Health and Welfare Sector Education and Training Authority

HWSETA

RESEARCH REPORT

THE SKILLS REQUIREMENTS OF THE SOUTH AFRICAN HEALTH SECTOR CREATED BY THE 4TH INDUSTRIAL REVOLUTION

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Abbreviations and Acronyms

AR	Augmented Reality
DHET	Department of Higher Education and Training
ECMO	Extracorporeal Membrane Oxygenation
EHR	Electronic Health Records
4IR	Fourth Industrial Revolution
HIT	Health Information Technologies
HPCSA	Health Professions Council of South Africa
HWSETA	Health and Welfare Sector Education Training Authority
ICT	Information and Communications Technology
NDoH	National Department of Health
NDP	National Development Plan
NHI	National Health Insurance
NHLS	National Health Laboratory System
OECD	Organisation for Economic Co-operation and Development
OFO	Occupational Framework for Occupations
SSP	Sector Skills Plan
SANBS	South African National Blood Services
TVET	Technical and Vocational Education Training
UN	United Nations
VR	Virtual Reality
WEF	World Economic Forum
WHO	World Health Organization
WSP	Work Skills Plan

EXECUTIVE SUMMARY

1. Introduction

The implications of the Fourth Industrial Revolution (4IR) are the new reality that is shaking both the workplace and skills training. Globally, employers are struggling to fill up vacancies due to high shortages of people with highly specialized skills. This mismatch between what the employers need and what the labour market offers is assumed to be exacerbated by the Fourth Industrial Revolution (4IR) technologies which require new skills. In addition to this, research shows that more than 50% of students entering primary school today will end up working in completely new job types that do not yet exist, which insinuates more challenges regarding skills needed for the future.

At the same time, the 4IR holds the promise of gains for many sectors including the health sector. Gains from the 4IR within the health sector may include reduced medical error; reduced inpatient days; cost savings; improved communication; access to information; effective monitoring; reduced mortality rates and improved patient experience. With so much promise, it is necessary to consider all necessary avenues such as ensuring readiness to adapt to change for the integration of the 4IR towards the desired impact. It is therefore essential for HWSETA to gain more insight into how the 4IR creates skills requirements. This study will inform interventions as far as skills development is concerned.

2. Research Methodology

The research methodology used to gather evidence involved both qualitative and quantitative methods of conducting research, which is termed, the mixed methods. The study was exploratory in its design, as thus, purposive sampling was used to identify employer organisations to participate in the study. Semi-structured interviews were used to collect data from the hospitals and laboratory. Seven Hospitals and one laboratory were identified as the best healthcare organisations that could provide insight on occupations affected by the 4IR and the new skills it requires. These included, for private health, Mediclinic Hospital, Netcare Hospital, Life-Healthcare Hospital, and Lancet Laboratories. For public health, Christ Hani Baragwanath Hospital, Steve Biko Hospital, Charlotte Maxeke Hospital, and the University Hospital in the Free State. Only five hospitals however participated in the study due to time constraints and in some cases low interest in the topic. Employer organisations that actually participated in the study included Mediclinic Hospital, Lancet Laboratories, Christ Hani Baragwanath Hospital, Steve Biko Hospital, and the University Hospital in the Free State. Interviews were conducted with training managers in these Hospitals. Data analysis used both qualitative methods for data collected through semi-structured interviews and quantitative data analysis techniques for database analysis, which was used to identify occupations most likely to be affected by the 4IR.

3. Discussion of Findings

The findings of the study are discussed in line with the objectives of the study as follows:

Objective 1: Establishing the existence of the 4IR in the South African health sector

Findings from this research show that 80% of respondents confirmed that there is 4IR taking place in the health sector, which is in the form of new technologies in equipment and electronic communication devices. The reasons stated for these developments included; putting skills to use, improving time efficiency; staff communication and offering advancements in products and services. Occupations in Medical technology, for example have a technology called "Auto Tracks" which carries human tissue samples to analysers. This technology reduced human resources needed per shift from 10 officials to 2 officials. Other examples of technology are the "Next generation Sequencing Technology", which reduced costs. There are several other technologies which are mentioned in the report. It has been identified that support and training in the usage of such technologies may be minimal as the employees are not confident enough to work with technological advancements. This lack of education related to technology was another finding which indirectly linked 4IR to skills requirements.

Objective 2: The degree to which the 4IR leads to changes in skills requirements in Public Healthcare compared to Private Healthcare

Public healthcare pursues innovation through seeking of knowledge and reliance on high level skills to better serve the society. Problem solving is therefore done through skills development. While private healthcare pursues problem solving through technological advancements. This is due to its competitive environment and focus on profitability. As thus, skills development in private healthcare is a result of technological advancements. The 4IR therefore, is prevalent in private healthcare than in public healthcare, and drives skills development.

Objective 3: Identifying occupations that are affected by the 4IR in the health sector

The study has found that occupations most affected are those that have more routine functions than non-routine functions, as routine tasks can be easily substituted by technology. Examples of such functions include diagnostics, data science and data analytics etc. The occupations affected therefore include:

- Radiation Oncologist
- Specialist Physician
- Emergency Medicine Specialist
- Medical Diagnostic Radiographer
- Cardiologist
- Bio-Medical Technologist
- Pathologist
- Phlebotomist

The degree to which these occupations were affected by the 4IR varied based on routine, non-routine functions, and functions that require the human touch. Occupations that involved more routine tasks were affected to a high degree as it is simpler to automate routine tasks than non-routine tasks. Occupations that required more human touch, such as Physiotherapy for example, were affected to a lesser extent as they do not use technology as the main component of innovation.

The effect of the 4IR to occupations such as Dental and Nursing Specialisations could not be established as a majority of the employer organisations that participated in the study were public hospitals. The implication maybe that there are not enough advanced technologies in public healthcare which would result in the creation of new skills requirements in these occupations.

Objective 4: Identifying the new skills requirements in occupations affected by the 4IR.

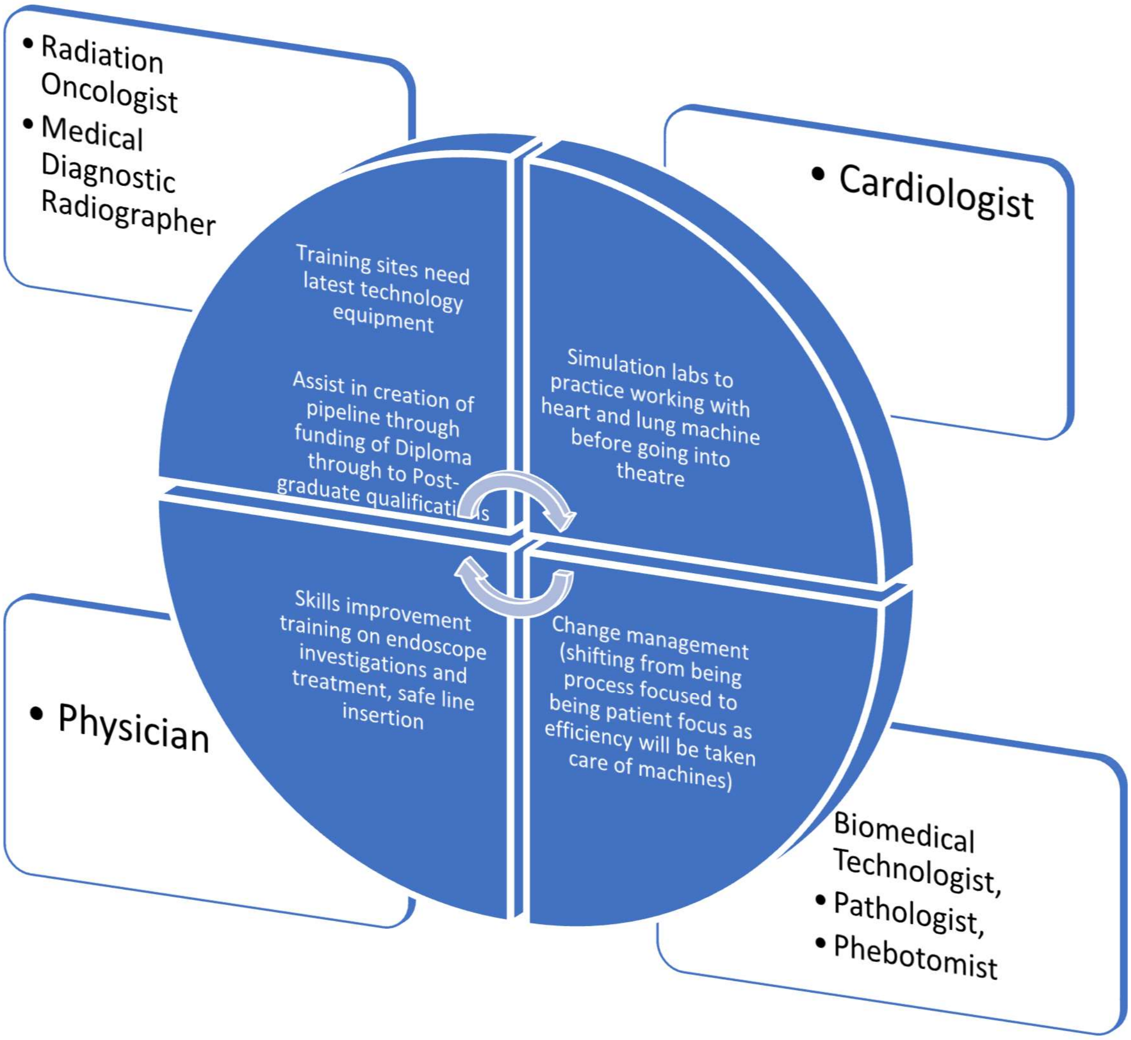
The study identified the following skills requirements, which are created by the 4IR:

SKILL REQUIREMENTS	*PHYSIOTHERAPY*	*RADIATION ONCHOLOGY*	*SPECIALISATION: PHYSICIAN*	*SPECIALISATION: EMERGENCY MEDICINE*	*MEDICAL DIAGNOSTIC RADIOGRAPHY*	*CLINICAL TECHNOLOGY: CARDIOLOGY*	*BIOMEDICAL TECHNOLOGY*	*PATHOLOGY*	*PHLEBOTOMY*
Diagnostics (Non-invasive, Remote, Telemedicine, heart valve)	✓		✓	✓	✓	✓			
Imaging skills (reading, interpreting, evaluation) 4dimension imaging from new radiation equipment		✓							
Investigation skills (Central Venous Pressure and Arterial line insertion)		✓	✓						
Therapeutic skills (Pneumatic exoskeleton for paralysed patients)			✓						
Data Science				✓					
Data Analytics				✓					
New Radiopharmaceuticals					✓				
Sonography									
Radiography: Nuclear Medicine									
Machine learning skills					✓				
Specialisation: Extracorporeal Membrane Oxygenation skills						✓			

Remote cardiac monitoring						✓			
Cardioversion						✓			
Business survey skills							✓	✓	✓
Financial Skills							✓	✓	✓
Multi-tasking skills and customer focus							✓	✓	✓
Interpretive skills							✓	✓	✓

Objective 5: Possible interventions to address these skills requirements

Interventions proposed by the employer organisations that participated in the study were expressed through the following needs:



Conclusion and recommendations

This report will serve as input to the SSP update for 2021-2022. Based on the findings of this study, it is recommended that the HWSETA provides support for training through tailored skills development programmes for the 4IR. This can either be occupation-specific or skill directed focusing on either soft skills or technical skills. Further research is also recommended to cover more categories of employer organisations in the health sector, and also investigate 4IR in the social development sector.

CHAPTER 1: INTRODUCTION AND SETTING THE SCENE

1.1 Introduction

This work explores the skills brought about by the 4th industrial revolution (4IR) in the South African health sector for selected occupations. The South African health system is characterized by high inequalities and poor healthcare mainly due to factors such as poor record-keeping (Kama, 2017), shortage of resources (Mokoena, 2017), litigation (Maphumulo & Bhengu, 2019), costly and inefficient (Senkubuge et al., 2018) and lack of skills (Edmeston & Francis, 2012). The UN (2016) also identified challenges faced by the South African health sector as growing old population age, infant and child mortality, maternal mortality, international migration, and internally displaced persons.

Bearing in mind these challenges, it is evident that greater efforts to improve and build on capabilities in health care are of paramount importance. Research shows that this can be made more feasible if access to timely and accurate information about the requirements of the public health sector is available (Yang et al., 2015). Technologies coming from the 4IR have been seen to improve the healthcare planning, systems of operations and access to healthcare in many countries (WHO, 2008). Nonetheless, in South Africa, the full potential benefits are not being realized because healthcare in South Africa is deemed to be about treatment and care delivery as opposed to a holistic approach that includes policies, skills needed, products and services aimed at disease prevention and well-being (Weeks, 2013).

Notwithstanding the above, there are gestures of intervention regarding the policy aspect of 4IR and healthcare in South Africa. The government has identified the 4IR as the priority towards a sustainable health care system and this has been reflected in strategies and policies such as the NDP; NHI; 4IR Presidential Commission; e-Strategy; National Digital Strategy; and eHealth Strategy. The Presidential Health Summit (2018) calls for connectivity at all health facilities using technology, especially for remote areas. Improved ICT infrastructure for connectivity is also flagged as essential towards the 4IR. Similarly, the South African Medium-Term Strategic Framework (2014) advocates for the use of technology and investment in subjects aligned with the 4IR.

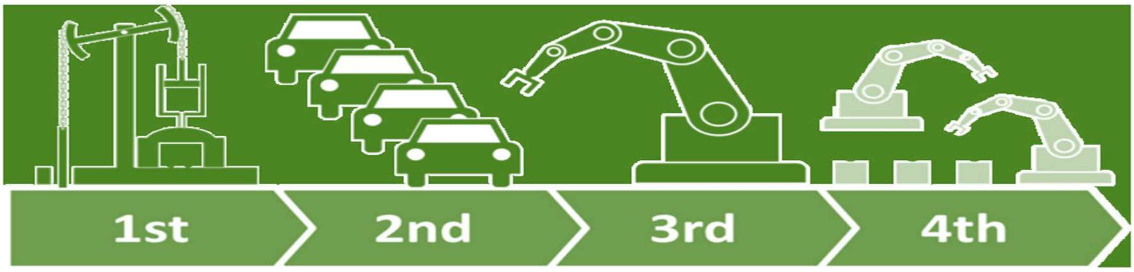
The 4IR is also changing a number of variables in South Africa (SA) such as jobs; inequality; skills; infrastructure; women participation and employment policy (Roux, Viljoen, & Samson, 2019). The SA's health sector has therefore undergone significant transformations including moving from the basic use of paper to phones and tablets for accessing patient results. Some of the basic advancements include the use of advanced machines that reduce the time for testing TB from 6 weeks to 24 hours. Of importance to using these new systems and equipment will be the appropriate skills to obtain full efficiency and effectiveness.

In an instance where the 4IR is identified as a key change driver for the sector, prompt response to these transitions can lay a strong foundation for policy and mechanisms towards desirable skills that can be useful for the functionality of the sector. It is for this cause that HWSETA partakes this research to identifying desirable skills requirements and come up with designed interventions based on the skills needs for this change. The policy formulation and strategy development process might also need to be re-aligned towards supporting the evolution of these new ways of work as well as supporting the already existing skills to accommodate this transition.

1.2 Setting the Scene and Context of the Study

The simple diagram below gives a brief demonstration of the evolution of technology and innovation.

Figure 1: Evolution of Technological Revolutions



These can be described in the following manner:

- *1st revolution:* water and steam-powered machinery (knowledge generation);
- *2nd revolution*: electronic energy for mass production (knowledge evolution);
- *3rd revolution:* computerization and internetization (knowledge distribution);

- *4th revolution:* cyber-physical (knowledge mutation).

Application of technological advancements is changing when and where work is done in practically every industry as workplaces of the industrial age give way to work practices of the digital age, including remote work, flexible work and on-demand gap (Higgins, 2013)**.** It is therefore important to understand how these changes the scope of work within the health sector, and the Organising Framework for Occupations (OFO) are a great guide towards this understanding. The OFO is important in that it groups occupations into successively broader categories and hierarchical levels based on the similarity of tasks, skills, and knowledge (*OFO Codes*, 2015).

The preceding arguments may, however, be hindered by the inequalities within the South African health system which makes it difficult to align OFO codes with the occupational job description and the actual tasks. The public sector is under-resourced and overstretched with having to cater to 80 percent of the population while the state contributes about 40 percent of expenditure. The private sector is left with catering only for 20 percent population from 60 percent expenditure (Younger, 2016). In such a context, the actual tasks performed under occupations falling within similar OFO codes might differ between public and private sectors due to resource capacity.

Different categories of occupations will, therefore, require different kinds of training interventions to fulfill the tasks and duties of the jobs. The table below provides an overview and classification of some of the occupations based on the Professional Councils and OFO.

Table 1: Overview and Classification of Occupations

HPCSA Professional Boards	**Occupational categories**
Emergency Care Practitioners	Primary Care Paramedic; Clinical Officer; Ambulance Officer;
Medical and Dental Professions	Orthodontists; Oral Pathologist; Prosthodontist;
Optometry and dispensing Opticians	Oculist
Physiotherapy, Podiatry, and Biokinetics	Physical Rehabilitation; Physiotherapy Technician; Masseur
Medical Technology	Pathology Technician; Phlebotomist; Medical Laboratory; Cytology Technician

HPCSA Professional Boards	Occupational categories
Occupational Therapy, Medical Orthotics/Prosthetics, and Arts Therapy	Prosthetist; Orthotist; Work Rehabilitation Therapist; Music Therapist
Speech, Language and Hearing Professions	Hearing Therapist; Speech Clinician; Language Therapist
Dietetics and Nutrition	Nutritionist; Health Advisor; Dietetic Consultant
Radiography and Clinical Technology	Medical Diagnostic Radiographer; Sonographer; Nuclear Medicine; Dialysis Technician
Psychology	Industrial Psychologist; Industrial Psychologist; Behaviour Therapist; Psychometrist
Dental Therapy and Oral Hygiene	Dental Health Advisor; Gum Therapist; Oral Health Therapist
Veterinarians	Veterinary specialists; Animal Health Technicians; Veterinary Nurse; Veterinary Technologists

The highlighted professional bodies cover occupations for which competent performance will require some formal training. More to this, technologies that come from the 4IR will not only have an impact on the skills needed, but the standard work operations will also be affected. For example, occupations such as Neurosurgeons that deal with the diagnosis and surgical treatment of disorders such as tumors will have their tasks changed due to robotic surgeries. Specifically, this technology assists surgeons in performing intricate procedures in a minimally invasive manner (Haffejee, 2014).

The Nursing professionals will also have occupations such as registered nurses who provide direct care or coordinators of care with changed practice. An ideal scope of practice for a registered nurse entails some of the following - diagnosing and prescribing; provision of comprehensive nursing treatment and where necessary, referral to a registered person, providing emergency care, etc (Gazette, 2012). However, technologies such as remote nursing care and telehealth will have to change the role and where nurses work. Nurses will no longer have to provide direct health care given remote patient monitoring via Apps and sensors on blood pressure, weight depression as well as e-prescribing (Rutledge et al., 2017).

According to Celie, Prager, Chaet, Johnston, & Yarmolinsky (2016), a pathologist will diagnose and characterize disease by examining a patient’s tissues, blood, and other body fluids. They are specially trained to interpret biopsy results, Pap tests, and other biological samples. However, with technologies such as computer-assisted diagnosis which provides advanced image analysis, the routine work of a pathologist will be changed (Farahani, Liu, Jutt, & Fine, 2017). Other technologies include electronic health records (EHR) which can provide patients with radiology reports and pathology results (Celie et al., 2016).

Another profession which plays an important role in the sector is the primary animal healthcare. Included in this category are the animal technicians, veterinary epidemiologists, and surgeons which play an important role in diagnosing, controlling and managing animal diseases including in the rural areas. The use of technologies such as biosensors and wearable technologies are increasingly being used in cattle and poultry farms to provide a timely diagnosis of diseases (Neethirajan, 2017). More to this, mobile Apps and drones are used to monitor animals. This implies that the functions of these occupations highlighted will be affected as some of the tasks such as monitoring of animals can be done remotely.

From the previous scenarios, not only will the scope of practice change due to advances in technology, but even the skills requirements will be affected. The integration of these technologies will, however, require ensuring the use of technology in accordance with code of conduct and ethics, as well as allowing learning of new skills required by these changes (WHO Guideline, 1980). Thoroughly examining different contexts of the 4IR under specific occupations is also key in coming up with better skills development intervention given that skills in the health sector have been a persistent challenge.

Globally, the shortage of healthcare workers is predicted to reach 12.9 million by 2035 (WHO, 2013). The WEF (2017) projects that 39% of core skills required across occupations in South Africa (SA) will be wholly different in 2020. At the same time, SA remains burdened with TB, HIV/AIDS as-well-as non-communicable diseases that require enough healthcare capacity. The problem of skills shortage is of fundamental importance because research shows that it is not disconnected from other problems of unemployment, work-loads, and overall sustainability (Rys, 2013). These problems are most prevalent within SA health care specialists and if left unaddressed, may worsen quality and inequality in health care.

Some studies refer to the 4IR as a threat that will replace human jobs on a large scale, resulting in mass unemployment or underemployment—and, consequently, widespread impoverishment—around the globe (Bruckner, LaFleur, & Pitterle 2017). Employment within different sectors is already being affected by this change. The Mineral Council SA projects that 54% of the platinum's sector's employment is at risk due to mechanization and automation (*Baskaran*, 2019). The Standard Bank announced it would be closing 91 branches as part of its efforts to digitize its retail and business banking, placing 1 200 jobs at risk. Other reports state an excess of 8000 jobs could be at risk at Absa (*Moneyweb*, 2019).

1.3 Problem Statement

It is not only that jobs will be affected by this revolutionary change, but the skills profile will also change as there would be increased demand for skilled labour (Gumede, 2018). The World Economic Forum (2016) Future Jobs Report predicts that 35% of core skills will change between 2015 and 2020 due to 4IR. It is also believed that this revolution is occurring at a very quick rate and large scale that will need all to catch up (WEF, 2017). With these views in mind and the extreme of skills shortages in the health sector, it is, therefore, justifiable to analyze the skills requirements of the South African health sector created by the 4IR to ensure informed interventions.

The aim of the study is:

- To develop a broader understanding of the implications that the 4IR may have on skills requirements for selected occupations in the health sector.

The objectives of the study are:

- Establishing the existence of the 4IR in the South African health sector.
- Identifying occupations that are affected by the 4IR in the health sector.
- Establishing the degree to which the 4IR leads to changes in skills requirements in Public Healthcare compared to Private Healthcare.
- Identifying the new skills requirements in occupations affected by the 4IR

- Exploring possible interventions to address the skills requirements.

Study Overview

Chapter 1 has introduced the study and sets the scene. Chapter 2 theoretical orientations and conceptions (including definitions and assumptions) of the 4IR, wand its implications of the South African workplace; chapter 3 outlines the methodology, design, sampling, data collection, analysis, and ethical considerations. Chapters 4 presents an interpretation and discusses the findings; and the last chapter (5), presents the summary of findings, conclusions and research implications.

CHAPTER 2. CONCEPTUAL FRAMEWORK OF THE 4TH IR

Introduction

This chapter is meant to provide an understanding of the theoretical context and empirical evidence on how the 4IR impacts on skills requirement. There is also a review of critical factors that determine the performance as a result of the IR. The subsequent analysis is provided on how countries are investing and taking advantage of the 4IR to substantiate why does it matter and provide an indication of the current and possible future demands by the 4IR.

2.1 Definitions, Conceptions, and Assumptions

This section sets the stage for key concepts, explanations, assumptions, and theories that support the relationship between the 4IR and skills requirements. This part further provides a network of different views regarding the 4IR and how it is linked to other variables excluding skills.

2.1.1 Definitions

Currently, the world has acknowledged that we are in the Fourth Industrial Revolution (4IR) which is coined by Klause Swab, founder and executive chairman of the World Economic Forum. This revolution describes a fusion of technologies that are merging the lines between the physical, digital, biological spheres and connected technology to better lives (WEF, 2017).

Prior to this were 3 other revolutions that transformed social structures and economic systems. According to Schwab (2017), the 4IR is fundamentally different from previous revolutions as it is impacting all disciplines, economies, and industries. For instance, the 1st IR which was the start of water and steam-powered machinery to shift from the reliance on the power of animals affected mainly the manufacturing sector. The 2nd IR witnessed the expansion of electricity, petroleum, and steel. The 3rd IR, on the one hand, came as a result of the use of computers and networking of computers to expand human activity from physical space to cyberspace.

The 4IR is also known as knowledge mutation and is said to be driven by disruptive technologies (Seet, Jones, Spoehr and Hordache 2018). This revolution can further be characterized by the following technologies:

Table 2: Technologies of the 4IR

Technology	Description
Artificial Intelligence	Computer sciences and algorithms - gives real-world information based analytical skills and logic to the machine. Just like machines augmented physical capabilities a century ago, AI machines are programmed to develop cognitive functions for learning and problem-solving.
Augmented Reality (AR) and Virtual Reality (VR)	Superimposes a computer-generated image on a user's view of the real world, thus providing a composite view.
Robotics	Deals with robots. Robots are programmable to carry out actions autonomously, or semi-autonomously
Internet of Things	Connects internet with physical devices
3-D Printing	Making 3 dimensional solid objects from a digital file
Autonomous Vehicles	The driverless car works on the basis of real-world information
Biotechnologies	Innovations in genetic engineering, sequencing, and therapeutics
Energy capture, storage, and transmission	Renewable energy through solar, wind, and tidal technologies; energy distribution through smart grid systems; wireless energy transfer, etc.
Design Thinking	A process of problem-solving that involves 5 steps: Whether the problem is coming up with creative ideas or figuring out how to save money, the steps are widely applicable. Technology is not yet able to fully replicate this human process, so the skill of design thinking is a valued commodity in the world of 4IR

Source: The WEF (2017).

In many ways, the table points to the likely implications of the 4IR, especially in the sector and subsectors. A range of operational activities and systems will have to be readjusted in order to keep with the demands of products and services. These implications extend to the skills development space, from both the universities and on the job training space.

2.1.2 CONCEPTIONS AND ASSUMPTIONS

2.1.2.1 Human Capital Obsolesce Theory

The Human Capital Obsolescence Theory pays attention to the nexus between technological advancements and skills. It stipulates that job-specific skills obsolescence may occur due to technological or organizational developments that change the skills demanded a particular kind of job. In that case, the skills the workers in that occupation possess are probably no longer sufficient to perform their jobs properly (de Grip, 2006). Evidently, the World Economic Forum (2016) shows that by one popular estimate, 65% of children entering primary school today will ultimately end up working in completely new job types that don’t yet exist, which implies a new set of matching skills requirements.

The task-based approach amplifies the relationship between technological developments and skills requirements. This approach specifies that due to technological advancements, there are tasks that are likely to be automated as opposed to others (Autor, Levy & Murname, 2003). The idea is that machines substitute for routine tasks performed by workers while the non-routine tasks which involve problem-solving, complex communication activities, and tacit knowledge are not easily replaceable (Ramaswamy, 2018).

Subsequent theories, therefore, explore the drive behind organizations' innovativeness as a result of technological developments. The Dynamic Capability Theory stipulates that in rapidly changing environments, organizations enhance and sustain performance by creating, extending, or modifying their resource base through investment and other managerial interventions (Evans et al, 2017). Prior research has distinguished between operational and dynamic capabilities (Winter, 2003; Teece, 2019). The ordinary capability enables the organization to perform an activity on an on-going basis using more or less the same techniques on the same scale to support existing products and services for the same customer population. Such a capability is ordinary in the sense of maintaining the status quo (Winter, 2003).

Nonetheless, with the 4IR in the picture, the status quo is expected to change, including the skills requirements. Consequently, WEF (2018) identifies three core concepts in the construction of future jobs as job roles, tasks, and skills. The task is defined as the actions necessary to turn a set of inputs into valuable outputs. As such, tasks can be considered to form the content of jobs. Skills, on the other hand, are defined as the capabilities that are needed to complete a task. In essence, tasks are what need to be done and skills define the capacity to do them. This work's definition of skills is therefore in line with the WEF report as outlined.

2.1.2.2 Systems Theory of Innovation

The human capital obsolesce theory is regarded as a subset of the systems theory of innovation which encourages a holistic approach towards working with change as a result of the 4IR (Mansoor & Williams, 2018). This approach will allow the 4IR to be translated into intended outcomes as it will go through a series of processes such as adoption, implementation, sustaining, diffusion, dissemination and scaling (Nolte, 2018). Although this study is only focusing on the relationship between 4IR and skills, it is relatively important to explore other variables that might determine the success of the 4IR.

The innovation systems approach is therefore important in understanding the interdependence and dynamic relationships between health system components, and an emphasis on studying the health system as a whole instead of individual components (De Savingy and Adam 2009, Hawe et al 2004). Primary concerns for healthcare according to (Mansoor & Williams, 2018) are largely on capacity which includes skills requirements, decentralization and health financing, prioritizing infrastructure, environmental concerns, education, and access.

An example of a systems approach that will enable innovation to be translated towards desired intention will entail a model that is made up of 4 levels (Reid, Compton, Grossman,& Fanjiang 2005). According to Reid et al (2005), at the centre of the systems healthcare approach is the individual patient whose needs and preferences should be the determining factors. The 4IR in this regard should support evidence-based, effective, efficient care encompassing the patient's medical record, including real-time physiological data; the most up-to-date medical evidence base; and orders in process concerning the patient's care.

The second level of the systems approach to healthcare is the care team which consists of the individual physician and a group of care providers, including health professionals, patients' family members, and others, whose collective efforts result in the delivery of care to a patient or population of patients. The care team is the basic building block of a “clinical microsystem,” defined as “the smallest replicable unit within an organization [or across multiple organizations] that is replicable in the sense that it contains within itself the necessary human, financial, and technological resources to do its work” (Quinn, 1992).

The third level of the health care system is the organization (e.g., hospital, clinic, nursing home) that provides infrastructure and other complementary resources to support the work and development of care teams and microsystems. Bankole, Osei-Bryson & Brown (2014) noted that telecommunications infrastructure is critical to enhancing efficiency, effectiveness, and transparency in an organization. The 4IR fits in here as it is dependent on telecommunications infrastructure.

The final level of the health care system is the political, economic (or market) environment, which includes regulatory, policies, financial, and payment regimes and entities that influence the structure and performance of health care. In South Africa for example, the government’s current economic policies are restrictive and hamper the ability to adapt timeously to the 4IR movement (Christian, Unathi, & Amy, 2018). With the advent of providing a better understanding of the impact of this technological drive, a holistic approach to how the 4IR can be translated into intended outcomes is of the essence.

2.1.2.3 Critical factors for innovation performance in an organization

Organizational capabilities are essential to realizing the intended outcome on performance as a result of the 4IR which in this case is regarded as an innovation. It, therefore, makes sense to review some of the critical factors to fully unlock this impact of innovation. The main idea is that innovation does not only need to be efficient and competitive but also equally important for economic and wider socio-wellbeing, that are robustly deliberated, accountable and legitimate as possible (Stirling 2010).

There are therefore identified critical success factors that organizations need to realize a full impact on performance, and these will be linked to changes that come as a result of the 4IR below:

Innovation Strategy: Beer & Beer (2002) stated that without a proper innovation strategy, organizations can easily pursue conflicting priorities. This means that organizational strategic direction is critical in determining the way any innovative change will be received. Specifically, findings from Kalay & Lynn (2015) confirm a positive impact of strategy for innovation on innovation impact.

Awareness for innovation: Besides an organization having a clear direction on its innovation strategy, of importance towards realizing the intended innovation impact is employee awareness and readiness to adopt such changes. Hoai Nam, Phong Tuan, & Van Minh (2017) further adds that for successful innovation, the process includes awareness of innovation, attitude formation, evaluation, decision to adopt, trial implementation and sustained implementation.

Human Resource for innovation: Having the right human resources is another element identified as key to creating a conducive environment for innovation performance. Shipton, West, Dawson, Birdi, & Malcolm (2006), highlights that it takes a package of human resource management practices such as training, appraisals, and induction to develop skills, knowledge, and attitudes needed for innovation implementation.

Perception towards innovation: Perceptions compared to the real impact of technological developments are another important element towards the final impact on performance. For instance, there is a general perception that the 4IR is taking over existing jobs and this has created fear among employees today (Ghislieri, Molino, & Cortese, 2018). On the other hand, there are arguments that the jobs lost will be overcompensated by the creation of new jobs from technological developments (World Bank, 2009). These perceptions will consequently influence the rate of adoption of technological changes.

The current stance of the South African health sector is faced with several uncertainties and misconceptions around the NHI Bill and its funding model as well as resource capacity. The above theories and assumptions confirm that the 4IR can pose similar challenges if not implemented carefully. Transitions into these technologies will require numerous variables in place to ensure optimum use from technological advancements.

2.2 Impact of the 4IR on the health sector performance

The adoption of Health Information Technology (HIT) applications may lead to improved quality of care by reducing medical error (Chandak, 2016); encouraging evidence-based guidelines (Cannon & Allen, 2000); reducing inpatient days (Mullet et al.,2001); improving appropriateness and filling time of medication orders (Chen et al., 2007); enhancing integrated data review (Schnipper et al., 2008); and improving medication and non-medication quality of care measures (Yu et al., 2009); cost savings (Anderson et al., 2006) reduced adverse drug reactions, and improving compliance to practice guideline (Alotaibi & Federico, 2017).

Other benefits of technological advancements from innovation include improved communication, access to information and effective monitoring (Bates et al., 2003) reduced mortality rates (Amarasingham et al., 2009); addressing the problem of information asymmetry between patients and providers as well as among providers; increasing the value of the available information in the hospitals; and increasing the value of the healthcare providers in order to keep them competitive in the market (Burke et al., 2002); improved access and health care services delivery (Bianchi & Labory, 2018).

While the 4th IR has its benefits within the health sector, the integration of technology into the health system requires greater investments in infrastructure; new policies to regulate the services and maintain a standard of quality service delivery (Uwaliraye, Ndimubanzi, Muhire, & Lyle, 2019). There are also challenges around data protection and ethics on sharing patient healthcare information with an attempt to make money (Montoyer, 2018). Others argue that the 4IR may result in increased inequality as the 4IR technologies are generally dependent on high speed (broadband) internet, which is uneven for different places (Asia & Pacific, 2001).

2.3 Empirical evidence of the implications of 4IR on healthcare performance

Globally, the rest of the world is investing in digital health, technology-enabled care, and mobile health to improve efficiency, accessibility, and affordability (Deloitte, 2018). Evidence quantifying these contentions exists and can be used as lessons on how SA can take advantage of technological advancements. The US government invested

$250 million in 2010 towards the Beacon Community Programme to build and strengthen health IT infrastructure. This program resulted in increased prescribing to 86.3 percent and improved patient and family engagement to 85.1 percent in 2012 (Jones & Wittie, 2015). Another study in the US found that hospitals that adopted electronic health records (ERH) experienced a decline in medication error from 66.6 percent to 55.2 percent (Silow-Carroll et al, 2012).

The United Kingdom has identified the potential in the telecare market and has committed 37.5 million pounds in 2018 towards technology-enabled care (Deliotte, 2018). The use of telecare has created benefits in clinics between 2008 and 2009 with a fall in bed days and a 10.8 % reduction in emergency medical admissions which saved them 2.4 million pounds (Taylor, 2012). Likewise, the use of healthcare apps has more than doubled in the UK and this has resulted in remote patient booking management and appointments, and a secured view of patients' medical records (Topol, 2019).

Coming to Africa, Rwanda is supposedly the pioneer in digital health care as it was the first country to use drone technology to deliver blood supplies through partnerships with Zipline company based in California. These drones have made more than 13,000 deliveries, about a third of which have been in emergencies when someone's life was on the line (McNabb, 2019). The Rwandan government also partnered with Babylon's digital health from the UK to launch Babyl Rwanda. The main aim of this initiative is to put affordable and accessible health care across the world. Babylon is said to offer 24-hour-a-day, 7-day-a-week access in some countries to a health professional through virtual consultations (Wakoba, 2019).

Other African countries that have followed suit regarding digital and mobile health include Ghana, Kenya, Botswana, Uganda, and Tanzania. The use of drones through the Zipline drone company has stretched to Tanzania and Ghana. In Ghana, operations will be in 4 centres, with each equipped with 30 drones and deliver to 2,000 health facilities, serving 12 million people across the country and with the capacity to make up to 500 flights each day (de Leon, 2019). In Kenya, health technology has improved antiretroviral medication compliance by 11 percent while Botswana's mobileenabled programme reduced government response time to malaria from four to three months (Deloitte Centre for Health Solutions, 2015).

South Africa has adopted a number of digital mechanisms geared towards addressing the inequalities and challenges faced by the health sector. The National Health Laboratory System (NHLS) can be used as a great example which was established in 2000 and went through extensive laboratories upgrade in 2016. Included were the automated machinery for validating Rapid Plasma Reagin (RPR) test which improved the quality and turnaround times of tests. The HIV Viral load test turnaround time improved from 32 percent of test results in 96 hours to 81 percent of tests in 92 hours. There was also a survey carried out on customer satisfaction regarding NHLS, which presented 72 percent customer satisfaction (NHLS Report, 2016).

Recently, South Africa joined the use of drones with the South African National Blood Service (SANBS) launching a new drone blood delivery service in May 2019. The drone has a range cover of over 100km including rural areas and can travel up to 180km/h (*Coetzee, 2019*). The South African National Department of Health (NDoH) also launched the MomConnect App in 2014 as a health initiative aimed at supporting maternal health through the use of cell phone technologies. Another app initiative by the NDoH was one for standard treatment guidelines and essential medicine list for primary healthcare in 2015.

There is further progress made regarding the use of digital technologies at the provincial level, and the Western Cape (WC) and Gauteng Province (GP) are making impressive headway. The WC has introduced automated dispensing services which is relieving pharmacy staff from repetitive and time-consuming tasks. Another development by the province is the electronic prescribing of medicines and a single integrated Pharmacy IT System which allows prescribers to have access to accurate information about the medication and medical history of the patient (Western Cape Government, 2014). The GP introduced an Impilo App aimed at health literacy and education. The province also launched ATM Pharmacy automation which eliminates long queuing hours; improves access to medication and enhances staff efficiency (*Kwinika, 2018)*.

Although the above studies present benefits arising from 4IR on healthcare performance, other studies question the reliability of the 4IR on unregulated Apps. For example, O'Neille and Brady (2012) found that only 32 percent of colorectal themed Apps had named medical professional involvement in their content. Similarly, in another study by Visvanathan et al (2012) analyzed the accuracy and reliability of the content of apps used in the diagnosis and patient management. Of 94 microbiology-themed apps they surveyed, only 34% had stated medical professional involvement. The lack of medical professionals involved in the design of the majority of these apps undermines users' ability to be informed regarding app content quality.

Other schools of thought argue that there is no direct correlation between introducing digital technologies and the health sector's improved performance. This was indicated by Kayyali et al (2017) who found that despite the growing number of mHealth apps in the UK, the level of awareness and usability of such apps by patients and pharmacists was still relatively low. Another argument is the lack of information management which is of greater importance in influencing performance rising from technological advancements (Mithas, 2011). Another concern is the lack of security investment for the use of electronic health data which has resulted in fewer patients participation in installing Apps or providing information (Beyala, 2017).

2.4 Impact of 4IR on roles and skills

Despite identified technological performance barriers, the success of technological support systems is highly dependent on a culture of learning as it is reliant on developed skills (Thomas, 2016). The idea is that with the 4IR in the picture, there will be increasing roles that require specific skills to support the changes. Roux, Viljoen, & Samson (2019) distinguishes between those roles in the health sector in South Africa that will be increasing against those that will have a decline due to the 4IR. The argument is that increasing technology is expected to create wholly new roles and tasks—from specialist data scientists to application (app) development to piloting drones to remotely monitoring patient health to certified care workers—all opening up opportunities for an entirely new range of livelihoods. Below is a list on predictions of increasing and decreasing roles within the health sector:

Table 3: Predictions of Roles in the Health Sector

Increasing roles	Decreasing roles
Recreational wellness therapist	Medical clinical lab technologists
Nurse practitioner	Medical transcriptionists
VR experience designer	Medical records and health information clerks
Drone monitors	Pharmacy aides
Home health aid	Medical equipment preparers
Online diagnosis	Dental lab technicians
Care-bots	Dental hygienists
Medical tourism	Opticians-dispensing
co-bot surgeon	Trainers
App developers	Medical insurance claims clerks
Geriatric Carer	
Geneticist	
Wellness mentor	

Source: Roux, A., Viljoen, D., & Samson, D. (2019)

These increasing roles will then require specific skills set to ensure new employability and current workforce transition into the new roles. A study by Subic & Gallagher (2017) identifies categories of skills that will be required to drive the 4^{th} IR as digital skills, project coordination skills, and soft skills. Similar research by McKinsey Global Institute (2018) reported that time spent using advanced technological skills will rise by 50 percent in the US and by 41 percent in Europe by 2013. More to this, among 25 skills that were analyzed, basic digital skills were the second-fastest-growing category, increasing by 69 percent in the United States and by 65 percent in Europe. Specific to the health sector, this work found that demand for advanced IT skills, basic digital skills, entrepreneurship, and adaptability will see the largest double-digit cumulative growth.

Another work by Flak (2001) is of the view that digitization means that 90 percent of jobs now require IT skills – even the traditional ones. This view was supported in a survey from the European Union which found that more than 50 percent of health professional participants (physicians; nurses; midwives; dentists; health assistants and technicians) use basic IT skills daily and digital skills more than once a week (Giedrojc, 2017). Akomolafe (2014) established key skills towards successful and efficient use of EHR by health professionals as good leadership, managerial and communication skills. An Ireland report revealed that upskilling and reskilling stood at

70 percent between 2012 and 2018 to complement the already existing skills (Department of Education and Skills, 2019).

The above posits and findings imply that at issue should be how technological developments affect skills tailored for specific occupations in the health sector as their roles are likely to be different. It can also be stipulated that the misalignment in the demand for skills for the new roles created by the 4IR and the current skills acquired by the health sector workforce can be detrimental towards the full performance of the sector. Proactive retaining, upskilling and reskilling will, therefore, be required towards sustainability of the sector in the presence of the 4IR.

CHAPTER 3: METHODOLOGY

3.1 Introduction

Through an application of research methodology and design, this chapter provides an understanding of how the impact of the 4IR on changing skills requirements will be answered. The outline of this section firstly presents the Research Methodology and Design that have been used. Furthermore, the section presents a discussion of the target population, sampling, sources, and analysis of data then follows. It also makes sense to provide a clear measure and definition of 4IR in this chapter.

Innovation is regarded as the heart of 4IR, which in health care is related to product, process, or structure (Varkey, Horne, & Bennet, 2008). The product is what the customer pays for and typically consists of goods or services. Process innovation entails innovations in the delivery method. Einspruch and Omachonu (2016) therefore define healthcare innovation as the introduction of a new concept, idea, service, process, or product aimed at improving treatment, diagnosis, education, outreach, prevention and research, and with the long-term goals of improving quality, safety, outcomes, efficiency, and costs. This work's definition of the 4IR is therefore in line with the works that identify innovation as the most inclined measure of 4IR.

3.2 Research Methodology and Design

This study uses a mixed-method approach in evaluating the impact of 4IR on the health sector changing skills, which is often employed to provide a more comprehensive analysis of the research at hand (Creswell, Plano & Clark, 2011). Mixed methods designs are also helpful for understanding the perceptions of practitioners and end-users of given evidence based.

The study is exploratory in its design, as it seeks to discover causal relationships between variables or events. Exploring this relationship is done in several ways, and firstly through understanding why organisations partake in the 4IR in the first place. This part is meant to provide validation on the need if any to complement human resources with technology and hence build on skills development. There is further focus on causal relationship between the 4IR and skills. This part is meant to explore whether the 4IR necessarily causes skills to change or skills can also be a cause of innovation/4IR.

Another way of testing some of the explanations of the 4IR is done through exploring the skills requirements created by the 4IR as per specific occupation. This will be to determine which occupations are mainly shifting in terms of skills as a result of 4IR. This is done through using quantitative analysis where the ordering of occupations was done according to the most and least likely to be affected by these changes in technology.

3.2 Target Population and Sampling

The criteria of selection for the target population that I applied was mainly guided by the findings from the HWSETA 2019 SSP on the hard to fill (HTF) vacancies. These findings provide an indication of occupations in which more than 20 vacancies remained unfilled as a result of different factors such as budget limitations to recruit; scarcity of candidates; geographic area; employment equity consideration; experience; qualifications as well as the scarcity of specialized skills.

Hard-to-fill vacancies (HTF)

- Regarded as one of the clearest indicators of skills shortages is vacancies that remain unfilled for long periods of time despite employers' active recruitment efforts.
- The employers that submitted WSPs to the HWSETA and the PSETA in April 2019 reported a total of 9 001 hard-to-fill vacancies…distributed over 114 occupations.
- Most (73.5%) of these vacancies were for professionals or for technicians and
- associate professionals (13.5%).

Table 4 below presents a list of some of the HTF vacancies which provide a clear indication that both private and public health sector suffers mainly from a shortage of medical doctors and specialists and registered nurses. This shortage has been persistent even for previous years and one can argue that the current skills development system might not be adequately addressing the skills needs in the health sector. It is important to address all avenues that might be the stumbling blocks towards obtaining this objective of reducing these occupations that remain unfilled for a long time.

Table 4: Hard to Fill Vacancies

Occupations	Private	Public	Total
Registered Nurse (Disability and Rehabilitation)	50	1271	1321
General Medical Practitioner	10	888	898
Registered Nurse (Medical)	780	47	827
Nursing Support Worker	1	714	715
Enrolled Nurse	480		480
Registered Nurse (Critical Care and Emergency)	79	314	393
Midwife	45	233	278
Clinical Nurse Practitioner	71	197	268
Registered Nurse (Child and Family Health)	10	239	249
Hospital Pharmacist	36	208	244
Registered Nurse (Medical Practice)	12	212	224
Ambulance Officer	0	170	170
Physiotherapist	70	94	164
Medical Diagnostic Radiographer	38	93	131
Dietician	14	96	110
Retail Pharmacist	106		106
Specialist Physician (General Medicine)	8	96	104
Registered Nurse (Operating theatre)	48	55	103

Source: SSP, 2019.

Although table 3 above presents extreme shortages particularly in areas of specialists, there are other occupation-specific skills otherwise known as critical skills required within specific occupations which can contribute towards having these occupations unfilled. These skills can be aligned with technology know-how and use; hence it becomes important to fully distinguish these skills needs according to the 4IR.

The technique used for sampling in this study is referred to as “purposive sampling”, which is a non-probability sampling technique that is used in the research that does not aim to generate results that were used to create generalizations pertaining to the entire population (Etikan, Musa, & Alkassim, 2016). In this case, the entire population consists of different occupations within the public and private health sector that require different specialized skills in terms of the 4IR, and hence generalization will not be applicable.

The sample, therefore, consists of 11 occupations listed in table 5 below. The targeted response from the sample was representative of a responsible manager who works directly under the occupation and has expertise in the occupation to provide valuable information regarding how advances in technology are driving the skills needs if any. There is an option to also accommodate the Human Resource Development (HRD) or training manager who is responsible for the entire value chain of HR including adding value through training and development.

Table 5: Sample Representation and Motivation

Occupations	Targeted responded	Motivation
Specialist Physician	A manager or HRD Manager	Overseeing operations under occupation or oversees training and development
Radiation Oncologist	A manager or HRD Manager	Overseeing operations under occupation or oversees training and development
Medical Diagnostic Radiographer	A manager or HRD Manager	Overseeing operations under occupation or oversees training and development
Dental Specialist	A manager or HRD Manager	Overseeing operations under occupation or oversees training and development
Physiotherapist	A manager or HRD Manager	Overseeing operations under occupation or oversees training and development
Cardiologist	A manager or HRD Manager	Overseeing operations under occupation or oversees training and development
Pathologist	A manager or HRD Manager	Overseeing operations under occupation or oversees training and development
Biomedical Technologist	A manager or HRD Manager	Overseeing operations under occupation or oversees training and development
Emergency care specialist	A manager or HRD Manager	Overseeing operations under occupation or oversees training and development
Nursing	A manager or HRD Manager	Overseeing operations under occupation or oversees training and development
Phlebotomy	A manager or HRD Manager	Overseeing operations under occupation or oversees training and development

3.3 Data Sources

The dataset that forms the basis of this work was done through a result of Semi-Structured Interviews with both public and private employers. From the private sector, the employers are chosen according to some of the biggest employers in terms of reach which was made up of Mediclinic; Netcare; Life Health Care and Lancet Laboratories. The public sector is chosen according to those hospitals that provide highly specialized skills which might be linked to 4IR. This representation is made by the following Central Hospitals: Chris Hani Baragwanath Hospital; Steve Biko Hospital in Gauteng; Charlotte Maxeke Academic Hospital (Gauteng) and the University Hospital in the Free State.

The interviews were conducted with skills development managers responsible for facilitating the training needs of employees or the responsible managers for the identified occupations. The questionnaire design is such that it becomes permissible to explore the “what” the 4IR is, “why” does it matter and “how” it impacts on skills requirements and eventually addressing the objectives of the study.

3.4 Data Analysis

In this study, I used a general analysis looking at the relationship between 4IR and skills. The interview questions came from open-ended questions that allowed new ideas coming out of the interview. Interpreting information received was be coded to allow measurement and ranking when determining which occupations are mainly being driven by this change. Definition and measuring 4IR is derived from the organization Dynamic Capability Theory which explains how organizations respond to changing environments. This is then measured from organizations' investment in innovation by introducing new products/designs/package/methods/services.

3.5 Ethical Considerations

The process of collecting, capturing, storing and preparing the data for this research analysis was in line with the following ethical standards: Ensuring quality, integrity, and honesty; consent form to be signed by participants; informed consent from HWSETA as a request for participation in the study; respecting the confidentiality and anonymity of respondents; ensuring that this research is independent and impartial, and avoiding any harm to participants.

3.6 Validity and Reliability

The sample representation is made up of managers who are a panel of experts in the different occupations chosen, or Human Resource Development (HRD) managers who oversee the human resource process including the type of training required for employees. The sample is also representative of majority of occupations chosen which make up a total of 9 out of 11. The questionnaire design of the study is valid as questions asked addressed the specific implications that the 4IR on skills requirements in the health sector.

3.7 Limitations of the study

The data collection process encountered challenges as participants were resistant to participate. This reduced the sample representation of selected occupations as the Nursing and Dental Specialists were not represented by specialists. This also affected the scope of analysis for the study. At organisation level, while some of the organizations did not provide feedback on reasons for not participating, some of the reasons for not participating included busy schedules and lack of interest. The lack of interest to participate could be a bad indication of the kind of relationship between HWSETA and its stakeholders or that the participants did not find the research at hand valuable.

For those participants that were unavailable due to busy schedules for either a face to face interview or telephonic interview, there were further proposed options to have questionnaires filled and returned electronically, but still there was no response due to lack of interest. This reduced the number of occupations from 11 to 9. Nonetheless, it must be noted that some managers responded on behalf of occupations they were not representing or specialists on which included the Nursing occupation.

CHAPTER 4: INTERPRETATION AND DISCUSSION OF FINDINGS

4.1 Introduction

This chapter provides the analysis of and the research findings. The findings relate to the research questions that guided the study. Secondary data was analyzed to identify, describe and explore the relationship between the 4IR and skills. This was done using questionnaires for different occupations in the selected sample. Only 2 private institutions responded from a target of 4. From the 2 organizations, 4 occupations were represented. The public sector's participation surpassed the private sector with 3 institutions participating for a total of 5 occupations. In total, 9 occupations out of the chosen sample of 11 occupations were then represented.

4.2 Establishing the existence of the 4IR in the South African health sector

Understanding why and whether the 4IR exists is important in unpacking the relationship between 4IR and skill requirements. This can further ensure that the skills gaps if any in the health sector are a result of the 4IR and nothing else. The majority of respondents representing 80% of occupations confirmed that there is some form of 4IR in the health sector which comes mainly in the form of new technologies in equipment and electronic communication devices.

Particularly, for occupations under Medical Technology who operate in labs, there have been new technologies put in place such as Auto Tracks which carry samples around to various analyzers. These tracks would require 2 to 3 people per shift unlike previously when one shift required 10 people. Other technologies include the Next Generation Sequencing Technology which does parallel and multiple processing at reduced costs. There has also been a shift from manual to the use of Mass Spectrometry Technology to genetically determine the identity of bacteria. Pap Smear used to be done manually but the Cytology Screening using machines that improve screening by about 30 percent.

Similarly, there are constant new imaging and delineation equipment and software with new radiation equipment bringing in new radiation techniques under the Radiation Oncologist occupation. These technological developments are essential to ensure more directed radiation to ensure accuracy. For example, these technologies allow higher doses to be targeted for the main tumour while lower doses will be targeted for the spread.

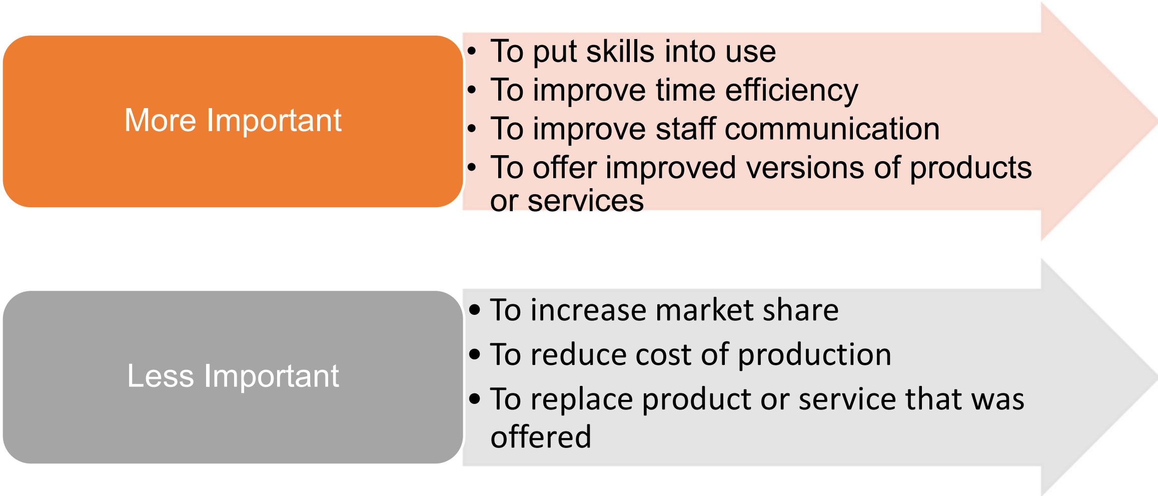
4.3 The degree to which the 4IR leads to changes in skills requirements in public Healthcare compared to Private Healthcare

The notion of whether skills are put at the centre while the 4IR takes place was also explored. Different views came from the public and private sector which provides an indication on how the 4IR leads to changes in these two. For the private sector, it appears that although skills are still relevant, technology is moving so fast that organizations continuously innovate to become competitive. This implies that the skill demanded have to follow innovation. This is also in line with the nature of the private sector which is always focusing on competitiveness and profitability.

As for the public sector, the skills can determine the decision to innovation where workers are highly skilled yet there is no technological equipment for practical use. As a result, there were cases where the 4IR was introduced to put skills into use. An example is under heart transplant, where there are skilled workers in some organizations yet with no equipment and resources to practice and pushes for the introduction of new technology. From this, it implies that there is a causality effect between the two variables where the cause and effect can be interchanged for skills and 4IR. More to this, the findings confirm the level of inequality that still exists with the public sector lagging in technology as opposed to the private sector.

More reasons became apparent when understanding why the 4IR was introduced in organizations in the first place. The figure below shows that the 4IR is valued according to different reasons that can be ranked according to relevance. In terms of priority, the response indicated that putting skills into use; improving time efficiency and improving staff communication matter the most while innovating. This response cut across both public and private institutions and shows that the 4IR results in an improved way of doing things in an organization.

Figure 2: Why Organizations Innovate?



It is not surprising that other factors such as increasing market share, reducing the cost of production and replacing the product or service that was offered fall under the less important factors while innovating. This is in line with the values of the public sector particularly health which are not profit-orientated, bearing in mind that the majority of participants were represented from the public sector. A different picture might have been depicted if most responses were from a private domain, whose model is mainly profit-oriented above all other factors.

4.4 Identifying occupations that are affected by the 4IR in the health sector

Response from the employers shows that the 4IR has resulted in changes in the skills requirements for the chosen sample. This is not surprising as the health professionals will need new skills to utilize the new technologies identified under each occupation. The findings are in line with the human capital obsolescence theory which predicts that technological developments will result in changes in skills demanded a particular job whereby the skills employees possessed become redundant.

More findings on the impact of skills show that there are those occupations that are more likely to be affected by technological changes while others will be less affected. The table below shows technological advancements affecting the chosen sample of occupations in different ways. The ranking is from 1 being the most likely and 2 representing the less likely occupation to be impacted from changes coming from the 4IR.

Table 6: Occupations Ranking According to the 4IR Impact

Most Likely Occupation	Ranking	Less Likely Occupation	Ranking
Radiation Oncologist	1	Physiotherapy	2
Specialist Physician	1	Emergency Medicine Specialist	2
Medical Diagnostic Radiographer	1	Dental Specialist	2
Cardiologist	1	Nursing	2
Medical Technologist	1		
Pathologist	1		
Phlebotomy	1		

These findings further confirm the task-based approach which postulates that the non-routine tasks are not easily substituted by technology as compared to the routine task. This can mainly be experienced with the physiotherapy occupation whose role does not include routine tasks as their role is extremely varied according to patient injury diagnosis and treatment plan. More to this, the human touch remains a significant part of the physiotherapists even though their role can be technology-assisted.

Coming to other occupations such as the Emergency Medicine Specialists, Nursing and Dental Specialist, the expectation would be that there would be a high likelihood of impact from technological advancements. However, given that response was mainly from the public sector as opposed to private, the implication may be that there are not enough advanced technologies resulting in changes in skills requirements in these occupations.

For occupations like Radiography, Pathologist, Phlebotomy and Medical Technologist, it was expected that technological advancements are mostly impacting on skills requirements. This is in line with some of the characteristics that these occupations fall under which require cognitive skills such as information processing, logic and pattern recognition which are essential in their daily roles. This was mainly emphasized under-identified increasingly new technologies driving these occupations which include computer-assisted diagnosis used for more informed diagnostic, accuracy and reliability which in turn requires cognitive skills.

4.5 New Skill Requirements from the 4IR in occupations affected

The general concurrence is that technology is changing the way work is being done in the identified occupations above and what differs is that some will be affected more than others. As a result of this change, new skills are required in almost all occupations and this section provides a discussion of these per occupation. The common consensus is that in the process of implementing technological advancements, there is some form of basic training that takes place through machine and equipment suppliers. However, it was noted that over time, workers are not confident enough going forward to operate the new equipment. Consequently, new skills are required to ensure that workers are confident and can work hand in hand with technology.

Table 7 below presents findings on the suggested new skills requirements as per specific occupation which respond to specific change that is taking place in these occupations.

Table 7: New Skills Requirements from 4IR

SKILL REQUIREMENTS	***PHYSIOTHERAPY***	***RADIATION ONCHOLOGY***	***SPECIALISATION:***	***SPECIALISATION: EMERGENCY***	***MEDICAL DIAGNOSTIC RADIOGRAPH***	***CLINICAL TECHNOLOGY: CARDIOLOGY***	***BIOMEDICAL TECHNOLOGY***	***PATHOLOGY***	***PHLEBOTOMY***
Diagnostics (Non-invasive, Remote, Telemedicine, heart valve)	✓		✓	✓	✓	✓			
Imaging skills (reading, interpreting, evaluation) 4dimension imaging from new radiation equipment		✓							
Investigation skills (Central Venous Pressure and Arterial line insertion)		✓	✓						
Therapeutic skills (Pneumatic exoskeleton for paralysed patients)			✓						
Data Science				✓					
Data Analytics				✓					
New Radiopharmaceuticals					✓				
Sonography									
Radiography: Nuclear Medicine									
Machine learning skills					✓				
Specialisation: Extracorporeal Membrane Oxygenation skills						✓			
Remote cardiac monitoring						✓			
Cardioversion						✓			
Business survey skills							✓	✓	✓

Financial Skills							✓	✓	✓
Multi-tasking skills and customer focus							✓	✓	✓
Interpretive skills							✓	✓	✓

The above skills requirements can be summarised according to categories in table 2 below. Categorizing the skills needs becomes important in directing HWSETA in executing plans and necessary interventions. For instance, the soft skills identified indicate that the general skills required for the daily work environment remain essential. Other skills that are technical also play a key role as they are specific to knowledge and abilities to perform work. The graph further indicates more of the technical skills that will be needed as a result of the 4IR compared to other categories.

Figure 3: Categories of Skills Requirements

4.6 Possible interventions for the sector to cope, adjust and adopt

It was of relative importance to understand from occupation-specific manager and HR training manager's perspective, on how best the sector can cope, adjust and adapt to the identified changes that come as a result of the 4IR. This part gives focus on these perspectives per specific occupation that were represented. It must be noted that the response was not only limited to skills development and it is useful in understanding different dynamics associated with the functionality of technology.

Radiation Oncologist: “Training sites need to be equipped with the latest technology to ensure skilled specialists and training sites need to be involved in clinical trials”.

Cardiologist: “The Cardiovascular Perfusion students are taken through simulation prior to entering the theatre environment and working with the heart-lung machine on patients. Therefore, simulation is a definite asset to increase the exposure of students to real simulation under simulation environment”.

Specialist Physician: “VR or AR training for skills improvement such as endoscope investigations and treatments, safe line insertions, sonography for diagnostic and biopsy”. This coincides with the identified increasing role of VR experience designer in the literature.

Medical Diagnostic Radiographer: Continued engagements with the SETA and its stakeholders, as well as research on what is happening in the sector concerning technological changes. Assisting with the right pipeline into the sector through the funding of students in Diploma. Funding in this area can act as a catalyst towards the desired skills as far as skills are concerned. Specialized training required in this occupation to enable workers to work confidently with the new technology.

Biomedical Technologist, Pathologist, and Phlebotomy: Change management across board and shifting from process-focused to be more patient-focused given that the efficiency element will now be taken care of by machines. This includes the process of managing employees through good communication and ensuring employee readiness to change. Upskilling is also key as well as teaching people how to problem solve and multi-task. Importantly having conversations and continued research around these changes remain key in order to keep up.

One of the respondents’ who was not representing any occupation emphasized that familiarising employees with new technology is of value in ensuring that the 4IR is directed towards the desired impact. This was based on a scenario that occurred in a hospital, where there was an introduction of new technology and the reception from workers was not desired due to lack of confidence, attitude and willingness to adopt. This led to workers vandalizing the equipment due to frustrations and lack of confidence in using the high technology equipment.

The above findings depict consistencies around theories and some of the critical factors identified for performance rising from the 4IR. Firstly, the structure of the health sector has proven to be dynamic in nature with organizations constantly changing and enhancing performance. At the same time, this work shows that ensuring alignment of the current human resource into transitions that come from technologies remains key to ensuring the desired impact of the 4IR. This includes employee awareness and education around understanding the need for technological changes being implemented.

Lastly, the shared sentiments from this work are that any organizational change such as technology requires a systematic approach whereby a more holistic intervention will be needed. For instance, organizational resources such as advanced technological equipment as well as organizational change management will all play part in taking advantage of the 4IR.

CHAPTER 5: SUMMARY, CONCLUSION, AND RECOMMENDATIONS

5.1 Introduction

This work set out to develop a broader understanding of the skills requirements created by the 4IR in the South African health sector. This was done firstly by understanding why organizations introduce technology in the first place in cases where it existed, before exploring how it impacts skills. General findings from this aspect confirm that there are transformations in the structure of the labour market, with 80% of organizations constantly introducing new machinery, improved services, improved logistics and new organizational methods in practice which changes the nature of work.

5.2 SUMMARY OF FINDINGS

These changes in technology have further proven to be positively linked with organizational efficiency in terms of time, cost, communication, and accuracy although it can come at a cost of a number of workers required per task. Being mindful of these advantages, it can as well be highlighted that not only will competitiveness be attainable, but even addressing other challenges faced by the health sector such as accessibility and affordability be addressed.

From the literature point of view, this research highlighted some of the critical success factors which can act as either enablers or barriers to obtaining the desired impact of the 4IR. These can be reflected as lessons and foundation required before any implementation of the 4IR. For instance, factors such as awareness and different interpretations around the impact of 4IR on jobs need to be dealt with. The skills planning in this aspect need also to be cognisant of the exponential pace that the 4IR is moving at, which will require a constant change in knowledge and skills to adapt to the health sector. This would also imply constant efforts towards research and engagements aligned to the 4IR and skills have given nature and pace technology is moving at.

The changes in skills requirements vary by occupation, and so it is vital to understand the occupation-specific outcomes of the fourth industrial revolution to inform specific intervention. For example, for occupations such as Radiation oncologists; Emergency Medicine Specialists; Biomedical technologists; Pathologists and Phlebotomy, they seem to require similar skills such as diagnostic and interpretive skills. For other occupations such as the Specialist Physicians and Cardiologists, the skills needs are specifically designed for the type of work they do. As an example the identified skills required namely the Central Venous Pressure and the Arterial Line Insertion are specific for the diagnostic information of the heart and arterial system.

The link between the 4IR and skills shows a general concurrence that putting skills into use forms a crucial part of why organizations introduce technological developments. Particularly, skills play an important role when it comes to working concurrently with 4R technologies. There are those skills that are continually reflected as requirements for most occupations which have been identified as diagnostic and interpretive skills. Skills requirements, however, go beyond expertise and technicalities, as soft skills such as multitasking and reading which are identified as key in the 4IR.

Education plays a further role in equipping learners with the right skills for the 4IR, and unfortunately, the current curriculum in South Africa does not allow such, as skills gap evidence also implies that the education structure is still lagging in curriculum and practical skills that are aligned to the 4IR. This does not only affect the 4IR skills requirements, but it also affects the future job placements of such learners in technologically advanced occupations as they are not well equipped for technologies of the 4IR.

The general conclusion reached is that the type of skills now demanded by employers within the identified occupations do not match those existing for the 4IR as there have been new skills demanded identified for each occupation. The new skills needed are also not the same across occupations and adjustments in skills development need to be done cordially. Lastly, there is still some level of inequality regarding technological advancements between the private and public sectors with the public sector less capacitated in technology.

5.3 RECOMMENDATIONS

Whilst empirical literature provides evidence on strides made on investments towards the 4IR within the South Africa health sector, findings show that investments specifically directed towards skills development may not necessarily be enough in the sector and may not be even across the public and private sector. This leaves HWSETA with an immense task concerning education and skills development.

It is worth referring to HWSETA's mandate which is to coordinate skills development; ensure that employees acquire skills they need; enhance skills development of those already employed and ensure training takes place in accordance with the standard national framework (DHET, 2019). This is obtainable through the facilitation of training programmes such as workplace training, work readiness training as well as technical training. This will ensure that HWSETA's intervention is within the scope of authority given.

Based on HWSETA's position and mandate, HWSETA's intervention should eventually be directed towards skills development for the 4IR in the sector. Firstly, HWSETA as the donor has the capacity to influence the packaging of training offered for different occupations to be re-evaluated according to the skills demanded by the 4IR. This intervention can be through the up-skilling and re-skilling of those that are already in the workplace to ensure catching up. This can be obtained through tailored skills development training courses aligned to the 4IR in each specific occupation or according to the category of skills such as technical or soft skills.

Not only will skills re-valuations for the employed be essential, but the content of the qualification offered in institutions and facilitating education relating to technology will be of great importance for ensuring sustainable pipeline into the sector. This includes exposing learners to technology in all learning levels including TVET colleges as well as ensuring innovation from the teaching side. Consequently, thereof, the problem of quality of learners coming from TVET colleges will be accounted for and the process of job placements will be eased. The recommendation here is for HWSETA to strengthen the strategic partnership between TVET colleges, employers and HWSETA which is directed towards innovation at colleges.

Lastly, given that the employers are inadequately capacitated regarding the 4IR aligned skills, the researcher strongly recommends future research to cover more categories of employer organisations in the health sector, and investigate 4IR in the social development sector. Another angle of proposed research is to explore the effectiveness of the 4IR in the health sector for those employed. This will also address the value proposition of the 4IR in depth. Further research recommendations are

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