research problem (Kothari, 2019). The study relied on structured research questionnaires in the data collection process. Bryman (2016) opines that, the questionnaires are the best data collection tools for the study since the researcher can collect data from a large sample in the shortest time possible. The structured study questionnaire was developed in cognizant of the measurements and operationalization shown in Table 2.2 of this protocol. The questionnaire relied on a 5-point Likert scale that analysed how various HIT influenced COVID-19 management based on the following key; 5 – to a very large extent, 4- to a large extent, 3- to moderate extent, 2- to a small extent and 1- to no extent at all. The questionnaire was grouped into five main sections covering the demographic profile of participants, the independent variables and the dependent variable of the research.

3.7 Data Collection Procedures

Data collection procedures involves the various steps and techniques that are employed in the course of conducting the field work and the main research work (Bryman, 2016). The first step in this study was to obtain the necessary approvals and permits that are required by the institution prior to conducting the survey. The researcher reviewed the research proposal and the instruments with the study supervisor to ensure they meet the required standards. The study was conducted across the country which may present geographical limitations thus utilizing a mixed research procedures in the data collection was necessary. To achieve this the study used physical questionnaires within Nairobi County and other neighbouring counties; for the far-reaching areas the study developed Google forms and Microsoft teams to assist in electronic data collection. To enhance the data collection

process, the researcher sought the primary contacts of the respondents and schedule data collection with them to improve the ease of their inclusion in the survey.

3.8 Research Quality

Pilot testing involves a prior data collection before the actual data collection process takes place. This activity acts as guide for examining the research questions and to determine whether it produces the expected results (Punch & Oancea, 2014). A pretest is meant to enhance the understanding of the question and yield relevant results. The pretest was conducted among 10% of the sample respondents who was not considered in the main research (Kothari, 2019).

3.8.1 Validity of Research Instrument

Validity is defined as the degree to which a research instrument is capable of measuring study attributes for a particular group (Newby, 2014). Check and Schutt (2011) offers that validity speaks to the ability of research instruments to suitably measure the phenomena they are meant to measure. The study conducted the validity of the research instruments in addition to validating the content and thus ensuring proper attuning of the instruments before the eventual data collection. Questionnaire validity was guaranteed through constant consultation with the University's supervisors. The study conducted Bartlett Sphericity test to determine the adequacy of the research questionnaire.

3.8.2 Reliability of Research Instrument

Reliability is defined as a measure of consistency that results if same result is obtained from a repeated trial tests (Cohen, Manion, & Morrison, 2017). The research conducted the internal consistency measure of reliability through applying the Cronbach Alpha analysis. A threshold value of 0.7 as suggested by Cherry (2013) was used as the cut-off in this study. The indicators that yield a value less than 0.7 were not considered reliable and hence was revised accordingly. Any variable with an alpha score above 0.7 was adopted for the main survey without any further amendments on the research instrument as shown in Table 3.2.

Table 3.2 Reliability Results

	Reliability Statistics		
	Cronbach's Alpha	N of Items	Decision
Health information exchange	.901	7	Accepted
Electronic surveillance	.935	7	Accepted
Digital connectivity	.912	6	Accepted
COVID Management	.939	5	Accepted

3.9 Data Analysis and Presentation

The collected research data was edited and coded into computerized programme (Excel and SPSS) to support the data analysis. The research data was dominantly quantitative hence the most appropriate analysis techniques was quantitative in nature comprising of both descriptive and inferential approaches. The descriptive tests applied measures such as frequencies, percentages, means and the deviation of the responses from the study participants. The study conducted correlation analysis to establish the direction of effect of the independent variables on COVID-19 management in Kenya. A regression analysis was applied to estimate the overall magnitude of the relationship between health information technologies on COVID-19 management. The selection of the regression is informed by the quantitative data and the need to establish the strength of interaction between the predictor and dependent variable of the study. Tests such as ANOVA and T-tests was used to determine the statistical significance of the relationship. The research adopted test such as collinearity, normality and heteroscedasticity to ensure the data used meets the basic threshold for regression analysis. The study sought to estimate the following regression model;

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon$$

Where

Y = COVID-19 management

X_1 = health information exchange

X_2 = electronic surveillance

X_3 = digital connectivity

$\beta_1, \beta_2, \beta_3$=Regression Coefficients

ε = Error term

3.10 Ethical Considerations

Ethical guidelines represent the various norms, standards and procedures that are requisite when conducting scientific studies (Crano, Brewer, & Lac, 2014). The first consideration that was observed in this study assuring all the respondents that their involvement in the survey is purely voluntary and the required data is for academic purposes. Secondly, the participants were not required to include personal identifying information in the research survey. Thirdly, the study obtained the required ethical approval from the Institutional Review Board as requirement for conducting the research work. Fourthly, the study sought the research permit from the National Commission for Science Technology and Innovation. Relevant authorization was sought from the Ministry of Health before engaging the county referral hospitals and any other health facility/institution. Lastly, the study ensured the collected study data is securely stored and no unauthorized access or utilization was allowed.

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CHAPTER FOUR

PRESENTATION OF RESEARCH FINDINGS

4.1 Introduction

The research focused on analysing the effectiveness of health information technologies utilization in COVID-19 Management in Kenya. This fourth chapter is critical in the presentation of the findings of the study. Highlighted in the chapter are the summary of descriptive tests, the correlation tests and the regression analysis showing the relationship between the conceptualized variables.

4.2 Response Rate

The research was interested in collecting study data from the health facilities in Kenya that were utilized in coordinating the use of health information technologies since the pandemic began. The facilities are chosen owing to the role they played in the management of COVID-19 in Kenya. The main focus was obtaining information from the senior doctors and directors in; Kenyatta National Hospital, Ministry of Health, ICT Authority Kenya, County Referral Hospitals, Private Referral Hospitals (Nairobi) and Regulators (KEMRI & KHF). The sample for the study was 86 participants from which the research obtained responses from 69% (n=59) respondents with only 31% of the participants not able to engage in the study. This response rate was deemed sufficient to undertake the quantitative analysis and provide inferences that can be applied in the context of this study.

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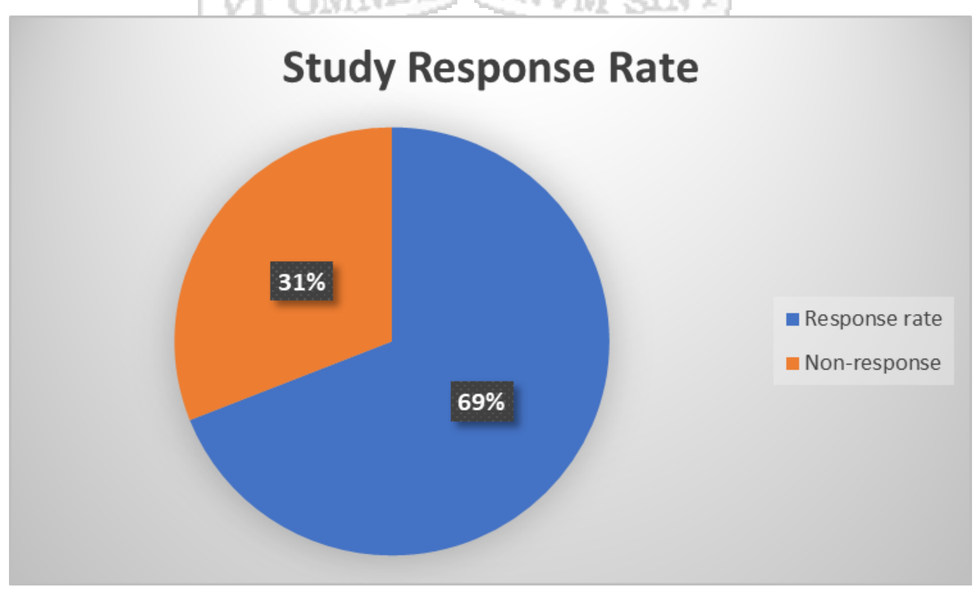

Figure 4.1 Response Rate

4.3 Demographic Characteristics

4.3.1 Health Facility/Institution of Work

The research sought responses from the participants on the health/institutions they operate within and the findings are shown in Table 4.1 as follows;

Table 4.1 Health/Institution of Work

		Frequency	Percent
	National Referral Hospital	2	3.4
	County Referral Hospital	31	52.5
	ICT Authority	6	10.2
	Ministry of Health	11	18.6
	Ministry of ICT	2	3.4
	Private Referral Hospitals	4	6.8
	KEMRI	2	3.4
	Immigration	1	1.7
	Total	59	100.0

Results presented above show that majority of the participants 52.5% (n= 31) were from county referral hospitals, 18.6% (n= 11) of the respondents were drawn from the Ministry of Health, 10% from the ICT authority and 3.4% (n= 2) from the National Referral Hospital and KEMRI respectively. These findings point out to an inclusive participation in the research, which was key to understanding how utilization of HIT supported the COVID-19 pandemic management in the country.

4.3.2 Health Information Technologies Utilized

The researcher was interested in understanding the various health information technologies that have been adopted within the country and results are presented in Table 4.2.

Table 4.2 Health Information Technologies Used

		Frequency	Percent
	Electronic surveillance	4	6.8
	Telemedicine	8	13.6
	Health information exchange systems	20	33.9
	Web-based services	7	11.9
	Artificial Intelligence	4	6.8
	Digital contact tracing	1	1.7
	Clinical information systems	10	16.9
	Mobile Telephony	5	8.5
	Total	59	100.0

Findings revealed that 34% (n= 20) had utilized health information exchange systems, 17% (n= 10) had used clinical information systems. 12% (n= 7) have utilized web-based services with only 6.8% (n= 4) using artificial intelligence and electronic surveillance systems. The results demonstrated that the various respondents considered in the survey have to some extent utilized the various HIT available in the health sector.

4.4 Descriptive Analysis

4.4.1 COVID-19 Management

The dependent variable for the survey focused on the management of COVID-19 within the country and the research findings are shown in the Table 4.3. The following key was applied; N = Tally, 5 – to a very large extent (VLE), 4- to a large extent (LE), 3- to moderate extent (ME), 2- to a small extent (SE) and 1- to no extent at all (NE)..

Table 4.3 COVID-19 Management

	N	NE	SE	ME	LE	VLE	Mean	Variance
The health sector was able to effectively contain the spread of the virus and limit runaway infection rates	59	5.1%	10.2%	16.9%	32.2%	35.6%	3.8305	1.385
The health sector was able to contain the spread of the virus and reduce casualties	59	6.8%	13.6%	20.3%	23.7%	35.6%	3.6780	1.636
The health sector has made strides in improving the detection capacity of the virus	59	1.7%	6.8%	25.4%	33.9%	32.2%	3.8814	1.003
The health sector has developed preventative measures that are well-documented for public consumption	59	8.5%	8.5%	16.9%	35.6%	30.5%	3.7119	1.519

The health sector has formulated clear control measures that have mitigated further spread of new variants of the virus locally	59	10.2%	11.9%	13.6%	35.6%	28.8%	3.6102	1.690

To a great extent with a high variance (M = 3.8814, Var = 1.003) the health sector has made strides in improving the detection capacity of the virus. Further to a great extent (M = 3.8305, Var = 1.385), the health sector was able to effectively contain the spread of the virus and limit runaway infection rates. The results also affirmed that to a great extent the health sector has developed preventative measures that are well-documented for public consumption (M = 3.7119, Var = 1.519). Analysis also revealed that to a great extent, the health sector has formulated clear control measures that have mitigated further spread of new variants of the virus locally (M = 3.6102, Var = 1.69).

4.4.2 Adoption of Health Information Exchange

The first study objective sought to establish the effect of adoption of health information exchange on COVID-19 Management in Kenya. The study undertook both descriptive analysis and results are shown in Table 4.4. The following key was applied; Tally (N), to no extent at all (NE), to a small extent (SE), to moderate extent (ME), to a large extent (LE), and, to a very large extent (VLE)..

Table 4.4 Adoption of Health Information Exchange

	N	NE	SE	ME	LE	VLE	Mean	Variance
Through agency collaboration, a health information exchange was developed which improved sharing of health-related data between facilities across the country	59	3.4%	10.2%	15.3%	39%	32.2%	3.8644	1.188
The health information exchange platforms supported ease of transmission of patient data between medical providers in the country	59	3.4%	5.1%	28.8%	32.2%	30.5%	3.8136	1.085
The application of health information exchange allowed medical practitioners to conduct remote consultation for facilities across the country	59	6.8%	10.2%	28.8%	30.5%	23.7%	3.5424	1.356
The health information exchange systems supported more data-driven diagnostics which were critical to the management of the pandemic	59	10.2%	11.9%	18.6%	25.4%	33.9%	3.6102	1.794
The health information exchange supported more direct consultations on symptom assessment and infection control in the country	59	5.1%	8.5%	32.2%	25.4%	28.8%	3.6441	1.302
The health information exchange was critical in supporting robust health services research on the pandemic	59	6.8%	8.5%	25.4%	25.4%	33.9%	3.7119	1.485

The health information exchange allowed private and public facilities to have a seamless information sharing platform on clinical data, outcomes and endpoint data	59	3.4%	15.3%	13.6%	37.3%	30.5%	3.7627	1.322

The analysis revealed to a great extent (M = 3.8644, Var = 1.188), that through agency collaboration, a health information exchange was developed which improved sharing of health-related data between facilities across the country. Results indicated that to a great extent (M = 3.7627, Var = 1.322) the health information exchange allowed private and public facilities to have a seamless information sharing platform on clinical data, outcomes and endpoint data. The study revealed to a great extent (M = 3.7119), the health information exchange was critical in supporting robust health services research on the pandemic. Results showed to a great extent (M = 3.6102) the health information exchange systems supported more data-driven diagnostics which were critical to the management of the pandemic.

4.4.3 Adoption of Electronic Surveillance on COVID-19 Management in Kenya

The second study objective sought to establish the effect of adoption of electronic surveillance on COVID-19 Management in Kenya. The study undertook descriptive test and results are shown in Table 4.5. The following key was applied; Tally (N), to no extent at all (NE), to a small extent (SE), to moderate extent (ME), to a large extent (LE), and, to a very large extent (VLE)..

Table 4.5 Adoption of Electronic Surveillance

	N	NE	SE	ME	LE	VLE	Mean	Variance
The health sector heavily relied on electronic surveillance tools in tracing of new patients	59	8.5%	18.6%	27.1%	22%	23.7%	3.3390	1.607
The application of electronic surveillance was critical in mapping the disease spread across the country	59	8.5%	13.6%	28.8%	16.9%	32.2%	3.5085	1.703
Through electronic surveillance health practitioners were able to access data on the disease screening patterns in the country	59	8.5%	11.9%	18.6%	32.2%	28.8%	3.6102	1.587
The electronic surveillance systems were essential in providing real-time data collection and visualization of the disease management in the country	59	6.8%	15.3%	18.6%	32.2%	27.1%	3.5763	1.524
The adoption of electronic surveillance tools supported private and public institutions to utilize more clinically approved temperature detection systems	59	8.5%	22%	18.6%	22%	28.8%	3.4068	1.797

The use of electronic surveillance provided health stakeholders with vital data to conduct effective prevention and control activities	59	3.4%	10.2%	20.3%	35.6%	30.5%	3.7966	1.199
The application of electronic health surveillance allowed facilities to provide timely medical services for remote areas	59	11.9%	11.9%	27.1%	27.1%	22%	3.3559	1.647

The participants revealed that to a great extent (M= 3.7966, Var = 1.199), the use of electronic surveillance provided health stakeholders with vital data to conduct effective prevention and control activities. Analysis revealed to a great extent (M = 3.6102, Var = 1.587) utilization of electronic surveillance health practitioners enabled access data on the disease screening patterns in the country. The study noted to a moderate extent the health sector heavily relied on electronic surveillance tools in tracing of new patients (M = 3.339, Var = 1.607). Further to a moderate extent the respondents noted that application of electronic health surveillance allowed facilities to provide timely medical services for remote areas (M = 3.3559, Var = 1.647).

4.4.4 Digital Connectivity On COVID-19 Management in Kenya

The second study objective sought to establish the influence of digital connectivity on COVID-19 Management in Kenya. The study undertook descriptive tests and results are shown in Table 4.6. The following key was applied; Tally (N), to no extent at all (NE), to a small extent (SE), to moderate extent (ME), to a large extent (LE), and, to a very large extent (VLE)..

Table 4.6 Digital Connectivity

	N	NE	SE	ME	LE	VLE	Mean	Variance
Health facilities were able to provide health services and information through mobile technology on COVID-19 management	59	3.4%	3.4%	28.8%	30.5%	33.9%	3.8814	1.072
Health facilities in the country had an effective system of digitally monitoring the health outcomes in the management of the pandemic	59	5.1%	13.6%	28.8%	30.5%	22%	3.5085	1.289
The reliance on digital technologies allowed health facilities to conduct routine surveillance of the infected individuals and close contacts	59	3.4%	16.9%	20.3%	35.6%	23.7%	3.5932	1.280

The utilization of the digital technologies allowed health practitioners to remotely provide and support a discussion of treatment plans for patients	59	3.4%	16.9%	22%	32.2%	25.4%	3.5932	1.314
The use of digital technologies in health facilities enabled collaboration between doctors on the best practices in management of the COVID-19	59	10.2%	6.8%	18.6%	30.5%	33.9%	3.7119	1.657
The application of telemedicine enabled doctors to conduct real-time observational assessment of patients	59	10.2%	13.6%	23.7%	25.4%	27.1%	3.4576	1.701

The analysis showed to a great extent (M = 3.8814, Var = 1.072), the health facilities were able to provide health services and information through mobile technology on COVID-19 management. Findings also revealed to a great extent (M = 3.7119, Var = 1.657), the use of digital technologies in health facilities enabled collaboration between doctors on the best practices in management of the COVID-19. Analysis revealed to a great extent (M = 3.5932, Var = 1.28) reliance on digital technologies allowed health facilities to conduct routine surveillance of the infected individuals and close contacts. To a moderate extent (m = 3.4576, Var = 1.701), the respondents noted that application of telemedicine has enabled doctors to conduct real-time observational assessment of patients.

4.5 Correlation Analysis

The study adopted Spearman rank correlation to analyse the direction of the relation between the independent and dependent variable in Table 4.7

Table 4.7 Correlation Matrix

			Health Information Exchange	Electronic Surveillance	Digital Connectivity	Covid Management
Spearman's rho	Health Information Exchange	Correlation Coefficient	1.000			
		Sig. (2-tailed)	.			
		N	59			
	Electronic Surveillance	Correlation Coefficient	.738**	1.000		
		Sig. (2-tailed)	.000	.		
		N	59	59		
	Digital Connectivity	Correlation Coefficient	.744**	.785**	1.000	

		Sig. (2-tailed)	.000	.000	.	
		N	59	59	59	
	Covid Management	Correlation Coefficient	.602**	.695**	.681**	1.000
		Sig. (2-tailed)	.000	.000	.000	.
		N	59	59	59	59
**. Correlation is significant at the 0.01 level (2-tailed).						

The results above confirmed there was a strong positive and significant relation between the adoption of health information exchange and COVID-19 Management (r = .602**, sig = .000). The results above confirmed there was a strong positive and significant relation between the adoption of electronic surveillance and COVID-19 Management (r = .695**, sig = .000). The findings revealed there was a strong positive and significant relation between the adoption of digital connectivity and COVID-19 Management (r = .681**, sig = .000).

4.6 Regression Analysis

The research was interested in determining the magnitude of the relationship between the independent and dependent variable.

4.6.1 Regression between Adoption of Health Information Exchange and COVID-19 Management

The study adopted simple linear regression to establish the extent of influence of the predictor variables on the level of COVID-19 management in Kenya and results are shown in Table 4.8

Table 4.8 Regression Summary for Adoption of Health Information Exchange and COVID-19 Management

Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	.575[a]	.331	.319	4.45283
a. Predictors: (Constant), Health Information Exchange				

ANOVAa						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	557.926	1	557.926	28.139	.000[b]
	Residual	1130.176	57	19.828		
	Total	1688.102	58			
a. Dependent Variable: COVID Management						

b. Predictors: (Constant), Health Information Exchange						
Coefficientsa						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.265	2.417		2.592	.012
	Health Information Exchange	.480	.090	.575	5.305	.000
a. Dependent Variable: COVID Management						

The findings above indicated a coefficient of determination ($R^2 = .331$). This result shows that 33.1% of the variations in COVID-19 management in the country are determined by the adoption of health information exchange. The ANOVA test aimed at determining the statistical significance of the regression model employed. The results indicate a F-calculated = 28.139 > (f-critical = (1.96), Sig = .000<.05. This is a clear indication that the relationship between adoption of health information exchange and COVID-19 management is statistically significant. The constant B-value (6.265) was statistically significant, as indicated by Sig = .012<.05. The B-value of the health information exchange (.480) was statistically significant, Sig = .000<.05. This indicates that a unit change in health information exchange will result in a .480 change in the management of COVID-19 in Kenya.

4.6.2 Regression between Adoption of Electronic Surveillance and COVID-19 Management

The study adopted simple linear regression to establish the extent of influence of the predictor variables on the level of COVID-19 management in Kenya and findings are shown in Table 4.9.

Table 4.9 Regression Summary between adoption of electronic surveillance and COVID-19 Management

Model Summary				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	.690[a]	.477	.467	3.93716
a. Predictors: (Constant), Electronic Surveillance				

ANOVAa						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	804.530	1	804.530	51.901	.000[b]
	Residual	883.571	57	15.501		

	Total	1688.102	58			
a. Dependent Variable: COVID Management						
b. Predictors: (Constant), Electronic Surveillance						

Coefficientsa

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.446	1.778		3.625	.001
	Electronic Surveillance	.499	.069	.690	7.204	.000
a. Dependent Variable: COVID Management						

The findings above indicated a coefficient of determination ($R^2 = .477$). This result shows that 47.7% of the variations in COVID-19 management in the country are determined by the adoption of electronic surveillance. The ANOVA test aimed at determining the statistical significance of the regression model employed. The results indicate a F-calculated = 51.901 > (f-critical = (1.96), Sig = .000<.05. This is a clear indication that the relationship between adoption of electronic surveillance and COVID-19 management is statistically significant. The constant B-value (6.446) was statistically significant, as indicated by Sig = .001<.05. The B-value of the electronic surveillance (.499) was statistically significant, Sig = .000<.05. This indicates that a unit change in electronic surveillance will result in a .499 change in the management of COVID-19 in Kenya.

4.6.3 Regression between Digital Connectivity and COVID-19 Management

The research was interested in determining the magnitude of the relationship between the independent and dependent variable. The study adopted simple linear regression to establish the extent of influence of the predictor variables on the level of COVID-19 management in Kenya.

Table 4.10 Regression between Digital Connectivity and COVID-19 Management

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.666[a]	.443	.434	4.06018
a. Predictors: (Constant), Digital Connectivity				

ANOVAa

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	748.454	1	748.454	45.402	.000[b]
	Residual	939.648	57	16.485		

	Total	1688.102	58			
a. Dependent Variable: COVID Management						
b. Predictors: (Constant), Digital Connectivity						

Coefficientsa						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.433	2.040		2.663	.010
	Digital Connectivity	.611	.091	.666	6.738	.000
a. Dependent Variable: COVID Management						

The regression results in Table 4.12 indicated a coefficient of determination (R^2= *.443*). indicating that 44.3% of the variations in COVID-19 management in the country are determined by the digital connectivity in the health sector. The ANOVA test aimed at determining the statistical significance of the regression model employed. The results indicate a F-calculated = 45.402 > (f-critical = (1.96), Sig = .000<.05. This is a clear indication that the relationship between digital connectivity and COVID-19 management is statistically significant. The constant B-value (5.443) was statistically significant, as indicated by Sig = .010<.05. The B-value of the digital connectivity (.611) was statistically significant, Sig = .000<.05. This indicates that a unit change in digital connectivity leads to a .611 change in the management of COVID-19 in Kenya.

4.7 Effectiveness of Health Information Technologies Utilization In COVID-19 Management in Kenya

The research employed a multiple linear regression to examine the magnitude of influence of the effectiveness of health information technologies utilization in COVID-19 management in Kenya and results are presented in Table 4.13.

Table 4.11 Regression Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.722[a]	.522	.495	3.83192	2.276
a. Predictors: (Constant), Digital Connectivity, Health Information Exchange, Electronic Surveillance					
b. Dependent Variable: COVID Management					

ANOVAa						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	880.503	3	293.501	19.988	.000[b]
	Residual	807.599	55	14.684		

	Total	1688.102	58			
a. Dependent Variable: COVID Management						
b. Predictors: (Constant), Digital Connectivity, Health Information Exchange, Electronic Surveillance						

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.857	2.156		1.789	.079
	Health Information Exchange	.081	.118	.097	.684	.497
	Electronic Surveillance	.297	.111	.411	2.663	.010
	Digital Connectivity	.251	.103	.274	2.437	.006
a. Dependent Variable: COVID Management						

$$\mathbf{Y = 3.857 + .081X_1 + .297X_2 + .251X_3 + 2.156}$$

The regression findings revealed that 52.2% of the variations in COVID-19 management in the country are determined by the adoption of health information technologies in the health sector in Kenya. The ANOVA results; F = 19.988, Sig = .000<.05 there was a positive and significant relation between health information technologies utilization and COVID-19 Management in Kenya.

To examine the effect of adoption of health information exchange on COVID-19 Management in Kenya.

Regression results showed that the coefficient of adoption of health exchange $X_1 = 081$, *Sig = .497>.05,* which showed there existed a positive and insignificant effect of the variable on COVID-19 management.

To establish the effect of adoption of electronic surveillance on COVID-19 Management in Kenya.

The regression tests showed that the coefficient of adoption of electronic surveillance $X_2 = 279$, *Sig = .010<.05,* which showed there existed a positive and significant effect. Thus, it was established that adoption of electronic surveillance will lead to .279 improvement in COVID-19 management in Kenya.

To evaluate the influence of digital connectivity on COVID-19 Management in Kenya.

The summary coefficient analysis showed that the coefficient of adoption of digital connectivity $X_3 = 251$, *Sig = .006<.05,* which showed there existed a positive and significant effect. Thus, it was established that adoption of digital connectivity will lead to .251 improvement in COVID-19 management in Kenya.

4.8 Chapter Summary

This chapter was critical in presenting the results obtained from the analysis of the research data. The survey obtained responses from 86% of the sample participants included in the research. Correlation tests established that the independent variables; adoption of health information exchange, adoption of electronic surveillance and digital connectivity had a positive relation with COVID-19 Management in Kenya. The regression findings revealed that 52.2% of the variations in COVID-19 management in the country are determined by the adoption of health information technologies in the health sector in Kenya.

CHAPTER FIVE

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This is the last chapter of the study. It compiles the study's findings and presents them in a summary of the discussion of the findings, conclusions and recommendations. These were presented in line with the study's objectives.

5.2 Discussion

This study carried out an analysis of the effectiveness of utilization of Health Information Technologies in COVID-19 management in Kenya. Specific focus was on the effectiveness of health information exchange, electronic surveillance and digital connectivity technologies on the management of COVID-19. Accordingly, this study was guided by the UTAUT and the TAM theories which aver that technology acceptance is determined by its perceived usefulness, and perceived ease of use (UTAUT) and that subsequent usage behaviour is a factor of performance expectancy, effort expectancy, social influence, and enabling conditions. The research employed multiple linear regressions in analysis revealing that the adoption of health information exchange technologies has a positive but insignificant effect on COVID-19 management in Kenya while the adoption of electronic surveillance and digital connectivity technologies was determined to exert a positive and significant impact on COVID-19 management.

These findings conform to the assertations from the TAM which asserts that a technologies' perceived usefulness and perceived ease of use will influence the degree of technology acceptance, while sustained use of these technologies can be determined by their ability to meet expectations, their ease of use, social influence, and facilitating conditions. Healthcare institutions' capacity to adopt the various technologies, and their ability to effectively utilize these technologies to address public safety needs was a key determinant to effectively managing the COVID-19 pandemic. Among the study variables, health institutions should strive to strengthen their health information exchange capacity to effectively manage pandemics in the future. The findings show that the technologies improved the country's ability to carry out effective management through

facilitating remote consultations, medical information sharing, remote screening and visualization, regional surveillance and intelligent diagnosis.

5.2.1 Health Information Exchange on COVID-19 Management

The study's first objective was to examine the effectiveness of health information technologies on COVID-19 management in Kenya. The study applied regressions in the analysis, which revealed that the adoption of health information exchange technologies has a positive but insignificant effect of the management of COVID-19 in Kenya. This implies low performance expectancy which according to the Unified Theory of Acceptance and Use of Technology (UTAUT), technologies that exhibit low performance will not be adopted since they are considered ineffective in guiding organizations towards realizing its goals. As per the study, adopting health information technologies improves health organizations' remote consultation, intelligent diagnosis and information sharing capability. These capabilities are essential to detecting and controlling the spread of the COVID-19 disease.

From the descriptive analysis, the study showed that respondents agreed that health information exchange technologies had improved the sharing of health-related information between facilities across the country. The analysis also revealed agreement that HIEs enabled seamless information exchange of clinical data and patient outcomes between private and public institutions, improving their efficiency in tracking and tracing the diseases' path of infection. The HIEs were also associated with improved data-driven diagnostics which was essential to guiding policy measures.

These findings are corroborated in China in the study by Ye, et al., (2020) whose study showed that different HIE technologies have been utilized at different stages of disease management, with information sharing platforms improving tracking, tracing and risk assessment, while big data facilitated diagnosis, risk assessment and information security. The technologies facilitated China's Zero COVID policy and have been key in facilitating early detection and post-intervention disease management. Wood, et al. (2019) makes similar observations, asserting that HIEs offer novel methods of disease management; phone-based decision trees have improved informed decision-making by increasing efficiency of data collection, diagnosis, analysis and utilization. These findings are also reported by Alam, Reegu, Daud and Shuaib (2021) who determined that blockchain technologies had improved how hospitals collect and utilize patient records. The

researchers also demonstrated increased data security, monitoring and prediction of disease clusters.

Dwivedi, et al. (2021) also reports that integrated data exchange systems had been key to improving healthcare delivery in Tanzania. Integrated systems improved planning, gap identification, and resource planning which has improved the country's ability to distribute essential products to healthcare centers. According to Tortolero, et al. (2021), health institutions in Texas leveraged HIEs in population analysis to identify the risk associated factors within the population. The technologies were improved how hospitals used previous patient history in risk assessment and mapping of diseases' spread. A positive association between HIEs and disease management is also established by Mekuria, et al. (2021) whose exploratory study determined that HIEs had improved the management of antibiotics medicines, placing automatic orders and facilitating digital payment. The technologies improved hospitals' inventory management and the researchers asserted that the technologies can be used in more innovative ways to increase inventory management.

Morgan, et al. (2021) also reported improved disease management through the use of mobile telephony tools. The study showed use of messaging applications in contact tracing, risk analysis, resource needs prediction and allocation, and in post-COVID disease management and patient followup. The study determined tha HIE technologies facilitate sharing of real-time data which enhances real-time informed decision making. Despite the study determining a positive but insignificant association between HIE and COVID-19 Management, empirical and theoretical evidence provides contrary opinions. The TAM model argues that an organizations' technical preparedness determines its ability to adopt and utilize emerging technologies effectively.

5.2.2 Electronic Surveillance on COVID-19 Management

The second objective sought after the effectiveness of electronic surveillance technologies in managing the COVID-19 pandemic in Kenya. Regression analysis were applied on the collected data revealing a positive and significant relationship between electronic surveillance use and effective management of the COVID-19 pandemic. Disease management entails early detection, follow up and reporting and effective public health surveillance systems are essential in quick detection and control of diseases before they spread to large sections of the population and become unmanageable. Surveillance

technologies abound and the basic technologies are usually easy to integrate into an organization’s operations, despite some being controversial and facing ethical backlash. The UTAUT shows how social influence and enabling conditions influence new technologies’ adoption. The TAM and UTAUT show that technologies with such properties will receive widespread acceptance.

From the descriptive analysis, electronic surveillance technologies provided health stakeholders with data that was vital to conducting effective prevention and control activities. Organizations that effectively utilized electronic surveillance health technologies were able to access first time and accurate data on the disease’s patterns which was helpful in resource needs’ prediction and allocation in a timely fashion. The descriptive analysis also showed that the health sector was highly reliant on surveillance technologies for tracing and tracking of new patients. Through use of surveillance technologies, the study determined that medical institutions were able to carry out an evaluation of the country’s pandemic readiness.

Empirical literature supports this finding. Fu, Zhang, and Zhang (2021), for instance, report that in China, public health surveillance technologies have been extensively used to carry out patient and institution analysis which was key to guiding policies surrounding how to manage the pandemic. The surveillance systems were used in as measures to facilitate monitoring and early warning. The study also showed improved risk analysis within populations which guided lockdown dans travel restriction measures. According to Ibrahim, et al. (2021), integrtaed surveillance systems improved the timeliness of disease outbreak alerts the completeness of reporting, and supervision. The researchers assert that integration of different systems would improve how data collected is actually utilized to address organizational needs.

Fall, et al. (2020) made similar observations when their study showed how a host of surveillance and data sharing technologies had improved medical providers’ ability to adequately monitor patient movement and track medications. The study concluded that surveillance technologies led to more proactive interventions in pandemic control. Golinelli, et al.’s (2020) literature review also provided evidence that robotics and arttificial technologies had improved health facilities’ efficiency in patient screening and temperature checcks which were key to controlling the diseases’ spread. The researchers also showed improved patient satisfaction with follow up mechanisms afforded by automized surveillence.

Gansel, et.al., (2019) study found minimal contributions of surveillance systems in European states, citing variations in data collection and reporting standards which impacted the quality of data collected. However, the study confirmed that with better inter-operability, e-health systems can improve disease etiology, diagnosis, treatment, and follow-up. Choi, et.al, (2016) systematic review determined that digital surveillance systems meet the requirement for effective public health tools since they complement traditional systems and guarantee real-time data collection and analysis. the study, however, determined that some of the digital surveillance systems can be manipulated, impeding accurate interpretation of collected data.

In China, Ruiz Estrada's (2020) evaluation determined that drones and other surveillance technologies had been used to control the spread of COVID-19 and provide relief humanitarian aid. The technologies were also used in controlling movement and enforcing recommended epidemic containment measures. Mwongela (2018), on the other hand studied surveillance technologies' use in tuberculosis disease management and determined that national tuberculosis surveillance systems collect information on newly reported cases, enabling countries and institutions to develop effective strategies, targeted interventions and robust policies to address epidemics. The study also concluded that surveillance systems enable institutions to monitor and improve on the quality of patient care.

5.2.3 Digital Connectivity on COVID-19 Management

The third objective of the study was to examine the effectiveness of digital connectivity in managing the COVID-19 pandemic in Kenya. Regressions were used in analysis, revealing that digital connectivity had significantly improved the management of COVID-19 in Kenya. Digital connectivity technologies were determined to facilitate system-wide integration, regional surveillance and patient health monitoring and this kind of technology is predicted to receive widescale adoption according to the UTAUT theory. Integration capabilities offered by digital connectivity technologies are considered key to managing infectious pandemics and their ease of use and expected performance will impact the extent of their effectiveness, according to the TAM model.

From the descriptive analysis, the study's findings revealed that healthcare providers have deployed mobile applications provide timely, credible and verifiable information on COVID-19 safety protocols and essential services. The study further ascertained that

digitally connected technologies had facilitated information sharing between medical practitioners on best practices to employ during the pandemic. The study also showed utilization of digitally connected tools in surveillance, enabling rapid tracing and quarantining of exposed individuals. The analysis also reported a positive association between the use of telehealth technologies and remote diagnosis and treatment.

Empirical evidence also points to a positive relationship between digital connectivity and disease management. Dey and Chatterjee (2022) study is one whose findings show how the IoT can be harnessed to address COVID-19 waste management needs through remote controls. The study also showed how smart systems can be deployed in analysis and mapping of infection hotspots. Heinemann, et al.'s (2021) literature review also found a positive association between smart insulin pens and single diabetes user self-management, which improved patient outcomes. The study also ascertained that smart technologies provided healthcare institutions the opportunity to carry out continuous monitoring, surveillance and reporting, increasing COVID-19 resilience.

Muyingo et.al., (2020) also found a positive relationship between digital connectedness and the management of pandemics. Digital systems improved information sharing and organizational awareness on disease management best practices. Wang et.al., (2021) made similar observations, reporting improved monitoring of disease through mobile GPS tracking. clusters and risky behavioral analysis. Budd, et al. (2020) study showed how large integrated databases have been utilized extensively to support the response to COVID-19 while machine learning and natural language processing technologies eased population surveillance, case identification, contact tracing and improved how to evaluate possible interventions.

5.3 Conclusions

The analysis conclusions were that the three independent variables have been employed in Kenya and have improved their ability to effectively manage the COVID-19 pandemic. Healthcare centres used health information exchange technologies, electronic surveillance technologies and digital connectivity in reducing the spread of the corona virus. According to the UTAUT, a technology that is perceived to be useful and easy to use will be adopted, while that social influence, and enabling conditions are factors that will determine whether a new technology will be used for longer periods of time.

The first independent variable was health information exchange and the conclusion was that HIE technologies have a positive but insignificant effect on management of the COVID-19 pandemic. This implies that healthcare facilities can rely on health information exchange technologies when managing pandemics in the future. However, the findings also showed that the effect is not as significant as that of the other variables implying that the specific technologies may not be easy to integrate or use due to certain technical or human resource deficiencies, considering the TAM supposes that behaviour is a factor of performance expectancy, effort expectancy and enabling conditions. Another conclusion is that healthcare exchange tools enhance COVID-19 management by facilitating seamless information exchange between centers and that facilitating conditions are essential to realizing the benefits of HIE potential.

The second objective was on the effectiveness on electronic surveillance technologies on COVID-19 management and the conclusion was that the technologies had a positive and significant effect on the pandemic's management. The finding implies that it would be paramount that healthcare institutions deploy surveillance technologies whenever a new pandemic emerges. The conclusions were that surveillance technologies such as track and trace apps are useful in enhancing exposure management and reducing risks associated with physical testing. Another conclusion is that surveillance technologies provide medical providers with timely data that has been useful in policy formulation and in intervention design.

Regarding the third independent variable which sought after the effectiveness of digital connectivity on COVID-19 management, the study findings point to the conclusion that digital connectivity has improved the effectiveness of COVID-19 management in Kenya. The implication is that countries attempting to manage pandemics can rely on digital connectivity technologies. The conclusions showed that mobile technologies have enabled collaboration between different government agencies, real-time data collection, and discussions on best practices on pandemic management. The study also concluded that healthcare providers can use digital connectivity technologies to carry out routine surveillance of the infected individuals and people who they had been in close contact with. The final conclusion is that digital connectivity has improved how healthcare centres collect, analyze and use data in decision making during pandemics.

5.4 Recommendations

This section presents the recommendations that can be inferred from the study's findings. Regarding the utilization of health information exchange technologies which were determined to have positive but insignificant effects, recommendations are for the government to ensure healthcare organizations are technically and materially ready to accommodate emerging technologies into their operations. The study recommends that regular staff training be carried out to make them capable of utilizing new technologies and improvising existing ones to serve current needs. The study also recommends that the government ensures that healthcare facilities are properly stocked with regularly updated technologies to make them users cognizant with technologies being utilized in other parts of the world. This will be key in determining their experience with new tools and increase the speed of adoption and utilization. The study also recommends aggressive support from the government through tax breaks for health technologies

The second objective was on surveillance technologies and from findings, it was determined that they were effective at managing the pandemic. However, the review showed that digital surveillance is controversial and that governments can use these technologies to carry out surveillance for purposes that do not involve healthcare delivery. The study recommends that data security and surveillance laws be regularly updated to address the loopholes that emerge when new technologies are introduced. Laws and regulations should be formulated to guide how patient data will be collected, shared and utilized to ensure unsolicited parties do not use patient data for profit goals. The laws should also be drafted to address when certain technologies can be used and by whom to guarantee the integrity of patient records.

The third objective was on digital connectivity and the conclusions were that they increased Kenya's effectiveness at managing the pandemic. The study, however, notes that apart from digital skills, a digital economy requires large investment to access broadband services. Recommendations are for the government to ensure there is adequate telecommunication infrastructure to ensure hospitals can access quality broadband. The study also recommends that regulatory frameworks be improved to facilitate sharing of best practice on digital infrastructure and ensure healthcare institutions adopt practices that have been proven to work. The study also found a positive impact of digital payments and the study recommends increased legislation to support electronic transactions and enable online purchase of medicinal supplies. The study also recommends better

legislation around cyber security to ensure protection of user data and guide on best practices to protect patient data. The study further recommends healthcare institutions partner with international partners to source technical assistance in various areas of digital connectivity.

5.5 Suggestions for Further Research

A host of technologies were utilized to manage the pandemic in a wide variety of ways in more developed countries. This study recommends a more focused exploration into the utilization of electronic surveillance technologies on disease management, considering surveillance laws are still in the early stage of development. The study also affirms that Kenya had a challenge in contact tracing and more research should be carried out to suggest ways for the Kenyan government to effectively utilize surveillance tools such as mobile phones in disease management. The study further recommends exploration into how Kenya can improve her data sharing capabilities and guarantee digital connectivity considering some of the technologies were determined to be ineffective due to existing institutional weaknesses. The study also recommends that research be carried out to examine how technologies can be used in managing other less virulent diseases.

5.6 Limitations of the Study

This study purports to evaluate the effectiveness of health information technologies on COVID-19 management, thus limiting itself to investigating technologies used to manage the pandemic. The study also limited itself from collecting data from senior managers who may desire to present an image of success in managing the pandemic. The study also limited itself to the TAM and UTAUT theories which explain utilization from specific perspectives. Other factors not presented in the theories can influence the effectiveness of technologies in disease management.

REFERENCES

Aceto, G., Persico, V., & Pescapé, A. (2020). Industry 4.0 and health: Internet of things, big data, and cloud computing for healthcare 4.0. *Journal of Industrial Information Integration*, 18, 100129.

Adepoju, P. (2022). *65% of Africans Had COVID – Nearly 100x More than Reported Cases, says WHO in Major Review*. Retrieved from healthpolicy-watch.news: https://healthpolicy-watch.news/africa-COVID-19-who-new-analysis/

Adler-Milstein, J., Garg, A., Zhao, W., & Patel, V. (2021). A survey of health information exchange organizations in advance of a nationwide connectivity framework. *Health Affairs*, 40(5), 736-744.

Africa Centres for Disease Control and Prevention. (2020). *Coronavirus disease 2019 (COVID-19).* Africa Centres for Disease Control and Prevention.

Ajibade, P. (2018). Technology acceptance model limitations and criticisms: Exploring the practical applications and use in technology-related studies, mixed-method, and qualitative researches. *Library Philosophy and Practice*, 9.

Alam, S., Reegu, F. A., Daud, S. M., & Shuaib, M. (2021). Blockchain-based Electronic Health Record System for efficient COVID-19 Pandemic Management. doi: 10.20944/preprints202104.0771.v1.

Alowayr, A. (2021). Determinants of mobile learning adoption: extending the unified theory of acceptance and use of technology (UTAUT). *The International Journal of Information and Learning Technology*.

An, M. H., You, S. C., Park, R. W., & Lee, S. (2021). Using an extended technology acceptance model to understand the factors influencing telehealth utilization after flattening the COVID-19 curve in South Korea: cross-sectional survey study. *JMIR medical informatics*, 9(1), e25435.

Asastani, H. L., Kusumawardhana, V. H., & Warnars, H. L. (2018). Factors affecting the usage of mobile commerce using technology acceptance model (TAM) and unified theory of acceptance and use of technology (UTAUT). *2018 Indonesian association for pattern recognition international conference (INAPR)* (pp. 322-328). IEEE.

Ashton-Hart, N. (2020). Leveraging digital connectivity for post-COVID competitiveness and recovery.

Bakibinga-Gaswaga, E., Bakibinga, S., Bakibinga, D. B., & Bakibinga, P. (2020). Digital technologies in the COVID-19 responses in sub-Saharan Africa: policies, problems and promises. . *The Pan African Medical Journal*, 35(Suppl 2).

Barasa, E., Kairu, A., Maritim, M., Were, V., & Akech, S. (2021). Examining unit costs for COVID-19 case management in Kenya. . *BMJ global health*, 6(4), e004159.

Barasa, E., Kazungu, J., Orangi, S., Kabia, E., Ogero, M., & Kasera, K. (2021). Indirect health effects of the COVID-19 pandemic in Kenya: a mixed methods assessment. *BMC Health Services Research*, 21(1), 1-16.

Bardhan, I., Chen, H., & Karahanna, E. (2020). Connecting systems, data, and people: A multidisciplinary research roadmap for chronic disease management. *Management Information Systems Quarterly*, 44(1):185–200.

Bayram, M., Springer, S., Garvey, C. K., & Özdemir, V. (2020). COVID-19 digital health innovation policy: A portal to alternative futures in the making. *OMICS: A Journal of Integrative Biology*, 24(8), 460-469.

Békés, V., Doorn, K. A., & Bőthe, B. (2022). Assessing patients' attitudes towards telepsychotherapy: The development of the unified theory of acceptance and use of technology-patient version. *Clinical Psychology & Psychotherapy*.

Bright, B., Babalola, C. P., Sam-Agudu, N. A., Onyeaghala, A. A., Olatunji, A., Aduh, U., . . . Folayan, M. O. (2021). COVID-19 preparedness: capacity to manufacture vaccines, therapeutics and diagnostics in sub-Saharan Africa. *Globalization and health*, 17(1), 1-14.

Brohi, S. N., Jhanjhi, N. Z., Brohi, N. N., & Brohi, M. N. (2020, _and_Eliminate_COVID). *Key applications of state-of-the-Art technologies to mitigate and eliminate COVID-19.* Retrieved from https://www.techrxiv.org/articles/Key_Applications_of_State-of-the-Art_Technologies_to_Mitigate_and_Eliminate_COVID-19_pdf/12115596

Bryman, A. (2016). *Social research methods.* . Oxford university press.

Budd, J., Miller, B. S., Manning, E. M., Lampos, V., Zhuang, M., Edelstein, M., . . . McKendry, R. A. (2020). Digital technologies in the public-health response to COVID-19. *Nature medicine*, 26(8), 1183-1192.

Calvo, R. A., Deterding, S., & Ryan, R. M. (2020). Health surveillance during COVID-19 pandemic. . *Biomedical Journal*, 369.

Caselli, M., & Fracasso, A. (2022). COVID-19 and technology. *Handbook of Labor, Human Resources and Population Economics*, 1-34.

Chang, C. M., Liu, L. W., Huang, H. C., & Hsieh, H. H. (2019). Factors influencing online hotel booking: Extending UTAUT2 with age, gender, and experience as moderators. *Information*, 10(9), 281.

Channa, A., Popescu, N., Skibinska, J., & Burget, R. (2021). The rise of wearable devices during the COVID-19 pandemic: A systematic review. *Sensors*, 21(17), 5787.

Check, J., & Schutt, R. K. (2011). *Research methods in education.* . Sage Publications.

Chiroma, H. (2021). Appraisal of Electronic Banking Acceptance in Nigeria Amidst Cyber Attacks Using Unified Theory of Acceptance and Use of Technology. *Information and Communication Technology and Applications: Third International Conference, ICTA 2020* (pp. 1350 (470), 24-27). Minna, Nigeria, November , 2020, Revised Selected Papers : Springer Nature.

Chitungo, I., Mhango, M., Mbunge, E., Dzobo, M., Musuka, G., & Dzinamarira, T. (2021). Utility of telemedicine in sub-Saharan Africa during the COVID-19 pandemic. A rapid review. *Human behavior and emerging technologies*, 3(5), 843-853.

Choi, J., Cho, Y., Shim, E., & Woo, H. (2016). Web-based infectious disease surveillance systems and public health perspectives: a systematic review. *BMC public health*, 16(1), 1-10.

Chuenyindee, T. O., Prasetyo, Y. T., Persada, S. F., Nadlifatin, R., & Sittiwatethanasiri, T. (2022). Factors affecting the perceived usability of the COVID-19 contact-tracing application "Thai chana" during the early COVID-19 omicron period. *International Journal of Environmental Research and Public Health*, 19(7), 4383.

Cohen, L., Manion, L., & Morrison, K. (2017). *Validity and reliability. In Research methods in education (pp. 245-284).* Routledge.

Colbert, G. B., Venegas-Vera, A. V., & Lerma, E. V. (2020). Utility of telemedicine in the COVID-19 era. . *Reviews in cardiovascular medicine*, 21(4).

Crano, W. D., Brewer, M. B., & Lac, A. (2014). *Principles and methods of social research.* . Routledge.

Daniel, J. (2012). Choosing between taking a purposive sampling and sampling. . *Sampling essentials: practical guidelines for making sampling choices*, 23-65.

Dey, M. T., & Chatterjee, P. (2022). COVID Waste Management Using IoT: A Smart Framework. *ICT Analysis and Applications* (pp. 923-931). Singapore: Springer.

Dwivedi, V., Ndesanjo, W., Bamsi, H., Busiga, M., Nyella, E., Massawe, J. V., . . . Taylor, P. (2021). One country's journey to interoperability: Tanzania's experience developing and implementing a national health information exchange. *BMC Medical Informatics and, Knowledge Management*.

Dwivedi, Y. K., Rana, N. P., Tamilmani, K., & Raman, R. (2020). A meta-analysis based modified unified theory of acceptance and use of technology (meta-UTAUT): a review of emerging literature. *Current opinion in psychology*, 36, 13-18.

Edejer, T. T., Hanssen, O., Mirelman, A., Verboom, P., Lolong, G., Watson, O. J., . . . Soucat, A. (2020). Projected health-care resource needs for an effective response to COVID-19 in 73 low-income and middle-income countries: a modelling study. *The Lancet Global Health*, 8(11), e1372-e1379.

Elebesunu, E. E., Oke, G. I., Adebisi, Y. A., & Nsofor, I. M. (2021). COVID-19 calls for health systems strengthening in Africa: A case of Nigeria. *The International Journal of Health Planning and Management*, 36(6), 2035-2043.

Elnadi, H., Odetokun, I. A., Bolarinwa, O., Ahmed, Z., Okechukwu, O., & Al-Mustapha, A. I. (2021). Correction: Knowledge, attitude, and perceptions towards the 2019 Coronavirus Pandemic: A bi-national survey in Africa. . *Plos one*, 16(2), e0247351.

Executive Office of the President. (2020). *National Emergency Response Committee on Coronavirus: Executive Order No 2 of 2020.* Office of the President.

Fall, I. S., Rajatonirina, S., Yahaya, A. A., Zabulon, Y., Nsubuga, P., Nanyunja, M., . . . Talisuna, A. O. (2020). Integrated disease surveillance and response (IDSR) strategy: current status, challenges and perspectives for the future in Africa. *BMJ global health*, 4 (4) .

Farrer, M. (2020). *Friday briefing: First COVID-19 case in sub-Saharan Africa.* The Guardian.

Fu, A., Zhang, Y., & Zhang, J. (2021). Analysis on the quality system and effect of Environmental Hygiene Surveillance in the Prevention and Control of Infectious

Diseases. *IOP Conference Series: Earth and Environmental Science* (pp. 769, (2)). IOP Publishing.

Gansel, X., Mary, M., & van Belkum, A. (2019). Semantic data interoperability, digital medicine, and e-health in infectious disease management: a review. *European Journal of Clinical Microbiology & Infectious Diseases*, 38(6), 1023-1034.

Geissler, P. W., & Prince, R. J. (2020). Layers of epidemy: Present pasts during the first weeks of COVID-19 in western Kenya. . *Centaurus*, 62(2), 248-256.

Gerard, F., Imbert, C., & Orkin, K. (2020). Social protection response to the COVID-19 crisis: options for developing countries. . *Oxford Review of Economic Policy*, 36(S1), S281–S296.

Golinelli, D., Boetto, E., Carullo, G., Nuzzolese, A. G., Landini, M. P., & Fantini, M. P. (2020). Adoption of digital technologies in health care during the COVID-19 pandemic: systematic review of early scientific literature. *Journal of medical Internet research*, 22 (11).

Goniewicz, K., Khorram-Manesh, A., Hertelendy, A. J., Goniewicz, M., Naylor, K., & Burkle, F. M. (2020). Current response and management decisions of the European Union to the COVID-19 outbreak: a review. . *Sustainability*, 12(9), 3838.

Hannemann, N., Götz, N. A., Schmidt, L., Hübner, U., & Babitsch, B. (2021). Patient connectivity with healthcare professionals and health insurer using digital health technologies during the COVID-19 pandemic: a German cross-sectional study. *International Journal of Hospitality Management*, 92, 102718.

Heinemann, L., Schnell, O., Gehr, B., Schloot, N. C., Görgens, S. W., & Görgen, C. (2021). Digital diabetes management: a literature review of smart insulin pens. *Journal of diabetes science and technology*.

Heist, T., Schwartz, K., & Butler, S. (2020). *How were hospital admissions impacted by COVID-19? Trends in overall and non-COVID-19 hospital admissions.* KFF Organization.

Hosi Kenya. (2022). *County Referral Hospital*. Retrieved from Hosi: https://hosi.co.ke/category/county-referral-hospital/?pg=5

Hwang, H., & Höllerer, M. A. (2020). The COVID-19 crisis and its consequences: Ruptures and transformations in the global institutional fabric. . *The Journal of Applied Behavioral Science*, 56(3), 294-300.

Ibrahim, L. M., Okudo, I., Stephen, M., Ogundiran, O., Pantuvo, J. S., Oyaole, D. R., . . . Alemu, W. (2021). Electronic reporting of integrated disease surveillance and response: lessons learned from northeast, Nigeria. *BMC public health*, 21(1), 1-9.

Ienca, M., & Vayena, E. (2020). On the responsible use of digital data to tackle the COVID-19 pandemic. *Nature medicine*, 26(4), 463-464.

Ienca, M., & Vayena, E. (2020). On the responsible use of digital data to tackle the COVID-19 pandemic. *Nature medicine*, 26(4), 463-464.

Ihekweazu, C., & Agogo, E. (2020). Africa's response to COVID-19. . *BMC medicine*, 18, 1-3.

Iwuoha, V. C., Ezeibe, E. N., & Ezeibe, C. C. (2020). Glocalization of COVID-19 responses and management of the pandemic in Africa. . *Local Environment*, 25(8), 641-647.

Jalabneh, R., Syed, H. Z., Pillai, S., Apu, E. H., Hussein, M. R., Kabir, R., . . . Saxena, S. K. (2021). Use of mobile phone apps for contact tracing to control the COVID-19 pandemic: A literature review. *Applications of Artificial Intelligence in COVID-19*, 389-404.

Jiancheng, Y. (2020). *The Role of Health Technology and Informatics in a Global PublicHealth Emergency: Practices and Implications From the COVID-19 Pandemic.* Feinberg School of Medicine, Northwestern University.

Joo, Y. J., Park, S., & Lim, E. (2018). Factors influencing preservice teachers' intention to use technology: TPACK, teacher self-efficacy, and technology acceptance model. *Journal of Educational Technology & Society*, 21(3), 48-59.

Kairu, A., Were, V., Isaaka, L., Agweyu, A., Aketch, S., & Barasa, E. (2021). Modelling the cost-effectiveness of essential and advanced critical care for COVID-19 patients in Kenya. *BMJ Global Health*, 6(12), e007168.

Karim, N., Jing, L., Lee, J. A., Kharel, R., Lubetkin, D., Clancy, C. M., . . . Ndebwanimana, V. (2021). Lessons learned from Rwanda: innovative strategies for prevention and containment of COVID-19. *Annals of global health*, 87(1).

Kebede, Y., Yitayih, Y., Birhanu, Z., Mekonen, S., & Ambelu, A. (2020). Knowledge, perceptions and preventive practices towards COVID-19 early in the outbreak among Jimma university medical center visitors, Southwest Ethiopia. . *PloS one*, 15(5), e0233744.

Khan, I. H., & Javaid, M. (2020). Big data applications in medical Field: A literature review. . *Journal of Industrial Integration and Management*, 5(3), 1–17.

Kogan, M., Klein, S. E., Hannon, C. P., & Nolte, M. T. (2020). Orthopaedic education during the COVID-19 pandemic. . *The Journal of the American Academy of Orthopaedic Surgeons.*, 28, e456–e464.

Kothari, C. R. (2019). *Research methodology: Method and techniques.* New Age International.

Kumar, K., Kumar, N., & Shah, R. (2020). Role of IoT to avoid spreading of COVID-19. *International Journal of Intelligent Networks*, 1:32–35.

Lal, A., Erondu, N. A., Heymann, D. L., Gitahi, G., & Yates, R. (2021). Fragmented health systems in COVID-19: rectifying the misalignment between global health security and universal health coverage. . *The Lancet*, 397(10268), 61-67.

Lenert, L., & McSwain, B. Y. (2020). Balancing health privacy, health information exchange, and research in the context of the COVID-19 pandemic. . *Journal of the American Medical Informatics Association*, 27(6), 963-966.

Makoni, M. (2022). The quest for more COVID-19 vaccinations in Africa. *The Lancet Respiratory Medicine*.

Malden, S., Heeney, C., Bates, D. W., & Sheikh, A. (2021). Utilizing health information technology in the treatment and management of patients during the COVID-19 pandemic: Lessons from international case study sites. . *Journal of the American Medical Informatics Association.*, Volume 28, Issue 7, 1555–156.

Marr, B. (2020). *Coronavirus: How artificial intelligence, data science and technology is used to fight the pandemic.* Retrieved from www.forbes.com: https://www.forbes.com/sites/bernardmarr/2020/03/13/coronavirus-how-artificial-intelligence-data-science-and-technology-is-used-to-fight-the-pandemic/#34645abe5f5f

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Martin, J., Klapsa, D., Wilton, T., Zambon, M., Bentley, E., Bujaki, E., . . . Majumdar, M. (2020). Tracking SARS-CoV-2 in sewage: evidence of changes in virus variant predominance during COVID-19 pandemic. *Viruses*, 12(10), 1144.

Maruta, T., & Moyo, S. (2022). Impact of pre-COVID-19 epidemic preparedness on the trajectory of the pandemic in African countries. *African Journal of Laboratory Medicine*, 11(1), 1571.

Mbunge, E., Akinnuwesi, B., Fashoto, S. G., Metfula, A. S., & Mashwama, P. (2021). A critical review of emerging technologies for tackling COVID-19 pandemic. . *Human behavior and emerging technologies*, 3(1), 25-39.

Mekuria, L. A., de Wit, T. F., Spieker, N., Koech, R., Nyarango, R., Ndwiga, S., . . . vant Hoog, A. (2021). Analyzing data from the digital healthcare exchange platform for surveillance of antibiotic prescriptions in primary care in urban Kenya: A mixed-methods study. *PLos One*, 14 (9).

Ministry of Health. (2022). *National Emergency Response Committee On Coronavirus: Update On COVID-19 In The Country And Response Measures, As At January 20, 2022.* Nairobi: Ministry of Health.

Miyawaki, A., & Tsugawa, Y. (2022). *Health and public health implications of COVID-19 in Asian countries.* . Asian Economic Policy Review.

MOH. (2022). *COVID 19 INFORMATION*. Retrieved from ke.usembassy.gov: https://ke.usembassy.gov/COVID-19-information/

MOH Kenya. (2022). *COVID 19*. Retrieved from Ministry of Health: https://www.health.go.ke/COVID-19/

Molla, K. A., & Abegaz, S. B. (2021). Community knowledge, attitude and practices to SARS-CoV-2 disease 2019 (COVID-19): A cross-sectional study in Woldia town, Northeast Ethiopia. . *PloS one*, 16(4), e0250465.

Morgan, A. U., Balachandran, M., Do, D., Lam, D., Parambath, A., Chaiyachati, K. H., . . . Asch, D. A. (2021). Remote monitoring of patients with COVID-19: design, implementation, and outcomes of the first 3,000 patients in COVID Watch. *NEJM Catalyst Innovations in Care Delivery*, 1 (4).

Muyingo, R. I., Mpoza, A., & Kasadha, J. (2020). Coronavirus in the era of digital connectivity: Opportunities and challenges. *Journal of Public Affairs*, 20(4), e2246.

VT OMNES VNVM SINT

Mwongela, S. W. (2018). A Mobile based Tuberculosis contact tracing and screening system. *Masters dissertation, Strathmore University*.

Nachega, J. B., Leisegang, R., Kallay, O., Mills, E. J., Zumla, A., & Lester, R. T. (2020). Mobile health technology for enhancing the COVID-19 response in Africa: a potential game changer? *The American journal of tropical medicine and hygiene*, 103(1), 3.

Newby, P. (2014). *Research methods for education.* . Routledge.

News Staff. (2020). *Blockchain emerges as useful tool in fight against coronavirus.* Retrieved from https://www.govtech.com/products/Blockchain-Emerges-as-Useful-Tool-in-Fight-Against-Coronavirus.html

Ogweno, S. O., Oduor, K., & Mutisya, R. (2021). Sources of information on COVID-19 among the youths and its implications on mental health. A cross-sectional study in Nairobi, Kenya. *East African Medical Journal*, 98(1), 3390-3400.

Ohannessian, R., Duong, T. A., & Odone, A. (2020). Global telemedicine implementation and integration within health systems to fight the COVID-19 pandemic: a call to action. *JMIR public health and surveillance*, 6(2), e18810.

Park, S., Choi, G., & Ko, H. (2020). Information technology-based tracing strategy in response to COVID-19 in South Korea privacy controversies. *Jama*, 323(21), 21279–2130.

Punch, K. F., & Oancea, A. (2014). *Introduction to research methods in education.* Sage.

Rab, S., Javaid, A., Haleem, M., & Vaishya, R. (2020). Face masks are new normal after COVID- 19 pandemic. . *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, 14(6), 1617–1619.

Rai, P., Kumar, B. K., Deekshit, V. K., Karunasagar, I., & Karunasagar, I. (2021). Detection technologies and recent developments in the diagnosis of COVID-19 infection. *Applied microbiology and biotechnology*, 105(2), 441-455.

reuters. (2022). *COVID-19 Tracker*. Retrieved from https://graphics.reuters.com/world-coronavirus-tracker-and-maps/regions/africa/

Ruiz Estrada, M. A. (2020). The uses of drones in case of massive epidemics contagious diseases relief humanitarian aid: Wuhan-COVID-19 crisis.

Saini, D. K. (2021). Cloud computing adoption status in Oman (Arab) higher education: unified theory of acceptance and use of technology in education management. *International Journal of Social and Humanistic Computing*, 4(1), 84-110.

Sayeed, R., Gottlieb, D., & Mandl, K. D. (2020). SMART Markers: collecting patient-generated health data as a standardized property of health information technology. . *NPJ digital medicine*, 3(1), 1-8.

Shahid, M., Ogira, d., McDade, K. K., Bharali, I., Mao, W., Ogbuoji, O., & Yamen, G. (2021). *Transition in the time of COVID-19: Lessons from Kenya.* Center for Policy Impact in Global Health.

Shemesh, T., & Barnoy, S. (2020). Assessment of the intention to use mobile health applications using a technology acceptance model in an Israeli adult population. *Telemedicine and e-Health*, 26(9), 1141-1149.

Shiferaw, K. B., & Mehari, E. A. (2019). Modeling predictors of acceptance and use of electronic medical record system in a resource limited setting: Using modified UTAUT model. *Informatics in Medicine Unlocked*, 17, 100182.

Sipior, J. C. (2020). Considerations for development and use of AI in response to COVID-19. *International Journal of Information Management*, 55.

Sittig, D. F., & Singh, H. (2020). COVID-19 and the need for a national health information technology infrastructure. . *Jama*, 323(23), 2373-2374.

Tessema, G. A., Kinfu, Y., Dachew, B. A., Tesema, A. G., Assefa, Y., Alene, K. A., . . . Tesfay, F. H. (2021). The COVID-19 pandemic and healthcare systems in Africa: a scoping review of preparedness, impact and response. *BMJ global health*, 6(12), e007179.

Thaiya, M. S., Julia, K., Joram, M., Benard, M., & Nambiro, A. (2021). Adoption of ICT to Enhance Access to Healthcare in Kenya. *IOSR Journal of Computer Engineering (IOSR-JCE)*, 23(2), 45-50.

Tortolero, G. A., Brown, M. R., Sharma, S. V., de Oliveira Otto, M. C., Yamal, J. M., Aguilar, D., . . . Boerwinkle, E. (2021). Leveraging a health information exchange for analyses of COVID-19 outcomes including an example application using smoking history and mortality. *Plos One*, 16 (6).

Tsai, W. H., Wu, Y. S., Cheng, C. S., Kuo, M. H., Chang, Y. T., Hu, F. K., . . . Chu, C. M. (2021). A technology acceptance model for deploying masks to combat the COVID-19 pandemic in Taiwan (my health bank): web-based cross-sectional survey study.

Turer, R. W., Jones, I., Rosenbloom, S. T., Slovis, C., & Ward, M. J. (2020). Electronic personal protective equipment: a strategy to protect emergency department providers in the age of COVID-19. *Journal of the American Medical Informatics Association*.

UNICEF. (2020). *Digital Contact Tracing and Surveillance During COVID-19*. Retrieved from UNICEF: https://www.unicef-irc.org/publications/1098-digital-contact-tracing-surveillance-COVID-19-response-child-specific-issues-irb.html

Vaishya, R., Haleem, A., Vaish, A., & Javaid, M. (2020). Emerging technologies to combat the COVID-19 pandemic. . *Journal of clinical and experimental hepatology*, 10(4), 409-411.

Wadekar, N. (2020). *Kenya's 3D printing community is making COVID-19 equipment to fill a deficit as caseloads rise.* . Quartz Africa.

Walliman, N. (2015). *Social research methods: The essentials.* . Sage.

Walrave, M., Waeterloos, C., & Ponnet, K. (2021). Ready or not for contact tracing? Investigating the adoption intention of COVID-19 contact-tracing technology using an extended unified theory of acceptance and use of technology model. *Cyberpsychology, Behavior, and Social Networking* , 24, 6: 377-383.

Wang, C. J., Ng, C. Y., & H., B. R. (2020). Response to COVID-19 in Taiwan: Big data analytics, new technology, and proactive testing. *Jama*.

Wang, Q., Su, M., Zhang, M., & Li, R. (2021). Integrating digital technologies and public health to fight COVID-19 pandemic: key technologies, applications, challenges and outlook of digital healthcare. *International Journal of Environmental Research and Public Health*, 18 (11), 6053.

Watkins, J. (2020). Preventing a COVID-19 pandemic. . *Bmj*, 368.

Webster, P. (2020). Virtual health care in the era of COVID-19. *The Lancet*, 395(10231), 1180-1181.

Whitelaw, S., Mamas, M. A., Topol, E., & Van Spall, H. G. (2020). Applications of digital technology in COVID-19 pandemic planning and response. *The Lancet Digital Health*, 2(8), 435-e440.

WHO. (2021). *COVAX: working for global equitable access to COVID-19.* World Health Organization.

WHO. (2021). *Global strategy on digital health 2020-2025.* WHO.

WHO. (2022). *Over two-thirds of Africans exposed to virus which causes COVID-19: WHO study*. Retrieved from www.afro.who.int/: https://www.afro.who.int/news/over-two-thirds-africans-exposed-virus-which-causes-COVID-19-who-study#:~:text=Brazzaville%20%E2%80%93%20Up%20to%2065%25%20of,larger%20than%20reported%20confirmed%20cases.

Woo, T. (2020). Cloud players and research groups join the fight against COVID-19 with high-performance computing. *Forrest*.

Wood, C. S., Thomas, M. R., Mashamba-Thompson, T. P., Herbst, K., Pillay, D., ..., & Stevens, M. M. (2019). Taking connected mobile-health diagnostics of infectious diseases to the field. *Nature*, 566(7745), 467-474.

World Health Organization. (2021). *Pandemic Fatigue: Reinventing the public to prevent COVID-19.* WHO.

Wu, J., Wang, J., Nicholas, S., Maitland, E., & Fan, Q. (2020). Application of big data technology for COVID-19 prevention and control in China: Lessons and recommendations. *Journal of medical Internet research*, 22(10), e21980.

Yaraghi, N., & Peter, L. (2021). *Five ways that health information exchange can help with vaccination efforts*. Retrieved from www.brookings.edu: https://www.brookings.edu/blog/techtank/2021/02/01/five-ways-that-health-information-exchange-can-help-with-vaccination-efforts/

Ye, Q., Zhou, J., & Wu, H. (2020). Using information technology to manage the COVID-19 pandemic: development of a technical framework based on practical experience in China. *JMIR medical informatics*, 8(6), e19515.

Zhang, X., Zhou, X., & Yoruk, E. (2020). Health self-monitoring devices adoption in China: a modified model theory of Technology Acceptance Model. *BAM Conference in the Cloud 2020: Innovating for a Sustainable Future.*

Zhou, M., Dzingirai, C., Hove, K., Chitata, T., & Mugandani, R. (2022). Adoption, use and enhancement of virtual learning during COVID-19. *Education and Information Technologies*, 1-21.

APPENDICES

Appendix I: Participant Information and Consent Form

Dear participant,

I am currently a student at Strathmore University, pursuing a Master of Business Administration degree. As part of the school requirements, I am required to conduct a research survey on my area of specialization. I am currently undertaking a study to analyse the effect of health information technologies in COVID-19 Management in Kenya. This research is being done under the supervision of Dr. Bernard Shibwabo who can be reached via Strathmore Business School.

In order to compete the research, I need to obtain research information from Managing Director/CEO, Senior Doctors and ICT Managers drawn from the various healthcare facilities that were involved in COVID-19 management in Kenya.

Kindly grant me about 10 to 15 minutes of your appointed time to complete the questionnaire.

Your participation in the survey is entirely voluntary and the researcher will ensure your anonymity is guaranteed throughout the research. The study data will only be used for the stated academic purposes and will not be shared with any unauthorized parties.

I thank you for your participation and the valuable time, which you are willing to spend on this endeavour.

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Researcher

Name: Antony Lenaiyara

Sign: ……………………….. Date: June 2022

Respondent

Sign: ………………................ Date: ………………

Appendix II: Research Questionnaire

Hello,

I am a student at Strathmore University currently undertaking research on the effect of health information technologies on COVID-19 management in Kenya. You have been selected to participate in this survey, and I am requesting your assistance in providing responses to the attached questionnaire. All the information being collected was confidential and was not shared or used for any other purpose.

Thank you for participating in this survey.

PART A: BACKGROUND INFORMATION

1. **Which of the following health facilities/institutions do you work within?**

   National Referral Hospital ( )
   County Referral Hospital ( )
   ICT Authority ( )
   Ministry of Health ( )
   Private Referral Hospitals ( )
   KFH ( )
   KEMRI ( )

2. **Which of the following Health Information Technologies were applied in the Country?**

   Electronic surveillance ( )
   Telemedicine ( )
   Health information exchange systems ( )
   Web-based services ( )
   Artificial Intelligence ( )
   Digital contact tracing ( )
   Clinical information systems ( )
   Internet of Medical Things (IoMT) ( )
   Mobile Telephony ( )

PART B: HEALTH INFORMATION TECHNOLOGIES

The questionnaire relied on a 5-point Likert scale that will analyse how various HIT influenced COVID-19 management based on the following key; 5 – to a very large extent, 4- to a large extent, 3- to moderate extent, 2- to a small extent and 1- to no extent at all.

	Health Information Exchange	**1**	**2**	**3**	**4**	**5**
1.	Through agency collaboration, a health information exchange was developed which improved sharing of health-related data between facilities across the country.					
2.	The health information exchange platforms supported ease of transmission of patient data between medical providers in the country					
3.	The application of health information exchange allowed medical practitioners to conduct remote consultation for facilities across the country					
4.	The health information exchange systems supported more data-driven diagnostics which were critical to the management of the pandemic.					
5.	The health information exchange supported more direct consultations on symptom assessment and infection control in the country					
6.	The health information exchange was critical in supporting robust health services research on the pandemic					
7.	The health information exchange allowed private and public facilities to have a seamless information sharing platform on clinical data, outcomes and endpoint data					

	Electronic Surveillance	**1**	**2**	**3**	**4**	**5**
8.	The health sector heavily relied on electronic surveillance tools in tracing of new patients					

9.	The application of electronic surveillance was critical in mapping the disease spread across the country					
10.	Through electronic surveillance health practitioners were able to access data on the disease screening patterns in the country					
11.	The electronic surveillance systems were essential in providing real-time data collection and visualization of the disease management in the country					
12.	The adoption of electronic surveillance tools supported private and public institutions to utilize more clinically approved temperature detection systems					
13.	The use of electronic surveillance provided health stakeholders with vital data to conduct effective prevention and control activities					
14.	The application of electronic health surveillance allowed facilities to provide timely medical services for remote areas.					

	Digital Connectivity	**1**	**2**	**3**	**4**	**5**
15.	Health facilities were able to provide health services and information through mobile technology on COVID-19 management.					
16.	Health facilities in the country had an effective system of digitally monitoring the health outcomes in the management of the pandemic					
17.	The reliance on digital technologies allowed health facilities to conduct routine surveillance of the infected individuals and close contacts					
18.	The utilization of the digital technologies allowed health practitioners to remotely provide and support a discussion of treatment plans for patients					

19.	The use of digital technologies in health facilities enabled collaboration between doctors on the best practices in management of the COVID-19					
20.	The application of telemedicine enabled doctors to conduct real-time observational assessment of patients					

PART C: COVID-19 MANAGEMENT IN KENYA

The questionnaire relied on a 5-point Likert scale that will analyse COVID-19 management based on the following key; 5 – to a very large extent, 4- to a large extent, 3- to moderate extent, 2- to a small extent and 1- to no extent at all.

	COVID-19 Management	**1**	**2**	**3**	**4**	**5**
21.	The health sector was able to effectively contain the spread of the virus and limit runaway infection rates					
22.	The health sector was able to contain the spread of the virus and reduce casualties					
23.	The health sector has made strides in improving the detection capacity of the virus.					
24.	The health sector has developed preventative measures that are well-documented for public consumption					
25.	The health sector has formulated clear control measures that have mitigated further spread of new variants of the virus locally.					

Thank you for Participating in this Survey

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Appendix III: Strathmore University Institution Review Board Licence

12th September 2022

Mr Lenaiyara Antony,
antony.ljukunye@strathmore.edu

Dear Mr Lenaiyara,

RE: Analysis of The Effectiveness of Health Information Technologies Utilization in COVID-19 Management in Kenya

This is to inform you that SU-ISERC has reviewed and **approved** your above **SU- master's** research proposal. Your application reference number is **SU-ISERC1478/22.** The approval period is from **12th September 2022 to 11th September 2023.**

This approval is subject to compliance with the following requirements:

i. Only approved documents including (informed consents, study instruments, MTA) will be used
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by SU-ISERC.
iii. Death and life-threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to SU-ISERC within 48 hours of notification
iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to SU-ISERC within 48 hours
v. Clearance for export of biological specimens must be obtained from relevant institutions.
vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.
vii. Submission of an executive summary report within 90 days upon completion of the study to SU-ISERC.

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology, and Innovation (NACOSTI) https://research-portal.nacosti.go.ke/ and obtain other clearances needed.

Yours sincerely,

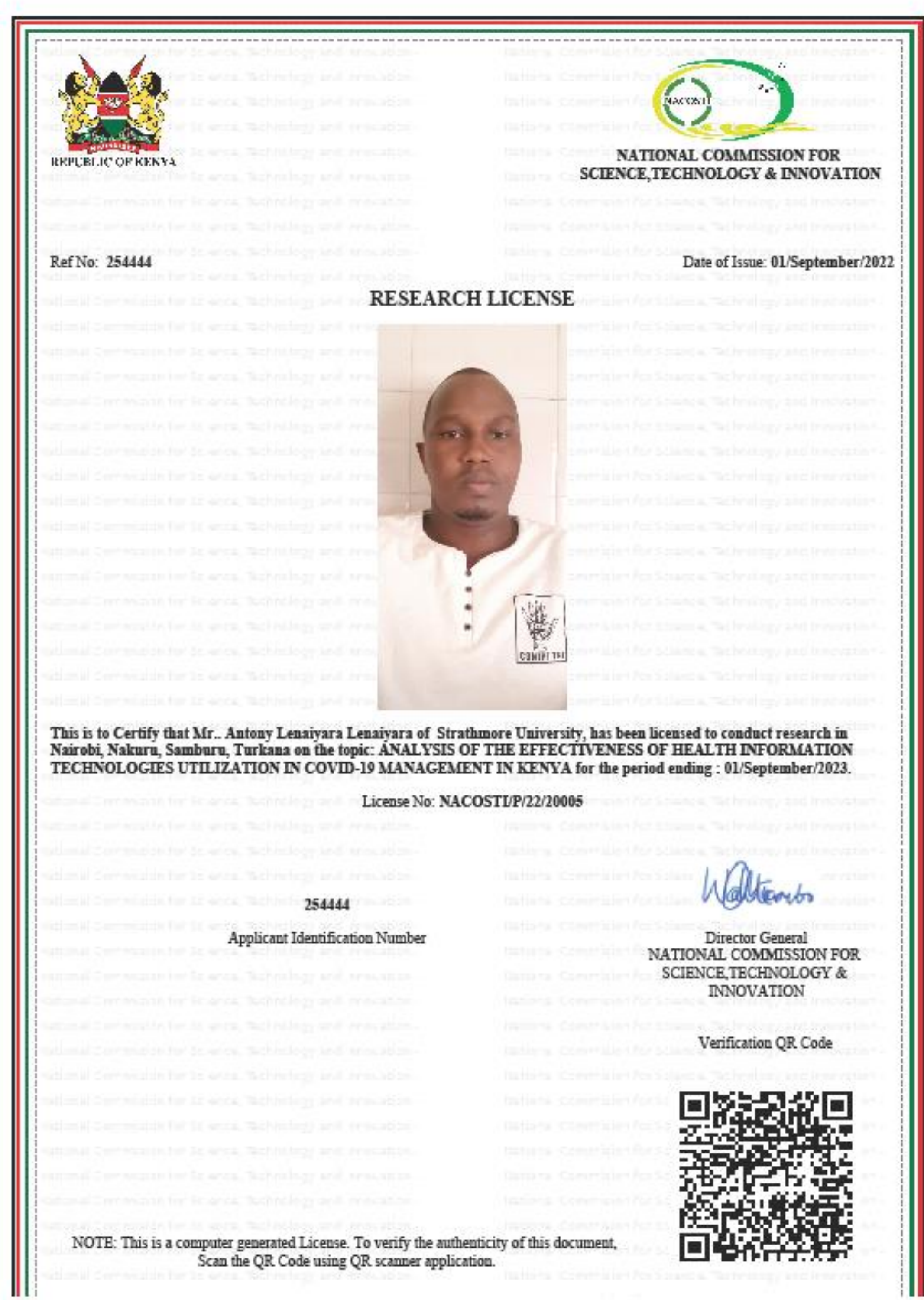
STRATHMORE UNIVERSITY INSTITUTIONAL SCIENTIFIC AND ETHICAL REVIEW COMMITTEE
(SU-ISERC)
12-Sep-2022
Email:ethicsreview@strathmore.edu
P.O BOX 59857-00200
NAIROBI-KENYA

for: **Dr Ben Ngoye,**
Secretary; SU-ISERC

Cc: Prof Fred Were,
Chairperson; SU-ISERC

Ole Sangale Rd, Madaraka Estate. PO Box 59857-00200, Nairobi, Kenya. Tel +254 (0)703 034000
Email admissions@strathmore.edu www.strathmore.edu

Appendix IV: NACOSTI Research Licence



REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

Ref No: 254444

Date of Issue: 01/September/2022

RESEARCH LICENSE

This is to Certify that Mr.. Antony Lenaiyara Lenaiyara of Strathmore University, has been licensed to conduct research in Nairobi, Nakuru, Samburu, Turkana on the topic: ANALYSIS OF THE EFFECTIVENESS OF HEALTH INFORMATION TECHNOLOGIES UTILIZATION IN COVID-19 MANAGEMENT IN KENYA for the period ending : 01/September/2023.

License No: NACOSTI/P/22/20005

254444

Applicant Identification Number

Director General

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

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