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Research Article

Identifying factors affecting the adoption of big data analytics in South African rural-based hospitals to improve service delivery

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ABSTRACT
The healthcare sector is progressively recognising the potential of big data analytics to revolutionise patient care, operational efficiency and decision-making processes. However, rural-based hospitals face challenges in embracing big data analytical tools to improve their service delivery to their patients. The adoption of big data analytics will assist rural-based hospitals in predicting and making informed decisions to manage the limited resources that they have and allocate them appropriately. However, there is a lack of literature that explores and identifies the factors that affect the adoption of big data analytics in rural-based hospitals to improve service delivery. This research employs a quantitative research methodology using surveys to identify the factors that affect the adoption of big data analytics in rural-based hospitals. This study found that rural-based hospitals prefer a hybrid method to collect data and it impedes the adoption of big data analytics in rural-based hospitals. Therefore, there is a need to implement modern infrastructure to integrate various data collection methods to promote the adoption of big data analytics in rural-based hospitals.

Keywords big data analytics, rural-based hospitals, healthcare, decision-making, service delivery

Categories • **Information systems ∼ big data, data analytics**

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1 INTRODUCTION

Globally, rural-based hospitals play a critical role in the local communities by providing emergency medical services to the citizens (Miller et al., 2020). These hospitals use a traditional method to collect data and provide services to the citizens (Khalifa & Househ, 2021; Malelelo-Ndou et al., 2019; Nevhutalu, 2016). However, urban hospitals use diverse platforms to collect data from the patients, which results in the government storing tons and tons of data (Kaur

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et al., 2021; Kelvin & Morrisson, 2023; Rehman et al., 2021). In the disposal of this data, rural-based hospitals are still grappling with managing their resources and allocating them accordingly in order to provide efficient service delivery (Batko & Ślęzak, 2022; McCarthy et al., 2021).

Nevhutalu (2016) reported that patients in many rural-based hospitals express frustration with the services received. These complaints often stem from the lengthy process of retrieving their files and waiting to be seen by a medical practitioner (McCarthy et al., 2021; Miller et al., 2020; Nevhutalu, 2016). Furthermore, patients with chronic diseases are subjected to long queues during their compromised health state (McCarthy et al., 2021; Nevhutalu, 2016; Zolbanin et al., 2022). However, other scholars have suggested big data analytics (BDA) to curb these challenges (Gomes et al., 2022; Imran et al., 2021; Ramesh & Santhi, 2020). Recently, BDA has become a popular mechanism for the survival and growth of many institutions worldwide (Brossard et al., 2022; Khanra et al., 2020; Miller et al., 2020).

Likewise, healthcare institutions are also progressively recognising the potential of BDA to transform patient care, operational efficiency and decision-making processes (Batko & Ślęzak, 2022; Ghaleb et al., 2021; Ramesh & Santhi, 2020). In recent years, these institutions have witnessed a paradigm shift with the advent of BDA, presenting unprecedented opportunities to manage and use resources efficiently daily (Gomes et al., 2022; Kelvin & Morrisson, 2023; Yu et al., 2021). However, these potential benefits of BDA are well documented from an urban hospitals' perspective (Shafqat et al., 2020; Shahbaz et al., 2019; Zolbanin et al., 2022).

On the contrary, there is a lack of evidence of the opportunities presented by BDA in rural-based hospitals. This challenge is attributed to the lack of widespread adoption of BDA in rural-based hospitals. In the context of this study, adoption refers to embracing and using BDA tools and technologies to inform rural-based hospitals' decision-making to improve service delivery. Adoption, in this sense, means the incorporation of BDA tools into hospitals' day-to-day operations to respond quickly in addressing patients' needs.

Other studies explored the challenges of data quality and implementation of computer-based knowledge management systems in public healthcare systems in urban areas (Botha et al., 2014; Maramba et al., 2020). Some of the studies that were conducted in rural public hospitals investigated the use of a virtual ICT framework to support the doctors (Nevhutalu, 2016). However, various scholars have postulated that it is significant for rural-based hospitals to adopt BDA to improve service delivery to their patients (Brossard et al., 2022; Miller et al., 2020; Nevhutalu, 2016). Therefore, this study seeks to address the gap in the existing literature by delving into the factors that affect the adoption of BDA in rural-based hospitals, with a primary focus on improving service delivery. Furthermore, the ultimate goal is to promote the successful adoption of BDA in rural-based hospitals, thereby enhancing service delivery, improving patient care, and addressing healthcare disparities in underserved communities (Batko & Ślęzak, 2022; Ghaleb et al., 2021).

This study is divided into six sections: Section 2 presents a literature review on big data analytics in healthcare institutions. Section 3 presents the research approach to choosing rural-based hospitals and their personnel who responded to the questionnaire. Section 4 presents

the results of the study and Section 5 discusses the results pertinent to the identification of the factors that affect the adoption of the BDA in rural-based hospitals. Section 6 concludes and provides recommendations to the rural-based officials who are contemplating adopting BDA (Khanra et al., 2020).

2 BIG DATA ANALYTICS IN THE HEALTHCARE INSTITUTIONS

Various scholars see big data as a precursor to big data analytics (Benzidia et al., 2021; Kelvin & Morrisson, 2023). Big data refers to enormously large and complex datasets that surpass the processing capabilities of traditional data analytical technologies and require sophisticated analytical methods and technologies for storing, processing and analysing (Hiremath et al., 2023; Kelvin & Morrisson, 2023; Seefong et al., 2023). Big data is characterised by four V's: velocity, volume, veracity and variety (Hiremath et al., 2023; Leow et al., 2023).

However, in the healthcare institutions big data is described as a high volume of health data collected from various sources, including physician notes, electronic health records (EHR), medical imaging, lab reports, X-Ray reports, case history, diet regime, genomic sequencing, payer records, pharmaceutical research, wearables, medical devices and many other sources that are not mentioned (Kaur et al., 2021; Ramesh & Santhi, 2020).

To analyse big data, there is a need of BDA techniques to uncover hidden information to assist organisations with decision marking (Leow et al., 2023; Yu et al., 2021). BDA refers to the process of examining and uncovering meaningful patterns, trends, and insights within vast and complex datasets, commonly known as big data (Ghaleb et al., 2021; Leow et al., 2023). In healthcare institutions, BDA involves the systematic analysis of vast and diverse datasets to extract valuable insights, identify patterns, and support informed decision-making for improving patient care, operational efficiency, and overall healthcare quality (Khanra et al., 2020; Zolbanin et al., 2022).

BDA in healthcare institutions includes the use of different techniques, such as statistical analysis, machine learning, data mining, and predictive modeling (Gomes et al., 2022; Shafqat et al., 2020). Most healthcare institutions leverage these analytics capabilities to gain more patient insights, optimise hospital processes, improve operational efficiency, and drive innovation (Batko & Ślęzak, 2022; Hiremath et al., 2023; Kaur et al., 2021). Overall, BDA plays a crucial role in helping organisations make informed decisions, identify opportunities and address challenges in today's data-intensive and rapidly evolving business landscape (Botha et al., 2014; Gomes et al., 2022).

Furthermore, integrating BDA in healthcare institutions with big data applications has the potential to enhance shared knowledge, monitor the outcomes of prevention focused approaches and enhance the efficiency of patient management (Gomes et al., 2022; Khalifa & Househ, 2021; Rehman et al., 2021). This context, often ignored by managers, engineers and policymakers, may present an opportunity that warrants exploration within the healthcare sector (Khalifa & Househ, 2021; Shafqat et al., 2020).

3 RESEARCH METHODOLOGY

This research employed a quantitative research methodology to investigate the factors that affect the adoption of big data analytics in rural-based hospitals to generalise the findings from a sample to the given population and draw conclusions that will apply beyond the sampled hospitals (Cresswell & Clark, 2011; Kothari, 2004; Saunders et al., 2019). The study focused on four rural-based hospitals in the Vhembe district in the Limpopo province, South Africa, utilising a convenience sampling method for selecting the hospitals. In this case, convenience sampling was used to select rural hospitals based on their availability and accessibility (Klein & Myers, 1999; Myers, 2013). Furthermore, this method was used for its simplicity and practicality, especially because of the tight given timeframe, budget and other constraints that made it difficult to implement more rigorous sampling techniques (Borgstede & Scholz, 2021; Crotty, 1998).

The target population included workers from the selected rural-based hospitals' Information and Communication Technology (ICT) departments, administrators, doctors and nurses. The sample comprised both computer-users and non-computer-users in the ICT departments who worked as data collectors. Computer users comprised of administrators and IT personnel. In addition, non-computer users are comprised of doctors and nurses. A total of 200 participants were sampled using simple random sampling techniques. Simple random sampling is considered one of the most straightforward and unbiased techniques for selecting a representative sample from a larger population (Myers, 2013). Furthermore, this method afforded all the participants from the population an equal opportunity to be selected (Kothari, 2004; Saunders et al., 2019). Fifty questionnaires were distributed to each selected hospital.

To collect data, this study utilised a structured questionnaire designed to gather information on factors influencing the adoption of BDA in rural-based hospitals. The questionnaire exclusively featured closed-ended questions, allowing for standardised responses and quantitative data analysis (Myers, 2013; Saunders et al., 2019). The questionnaire covered key aspects related to the adoption of BDA and questions were designed to assess participants' perspectives on the barriers that affect the incorporation of big data analytics into their daily work.

Prior to data collection, ethical approval was obtained from the University of Venda (UNIVEN), Faculty of Management, Commerce and Law ethics review committee. Participants were provided with informed consent forms explaining the purpose of the study, ensuring confidentiality and emphasising their voluntary participation. The anonymity and privacy of participants were strictly maintained throughout the research process.

4 RESULTS

From the distributed questionnaires, 174 were returned. Out of 174 questionnaires, 17 were not completed in full and were discarded from the analysis. Out of the collected questionnaires, 150 questionnaires were analysed using appropriate statistical methods, such as descriptive

statistics and inferential statistics. The aim of data analysis was to identify patterns, correlations and trends in the responses, providing insights into the factors that affect the adoption of big data analytics in rural-based hospitals. Results extracted from participants are presented in the following subsections:

4.1 Participants' demographic information

Participants' demographic information is depicted in Figure 1. The gender distribution in Figure 1 shows a slightly higher representation of females (59,3%) compared to males (40,7%). This gender balance is important for ensuring diverse perspectives in the study, particularly considering the potential impact of gender on attitudes and perceptions.

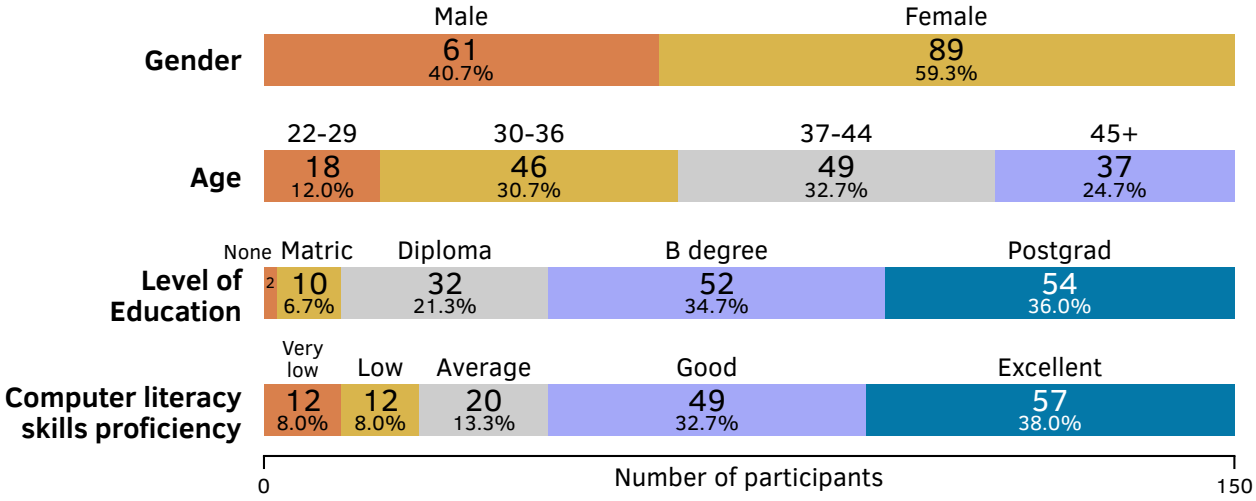

Figure 1: Demographic information

The age distribution shows that few participants (12,00%) were between the age of 22–29 and 24% of the respondents were between the age of 45 and above. While a diverse range of participants, with a significant portion falling within the 30–36 age groups (30,70%) and 37–44 age group (32,70%). This diversity is beneficial for capturing a broad range of experiences and viewpoints, as different age groups may have varying levels of familiarity and comfort with technology, including BDA tools.

Similarly, the educational backgrounds of participants are diverse, with a substantial proportion of participants holding university degrees. A total of 21,30% of the participants hold a diploma, while 34,70% hold a bachelor's degree. The highest proportion (36,00%) of the participants hold postgraduate qualifications. This indicates that the rural-based hospitals have a well-balanced sample of educated staff, which may positively impact their ability to comprehend and engage with complex topics such as BDA.

Furthermore, the results in Figure 1 show that the majority of participants (70,70%) reported having either good or excellent computer literacy skills proficiency. This high level of

computer literacy is a positive aspect, suggesting that a significant portion of the sample may be well-equipped to engage with and adopt new technologies, such as BDA tools.

4.2 Status of big data

A significant majority of respondents (67,30%) indicated that they collect data using both data collection methods (see Figure 2). While 32,70% of the respondents indicated that they use traditional data collection method. However, there was no participant who used a digital platform as a single means of collecting data from the source systems. The results show that rural-based hospitals are using a hybrid data collection method.

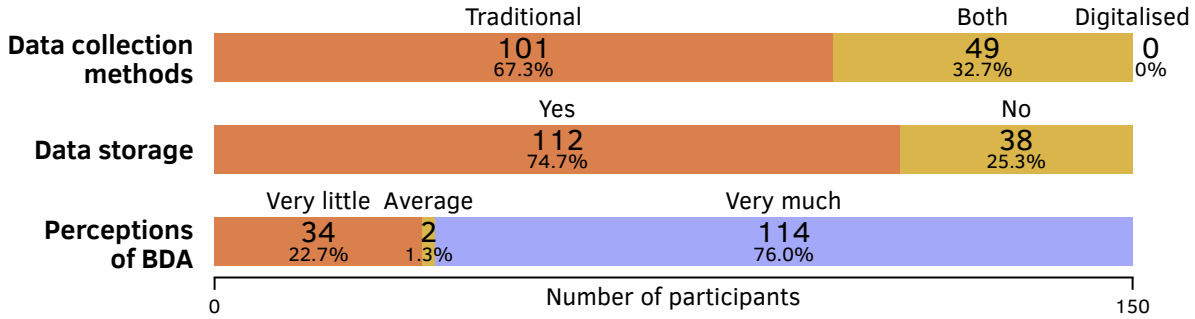

Figure 2: Status of big data

The researchers also explored data storage in rural-based hospitals. Figure 2 shows that the majority of respondents (75.00%) indicated that the data is stored in a centralised storage. While 25,00% of the respondents indicated that the data is not centralised. Furthermore, the researcher examined if the participants were aware of BDA tools. All the participants indicated that they were aware of the BDA tools.

Figure 2 presents the results of the respondents' perceptions of the extent to which rural-based hospitals use BDA. The majority of respondents (76.00%) indicated that rural-based hospitals use BDA to an average extent. This suggests that, according to the respondents' perceptions, these hospitals are actively incorporating BDA into their operations, albeit not at an extremely high level. A notable portion of respondents (23.00%) expressed the perception that the usage of BDA in rural-based hospitals is very little. While 1,00% of the respondents expressed that the usage of BDA is very much.

4.3 Perception of big data analytics

The results in Figure 3 show that, a vast majority of 92,00% of the respondents strongly agree that, in general, they find the integration of big data analytics useful in the rural-based hospitals and 6,70% of the respondents support this statement. This high level of agreement indicates a strong belief in the value and utility of incorporating BDA into hospital practices.

While 1,30% of the respondents are not sure of this statement. The results also show that there are no participants who dispute this statement.

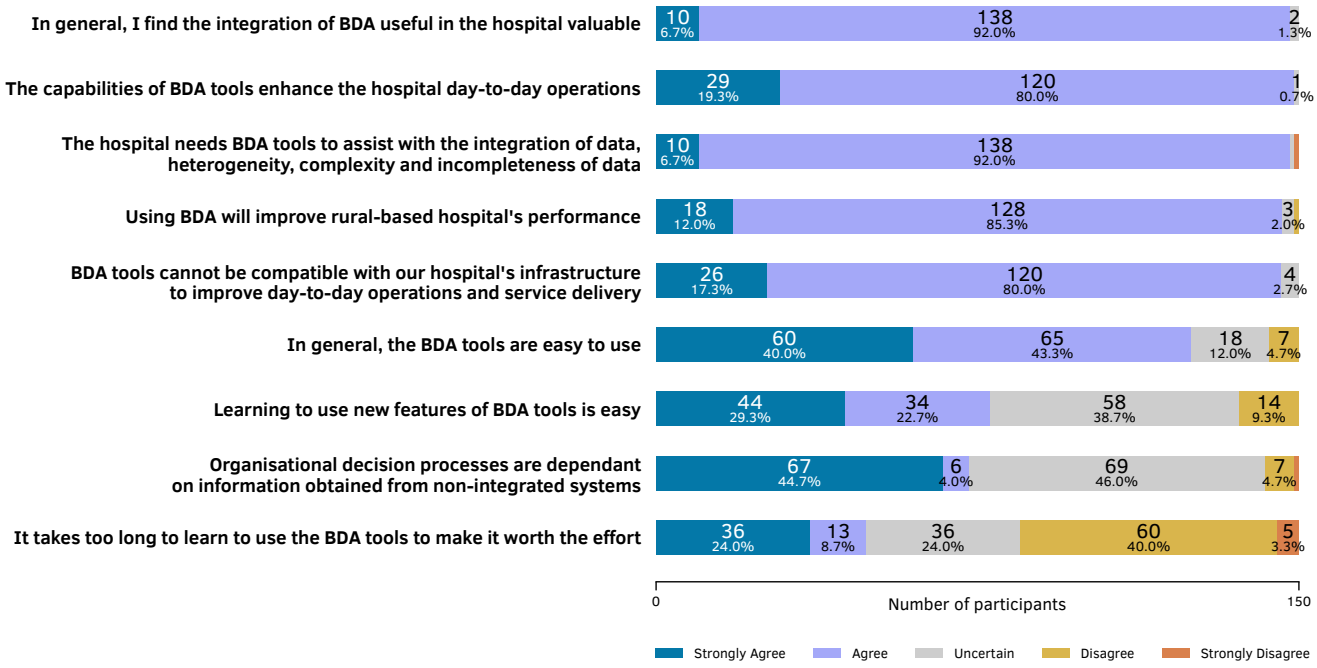

Figure 3: Perceptions of big data analytics

This study also explored the capability of BDA tools to enhance rural-based hospitals' day-to-day operations. The results reveal that 19,3% of the participants agree and 80,00% of the participants strongly agree that the capabilities of BDA tools enhance day-to-day operations and can be compatible with the hospital's operations and service delivery. This underscores a positive perception of the potential impact of these tools on hospital functions.

Furthermore, the participants responded to a question about the need for BDA in rural-based hospitals. An overwhelming majority of 6,70% of the respondents agree and 92,00% strongly agree that rural-based hospitals require BDA tools to address the integration of data, heterogeneity, complexity, and incompleteness of data. This suggests a consensus among participants regarding the critical role of BDA tools in managing diverse and complex healthcare data. Few participants (0,70%) were not sure about this and 0,60% strongly disagreed that rural-based hospitals require BDA tools to address the integration of data, heterogeneity, complexity, and incompleteness of data.

The majority of the respondents (85,30%) strongly agree that using big data analytics will improve rural-based hospitals' performance. While 12,00% of the respondents concur with the majority. This positive perception aligns with the potential benefits associated with the integration of analytics in healthcare operations. Only 2,00% of the participants indicated that they are unsure about using data analytics to improve healthcare performance. Fewer

respondents (0,70%) disagree that using big data analytics will improve rural-based hospitals' performance.

Furthermore, the researchers probed infrastructure compatibility with BDA tools in rural-based hospitals. The results show a consensus that there is a lack of infrastructure that accommodates BDA tools in rural-based hospitals. A total of 98,00% of the participants agree (17,30%) and strongly agree (80,00%) that BDA tools are not compatible with the existing infrastructure in rural-based hospitals. However, 2,70% of the respondents were not sure about this statement.

In Figure 3 the results show a consensus that it is easy to use BDA tools. A total of 83,30% of the participants agree, out of 83,30%, 40,00% agree and 43,30% strongly agree that, in general, BDA tools are easy to use. On the other hand, 12,00% of the participants are uncertain about this statement. In addition, 4,70% of the participants highlighted that BDA tools are difficult to use.

As depicted in Figure 3, the results show that 29,30% of the respondents agree and 22,70% strongly agree that learning to use new features of BDA tools is easy. However, 38,70% of the respondents were uncertain about this statement. A total of 9,30% disagree that learning new features of BDA tools is easy. The responses on learning new features of BDA tools show a more varied pattern, indicating that opinions on ease of learning differ among participants.

The results in Figure 3 show that 44,60% of the respondents agree and 4,00% of the respondents strongly agree. Therefore, a substantial portion 48,60% of the respondents believe that organisational decision processes depend on information obtained from non-integrated systems. On the contrary, 46,00% of the respondents were uncertain about the organisational decision process, which depends on the information extracted from the data collected from non-integrated systems. This indicates a significant concern or acknowledgment among participants about the influence of non-integrated systems on decision-making. A total of 5,40% of the respondents disagree with this statement.

Lastly, a notable 32,70% percentage feel that learning how to use BDA tools takes too long, which may impact the perceived value of investing time and effort in utilising these tools. While on the other hand, 24,00% of the respondents are not sure how long it takes to learn BDA tools. A total of 43,30% disagree with the statement.

In Figure 3 the results show a consensus that it is easy to use BDA tools. A total of 80,30% of the participants agree (40,00%) and strongly agree (43,30) that, in general, BDA tools are easy to use. On the other hand, 12,00% of the participants are uncertain about this statement. In addition, 4,70% of the participants highlighted that BDA tools are difficult to use.

The majority of the respondents (85,30%) strongly agree that using big data analytics will improve rural-based hospitals' performance. While 12,00% of the respondents concur with the majority. This positive perception aligns with the potential benefits associated with the integration of analytics in healthcare operations. Only 2,00% of the participants indicated that they are unsure about using data analytics to improve healthcare performance. Fewer respondents (0,70%) disagree that using big data analytics will improve rural-based hospitals' performance.

Lastly, a vast majority of 92,00% of the respondents strongly agree that, in general, they find the integration of big data analytics useful in the rural-based hospitals and 6,70% of the respondents support this statement. This high level of agreement indicates a strong belief in the value and utility of incorporating BDA into hospital practices. While 1,30% of the respondents are not sure of this statement. The results also show that there are no participants who dispute this statement.

5 DISCUSSION OF THE RESULTS

The results showed a gender balance, and it is essential to ensure diverse perspectives in the study, particularly considering the potential impact of gender on attitudes and perceptions. Furthermore, age was explored to solicit a diverse opinion and capture a broad spectrum of experiences and viewpoints because different age groups may have different perceptions when it comes to the adoption of innovation in an organisation (Rogers, 2003). The results show that all genders and ages are aware that BDA will enhance decision-making to improve service delivery in rural-based hospitals. This is in support with McCarthy et al. (2021) and Mashau and Mokwena (2017) who indicated that awareness has a positive impact on the adoption of new innovation.

The results also showed a good balance of education level and computer literacy skills proficiency. This may positively impact the ability to adopt BDA in rural-based hospitals because their staff are well-equipped to engage and adopt new technologies such as big data analytics tools. Various scholars postulate that education and computer literacy are paramount when adopting new technologies (Mashau et al., 2021; Rogers, 2003; Yadegaridehkordi et al., 2019).

The data suggests a preference for a hybrid approach in rural-based hospitals for data collection, incorporating both traditional paper-based and digitalised data collection methods. An enormous amount of data is still collected using the traditional paper-based data collection method. This could be a hindrance to adopting BDA in rural-based hospitals. Various scholars highlight the need to automate processes to collect data and to analyse it for decision-making purposes (Gomes et al., 2022; McCarthy et al., 2021; Shafqat et al., 2020). Furthermore, 25,00% of rural-based hospitals' data is not centralised, which will result in wrong information. When analysing data, there is a need to centralise all collected data to ensure the accuracy of the information (Benzidia et al., 2021; Leow et al., 2023). Decentralisation of data could be the reason for the low usage of BDA in rural-based universities (Benzidia et al., 2021; Ramesh & Santhi, 2020).

The results also revealed that infrastructure is incompatible with BDA tools in rural-based hospitals. Thus, the literature postulates for the successful adoption of innovation, the infrastructure should be up to date (Mashau et al., 2021; Rehman et al., 2021). However, organisations (hospitals) may improve their infrastructure to accommodate innovation (Imran et al., 2021; Rehman et al., 2021). Lack of infrastructure is a main barrier to the adoption of innovation in most organisations (Mashau et al., 2021; Shafqat et al., 2020).

6 CONCLUSION AND RECOMMENDATIONS

This study explored the factors that affect the adoption of big data analytics in rural-based hospitals with a focus of improving service delivery. The insights gathered through the survey responses presented the current landscape by providing valuable information about the staff of rural-based hospitals. The demographic information revealed a diverse and well-educated sample with a balanced gender distribution. The majority of participants demonstrated a high level of computer literacy, a crucial factor for successful implementation of big data analytics tools in rural-based hospitals.

Furthermore, this study found that rural-based hospitals prefer a hybrid method to collect data from the sources. This was highlighted as one of the factors that impede the adoption of big data analytics in rural-based hospitals. In addition, this study also found that data is not centralised, which may result in inaccurate information. Centralised data may present potential benefits in terms of streamlined access, improved consistency and enhanced security, but it also necessitates careful consideration of governance and security measures. Lastly, this study found that infrastructure is still an issue in rural-based hospitals. In rural-based hospitals, the infrastructure must be upgraded to be compatible with big data analytics tools. Therefore, these findings of this study contribute to the body of knowledge by offering a deeper understanding of the factors influencing the adoption of big data analytics in rural hospitals, thereby informing strategies for enhancing healthcare service delivery and quality in rural areas.

This study recommends that rural-based hospitals should automate all their processes because it is difficult to clean and extract meaningful information from data that are in different forms. This will also assist rural-based hospitals in centralising their data, making it easier for knowledge workers to analyse it. In addition, this study recommends that rural-based hospitals should invest more in upgrading their infrastructure to adopt big data analytics successfully.

Since the healthcare landscape continues to evolve, the findings from this study serve as a foundation for healthcare managers, policymakers, decision-makers, administrators, and technology developers. Furthermore, healthcare stakeholders can leverage the insights gained from this study and navigate the complexities of adopting big data analytics in rural-based hospitals, ultimately contributing to more effective and patient-centric healthcare services. The recommendations derived from this study aim to guide future initiatives, ensuring that the integration of big data analytics aligns with the unique needs and challenges of rural-based hospitals.

Future studies may explore critical factors that can affect the implementation of modern digital infrastructure that will support big data analytics and Industry 4.0 in rural-based hospitals to enhance decision-making. Finally, it was significant to investigate the factors that affect the adoption of big data analytics in South African rural-based hospitals in order to assist them in addressing all key factors before implementing big data analytics to potentially address critical gaps in healthcare service delivery.

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