

The Use of Artificial Intelligence in Improving Public Healthcare Efficiency at Galeshewe Community Health Clinic Northern Cape Province

Dr. John Motsamai Modise
South African Police Service

Phemelo Sheldon Modise
North-West University, Potchefstroom

Abstract :- This study is founded upon the Technological Determinism Theory as the theory is considered to provide the most appropriate foundational framework for the study's intent to establish how artificial intelligence can be used to improve the efficiency of public healthcare at Galeshewe Community Health Clinic. Consequently this study's central theoretical statements indicated below are derived from the aforementioned theoretical perspective. The technological advancements introduced in the 4IR have presented opportunities for the efficient use of technology within the public healthcare arena. The study will tackle the problem of extended waiting time, poor record-keeping, poor infection and hygiene control procedures, adverse events situations, medicine and equipment shortages, and heightened litigation that GCHC is facing. A qualitative research approach was chosen for this study, to develop an in-depth understanding how artificial intelligence can be used to improve the efficiency of public healthcare, with specific reference to GCHC.

Keyword:- Artificial Intelligence; Healthcare Efficiency; Public Healthcare Services; Improve

I. INTRODUCTION

Healthcare is a basic need and the main purpose of any government is to ensure that the needs of its citizens are taken care of through service delivery (Besley & Ghatak, 2007:127; Nealer 2014:164). The Constitution of the Republic of South Africa, 1996 (hereafter referred to as 'the Constitution') is the supreme law of the country, and all public service regulations, strategies, policies, and legislation must be consistent with the Constitution. Moreover, it is a directorial document that makes provision for efficient public services, including the effective and efficient provision of public healthcare service enshrined in sections 27 and 195 of the Constitution. The Bill of Rights in chapter 2 of the Constitution, (also referred to as the cornerstone of democracy in South Africa) provide for the mandatory human rights of all citizens such as the right to healthcare service.

The aforementioned right to healthcare serves as the context within which this study is conducted, focusing on the use of artificial intelligence in improving public healthcare efficiency at Galeshewe Community Health

Clinic (GCHC). Several legislations deal with healthcare such as the National Health Act 61 of 2003, The Constitution of the Republic of South Africa, 1996, and policies such as the National Development Plan (NDP) 2030 to mention a few. Despite considerable strides in attempting to change the healthcare narrative in South Africa (SA), GCHC is still not efficient as far as the promises that the Constitution and all the healthcare legislation are concerned. GCHC still faces prevalent issues such as extended waiting time, poor record-keeping, poor infection and hygiene control procedures, adverse events, medicine and equipment shortages, and heightened litigation (Maphumulo & Bhengu, 2019:2).

Quality healthcare is classified as, "perpetually satisfying patient needs through offering efficient and effective healthcare services" (Mosadeghrad, 2013:201). According to Powell, Rushmer & Davies (2009:53) The Institute of Medicine, an American non-governmental organisation, lists six quality principles for general quality healthcare six quality principles for, which is:

- Patient protection;
- Efficiency;
- Effectiveness;
- Equality;
- Patient centeredness and;
- Timelessness.

These six principles also arguably apply to GCHC as the National Health Act 61 of 2003 similarly states that it intends to provide a structured and unified health system within SA, that is dedicated, effective, safe, and timely towards healthcare patients (Department of Health, 2004:18) It is not enough that patients receive healthcare, but they should receive healthcare through the utmost quality means so that the well-being of public healthcare patients can be guaranteed. GCHC is clearly in need of help and with the ever-growing society, new healthcare strides are needed to change the healthcare dynamic at GCHC. An American Clinic called Mayo Clinic which rated as one of the best clinics in the world, seeing that it applies advanced and innovative quality healthcare models such as 24 hour online referrals, eConsults requests and notes, laboratory and radiology reports, and clinical discharge summaries that are consistent with all of the six quality principles for general quality healthcare that the Institute of Medicine lists (Mayo Clinic, 2013:8-9). Technology in essence is the use of

scientific knowledge for practical applications in the day-to-day human life or within the production of goods and services. It is a discourse of devices that is capable of fulfilling tasks (Merriam-Webster Inc., 2022). Hillyer (2020), asserts that healthcare technology has considerably grown in the past two decades and this has led to advanced technological healthcare innovations such as the use of virtual reality to train medical students and professionals, and the use of medical drones to deliver healthcare resources at dedicated destinations (Plotzky et al, 2021:1; Nyaaba & Ayamga, 2021:1).

In the wake of the Fourth Industrial Revolution (4IR), it has become somewhat of an imperative to incorporate technology in the improvement of everyday problems (The Scientific World, 2019). Artificial intelligence (AI) is one of the popular technologies advanced by the 4IR and refers to a revolutionary smart computer-enabled technology that allows machines to function with increased levels of intelligence. It is the ability of machines to simulate human intelligence processes so that human tasks can be efficiently undertaken or even assisted or taken over (Copeland, 2021). AI is a fast-developing computer proficient technology that has great potential to radically change the efficiency and quality of the medical field and give it a new identity that is nothing short of “outstanding”. The medical arena is a critical area because health is a basic human right in section 27 of the Constitution and there is an exclusive department called the Department of Health and there is even a public health insurance body that is called the National Health Insurance. The incorporation of AI into the health field adds a new layer of formidability that propels humanity into the modern era that is filled with the use of technology.

The use of AI is becoming widespread globally and it is replacing the traditional ways of everyday living in all aspects of life. AI is the collection of several technologies and has the utmost importance in the healthcare arena. AI consists of machine learning and deep learning, both of which are extensively used in the healthcare service (Karthikeyan, & Priyakuma, 2021:30). Karthikeyan et al., (2021:30) further state that machine learning is a computational algorithm that imitates human intelligence by obtaining knowledge from nearby settings by learning from new data. Deep learning is a subset of machine learning that focuses on data and focuses on intricate features such as scanning body parts and detecting the affected parts that cannot be identified by the human eye (Karthikeyan et al., 2021:30).

AI is dynamic in application and it has the ability to influence several public sector departments and in this context, the influence of AI is applied in the public healthcare sector. AI in itself brings new revelations to the healthcare service in the form of AI robotics, AI chatbots, AI digital healthcare applications, AI software integration, and AI-based automation of administrative workflow (Bates, 2019:13; Robert, 2019:30; Reddy et al., 2019:24; Lee & Yoon, 2021:2; Guo & Li, 2018:176; Davenport & Kalakota, 2019:96). AI Chatbots are virtual conversational agent that

imitates human interactions to assist in healthcare provision (Gupta et al., 2020:255). AI digital healthcare applications are AI-based digital healthcare applications that provides healthcare information or assistance to individuals in order to assist them with their healthcare needs and AI robotics refer the use of various artificially modified physical robots such as surgical robots (Owen-Hill, 2017). AI software is simply software that is capable of intelligent behaviour, this includes simulating capabilities such as reasoning, perception, knowledge representation, learning and problem solving (Expert.ai, 2016). AI Automation or Intelligent Automation (IA) is a combination of AI and Robotic Process Automation which together empower end-to-end business process automation (Donepudi, 2017:11).

As mentioned earlier, strides have been made to improve public service delivery yet GCHC stills faces difficulties in providing efficient healthcare services to public patients. Although technology is used within South Africa, offering quality public healthcare has become a degrading problem. Healthcare is an essential service that every citizen should have and Chapter 2, Section 27 (1) (a) of the Constitution echoes these sentiments stating, “Everyone has the right to have access to – (a) health care services, including reproductive health care”. Public healthcare will always be a basic essential and since it is never lost its worth, undertaken steps will be needed to help improve healthcare as a field of necessary customer service. This can only be done by improving the efficiency of the services that are currently available within the healthcare sector.

President Cyril Ramaphosa established a Presidential Commission on the Fourth industrial Revolution (4IR). This emphasises the degree to which the country, even at the highest level acknowledges 4IR as something we need to prepare for. The rise of 4IR has encouraged SA to focus on the development of policies; frameworks; strategies and innovative ideas, and in an effort to realise 4IR and take advantage of rapid 4IR technological advancements in SA the Presidency and the Department of Telecommunications and Postal Services established the Presidential Commission on the Fourth Industrial Revolution (DTPS, 2019:5).

Improving the efficiency of healthcare is arguably a comprehensive task, however, AI offers the opportunity to considerably ease the GCHC from several health burdens. Formal healthcare service delivery strides have been made to change the healthcare narrative of prevalent healthcare issues as mentioned earlier, even though the struggles of the past are still prevalent. Through the incorporation of AI, healthcare efficiency at GCHC can become the new basis of what healthcare is classified as in the healthcare environment.

II. RESEARCH METHODOLOGY

There are generally two types of research approaches namely: quantitative and qualitative research approaches. This study will make use of a qualitative research approach.

Babbie and Mouton (2001:270) refer to the main objective of qualitative research as a technique that can provide a researcher with an understanding and narrative of a study. Qualitative research is an unstructured research approach that is open and flexible (Kumar, 2019:16). Struwig and Stead (2001:11) explain that qualitative research elaborates on meanings, explanations, and an understanding of conceptualised ideas and it is a detailed analysis between an individual and a concept. A qualitative research approach was chosen for this study, to develop an in-depth understanding how artificial intelligence can be used to improve the efficiency of public healthcare, with specific reference to GCHC.

III. STATUTORY AND REGULATORY FRAMEWORK FOR PUBLIC HEALTHCARE AND TECHNOLOGY-BASED LEGISLATIVE PROVISIONS

A. *Constitution of South Africa, 1996*

The Constitution is the supreme law of the country, and all public service regulations, strategies, policies, and legislation must be consistent with the Constitution. Both the Bill of Rights and Chapter 10, Section 195 (1) states that the Constitution is the main body which provides for the effective and implementation of public administration (Moshela, 2014:5).

The Bill of Rights in chapter 2 of the Constitution, explicitly states that “everyone has the right of access to healthcare services”. This is the basic human right upon which this study is founded, and provides evidence that every South African citizen has the right to have access to healthcare. Moreover, Chapter 1 section 1.1 of this study alludes that quality healthcare is imperative and it is regarded as the ability to, “perpetually satisfy patient needs through offering efficient and effective healthcare services” (Mosadeghrad, 2013:201). The promise of Chapter 2, section 27 (1) (a) of the Constitution is still not delivered to healthcare patients despite South African citizens having the democratic right to quality healthcare.

Chapters 3, Section 41 (1) and chapter 10, section 195 (1) of the Constitution mandates improved government service delivery where it is specified that public administration must obey to several democratic standards and principles comprising:

- “A high standard of professional ethics must be promoted and maintained,
- Efficient, economic and effective use of resources must be promoted,
- Public administration must be development-oriented,
- Services must be provided impartially, fairly, equitably and without bias,
- People’s needs must be responded to and the public must be encouraged to participate in policy-making,
- Public administration must be accountable,
- Transparency must be fostered by providing the public with timely, accessible and accurate information,

- Good human-resource management and career-development practices, to maximise human potential, must be cultivated, and
- Public administration must be broadly representative of South African citizens with employment and personnel management practices based on ability, objectivity, fairness and the need to redress the imbalances of the past to achieve broad representation”.

The above Section 195 (1) insinuates that public administration (GCHC inclusive) must be accountable and provide efficient, economic and effective use of resources and that the needs of people must be responded in a timely fashion. The GCHC has a responsibility to efficiently provide to the needs of the South African citizens that it provides service to. This again implies that the employees at GCHC must have a positive and progressive environment so that they can exercise their abilities and excel at their jobs, since it would directly influence both the employees and organisational performance of GCHC, which translate into service delivery.

Moreover, Section 195 (2) of the Constitution provides that the above listed principles apply to all government administrations, public enterprises and, all organs of state, including GCHC. Thus, this entails that the CHGC must operate in alignment with ethical principles that maintain high standards of professional ethics and that the GCHC must be development-oriented. GCHC falls directly into the public organs of state and has the responsibility to maintain all the principles as indicted in the list above. This paves the way for the use of AI to find expression seeing that AI in practice offers a 94% average accuracy in fulfilling tasks compared to humans’ 85% accuracy (Sergeenkov, 2019). Conventional health practices has always been emphasised and the same health administration problems keeps on recurring, the introduction of AI boasts a new age solution to problems that has spanned for decades in SA.

As mentioned, AI is dynamic in application and it has the ability to influence several public sector departments and in this context, the influence of AI is applied in the public healthcare sector. AI in itself brings new revelations to the healthcare service in the form of AI robotics, AI chatbots, AI digital healthcare applications, AI software integration, and AI-based automation of administrative workflow (Bates, 2019:13; Robert, 2019:30; Reddy et al., 2019:24; Lee & Yoon, 2021:2; Guo & Li, 2018:176; Davenport & Kalakota, 2019:96). Also indicated in chapter 1, section 1.5, AI systems, possesses the capability to advance analysis or decision-making procedures while imitating human behaviour (Nardarzynski et al., 2019:1). AI within the public healthcare sector, specifically the GCHC offers efficient, economic and effective use of its resources within a development-oriented setting that aims to meet the healthcare needs of people specifically at the GCHC. As alluded in chapter 1 section 1.1, quality healthcare is classified as, “perpetually satisfying patient needs through offering efficient and effective healthcare services” (Mosadeghrad, 2013:201), AI, hence retains the quality of

offering efficient and effective healthcare services toward GCHC. In addition to the Constitution, the NDP is a significant and vital policy considered in the setting of the study. Currently, the NDP is the main developmental policy of the government, which emphasises the socio-economic developmental needs. The next section deliberates on the National Development Plan, 2030.

B. National Development Plan, 2030

The necessity for an effective public service comprising structured, proficient, capable, and consistent public service provision is supported and encouraged by the National Development Plan (NDP) which states that two of the main challenges in SA are the inadequate infrastructures and the poor quality of public services (National Planning Commission, 2012:15). One of the prevalent public healthcare service issues that SA still faces are issues such as long waiting time periods, poor record-keeping, poor infection and hygiene control procedures, adverse events situations, medicine and equipment shortages, and heightened litigation (see chapter 1, section 1.1 & 1.2) (Maphumulo & Bhengu, 2019:2). One of the enabling milestones of the NDP is to provide affordable access to quality public healthcare while endorsing wellbeing and health (National Planning Commission, 2012:24), one main purpose of the NDP is to strengthen primary healthcare and health-enhancing programmes (National Planning Commission, 2012:218), AI clearly, fits within the requirements of health-development and its integration will thus fulfil the constitutional agenda of improving the quality healthcare of all South African citizens.

The NDP maintains nine long term-health goals that are listed in the (National Planning Commission, 2011a:297):

- Increasing the average lifespan to 70 years for both all genders;
- improving tuberculosis (TB) prevention and treatment;
- decreasing the rates of infant, maternal, and child mortality;
- reducing chronic diseases and non-communicable illnesses;
- ensuring equal healthcare access for all citizens;
- assigning skilled, efficient and devoted individuals to fill occupational posts;
- decreasing injury, accidents and crime by 50%;
- restructuring healthcare systems; and
- Improving primary healthcare through offering care to families and communities.

Attaining these nine long term-health goals of the NDP, underlines the need for health intervention through a modern based approach to healthcare service delivery such as the use of AI and its medical enhancing technologies in the public health sector. It can be argued that for the NDP's goals to materialise, new innovative ideas such AI through AI-based smart robots, AI chatbots, AI digital healthcare applications, AI software integration, and AI-based automation of administrative workflow may be helpful, as alluded to in Chapter 2, Section 2.2.1. Conversely, the NDP states that a core component of restructuring primary

healthcare strategy is the proposal to commit more emphasis for services dedicated to the South African community through a primary healthcare outreach, such as provision through health information and meeting the concerns as identified by the communities. It is clear that through the introduction of AI and its integration into the primary healthcare system is not only a possibility but a fundamental element that should be incorporated at GCHC and that it can improve healthcare at GCHC, as indicated in chapter 1, section 1.1. (National Planning Commission, 2011b:315).

One of the nine key challenges that the NDP outlines is that SA still faces slow progress in bettering the economy of SA, with this being said the public service health system is unable to satisfy the demand or sustain quality healthcare which is should be a basic necessity for every South African citizen (National Planning Commission, 2012:15). There is a clear discrepancy of what is promised in Section 27 (1) (a) of Chapter 2 of the Constitution which states that, "Everyone has the right to have access to – (a) health care services, including reproductive health care". As mentioned in chapter, section 1.2 that a one-year old baby died on his grandmother's back after waiting to be assisted for over 2 hours at GCHC, GCHC is clearly unable to sustain the basic right that is promised by the Constitution (Kama, 2017:2).

It is clear that the public service health system is unable to satisfy the demand or sustain quality healthcare and AI hence maintains the ability to improve the efficiency through consistent and dedicated healthcare assistance to GCHC and offer 94% accuracy in fulfilling tasks at the GCHC compared to the 85% accuracy humans' have (Sergeenkov, 2019). Consequently, the prospect of reaching the developmental goals of the NDP and the health goal of the NDP specially is increased through the deployment of AI within the GCHG. Furthermore, GCHC is reliant on The National Health Act No. 61 of 2003. The National Health Act No. 61 of 2003 is the Act that is responsible for setting out the confinement of what is recognised as providing comprehensive primary and assuring that healthcare is provided. The succeeding section deliberates on the National Health Act No. 61 of 2003.

C. The National Health Act No. 61 Of 2003

The National Health Act No. 61 of 2003 (hereafter referred to as the National Health Act) provides that no one can be declined medical treatment even in the case of emergencies by healthcare establishments, healthcare provider or healthcare worker. The Act gives effect and content to the right to access health care services as provided for in the Constitution. This Act sets out the laws that oversee national, provincial and local government with regard to healthcare service delivery (The Presidency, 2004:5-6). Beyond the regulation of the provision of healthcare services by the different spheres of government, the Act also recognises the need of health technology, to modify and establish and construct health establishments and provide prescribed healthcare services (The Presidency, 2004:44).

The provision of a transformed and modified health system that uses improved technology to meet the needs of patients are clear. It is evident that the National Health Act emphasises the importance and insistence to erect greater health technology and establish health establishments that provide prescribed healthcare services, AI evidently synchronises with the needs of not only to erect greater healthcare technology but the need to provide establish a healthcare system that provide and meet prescribed patient healthcare needs. Though the National Health Act No. 61 of 2003 makes provision for Information Communication Technology, it does not make provision for the growing need of 4IR which strongly changing the world. The National Health Act No. 61 of 2003 is still based on the Third Industrial Revolution (3IR) and it has not aligned itself with the necessities of the current day and as a result, public institutions (clinics, hospitals etc.) are also behind in the way that they provide healthcare services due to the failure of a reformed legislation. The National Health Act No. 61 of 2003 is clearly in need of reform which can allow the provision of 4IR technology particularly at GCHC to harmoniously provide the latest and most medically advanced healthcare through AI provisions.

Additionally the National Health Act No. 61 of 2003 outlines 4 imperative objectives which are to (Department of Health, 2020:4):

- Unite the several fundamentals of the national health system to actively promote and improve SA's the national health system;
- Provide a cooperative system of health services, within national guidelines, standards that has the goal of delivering quality healthcare services;
- Erect a healthcare system based on decentralised management of healthcare service, principles of efficiency, equity, sound governance, globally acknowledged standards and a nature of advocacy and an enquiry; and
- Create the basis of the healthcare system, and understood in relation to other polices and laws that relates to healthcare in SA.

For GCHC to effectively function it should prioritise the key objectives of the National Health Act through providing a cooperative healthcare system through AI to satisfy national guidelines, and healthcare dispensation standards. GCHC through the National Health Act can satisfy needs of the National Health Act of creating a healthcare basis and erecting a healthcare system based on decentralised management of healthcare service through instituting and building a healthcare dispensation system around AI where there is a decentralisation in healthcare services between AI and healthcare workers at GCHC to ensure an efficient, fair, and sound healthcare service that is maintains a globally acknowledged healthcare standards and is relevant and understood in relation to other healthcare polices and laws of SA.

D. The White Paper for the Transformation of the Health System, 1997

The original key policy document which directed transformation in the South African public healthcare sector was the White Paper for the Transformation of the Health System (Department of Health, 1997:1). Chapter 2 of White Paper vouches for the transformation of the health system is distributed to different health departments in order to reach the goal of restructuring the health service organisation, through new structures being erected in health service organisations (Department of Health, 1997:9). The White Paper recognises the need for change in the health systems of SA and providing a community-oriented health system that offers improved health services and development.

E. Health Service Training, Development And Integration

Section 4(1) of the White Paper acknowledges and to both train and develop medical employees, integrating them into the ethos of the health system, and the significance of producing frameworks for future training and development opportunities to obtain excellence for healthcare-based employees (Department of Health, 1997:34-36). The integration and training of healthcare workers particularly at GCHC with regards to understanding, being taught and the integration of AI within the GCHC is of need and significance. Training, development and integrating into the work space are critical organisational requirements to contend in global affairs because it satisfies the constant changing environment of organisational structure (Grobler et al., 2015:341).

F. The Reorganisation of the Health System

A quality health system is characterised by a system that provides trustable healthcare that is in line with the standards set by the Office of Health Standards Compliance (OHSC) and one that holds positive testimonies from patients (Department of Health, 2020:22). One of the main aims of the White Paper is to reorganise the healthcare system in a manner that brings better healthcare results. To give effect to this mandate it is imperative that, inter alia, a restructure of the health system where service delivery responsibility is committed to different departments (Department of Health, 1997:9). For GCHC this would mean that the AI will function in certain positions (departments) within GCHC to provide better and efficient means of satisfying and meeting the needs of GCHC. As alluded in chapter 1, section 1.1. AI can and will improve the efficiency of how GCHC provides its services to the community this will help GCHC to alleviate the critical healthcare issues that are plaguing it from reaching its full potential. The introduction of AI clearly is supported for by the White Paper for the Transformation of the Health System of 1997. The reorganisation of AI will not only transform GCHC but it will bring about noticeable healthcare results to GCHC.

G. Better Healthcare Provision

The White Paper recognises the need for change within the healthcare sector and the need for better healthcare provision by public healthcare for effective, efficient and

quality healthcare (Department of Health, 1997:101). Services to combat issues such as HIV/ AIDS and sexually transmitted and communicable diseases such as tuberculosis (TB) cholera, measles, malaria, hepatitis, and other health concerns (Department of Health, 1997:68, 75). The White Paper contends that the healthcare system should provide a system for an improved health information that provide accurate monitoring, and health measurement result; applicable management and treatment of patients pursuing treatment; promotion of appropriate support and care, an external and internal means of communication; and quality peripheral microscopy network (Department of Health, 1997: 8, 72, 73, 77, 80). Chapter 1, section 1.5, already demonstrated that AI technologies that can be used to transform the healthcare system for better healthcare efficiency at GCHC. It argued that AI can bring improved healthcare provision and thus it can be argued that through the changing world and the necessity for enhanced technology with the growing health needs, that it is imperative to incorporate AI within the healthcare system, particularly at GCHC, as the White Paper for the Transformation of the Health System of 1997 demonstrates.

IV. STATUTORY AND REGULATORY FRAMEWORK FOR DIGITAL HEALTHCARE

A. National Ehealth Strategy, South Africa 2012/13-2016/17

The National eHealth Strategy, South Africa, 2012/13-2016/17 seeks to establish an eHealth as a crucial part of the improvement and transformation concerning healthcare service (Department of Health, 2012:21). eHealth is seen as an investment in ICT in healthcare that enables transformation and improvements in working and clinical activities (Department of Health, 2012:21). One key objective of the National eHealth Strategy, South Africa 2012/13-2016/17 is to improve ICT infrastructure and connectivity but it does not have any proper provision or explicit mention of AI or 4IR, (Department of Health, 2012:26). Despite the ambition to improve ICT this strategy still lacks the aim of specifically focusing on new 4IR technology such as AI and if this strategy can shift its narrow focus from only focusing on ICT and be inclusive of modern technology such as AI, which can be used and build into GCHC's healthcare structure to bring establish the main goal of the National eHealth Strategy, South Africa, 2012/13-2016/17 and of the assignment which is to institute improvement and transformation at the GCHC in working and clinical activities for better healthcare provision to patients.

B. National Digital Health Strategy for South Africa 2019 - 2024

Digital health is described as the use of Information and Communication Technology (ICT) for health to, for instance monitor patient health, educate students, pursue research, and track diseases. Digital health refers to field of knowledge and implementation that concerns itself with any aspect of integrating digital technologies to improve health from exception to action (Department of Health, 2019:12-

13). Digital governance provides for following, accountability, and driving of the strategy to ensure the healthcare sector reaches the expected results (Department of Health, 2019:16). SA's digital health vision is a "Better health for every South African allowed by person-centred digital health" with a foundational grounding is that is based on "A lengthy and healthy lifespan for all South African citizens (Department of Health, 2019:17) National Digital Health Strategy for South Africa, 2019 -2024 seeks to establish an intertwined and unified digital health network of individuals, technology and procedures that support health systems empowering to allow efficient, effective patient service delivery through five key strategic principles of which 3 is of crucial importance within the study namely (Department of Health, 2019:18). The only negative aspect about these principles is they do not clearly define the extent to which technology can be intimate involved around individuals. These 3 key strategic principles are:

C. Person-Centred Focus

A person-centred approach consider residents as members that provide or need care that is curative palliative, avoidable or a mixture between life and death and hence the National Digital Health Strategy for South Africa, 2019 - 2024 makes use of patient monitoring that collect epidemiological management data to which they make decisions from this data. AI chatbots and robots in the workplace contributes to higher performance levels and redundant administration work alleviation (sikwela, 2016:3). GCHC can infuse the use of AI together with manual labour at GCHC and GCHC can through a person (patient)-centred focus use AI to enhance healthcare provision and mitigate redundant administration work.

D. Expand Access to Services for Effective Health Coverage

National Digital Health Strategy for South Africa, 2019 - 2024 provides that a reorganisation of the transformative elements provides the instance for unravelling information requirements and what becomes conceivable when ICT (inclusive of AI) is used. Expanding access is a key part, concentrated on providing access to healthcare service delivery. The National Digital Health Strategy for South Africa, 2019 - 2024 clearly makes provision for the transformation of digital healthcare for technology to be used through the expansion of access to for the efficient provision of health coverage. In this regard AI can expanded to GCHC patients for the purpose of effective health coverage.

E. Innovation for Sustainable Digital Development Impact

Innovation is a key element of the strategy. This strategy clearly states that digital health presents opportunities to change the manner in which health is conducted. Technological innovation can be explored through adding technologies such as Artificial Intelligence, increasing automation, establishing new opportunities and introducing efficiencies for transforming the manner health decisions, obtaining or dispensing healthcare within the healthcare system, particularly in this scenario the dispensation healthcare at GCHC. This will allow GCHC to

constructively employ AI through a well-defined sustainable structure that will innovatively impact healthcare at GCHC.

V. GLOBAL STRATEGY ON DIGITAL HEALTH 2020-2025

According to Clift (2013:44), the World Health Organisation is the global health organisation that is responsible for international public health through connecting, nations, partners and people to promote health and offering health advice globally. This global strategy seeks to strengthen health systems through the execution of digital technologies for healthcare providers and relevant bodies towards strengthening patients and attaining health for all (Global strategy on digital health, 2020-2025:11). Global strategy on digital health maintains two its guiding principles that is relevant for this study, the recognition that successful digital health initiatives need a cohesive strategy guiding and promoting the appropriate use of digital technologies for health. The global strategy on digital health, 2020-2025 is in recognition that healthcare technology needs to be integrated and promoted in healthcare institutions such the GCHC for more efficient and improved healthcare.

VI. THE ARTIFICIAL INTELLIGENCE TECHNOLOGIES THAT CAN BE INTEGRATED AND USED AT COMMUNITY HEALTHCARE CLINIC TO BRING EFFICIENT HEALTH CARE

A. Ai Healthcare Chatbots

The use of chatbots has been identified as an effective instrument for conducting conversational engagements with patients and family members in healthcare facilities (Lee & Yoon, 7:2021). Chatbots are natural language processing systems that act like a virtual conversational agent imitating human interactions, healthcare chatbots maintain the ability to raise healthcare access, improve doctor-patient and clinic-patient interaction, or assist in controlling the growing demand for healthcare services such as via remote testing, medication conformity monitoring or teleconsultations (Divya, 2018:2,4). AI chatbot technology opens the window for ventures such as precise health surveys, booking appointments, personal healthcare reminders setups, clinical teams communication, collecting and analysing healthcare data or the interpretation and communication of diagnostic patterns also considering behavioural pointers such as nutrition, physical activity, or sleep (Bates, 13:2019; Nadarzynski et al., 2:2019). This AI technology can change the GCHC healthcare service delivery, by deploying chatbots within the GCHC mainframe, which increases equality, uptake and cost-effectiveness and time consumption patterns.

Divya (2018:2) argues that all these chatbot opportunities are possibilities that can further enhance GCHC but the key practice that the chatbots can do is to provide on-site relevant and helpful information, for instance, text-to-speech; or a speech-to-speech

conversational agent that asks the user about their health problem. The user can chat as if chatting with another human, a series of questions will then be asked by the bot about the user's symptoms in order the chat or to can diagnose the disease, afterwards, the Chabot will provide suggestions concerning the various symptoms to clarify the disease (Divya, 2018:2; Sophia et al., 2020:207). Based on the user's response the precise disease is found and it suggests the doctor who needs to be consulted in case of major diseases the chatbot system also remembers previous responses and asks progressively more precise questions in order to retrieve and provide a good health solution (Divya, 2:2018; Sophia et al, 2020:208-209; Gerke et al, 2020:1).

GCHC can have a designated area where the chatbots can be found this will cut short unnecessary cue standing for patients waiting to obtain information that a chatbot can provide. Chatbots can grant GCHC accurate information that is not bombarded by tired and incorrect answers from clinicians and it can provide an organised flow of quality care because it grants clinicians the opportunity to be able to focus on key medical work. Clinicians at GCHC can also make use of chatbots to rapidly and easily retrieve information about drug communications and side effects. Safedrugbot, for instance, is a messaging chat service that aids doctors and other medical professionals retrieve data concerning the safety of drugs for breastfeeding women (Bates, 2019:12). Another Chabot that GCHC can use is the Sophie Bot which provides a platform for reproductive and sexual health questions. The Sophie Bot guarantees sound answers, anonymity, an independent platform and a user-friendly communicational interface (Pillay, 2018:11; Parviainen & Coekelbergh, 2020:718).

For clinicians, chatbots at GCHC can streamline the interaction with electronic health records and decrease the documentation burden. Lee and Kim (2021:282) argue that modern electronic health records depend highly on clinicians to either type or control consultation notes, which causes clinical burnout, heightened cognitive load, data loss, and distraction from other duties in the clinical setting, conversational interfaces can employ recent advances in speech recognition, natural language processing, and artificial intelligence to provide clinics such as GCHC with tools to automatically document elements of the spoken clinical encounter (Johnson et al., 2020:967).

B. Ai-Enhanced Robotics

Medical literature doubles every 3 years and it is estimated that a physician needs to read 29 hours per workday to remain completely updated with medical-related literature, consequently, it is not possible and feasible to depend solely on humans to undertake medical-related work (Guo & Li, 2018:175). According to Reddy et al. (2019:24-25), there are various types of AI robots including mobile autonomous (such as surgical robots), industrial (such as hardware moulding AI robots), and AI modular robots (such as educational AI robots that provide medical literature) are being used in the health system. Autonomous surgery is the most anticipated field of AI robotics and this is the direction

of AI robots that the study will undertake (Shekhar, 2019:14). Guo and Li (2018:176) argues that AI robots are effective, efficient, and can relieve individuals from taking on dull, dirty, harmful and repetitive tasks while generating good quality work on mass-production. The same words can be said for the healthcare industry, particularly GCHC. Telerobots can facilitate communication between patients with medical professionals, AI robots can also be used in surgery as assistant surgeons (Guo & Li, 2018:176; Shehab et al., 2020:5).

Robotic-assisted surgery is preferred by surgeons due to its high precision; controllability; and flexibility, additionally, robotic-assisted surgery can allow surgeons to perform surgeries that are very complicated or that were previously impossible (Lee & Yoon, 7:2021; Dasgupta, 2018:221). With the growth of medical AI, faster research data has been produced. AI-enhanced robotic surgeries are minimally invasive due to its high accuracy rates, unlike human surgery, which compels healthcare doctors to perform incisions that are painful and take an extensive time to heal. AI-enhanced robot surgery can decrease a patient's post-operational stay by 21% because they are far more precise and allow patients to heal faster compared to human-made incisions (Alugubelli, 2016:4; Robert, 2019:36).

Reddy et al. (2019:24) assert that the greatest potential of AI is probably found in the use of Robotics. Health robotics allows rapid patient care mobility, efficient clinical setting processes, and a safe space for both patients and health employees (Gayle, 819-820). Though AI robots can specifically offer surgical assistance at GCHC. As motion control technologies have grown, surgical-assistance robots have become more precise, these robots help surgeons execute micro processes without instilling large incisions, eliminate vibrations and allow safe suturing in narrow areas whilst conducting surgeries (Intel, 2022; Gumbs et al., 2021:9-10; Robert, 2019:35; Kose et al, 2018:5).

For instance, one of the key problems in spine surgery is controlling accuracy and precision and motion during time-consuming operations (Rasouli et al, 2020:560). The SpineAssist robot mounts on bony landmarks, such as a spinous process, during the operation with 6 degrees of freedom, this device permits for accurate positioning of surgical tools and interface with computer-assisted navigation, ultimately disclosing the most precise position for pedicle placement based on the position of the chosen entry point and screw trajectory (Rasouli et al, 2020:560; Camarillo et al, 2004:4; Staub & Sadrameli, 2019:34). Various studies have tested the SpineAssist robot's accuracy such Dennis et al (2019:6) who documented an accuracy rate of 99% in pedicle placement with SpineAssist, compared to the 92% accuracy rate with navigation only (Rasouli et al, 2020:560).

According to Van Mulken et al. (2020:2), MUSA a robot created by Microsure, a company of the Eindhoven University of Technology, is a surgical robot that a surgeon controls, whose hand movements are translated into smaller,

more accurate movements that are executed by a set of "robot hands", the device makes use of AI to steady any form of tremors in the surgeon's movements, to warrant the robot to accurately execute the operation, which makes it ideal for difficult surgical procedures involving blood arteries, nerves, and other soft tissue components with a diameter of just 0.3 mm (Holland, 2021:2; Van Mulken et al., 2020:2). A surgical operation was conducted on a patient at the Maastricht University Medical Center, and the medical center stated that the AI-assisted surgery was a success, and that the patient is recovering the success has led the medical center to use the robot for different microsurgery procedures (Britt, 2018; Mogali, 2021:4). AI robots can rapidly improve the medical outcome of GCHC holistically and this will thus help decrease surgical variation and its attendant shortcomings and poor results, as GCHC surgeons better comprehend the techniques that align with better results and in addition these deductions can relate to GCHC's patient's post-functional and long-term health results (Mogalia et al., 2021:2).

C. Ai Automation of Administrative Workflow

Tsai et al. (2020:1) deduct that electronic health record (EHR) documentation has become one of the most time-consuming duties in healthcare institutions. The use of the usual EHR system which systematised the collection of patient health data that is electronically stored in a digital format, is well recognised to be inaccurate and prone to unintended fluctuation (HSCCC, 2020:1; Gumbs et al, 2021:18; Waring et al., 2020:9). These issues mostly arise from the fact that EHRs were initially intended for billing and coding purposes rather than analytics or actively enhancing healthcare quality. Furthermore, many health systems claim to use EHR platforms that are only partially compatible, which makes it challenging to get complete patient data histories (Waring et al., 2020:9; Matheny et al., 2019:105; Howard et al., 2012:107).

It is suggested that AI automation is regarded among the most promising approaches to improve healthcare administration through increasing clinical care and reducing administrative demands on clinicians (Reddy et al, 2019:23). By taking on repetitive and routine duties such as patient data entry and automated review of laboratory, clinical ward data, patient diagnosis data and imaging results, AI technology within healthcare service automation could assist GCHC to retrieve, store, restructure, and trace clinical data, as well as develop personalised assessments and plans which can free time for clinicians to dispense direct care for patients and/or perform other imperative clinician duties (Acemoglu & Restrepo, 2019:202; Guo & Li, 2018:175; Alugubelli, 2016:6)

Joining machine learning algorithms to EHR can assist GCHC clinicians and administrators to retrieve precise and context-specific patient data to perform more important medical duties and by using machine learning and concept-based information collection system, search accuracy and collection speed can be improved (N'gbesso, 2020:2; Waring et al., 2020:1, 9). If GCHC can integrate AI

automation technology, it can help in predicting the time patients stay at the pre-admission stage, allowing more appropriate and efficient use of stretched resources and a decrease in clinician burnout that causes poor healthcare services to needy patients at GCHC (Reddy et al, 2019:23; Ho et al., 2019:330; Alugubelli, 2016:5; Muro et al., 2019:14). The integrated machine learning with electronic health records can analyse biometric and other health information of individual patients and propose treatment plans based on present clinical guidelines (Reddy et al, 2019:23; Katuu, 2016:10)

D. AI Software Integration

AI has been proven to be specifically efficient with a great volume of radiology data to improve the quality of healthcare services with medical imaging. Davenport and Kalakota (2019:95-96), argue that AI-based software can improve the precision of patient diagnoses, which will greatly help both the patients and the work of medical employees. For instance, the frequency analysis of mitosis in cancer cells through pictures or a microscope is a straightforward process (Pantanowitz et al., 2020:5). AI software can undertake this duty with greater precision and speed, therefore, assisting medical personnel with their professional work while disintegrating some of the drudgeries of duties (Yu et al, 2018:725; Filipp, 2019:209). AI-supported healthcare software can develop by learning from the increased volume of the retrieved information and new medical research, this fact is demonstrated as the increased precision of AI-supported medical software is exceeding the precision of healthcare experts in diagnosing diseases (Bajwa et al., 192:2021; Lee & Yoon, 9:2021). Machine learning algorithms are currently being used to predict the progress of septic shock and aid diagnosis and fatal obstructive pulmonary disease patient treatment, and they also have the potential to help personalise treatment decisions for patients drawing upon large-scale data about prior cases that historically would have been difficult to use in clinical decision making (Akhil et al, 2018:24; Mogali, 2021:14; Reddy et al, 2019:23).

AI software can match the performance of pathologists and radiologists, and its integration may assist in identifying gaps in treatment procedures and mitigate possible errors (Reddy et al, 2019:23). Multiple AI advantages range from stronger interpretability, better clinician understanding leading to evidence-based practise, and improved clinical outcomes, which can be attained along with a second degree of explainability (Reddy, 2022:215; Kulkarni & Padmanabham, 2016:23; Hany et al, 2012:27; Shehab et al, 2020:5).

Reddy et al, (2019:24) again asset that AI-enabled software can be employed in intensive care units for respiratory and cardiovascular monitoring through the interpretation of vital signs. After a visit to GCHC, GCHC can communicate relevant health and medication information and schedule follow-up patient visits through chatbots as mentioned earlier. Using such technological innovations has been found to augment medication

conformity and patients taking their serious (Reddy et al, 2019:24). With the ability of AI-supported healthcare software, to become more accurate and smarter with learning from the increased number of obtained data and new medical research, the GCHC computational system will be and grow to be more smarter and accurate (Reddy et al., 2019:492; Reddy, 2020:1-2).

E. AI Digital Healthcare Applications

The introduction of digital AI applications into the healthcare setting focuses on the interactions between patients and healthcare providers and it can also be used to provide healthcare administration to a large-scale of patients (Bustow & Hoque, 2020:51). Digital healthcare applications can cut healthcare expenditures, cost recovery, and responses to treatment, consequently increasing the wellness of GCHC patients and the quality of care while decreasing costs for GCHC (Bohr & Memarzadeh, 2020:28-29).

Digital healthcare applications can increase the healthcare ratings; provide greater credibility to GCHC and supply a higher healthcare provision success and healthcare return rates; this will also encourage patient participation; make healthcare dispensation and attraction more feasible; and provide an easier medical care provision outside of GCHC (Lee & Yoon, 2021:15; Botha et al, 2014:7). There are 3 ideal digital applications that GCHC can use in the form of Sense.ly, Babylon; and ADA health.

F. Sense.ly

Khadija (2021:357) asserts that Sense.ly is a healthcare digital application that has and makes use of a built-in digital avatar called Molly to offer healthcare-related provisions. The sense.ly avatar can provide feedback and ask questions about the patient's condition in addition to asking them to check their vital statistics like their blood pressure and weight (Ricci, 2017). The results are recorded by the inbuilt AI technology which then sends the medical results of patients back to the doctors, through selecting the available options on the screen, patients can initiate communication with the nurse avatar (Fierceelectronics, 2015). Through calling and making appointments on the patient's behalf, Sense.ly can also communicate with the healthcare providers and provide them with the necessary medical information or the avatar can be on standby and take instructions from healthcare providers to the benefit of the patients (Schnur & Odessky, 2017; Pennic, 2017).

The avatar can one or more times verbally check in with the patient daily and gather crucial data like a person's weight; blood pressure; and details about their condition, the doctor will then receive all of the information online which will make the doctor aware of the medical conditions of patients to better treat or provide sound recommendations to the patients (Chakraborty, 2021; Demigos, 2022). The app additionally contrasts the patient's health outcomes with their prior historical outcome and points out any risks or concerns (Bajwa et al, 2021:191; Fierceelectronics, 2015; Ricci, 2017). Due to the smart machine learning capability of AI, the Molly avatar can store and match information,

providing the patient with the best possible care, providing a patient with a similar experience as going to the doctor (Bajwa et al, 2021:191; Schnur & Odessky, 2017).

G. Babylon Health

According to Swiss Cognitive (2020), Babylon is a digital healthcare app that provides a patient with the opportunity to schedule a doctor's appointment through video without making a phone call or waiting in a waiting area. Babylon can also send a patient's prescription to their local pharmacy, or even to their home or place of business (Swiss Cognitive, 2020). By responding to inquiries about family history, mood, and lifestyle, an integrated "Symptoms Checker" (Babylon health) generates a health report, almost like having a General Practitioner nearby of which the goal is to make constructive lifestyle adjustments (Khadija, 2021:357; Bustreo & Tanner, 2020:232; You & Gui, 2020:1357).

Babylon's AI interface is designed to portray a doctor's brain, therefore, providing the same care to patients at home (Copestake, 2017; Swiss Cognitive, 2020). A group of scientists, epidemiologists, physicians, and engineers created the algorithm to advance the possibilities of machine learning research for the Babylon app to can yield a continuously upgraded return in healthcare outcomes to patients and ensure efficient, ethical and effective healthcare standards (Swiss Cognitive, 2020; Bates, 2019:13; Spena & Cristina, 2019:394).

H. ADA Health

According to Chakraborty (2021), ADA is another digital healthcare application that asks users (patients) simple health-related questions to gain a deeper understanding of the user's conditions. To help users truly understand their health conditions and solve problems, ADA draws data out from its continuous updating digital medical library using identification, coordination, and knowledge extraction (Duties, 2017; Holdener et al, 2020:3). Information kept in the digital medical library makes it easy to match the asked questions with available information (Robert, 2019:35; Swiss Cognitive 2020). ADA collects patient-friendly medical data offering a comprehensive understanding of their symptoms (Swiss Cognitive, 2020). In the case of GCHC's, ADA can extract medical information from GCHC's medical library in order to provide the best medical experience to GCHC patients and use the array of data to bring its features to actualisation.

The ADA app provides a diagnosis that is determined relative to the best-matched symptom pattern that the ADA app identified, the user receives a probability of a plausible diagnosis and, as differential diagnoses, other likely diagnoses. Patients obtain an evaluation of seeking medical advice. Furthermore, the app takes into account a wide range of mental health issues; (2) the app offers probabilities of potential and differential diagnoses (indications of comorbidities) (Jungman et al., 2019:121; Bayer, 2022; O'Hear, 2017; Park, 2022). ADA's business model is not to replace doctors but it is there to establish a partnership with

healthcare providers (Sophia et al., 2020:206; Park, 2022). This can be the exact manner that GCHC will use ADA, where this app will be used relative to GCHC to give further credibility to GCHC. Gilbert et al. (2021:1), argue that from a 200-vignette conducted a study, the performance of the ADA health app was nearest to that of the human doctors and higher compared to the best-performing system evaluation apps such as Your.MD; it provided 99% condition coverage for the vignettes, offered safe advice 97% of the time and offered accurate suggested conditions in its Top 3 precisely 70% of the time (Jungman et al., 2019:121).

These healthcare apps can be used by GCHC patients, where GCHC can create Sense.ly, Babylon Health, and ADA health profiles that GCHC can register under and these apps will work side by side with the GCHC medical workers where the healthcare results that these apps obtain will be credited to GCHC such as these apps performance and healthcare credibility ratings and it's efficiency level that it provides to its patients. GCHC can make use of these 3 digital applications and create profiles on these applications and the GCHC patients can register under the GCHC profile, this step will permit GCHC to have an efficient and professional manner in dealing and dispensing medical help to its patients through these digital healthcare applications that will relatively decrease issues such time spent on booking appointments, waiting for medical prescriptions, repetitive and unnecessary clinical visit health status check-ups, and general check-ups for certain GCHC patients.

VII. CONCLUSION

Galeshewe Community Health Clinic is a community health care facility situated in Kimberley Northern Cape Province. It is one of the facilities that does not provide a 24 hour service. Its main focus is to deliver quality health care to the community. The quality of the service that the facility offers or delivers depends on the effectiveness and efficiency of the employees. Employees should at all times strive to deliver a service that is up to standard and should strive for efficiency and effectiveness. The effectiveness and efficiency of the employees would be determined by fewer queues especially at reception and pharmacy; and fewer problems when it comes to patients accessing Community Health Clinic.

REFERENCES

- [1.] Economic Commission for Latin America and the Caribbean. 2021. Digital technologies for a new future. https://www.cepal.org/sites/default/files/publication/files/46817/S2000960_en.pdf Date of access: 7 Mar. 2022.
- [2.] Abend, G. 2008. The Meaning of 'Theory'. *Sociological theory*, 26 (2):173-199.
- [3.] Adler, P.S. 2006. Technological Determinism. <http://faculty.marshall.usc.edu/Paul->

- Adler/research/revisingTechnological%20Determinism.pdf Date of access: 7 Mar. 2022.
- [4.] Ayanga, M. & Nyaaba, A. A. 2021. Intricacies of medical drones in healthcare delivery: Implications for Africa, *Technology in Society*, 66, 1-8. <https://doi.org/10.1016/j.techsoc.2021.101624>.
- [5.] Babbie, E. & Mouton, S. 2001. *The Practice of Social Research*. Cape Town: Oxford University Press.
- [6.] Babbie, E. 2011. *Introduction to Social Research*. 5th ed. Belmont, California: Wadsworth Cengage Learning.
- [7.] Bahadori, M., Izadi, M. & Hoseinpourfard, M. 2012. Plagiarism: concepts, factors and solutions. *Iranian Journal of Military Medicine*, 14(3):168-177.
- [8.] Bajwa., Munir, U. Nori, A. Williams, B. 2021. Artificial intelligence in healthcare: transforming the practice of medicine. *Future Healthcare Journal*, 8(2):188-194. doi: 10.7861/fhj.2021-0095
- [9.] Bates, M. 2019. Health Care Chatbots Are Here to Help. *Institute of Electrical and Electronics Engineers Pulse*, 10(3):12-14. doi: 10.1109/MPULS.2019.2911816.
- [10.] Besley, T. & Ghatak, M. 2007. Reforming public service delivery. *Journal of African Economics*, 16(1):127-156.
- [11.] Copeland, B.J. 2021. Artificial intelligence. In: *Britannica academic*. <https://www.britannica.com/technology/artificial-intelligence> Date of access: 5 Mar. 2019.
- [12.] Dafoe, A. 2015. On Technological Determinism: A Typology, Scope Conditions, and a Mechanism. *Science, Technology, and Human Values*, 40(6):1047-1076. doi: 10.1177/0162243915579283
- [13.] Devi, P. Reddy, M. A. Zahan, Sharma, J. V. C. 2019. THE EFFECT OF STRESS ON HUMAN Life. *ADALYA Journal*, 8(9):792-811. <https://www.dropbox.com/s/9lghyk9kdobipah/79-Sep-1751.pdf?dl=0> Date of access: 3 Apr. 2022.
- [14.] Dictionary, 2008. *Oxford Popular School Dictionary*. Cape Town: Oxford University Press.
- [15.] Fouche, C. B. & Delpont, C. S. L. 2011. Introduction to the research process, in *Research at grass roots: for the social science and human service professions*, 4th ed. Edited by A.S De Vos, H. Strydom, C.B. Fouche. Pretoria: Van Schaik Publishers.
- [16.] Grobler, P. A., Warnich, S., Carrell, M. R., Elbert, N. F. & Hatfield, R. D. 2015. *Human Resources Management in South Africa*. 5th edition. Melbourne: Cengage Publishers.
- [17.] Guo, J., & Li B. 2018. The Application of Medical Artificial Intelligence Technology in Rural Areas of Developing Countries. *Health Equity*, 2(1):174-181. doi: 10.1089/hec.2018.0037.
- [18.] Hillyer, M. 2020. How has technology changed – and changed us – in the past 20 years? <https://www.weforum.org/agenda/2020/11/heres-how-technology-has-changed-and- changed-us-over-the-past-20-years> Date of access: 5 Mar. 2022.
- [19.] Karthikeyan, A., & Priyakumar, U. D. 2021. Artificial Intelligence: Machine Learning for Chemical Sciences. *J. Chem. Sci.* 134 (1), 2. doi:10.1007/s12039-021-01995-2.
- [20.] Kothari, C.R. 2004. *Research methodology: methods and techniques*. 2nd ed. New Delhi: New Age International Publishers.
- [21.] Kumar, R. 2014. *Research methodology: a step-by-step guide for beginners*. London: Sage Publications.
- [22.] Kumar, R. 2019. *Research Methodology: a step-by-step guide for beginners*. 5th ed. SAGE Publications.
- [23.] Lee, D., & Yoon S.N. 2021. Application of Artificial Intelligence-Based Technologies in the Healthcare Industry: Opportunities and Challenges. *International Journal of Environmental Research and Public Health*, 18(1):271. <https://doi.org/10.3390/ijerph18010271>
- [24.] MacMillan, J. H. & Schumacher, S. 2001. *Research in education: a conceptual introduction* 5th ed. New York: Longman.
- [25.] Maphumulo, W. & Bhengu, B. 2019. Challenges of quality improvement in the healthcare of South Africa post-apartheid: A critical review. *Curationis*, 42(1), a1901. <https://doi.org/10.4102/curationis.v42i1.1901>
- [26.] Mathekga, H. L. & Sekudu, J. 2019. Employee Wellness: Preparation for the Fourth Industrial. *International Journal of Innovative Studies in Sociology and Humanities*, 4(5):31-39.
- [27.] Merriam-Webster Inc. 2022. *Merriam-Webster dictionary*. <https://www.merriam-webster.com/dictionary/> Date of access: 5 Mar. 2022.
- [28.] Mosadeghrad, A. M. 2014. Factors Influencing Healthcare Service Quality. *International Journal of Health Policy Management*, 3, 77–89. doi: 10.15171/ijhpm.2014.65
- [29.] Mosehla, R. S. 2013. Recruitment and retention of employees at the Gauteng department of education head office from 2005 to 2009. *Johannesburg: University of Johannesburg (Master's Dissertation)*.
- [30.] Nadarzynski, T., Miles, O., Cowie, A., & Ridge, D. 2019. Acceptability of artificial intelligence (AI)-led chatbot services in healthcare: A mixed-methods study. *Digital Health* 2, doi: 10.1177/2055207619871808
- [31.] Nayak, J. K. & Singh, P. 2015. *Fundamentals of Research Methodology: Problems and Prospects*. 1st ed. New Delhi: SSDN Publishers and Distributors.
- [32.] Nealer, E. 2014. Local government and service delivery, in *Municipal management: serving the people*, 2nd ed. Edited by G. Van der Walddt. Cape Town: Juata.
- [33.] Plotzky, C. Lindwedel, U. Sorber, M. Loessl, B. Königa, P. Kunze, C. Kugler, C. & Meng, M. 2021. Virtual reality simulations in nurse education: A systematic mapping review, *Nurse Education Today*, 101, 1-11. <https://doi.org/10.1016/j.nedt.2021.104868>
- [34.] Powell, A. E., Rushmer, R. K., & Davies, H. T. O. 2009. A systematic narrative review of quality improvement models in health care. pp 1-164.

- <http://www.crd.york.ac.uk/CRDWeb/ShowRecord.asp?ID=32011000041> Date of access 7 March 2022.
- [35.] Rajasekar, S., Philominathan, P. & Chinnathambi, V. 2013. Research methodology. <https://arxiv.org/pdf/physics/0601009.pdf>. Date of access: 11 March 2022.
- [36.] Rajesh, T. 2021. Artificial intelligence's impact on our everyday lives. In: Karthikeyan, J., Ting Su Hie. & Ng Yu Jin., eds. Artificial intelligence. India: L Ordine Nuovo Publication. pp. 30.
- [37.] Randolph, J. 2009. A guide to writing the dissertation literature review. *Practical Assessment, Research, and Evaluation*, 14(1):1-13.
- [38.] Reddy, S., Fox, J., & Purohit, M.P. 2019. Artificial intelligence-enabled healthcare delivery. *Journal of the Royal Society of Medicine*, 112(1):22-28. <https://doi.org/10.1177/0141076818815510>.
- [39.] Robert, N. 2019. How artificial intelligence is changing nursing. *Nursing management*, 50(9):30–39. doi-10.1097/01.NUMA.0000578988.56622.21.
- [40.] Sergeenkov, A. 2019. Artificial Intelligence is Becoming Better than Human Expertise <https://hackernoon.com/artificial-intelligence-is-becoming-better-than-human-expertise-16903f4fc3c0> Date of access: 01 June 2022.
- [41.] South Africa: Constitution of the Republic of South Africa, 1996.
- [42.] Department of Health. 2019. National Digital Health Strategy for South Africa. <https://www.health.gov.za/wp-content/uploads/2020/11/national-digital-strategy-for-south-africa-2019-2024-b.pdf> Date of access: 06 June 2022.
- [43.] National Planning Commission. 2011a. National Development Plan 2030: Our future make it work. nationalplanningcommission.org.za/assets/Documents/NDP_Chapters/devplan_ch10_0.pdf Date of access: 01 June 2022.
- [44.] National Planning Commission. 2011b. National Development Plan Vision for 2030. www.gov.za/sites/default/files/gcis_document/201409/devplan2.pdf Date of access 01 June 2022.
- [45.] National Planning Commission. 2012. National Development Plan 2030: Our future make it work Executive Summary. www.gov.za/sites/default/files/gcis_document/201409/ndp-2030/-our-future-make-it-workr.pdf Date of access: 01 June 2022.
- [46.] Department of Health. 2012. <https://www.knowledgehub.org.za/system/files/elibdownloads/2019-07/South%20Africa%20eHealth%20strategy%202012-2017.pdf> Date of access: 06 June 2022.
- [47.] Department of Health. 2020. Strategic Plan 2020/21-2024/25. <https://www.health.gov.za/startegic-plans/> Date of access: 06 June 2022.
- [48.] Metro District Health Services. Metro District Health Services: Overview. https://www.westerncape.gov.za/your_gov/159 Date of access: 09 June 2022.
- [49.] Struwig, F. W. & Stead, G. B. 2001. Planning, designing and reporting research. Cape Town: Maskew Miller Longman.
- [50.] Department of Telecommunications and Postal Services. 2019. Terms of Reference for Commission on the Fourth Industrial Revolution. <https://www.gov.za/documents/presidential-commission-fourth-industrial-revolutions-members-and-terms-reference-9-apr> Date of access: 03 Sep. 2022.
- [51.] The Scientific World. 2019. The Importance of Technology in Our Daily Life – How Technology Changed Our Lives? <https://www.scientificworldinfo.com/2019/11/importance-of-technology-in-our-daily-life.html?m=1> Date of access: 5 Mar. 2022.
- [52.] Yu, K, Beam, A. L, & Kohane, I. S. 2018. Artificial intelligence in healthcare. *Nature biomedical engineering*, 2, 713-791. <https://doi.org/10.1038/s41551-018-0305-z>.