Acta Commercii - Independent Research Journal in the Management Sciences
ISSN: (Online) 1684-1999, (Print) 2413-1903

Competitiveness of a clinical laboratory within the Fourth Industrial Revolution

Authors:
Blessing T. Kadira[1]
Dirk Rossouw[1]

Affiliations:
[1]Department of Business Management, College of Business and Economics, University of Johannesburg, Johannesburg, South Africa

Corresponding author:
Dirk Rossouw,
drossouw@uj.ac.za

Dates:
Received: 16 Feb. 2023
Accepted: 01 May. 2023
Published: 19 June 2023

How to cite this article:
Kadira, B.T. & Rossouw, D., 2023, 'Competitiveness of a clinical laboratory within the Fourth Industrial Revolution', *Acta Commercii* 23(1), a1133. https://doi.org/10.4102/ac.v23i1.1133

Orientation: A clinical laboratory supports research for drugs, vaccine and device development. These laboratories in developing countries seem not to fully use technology arising from the Fourth Industrial Revolution (4IR) to enhance their competitiveness and, consequently, market share.

Research purpose: The purpose was to explore how a clinical laboratory in a developing country may become more competitive by implementing strategies in support of 4IR advancements.

Motivation for the study: This study attempted to reflect literature on the topics of 4IR and competitiveness and also to acquire an understanding of how a clinical laboratory in a developing country can use 4IR technology to improve its competitiveness.

Research design, approach and method: This study followed an interpretive paradigm and a qualitative enquiry, supported by a case study strategy. Data were collected by means of semi-structured interviews with 20 purposively selected stakeholders from the clinical laboratory. Conventional content analysis was applied to create codes, groups and themes.

Main findings: It was found that a clinical laboratory in a developing country can be competitive within the 4IR environment, and a link was established between strategy, 4IR and the improvement of competitiveness of the clinical laboratory.

Practical/managerial implications: The clinical laboratory has to build a strategy around the latest technology to ensure competitiveness and growth in its operations. The 4IR will also require continuous upgrades of new technology, and staff should be made part of this process.

Contribution/value-add: The developing world has to catch up with the advanced economies. To assist in this, this study concludes that strategies supporting 4IR technology advancements can improve the competitiveness and sustainable growth of a clinical laboratory.

Keywords: strategy; competitiveness; Fourth Industrial Revolution; technological advancements; clinical laboratory.

Introduction

The Fourth Industrial Revolution (4IR) has brought about improvement in all electronic equipment used in most industries, including medical diagnostic or clinical trial research testing. By definition, the 4IR describes the combination of physical, electronic and connectivity aspects to bring about unprecedented improvements in the daily livelihoods of individuals. Newer technologies are available, which when incorporated with workflows for clinical laboratory testing and data management, resulting in significant changes being incorporated (Sertkaya et al. 2016). This allows for quality improvement and bridging gaps in clinical research or laboratory diagnostics testing between low- to medium-income and high-income countries. As a result of the larger scale of human clinical trial studies in developing countries, the cost is much lower, leading to the creation of lower-cost research centres (Rawlins 2004). Participant samples collected can then be shipped to be analysed in developed countries (Conradie et al. 2018).

A theoretical analysis of the internal and external environments was conducted by the clinical laboratory in South Africa to identify the gaps between the current and desired future state of the laboratory (Mhlanga 2022; Porter 1990). This analysis provided the foundation for conducting this research on a clinical laboratory in South Africa. However, the literature seems to be silent on the topic of competitiveness of a clinical laboratory based on utilising the technological advancements brought about by the 4IR (Heaton 2020; Moon et al. 2014).

Against this background, an overview of the literature will be given on competitiveness, 4IR and the clinical laboratory under study.

Competitiveness

Competitiveness, as part of the strategy, is the ability of an organisation to create a business environment that allows it to operate at the same level as or better than its competitors. Strategy is about taking an organisation from a position of failure or underutilised potential to that of greater competitiveness (Maritz & Du Toit 2018). When successfully performed, strategy involves planning 'wars' and winning them, leading to greater influence, competitiveness, success and revenue (Du Toit 2013; Yu & Ramanathan 2013). Furthermore, competition is not seen to constitute competitiveness, as this may merely be benchmarking. Competitiveness may be created by a strategy that enhances performance drivers, namely innovation, quality, service, speed, cost effectiveness and sustainability (Bateman, Snell & Konopaske 2019).

Sibulali (2018) and Vukovic, Jovanovic and Dukic (2012) define competitiveness as an organisation's ability to compete within its industry or in overlapping areas with similar services provided. Schwab (2018) states that competitiveness is the ability to contest with other organisations providing similar services. An organisation can maintain a competitive advantage over its competitors, provided the organisation remains within its capability to utilise the advantage. The ability to have more influence, either through the provision of superior service or by being able to be the trendsetter among competitors, defines the competitiveness of an organisation (Judeh 2011; Maritz & Du Toit 2018). Being competitive demands integrating an organisation's marketing or business development strategy into policymaking processes. Competitiveness is the ability of an organisation's management team to consistently implement or align its decisions with greater success than other players in the industry. It also means being able to compete within its industry or in overlapping service provision areas (Kitson, Martin & Tyler 2012; Sibulali 2018; Vukovic et al. 2012).

An organisation's success or failure is thus determined mainly by its capacity to compete in its industry of operation. To compete requires the ability to innovate, a coherent culture and actions related to strategy implementation. It also necessitates an understanding of the external business environment, suggesting that competitive intelligence is of strategic importance (Bateman et al. 2019). Competitive intelligence is an ethical collection and analysis of total industry business data for use in strategy creation and implementation. This is an ongoing business process of acquiring information, filtering the information to obtain data, analysing the data and finally spreading the intelligence derived from the information gathered for decision-making purposes (Anica-Popa & Cucui 2009; Stefanikova, Rypakova & Moravcikova 2015).

The Fourth Industrial Revolution

The 4IR is defined as a very abrupt change in the supply of goods and services, driven by intelligent, cutting-edge technology connectivity (Schwab 2016). The advent of mobile networking and communication tools that pave the way for point-of-care testing is one of these new technologies. By changing the supply side of things, machines grow smarter, connect with one another more easily and define consumer requirements. The 4IR, like the First, Second and Third Industrial Revolutions before it, is expected to have a very large and profound impact on everyone's life (Xu, David & Kim 2018).

The term '4IR' was coined by Karl Schwab in 2016, the founder and executive chairman of the World Economic Forum (Miller 2016). He characterises the 4IR as a setting in which people live and work in a digital world that is an essential component of their reality (Schwab 2017). With the use of technology advancements, people's online and offline modes become synchronised, enabling users to integrate global connectivity with the management of their daily life (Rohr et al. 2016).

Innovation is central to the 4IR, with the largest beneficiaries being the providers of intellectual capital, shareholders, investors and inventors (Schwab 2017). However, in reaching possible new markets, emerging inventors were inhibited owing to a lack of exposure, assistance and organisations with larger capital and marketing budgets dictating the industry. The 4IR provides access to markets as well as an opportunity for low-resource entrepreneurs to advertise on social media platforms at minimal cost and become known globally through access to the Internet of Things (IoT) (Prisecaru 2016).

Clinical laboratory

Pharmaceutical research organisations and corporations that create therapeutic drugs are situated primarily in industrialised nations or developed countries such as Europe or North America (Nawrat 2018). Clinical laboratories have been incorporated by clinical research organisations as a component of their operational objectives or requirements (Vashist et al. 2015). There is little representation of clinical laboratories built in developing countries such as South Africa or the rest of the African continent and Asia (Crewe & Mayosi 2009).

It is the responsibility of a clinical laboratory to conduct the required testing on human samples and generate results that can be utilised to determine whether the participant is now in a pathological or normal state (Elgamal 2018). The data from these two-way streams is eventually analysed and used as proof to bolster medical theory concepts (Leslie, Story & Diouf 2018). Clinical laboratory investigations are essential for reliable data gathering, utilising approved testing procedures in routine patient management and during the course of treatment (Lloyd 2018). The analysis of patient conditions using biological samples taken from test subjects forms the

cornerstone of laboratory medicine and gives precise details on the human body's current state of health (Rohr et al. 2016).

There are major barriers to entry in the clinical laboratory market because of high technological requirements and the cost of laboratory equipment (Mhlanga 2022). Laboratories also build long-term client connections, retain skilled staff and secure better-negotiated rates from suppliers based on high-volume purchases (Heaton 2020). There is very little room to break the aforementioned connections once they have become entrenched, and the reliance on academia makes it a specialised industry (Graef et al. 2020). Advances in medical testing and medical device technologies have brought end-point assays and specialised diagnostic testing closer to clinical research locations in poor countries (Conradie et al. 2018; Crewe & Mayosi 2009).

The combination of senior clinical laboratory industry leadership and highly regarded academic staff result in an almost exclusive interactions from the client to the service provider. This gives more established organisations an advantage in attracting more important clients. In terms of strategy implementation and management planning capacity, management's personality is strongly reliant on mature industry experience. This gives organisations with more skilled management teams a strategic competitive advantage. A leadership study (Dargahi 2021) revealed that personality has a definite impact on creating a competitive advantage in strategic decision-making. Leaders with the most charismatic personalities build relationships with more established and competitive clinical laboratories, resulting in a larger market presence (Buljanovic, Patajac & Petrovecki 2011).

In the clinical laboratory industry, identifying the appropriate general strategic approach is crucial because it allows for optimal market segmentation. In order for the organisation to become a full clinical services provider, it must find a middle ground in the clinical laboratory industry. This is the point at which clinical research organisations broaden their offerings to include clinical laboratory services, increasing their competitiveness (Moon et al. 2014; Porter 1990). The efficiency generated by the use of improved technology may have been a breakthrough in the drive to replace low-skilled staff with technology-driven improvements for affordable high-quality outcomes, as demonstrated in the literature (Wu et al. 2020; Xu et al. 2018). Improved technology will reduce running costs, decentralise testing to lower cost centres in developing countries and improve communication of results across borders or continents (Padoan & Plebani 2022).

Research problem and question

It is clear that the 4IR can level the playing field in the struggle for global market share between the developed and developing countries across a variety of industries. However, the competitiveness of clinical laboratories in developing countries seems to be a challenge, and the potential of the 4IR seems underutilised. From this problem, the following research question was formulated:

> How does the clinical laboratory in a developing country become competitive within the Fourth Industrial Revolution?

Aim and objectives

The advent of the 4IR has led to greater technological developments that have increased interconnection and efficiency globally. This research sought to determine whether a clinical laboratory in a developing country may become more competitive by implementing 4IR advancements. Given the research question, the primary and secondary objectives of this study were identified.

The primary objective was to explore how the clinical laboratory in a developing country can be competitive and grow within the 4IR environment. Following the primary objective, the secondary objectives were: (1) to explore the understanding of competitiveness and 4IR within the clinical laboratory; (2) to determine the importance of competitiveness for a clinical laboratory and (3) to describe the impact of 4IR and technological advancements on the competitiveness and growth of the clinical laboratory.

Research methods and design

An interpretivist paradigm with a qualitative research design was applied. In support of this and the research question, an exploratory case study strategy was used in which research was conducted on a clinical laboratory in South Africa. Thus, the population consisted of all individuals employed at the clinical laboratory. Although 25 interviewees were initially purposively selected to be part of the sample, only 20 interviews were conducted because of operational engagements. However, this still falls within the range of meaning saturation as suggested by Hennink, Kaiser and Marconi (2017). Semi-structured interviews were conducted via electronic platforms with the assistance of an interview guide. Data were analysed by means of a conventional data approach, because no predetermined codes existed and to allow for open-ended coding (Hsieh & Shannon 2005; Maguire & Delahunt 2017). From the analysed data, codes, categories and themes were created. Trustworthiness was also ensured by applying the measurements of credibility, dependability, confirmability and transferability (Amankwaa 2016; Guba & Lincoln 1994; Saunders, Lewis & Thornhill 2019).

Ethical considerations

Ethical clearance to conduct this study was obtained from the University of Johannesburg College of Business and Economics Research Ethics Committee (No. 20SOM30) and the committee granted written clearance on 10 September 2020. All necessary steps were taken to ensure that ethical considerations were adhered to and the ethical clearance code is 20SOM30. Permission was also granted by the clinical laboratory to conduct the study. Participation was voluntary, and written consent was obtained from interviewees before the interviews were conducted. The anonymity of interviewees was also strictly upheld, and all data and relevant documents are saved and password protected on a

laptop and are available on request (Išoraitė 2018; Lewis 2015; Saunders et al. 2018).

Findings

The findings pertain to the biographical information of the interviewees and responses on the interviewees' understanding of competitiveness and 4IR, its importance and the impact of 4IR and technological advancements on the clinical laboratory's competitiveness.

Biographical information

Among the 20 sampled interviewees, there was evenly distributed representation from junior or entry-level staff who predominantly carried out supporting duties such as the actual day-to-day processing of the samples in the laboratory. Other support staff who performed non-laboratory key functional activities were also represented. There was 20% representation of all levels from entry-level, supervisory, management, executives and stakeholders, the latter of which included individuals who worked with, served as advisory or board members, but were not part of the daily operational running of the clinical laboratory.

The total number of years in the clinical laboratory, in other words, the experience of the interviewees who had an active role, that is, ran the day-to-day operations, was determined. The experience of the interviewees was evenly distributed and ranged from less than 10 to 50 years, with three individuals having more than 50 years of experience. It was noticeable that these three people were leaders and stakeholders among the interviewees. In terms of the academic background of all the interviewees, the majority had a diploma, followed by a bachelor's degree (including honours degrees) and, as expected, very few people working in the organisation had a PhD.

The understanding of competitiveness and the Fourth Industrial Revolution

The interviewees' main understanding of competitiveness comprised the laboratory's profitability and market share. Interviewee 1 mentioned that 'it [*is*] very important as it makes it hard for new entrants to penetrate your current market share ...', while interviewee 3 said 'competitiveness is the contest between organisations that provide similar services in order to achieve or get profit and revenue'. Interviewee 1 also referred to competitiveness as 'being able to be the preferred service provider without compromising on quality in service delivery. From the interviews, it was mentioned that bigger competitors tend to have more abilities in the growth in their bottom line, translating into more resources being allocated to better service provision and establishment of growth within the organisation. According to interviewee 11, 'competitiveness is a demonstrated ability to design, produce and commercialise an offer that fully, uniquely and continuously fulfills the needs of targeted market segments ...' when commenting on the organisation's competitiveness. The organisation was able to make all of this possible by means of a sustainable strategy as per the interviewees' responses.

In response to the question on 4IR and strategy, interviewees 6, 17, 18 and 19, for example, included the following terms in their responses: (1) 'new technology, (2) artificial intelligence, (3) innovation and (4) electronic robotics'. Some interviewees had no response, clearly indicating a lack of understanding of the concepts being discussed as part of the research study. Furthermore, in response to a question on what the next generation of clinical laboratories would look like, interviewees emphasised the importance of automation and the efficiency of laboratory processes that create value to the customer. Interviewee 19 said the following: 'Automation and/or robotics [,] these technology is positively associated with increased efficiency, reduction in errors and improved quality delivery of health care services ...'

The importance of competitiveness

The main themes identified from the interviewees' responses in relation to the importance of competitiveness are profitability, market share, growth and sustainability.

Most interviewees mentioned profitability as being the highest indicator of competitiveness for organisations. They also highlighted that as an indicator that a clinical laboratory is competitive, there needs to be clear growth in market share of the organisation. For example interviewee 10 said: 'It makes them remain relevant and also benefit them to making profit because it is through strategic competitiveness that the lab can be competitive and remain relevant.' Therefore, being a highly profitable clinical laboratory would raise the assumption that the business maintains a high level of competitiveness. As observed, the ability to be highly profitable indicates that the organisation is in a position to allocate resources much more effectively than their competitors, thus stimulating sustained internal growth.

Based on the number of responses, market share was the second most important theme of competitiveness. This shows that a higher market share indicates that the organisation is more competitive. However, in a clinical laboratory context, services are also supplied at a premium for a niche market, resulting in large profits without necessarily being the largest competitor in terms of overall industry market share, according to the responses from the interviewees. This is referred to as market segmentation, which is required to identify the desired target clients, resulting in the subsequent creation of a working relationship which further enables the organisation to differentiate its service offering to meet the requirements of its niche clients. Interviewee 6 alluded to competitiveness as 'important for growth and continuous improvement' and interviewee 12 said that 'it is very important within a clinical laboratory [*as*] this provides the clinical laboratory profits that exceed the average for its industry ...'

Growth was mentioned as the third most popular response, trailed by sustainability. Sustainability is required for ensuring that competitiveness is viable over the long-term to assure sustained growth and profitability.

The impact of the Fourth Industrial Revolution and technological advancements on the clinical laboratory's competitiveness

The key themes around the 4IR that emerged from the interviewees' comments were infrastructure upgrades, information and communication technology (ICT) enhancements, resource reorganisation and quality assurance.

Infrastructure renovations had the highest interviewee responses, which pertained to the revamp of the clinical laboratory's equipment, laboratory and data management software, and the physical building where these improvements take place. This was identified by interviewees as the first step in making a clinical laboratory recognisable, as most complex technology now requires physical housing that meets high engineering criteria. To house the latest molecular instruments, a solid building authorised by a structural engineer is required, and more complex systems capable of handling the data processing requirements of the newer equipment become vital. Interviewee 2 gave an example of a clinical laboratory 'that uses a mobile phone-based application to deliver results to clinicians', which can be used to resolve the issue of the distance of the testing centre from the source of material to be processed.

Information and communication technology and *resource restructuring* were the second most prominent themes as it had a similar number of interviewee responses. Information and communication technology refers to the interviewees' understanding of any electronic data capture, management and communication tools. This covers the laboratory information management system as well as the analysis software that comes with the equipment used in participant sample testing. Resource restructuring relates to the human capital deployed to take advantage of ICT advancements and operate newer technology equipment.

Quality assurance was the least common theme, despite its importance in terms of overall competitiveness. The interviewees indicated that clients will not employ a clinical laboratory if it does not prioritise quality work. Increased competitiveness translates to excellent quality and the ability to ensure that quality is given, backed by technology; this is critical to becoming the preferred supplier of services in any business. Interviewee 2 mentioned that '... I think the use of technology to identify and monitor quality indicators will greatly enhance the service that the laboratory provides' to its clients. These quality indicators are tools used to measure the quality assurance improvement process of the organisation.

Regarding the impact of technological advancements on competitiveness, the interviewees reported that innovation, automation, efficiency and new methodologies were applicable. Interviewee 1 highlighted the link between strategy and 'calculated actions and milestones', competitiveness and 'preferred service provider' as well as 4IR and 'digital orientation of the world innovatively'. Automation was the most common theme, being identified by most interviewees. Automation refers to the understanding of how clinical laboratory testing employing an instrument or technology requires less human interaction. After the processing is completed, the results are produced for examination by the technologist or scientist on the bench. With the reduction in errors brought about by the greater use of devices that require less human intervention, the drive is to have more tests handled in this manner. Other areas, however, still require some human interaction, and these will continue to receive more input from the technician or scientist on the bench. Interviewee 2 described strategy as '... adequate planning and positioning to navigate the challenges in the business environment' linked to the technology required to successfully complete the tasks at hand.

Automation is influenced by innovation because the end result is smarter or more efficient strategy for finishing sample processing to obtain the most accurate output. According to the interviewees, this was the second most prominent theme and represents a clinical laboratory that is continually looking for new procedures or ways to produce more accurate results in the quickest feasible timelines. Innovative procedures lead to better productivity, a larger test portfolio and more accurate test results in less time. Finally, when more tests can be performed with less human intervention, innovation flows towards automation. Interviewee 11 mentioned 'virtual reality, IoT, artificial intelligence and robotics' as the basis for the 4IR.

All of the above is complemented by efficiency as a theme, which was addressed by four interviewees, suggesting that the inclusion of novel automation does ultimately result in an increase in efficiency for the clinical laboratory while processing patient or participant samples. Efficiency is boosted by the clinical laboratory's technological innovations leading to a higher preference for its services, resulting in gaining market share. From the interviews, continued automation driven by innovation will eventually result in higher efficiency, boosting the opportunity to improve the clinical laboratory's competitiveness. The rapid turnaround time of the laboratory test results with fast precise instruments linked to newer technologies was recommended by interviewee 17. This interviewee stated that 'as an organisation, we have to be at the forefront of technological advancements. This will ensure that we deliver results at the best costing and improving existing turnaround times.' Allowing a clinical laboratory to stay competitive as times change, according to the interviewee. This is a main indicator of the efficiency of the organisation as it translates to the speedier provision of services to clients.

The least common theme was the introduction of new test mechanisms. When new technology is introduced,

it improves existing procedures through automation, resulting in higher efficiency. However, it does not always result in new methods of processing samples. This is demonstrated by the theme being the least prevalent, with only two responses. Developing new techniques necessitates more than simply improved technology; it also necessitates the discovery of novel sample processing concepts. Interviewee 1 alluded to the positives 'for those who embraced it and detrimental to some who did not want to embrace it in competitive areas', in relation to the technological advancements of the 4IR.

Discussion of the findings

Following the findings regarding the *understanding of competitiveness and 4IR* among the interviewees, competitiveness mostly suggests a symbiotic relationship between strategy and competitiveness. Reference was made by the interviewees to the sustainable growth in market share, resulting in the overall profitability of the clinical laboratory that commands a larger market share. The importance of segmenting the market to identify areas of consideration in strategy formulation was evident in the responses provided by the interviewees. This streamlines the overall strategy by setting goals along the requirements of the segmented market, which is in line with the literature on the topics (Applebaum et al. 2020).

Deductions are that the 4IR entails the use of interconnected instruments to lower the degrees of human involvement in clinical laboratory instrument work. During the severe Acute Respiratory Syndrome Cornonavirus 2 (SARS-CoV-2 virus) epidemic, interviewees observed that the epidemic required large numbers of human samples to be examined in using novel molecular techniques. This created the need for the clinical laboratory to improve the technology used in testing, as mentioned in the responses to interview questions. Testing was developed, validated and implemented in a huge number of clinical laboratories, leveraging on improved technology and connectivity to ensure faster turnaround times for testing and diagnosis (Heaton 2020; Jee 2017).

The more a clinical laboratory automates its operations, the more likely it is to have built-in efficiencies, according to this research, which is also in line with the literature. This is especially true in a market that is not particularly forgiving of errors. According to research, laboratories that have automated their processes and testing services have ultimately benefited, enhancing their commercial performance (Buljanovic et al. 2011; Dargahi 2021). A clinical laboratory's entire plan is required to include provisions for more automation and improved technology, as well as expenditures in cutting-edge equipment and software. Clients prefer a more automated clinical laboratory over one with more humans running instruments, as the latter may result in an increase in human errors (Schwab 2017).

A clinical laboratory in a developing country might use the 4IR to strategise how to compete in the global arena. While the introduction of new technology may not always result in the intended competitiveness, the ultimate gain in market share is related to the relevance of the new equipment to the clinical laboratory's strategic goals. As indicated in this research, the linking of the market requirements with the technology introduced into the organisation has an impact on the ultimate competitiveness of the business.

Regarding the *importance of competitiveness* in a clinical laboratory, market share, growth, sustainability and profitability seem most profound, according to the research findings. Efficiency in all aspects of the clinical laboratory covers the basics to be competitive, as this allows for repeat business from current customers, ensuring possible growth from the introduction of new clientele. The interviewees showed a significant understanding of the requirements for the overall success of the organisation being linked to its profit-making capabilities. This is in line with the literature, which confirms that repeat business brings in a marked return on investment, which translates to profits (Anica-Popa & Cucui 2009; Stefanikova et al. 2015).

Clinical laboratories have a very tight circle of service providers, making it difficult for new entrants to enter the market (Mhlanga 2022; Porter 1990). This is in line with the findings of this research as the increased costs of equipment and specialised personnel were evident. Clients' preference for a tried and tested organisation was also evident in the findings of this research. Most clients in the clinical research field, as in many other industries, are not willing to take the risk of trying out a new service provider that may result in disappointment, lowering their support base below that of rivals in their industry or market served (Bateman et al. 2019).

The importance of being competitive and having a solid strategy for the clinical laboratory was apparent in the findings of this research. In support, Brujil (2018), Buljanovic et al. (2011) and Dargahi (2021) purport in being competitive demonstrates the ability to meet customers' needs and objectives, enabling accurate patient or participant outcomes, which improves community care; this is the overall goal of clinical laboratory service provision. For a more sustainable competitive strategy, management needs to conduct a survey before creating goals and linking them to client requirements.

Researching the current market expectations is required to ensure the correct selection of a strategy that will allow the clinical laboratory to be competitive. The linking of long-term goals to what the market is seeking allows consistency in ensuring that all the services provided by the clinical laboratories are relevant. In the developing world, local clinical laboratory standards may not be as high as those expected on the international market. In this instance, local clinical laboratories seem less competitive than other international laboratories across the world, which are in a better position to support research (Ali et al. 2018; Elgamal 2018). Thus, the presence of a strategy may result in the laboratory being more competitive.

The *impact of 4IR and technological advancements on the competitiveness* of the clinical laboratory is the innovation in how samples are tested. Some of the interviewees expressed that they observed the impact of having the latest technology in the form of equipment and analysis software having the ability to increase the test portfolio of the clinical laboratory by allowing the use of newer techniques linked to advanced technologies. By experience, clinical laboratories are required to be equipped with the latest equipment and software for processing samples for the determination of the patients' health. This information requires communication with recommendations to clinicians in the least possible time in the author's deduction of the responses from the interviewees. This clinic and laboratory interface links the patient-facing clinician with the scientists processing samples in the laboratory for a fast turnaround of results provision, which is in line with literature reviewed from Manyika (2017) and Xu et al. (2018).

The distance between the laboratory and the clinical research location is a factor that requires consideration while establishing the laboratory. There are advantages to it being nearer to the sample collection centres to allow for a faster turnaround time for sample collection, receipt at the laboratory, processing and results provision. To ensure that researchers have access to what is happening on the ground, data transfer may be required to be near real time or live being the most preferred. The findings of this study support the position that optimally gives the provision of results in shorter turnaround times, as is the practice on continents where research resources are provided (Conradie et al. 2018).

Technology, as a driver of progress in clinical laboratories, is believed to create significant hurdles to entry in this industry. With the 4IR, some of the interviewees experienced that there are considerable expectations for the introduction of mobile technological interventions in communication and remote control of devices. This has been known to enable individuals in very different parts of the world to control and monitor an industrial process taking place on a different continent as observed for intercountry research studies. The ability to tap into newer technology and technical expertise from developed countries is seen to have resulted in improved technical capacity and increased productivity. The coronavirus disease 2019 (COVID-19) outbreak may have been a clear indication of the advantages of improved technological advancements, with fully fledged molecular testing laboratories springing up all over Africa, even in the most remote locations on the continent. The urgent dispatch of molecular equipment to all corners of the world, including extremely remote ones, is described as one of the main drivers resulting in quicker identification of active cases in line with observations from Wang et al. (2020).

Improved mobile technology and automation meant that new information on molecular testing requirements could be disseminated to all COVID-19 testing centres within shorter than expected turnaround times as experienced by the interviewees during the pandemic. Clinical laboratories demonstrated the ability to carry out more molecular tests than they were previously capable of. This materialised with the automated paperless interactive systems, with the use of robotics. Clinical laboratories contributed to bringing the COVID-19 pandemic under control in all countries as observed by the author.

This research attempted to demonstrate that a clinical laboratory may be required to have up-to-date equipment and technology to stay ahead in the market. A clinical laboratory, according to the findings, may have the ability to maintain its positioning as the facility of choice for laboratory testing procedures by using advanced technological offerings. Clinical laboratories need to stay updated with the technologies of the 4IR, by regularly updating their technical offerings. Some individuals participating in this study were not able to fully realise the value of modern laboratory equipment with the latest advanced technology as a contributor to competitiveness. Many seemed to believe that the introduction of new types of equipment was the only standard measure of the clinical laboratory's adoption of the 4IR, without taking into consideration connectivity. The overall definition of the 4IR speaks about interconnectivity and not just the introduction of newer technology (Shaw & Palmer 2018; Xu et al. 2018).

A clinical laboratory that incorporates 4IR is demonstrated to become more competitive, with evidence of linking to a comprehensive strategy. Establishing a connected organisation with automation coupled with software remote access may demonstrate a focus on innovation and technology. The need for internet interconnection and automation throughout the laboratory for all resources has been shown to be apparent. In a clinical laboratory, as demonstrated by the findings of this research, knowledge of the 4IR may be considerably weak. Connectivity to the internet may still be a challenge in the developing world, and a lack of some of the basics of the 4IR, such as 24 h electricity supply, forces these laboratories to focus more on keeping the lights on than keeping the internet connected. Infrastructure deficiencies, which are typically not the responsibility of a clinical laboratory in a developing nation, can also cause some unexpected barriers to the start of the 4IR and its benefits (Conradie et al. 2018; Schwab 2018).

In a bid to improve competitiveness in developing countries, this research demonstrates the need for clinical laboratories to incorporate technology, innovation, connectivity and interoperability in their daily operations. Uptake of the 4IR is seen to still be restricted, according to the research findings, as clinical laboratories may be required to circumnavigate other obstacles to meet basic needs. Support from instrument suppliers, electricity providers and internet service providers might be able to provide more traction in integrating the 4IR for the case study clinical laboratory to compete globally (Manyika 2017).

To conclude, the findings indicate that a clinical laboratory in a developing country can be competitive within the 4IR environment, possibly with the introduction of connected instruments, which reduces the levels of human interference in the work carried out using instruments (Applebaum et al. 2020). Sustainable growth in market share based on competitiveness linked to a sound strategy is shown to allow for an improved clinical laboratory, according to the research findings; this is also in line with the literature (Ali et al. 2018; Machin, Fayers & Tai 2021). Evidence shows that strategy may be a basic requirement to allow the clinical laboratory to be competitive. In support, Abdel-Basset, Mohamed and Smarandache (2018) describe strategy as the ability to have a plan to achieve the goals, which in this case is competitiveness.

Limitations

Although the sample size of 20 interviewees was appropriate given the nature of the study, the inclusion of interviewees at entry-level posed some limitations because of their lesser involvement in the strategy. Other limitations were time and resource constraints. As this was an exploratory study, more resources for a more in-depth study with participants from other clinical laboratories and developing countries could have provided more insights.

Management implications and recommendations

This research considered how a clinical laboratory can remain relevant while also building its clientele base to ensure sustainable growth. The overall implications of effective strategic management are to have a clear vision, mission statement and strategic goals. As strategy is a way to communicate a road map of utilising resources, and in this case 4IR technology, there has to be alignment between the vision, mission statement and strategic goals and 4IR technology. It is thus the responsibility of management to ensure that 4IR technology is in place to meet market needs and to be competitive.

The following recommendations for the clinical laboratory are thus made:

- The success of a clinical laboratory has a strong relation to its competitiveness. The only way the clinical laboratory can be aware of what the market is requiring at any particular time is by keeping track of current or potential client needs. This could be performed through extensive and regular market research. This could ensure a better fit between the clinical laboratory's vision and mission statement and strategies.
- There is a need for more staff involvement during the strategy formulation process to allow for a better understanding. This could be performed through workshops, involvement and improved communication within the clinical laboratory.
- The 4IR requires continuous upgrades of new technological equipment. As a driver, the clinical laboratory has to build a strategy around the latest relevant technology to ensure sustainable competitive growth in its operations.
- Strategy should be pivotal to ensure a common understanding of what successes the clinical laboratory is aiming towards. When introducing new technology as part of strategies and goals, staff will have to be upskilled to operate the equipment as per specification. This training could be outsourced to other clinical laboratories or suppliers, as the clinical laboratory has agreements in place, especially with suppliers.

Future research

For future research, more clinical laboratories in developing countries should be included in the study to allow for a broader insight into this topic. Further research in formulating strategies on technology apportionment could also be considered as the next step.

Conclusion

The findings, supported by the literature, are that a clinical laboratory in a developing country can be competitive within the 4IR. The level of understanding of the concepts of competitiveness and 4IR within a clinical laboratory is significant, even taking into consideration the different levels of staff and their different understanding. The importance of competitiveness in a clinical laboratory is acknowledged, while the level of 4IR technology uptake is growing.

However, the clinical laboratory should do more to involve staff in strategy and market research because strategy speaks directly to effective resource utilisation and competitiveness. Therefore, clear and effective strategies are needed to improve the competitiveness of the clinical laboratory in a developing country within the context of the 4IR.

Acknowledgements

This article is based on a Master's study in Strategic Management, entitled Strategic competitiveness within the Fourth Industrial Revolution: A case of a clinical laboratory, conducted by B.T.K. under the supervision of D.R. B.T.K. would like to express his sincere appreciation to all parties directly or indirectly involved in this study, from faculty to family members, including staff and stakeholders of the clinical laboratory.

Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

B.T.K. and D.R. as co-authors evenly contributed to this article.

Funding information

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Data availability

The data in support of the findings in this study are available on request from the first author, B.T.K. The data are not publicly available as it could compromise the privacy of research participants.

Disclaimer

The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of any affiliated agency of the authors.

References

Abdel-Basset, M., Mohamed, M. & Smarandache, F., 2018, 'An extension of neutrosophic AHP-SWOT analysis for strategic planning and decision-making', *Symmetry* 10(4), 116–134. https://doi.org/10.3390/sym10040116

Ali, S., Egunsola, O., Babar, Z.U.D. & Hasan, S., 2018, 'Challenges of conducting clinical trials in Asia', *International Journal of Clinical Trials* 5(4), 194–199. https://doi.org/10.18203/2349-3259.ijct20183748

Amankwaa, L., 2016, 'Creating protocols for trustworthiness in qualitative research', *Journal of Cultural Diversity* 23(3), 121–127.

Anica-Popa, I. & Cucui, G., 2009, 'A framework for enhancing competitive intelligence capabilities using decision support system based on web mining techniques', *International Journal of Computers, Communications and Control* IV(4), 326–334. https://doi.org/10.15837/ijccc.2009.4.2450

Applebaum, A.J., Cerf, M., Forlizzi, J., Hauser, J.M., Jordan, A.J., Lum, H.D. et al., 2020, 'Social media perceptions of legacy-making: A qualitative analysis', *Palliative Medicine Reports* 1(1), 326–330. https://doi.org/10.1089/pmr.2020.0069

Bateman, T.S., Snell, S.A. & Konopaske, R., 2019, *Management: Leading and collaborating in a competitive world,* 13th edn., McGraw Hill, New York, NY.

Brujil, G.H.T., 2018, 'The relevance of Porter's 5 forces in today's innovative and changing business environment', *Social Science Research Network Journal,* viewed 13 March 2021, from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3192207.

Buljanovic, V., Patajac, H. & Petrovecki, M., 2011, 'Clinical laboratory as an economic model for business performance analysis', *Croatian Medical Journal* 52(4), 513–519. https://doi.org/10.3325/cmj.2011.52.513

Conradie, A., Duys, R., Forget, P. & Biccard, B.M., 2018, 'Barriers to clinical research in Africa: A quantitative and qualitative survey of clinical researchers in 27 African countries', *British Journal of Anaesthesia* 121(4), 813–821. https://doi.org/10.1016/j.bja.2018.06.013

Crewe, B. & Mayosi, B., 2009, *The Academy of Science of South Africa consensus report on revitalising clinical research in South Africa: A study on clinical research and related training in South Africa*, viewed 18 March 2019, from https://www.assaf.org.za/files/2009/09/ASSAf-Clinical-Report-2009.pdf.

Dargahi, H., 2021, 'Organizational behaviour management in clinical laboratory: A literature review', *Journal of Education and Health Promotion* 10, 210, viewed 11 December 2022, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8318186/.

Du Toit, D., 2013, 'Comparative study of competitive intelligence practices between two retail banks in Brazil and South Africa', *Journal of Intelligence Studies in Business* 3(2), 30–39. https://doi.org/10.37380/jisib.v3i2.67

Elgamal, B., 2018, *Role of the laboratory in clinical trial,* viewed 21 May 2019, from http://nci.cu.edu.eg/App_Files/RecenciFiles/images/1165054343.pdf.

Guba, E.G. & Lincoln, Y.S., 1994, *Competing paradigms in qualitative research,* Sage, Thousand Oaks, CA.

Graef, K.M., Okoye, I., Ohene Oti, N.O., Dent, J. & Odedina, F.T., 2020, 'Operational strategies for clinical trials in Africa', *JCO Global Oncology* 6, 973–982. https://doi.org/10.1200/JGO.19.00204

Heaton, P.M., 2020, 'The COVID-19 vaccine-development multiverse', *The New England Journal of Medicine* 383(20), 1986–1988. https://doi.org/10.1056/NEJMe2025111

Hennink, M.M., Kaiser, B.N. & Marconi, V.C., 2017, 'Code saturation versus meaning saturation: How many interviews are enough?', *Qualitative Health Research* 27(4), 591–608. https://doi.org/10.1177/1049732316665344

Hsieh, H.F. & Shannon, S.E., 2005, 'Three approaches to qualitative content analysis', *Journal of Qualitative Health Research* 15(9), 1277–1288. https://doi.org/10.1177/1049732305276687

Išoraitė, M., 2018, 'The competitive advantages theoretical concepts', *Ecoforum Journal* 7(1), viewed 10 October 2020, from http://www.ecoforumjournal.ro/index.php/eco/article/view/705/449.

Jee, Y.S., 2017, 'Exercise rehabilitation in the Fourth Industrial Revolution', *Journal of Exercise Rehabilitation* 13(3), 255–256. https://doi.org/10.12965/jer.1735012.506

Judeh, M., 2011, 'An examination of the effect of employee involvement on teamwork effectiveness: An empirical study', *International Journal of Business Management* 6(9), 202–209. https://doi.org/10.5539/ijbm.v6n9p202

Kitson, M., Martin, R. & Tyler, P., 2012, *Regional competitiveness*, 2nd edn., Routledge, New York, NY.

Leslie, K., Story, D.A. & Diouf, E., 2018, 'Out of Africa: Three generalisable lessons about clinical research', *British Journal of Anaesthesia* 121(4), 700–702. https://doi.org/10.1016/j.bja.2018.07.005

Lewis, S., 2015, 'Qualitative inquiry and research design: Choosing among five approaches', *Health Promotion Practice* 16(4), 473–475. https://doi.org/10.1177/1524839915580941

Lloyd, I., 2018, *Pharma Intelligence website presentation on research spend*, viewed 21 May 2019, from https://pharmaintelligence.informa.com/resources/product-content/sitecore/shell//~/media/informa-shop-window/pharma/files/pdfs/pharma-rd-annual-review-webinar-2018-slides.pdf.

Machin, D., Fayers, P.M. & Tai, B.C., 2021, *Randomised clinical trials: Design, practice and reporting,* 2nd edn., John Wiley & Sons, Oxford.

Maguire, M. & Delahunt, B., 2017, 'Doing a thematic analysis: A practical, step-by-step guide for learning and teaching scholars', *All Ireland Journal of Teaching and Learning in Higher Education* 3(autumn), 33501–33514.

Manyika, J., 2017, *Harnessing automation for a future that works*, viewed 19 May 2019, from http://www.mckinsey.com/global-themes/digital-disruption/harnessing-automation-for-a-future-that-works.

Maritz, R. & Du Toit, A., 2018, 'The practice turn within strategy: Competitive intelligence as integrating practice', *South African Journal of Economic and Management Sciences* 21(1), 1–14. https://doi.org/10.4102/sajems.v21i1.2059

Mhlanga, D., 2022, 'The role of artificial intelligence and machine learning amid the COVID-19 pandemic: What lessons are we learning on 4IR and the Sustainable Development Goals?', *International Journal of Environmental Research and Public Health* 19(3), 1879. https://doi.org/10.3390/ijerph19031879

Miller, D., 2016, *Natural language: The user interface for the Fourth Industrial Revolution.* Opus Research Report, viewed 13 May 2021, from http://marketing.artificial-solutions.com/rs/177-TDV-970/images/201609OpusNaturalLanguageTheUserInterface.

Moon, H.C., Hur, Y.K., Yin, W. & Helm, C., 2014, 'Extending Porter's generic strategies: From three to eight', *European Journal of International Management* 8(2), 205–225. https://doi.org/10.1504/EJIM.2014.059583

Nawrat, A., 2018, *Ranking the top 10 clinical research organisations in the world*, viewed 21 May 2019, from https://www.pharmaceutical-technology.com/features/top-ten-clinical-research-organisations/.

Padoan, A. & Plebani, M., 2022, 'Flowing through laboratory clinical data: The role of artificial intelligence and big data', *Clinical Chemistry and Laboratory Medicine* 60(12), 1875–1880. https://doi.org/10.1515/cclm-2022-0653

Porter, M.E., 1990. 'New global strategies for competitive advantage', *Planning Review*, 18(3), 4–14. https://doi.org/10.1108/eb054287

Prisecaru, P., 2016, 'Challenges of the Fourth Industrial Revolution', *Knowledge Horizons – Economics* 8(1), 57–62.

Rawlins, M.D., 2004, 'Cutting the cost of drug development', *The Journal of Nature Reviews: Drug Discovery* 3, 360–364. https://doi.org/10.1038/nrd1347

Rohr, U.P., Binder, C., Dieterle, T., Giusti, F., Messina, C.G.M., Toerien, E. et al., 2016, 'The value of in-vitro diagnostic testing in medical practice: A status report', *PLoS One* 11(3), 1–16. https://doi.org/10.1371/journal.pone.0149856

Saunders, B., Sim, J., Kingston, T., Baker, S., Waterfield, J., Bartlam, B. et al., 2018, 'Saturation in qualitative research: Exploring its conceptualisation and operationalisation', *Internal Journal of Methodology: Quality and Quantity* 52(4), 1893–1907. https://doi.org/10.1007/s11135-017-0574-8

Saunders, M., Lewis, P. & Thornhill, A., 2019, *Research methods for business students,* 8th edn., Prentice Hall, New York, NY.

Schwab, K., 2016, *The Fourth Industrial Revolution: What it means and how to respond*, viewed 28 April 2020, from https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/.

Schwab, K., 2017, *The Fourth Industrial Revolution*, Penguin Books, London.

Schwab, K., 2018, *The global competitiveness report 2018*, World Economic Forum, viewed 12 December 2022, from https://apo.org.au/node/262576.

Sertkaya, A., Wong, H., Jessup, A. & Beleche, T., 2016, 'Key cost drivers of pharmaceutical clinical trials in the United States', *Journal of the Society for Clinical Trials* 13(2), 117–126. https://doi.org/10.1177/1740774515625964

Shaw, M. & Palmer, D., 2018, *Overview: Translational biomedical research funding in advanced, market-based economies*, viewed 17 March 2019, from https://eyebonds.com/wp-content/uploads/2018/09/Translational-Biomedical-Research-Funding-in-Advanced-Market-Based-Economies.pdf.

Sibulali, A., 2018, *Analysing the competitive performance of the South African subtropical fruit industry*, viewed 29 October 2020, from http://scholar.sun.ac.za/handle/10019.1/104958.

Stefanikova, Ľ., Rypakova, M. & Moravcikova, K., 2015, 'The impact of competitive intelligence on sustainable growth of the enterprises', *Procedia Economics and Finance* 26, 209–214. https://doi.org/10.1016/S2212-5671(15)00816-3

Vashist, S.K., Luppa, P.B., Yeo, L.Y., Ozcan, A. & Luong, J.H., 2015, 'Emerging technologies for next-generation point-of-care testing', *Trends in Biotechnology* 33(11), 692–705. https://doi.org/10.1016/j.tibtech.2015.09.001

Vukovic, D., Jovanovic, A. & Dukic, M., 2012, 'Defining competitiveness through the theories of new economic geography and regional economy', *Journal of the Geographical Institute* 62(3), 49–64. https://doi.org/10.2298/IJGI1203049V

Wang, W., Xu, Y., Gao, R., Lu, R., Han, K., Wu, G. et al., 2020, 'Detection of SARS-CoV-2 in different types of clinical specimens', *The Journal of the American Medical Association* 323(18), 1843–1844. https://doi.org/10.1001/jama.2020.3786

Wu, D., Wu, T., Liu, Q. & Yang, Z., 2020, 'The SARS-CoV-2 outbreak: What we know', *International Journal of Infectious Diseases* 94, 44–48. https://doi.org/10.1016/j.ijid.2020.03.004

Xu, M., David, J.M. & Kim, S.K., 2018, 'The Fourth Industrial Revolution: Opportunities and challenges', *International Journal of Financial Research: Science Education Press* 9(2), 90–95. https://doi.org/10.5430/ijfr.v9n2p90

Yu, W. & Ramanathan, R., 2013, 'Business environment, employee competencies and operations strategy: An empirical study of retail firms in China', *International Management Accounting Journal of Management Mathematics* 2(2), 231–252. https://doi.org/10.1093/imaman/dpr026