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ORIGINAL RESEARCH

The Impact of Big Data Quality Analytics on Knowledge Management in Healthcare Institutions: Lessons Learned from Big Data's Application within The Healthcare Sector

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Abstract

It is widely acknowledged that knowledge management is critical to an organization's survival and growth. Every day, higher education institutions that are considered knowledge centers generate massive volumes of data. When this data is analyzed using appropriate computational methods and technology, it can provide knowledge to improve organizational performance and students' academic experience. Healthcare organizations create massive volumes of data as a result of the usage of digital technologies to manage patient information and the organization's operations. When used successfully, this data aids in the creation of information that improves patient health and everyday organizational functioning, as well as the prevention of unfavorable public health scenarios such as the spread of infectious illnesses. This is where big data analytics comes in, providing rational methods for navigating enormous quantities of data to disclose knowledge that assists businesses and analysts in making faster and better decisions. Higher education, like healthcare, creates large amounts of heterogeneous data that hides useful knowledge. As a result, the strategies used by healthcare companies to improve their performance using big data are replicable in the education domain as well. This article examines the use of big data for knowledge management in healthcare using case studies incorporating various analytics and draws parallels to be applied in higher education. As a result, it highlights the possibility of adapting analytics technology and tools from healthcare to higher education with appropriate revisions and adaptations.

Keywords: Big Data, Higher Educational Institutions, Healthcare, Knowledge Management, Big Data Analytics**,** Learning Analytics**,** Education

Introduction

Knowledge management is most important for the growth and sustenance of organizations (1-3). Researches state that the benefits of knowledge management can only be obtained if organizations invest in the technology and also emphasize and support the other elements at the organizational level such as the cultural, and managerial elements of the organization (4–10). A proliferation of information technology has led to knowledge being generated from millions and millions of sources. Some of this knowledge is not visible and available for use immediately unless techniques and technology are used to reveal the knowledge. Data generated in each industry is therefore valuable for the industry as it conceals knowledge that can be harnessed to enhance organizational value. One such tool that can harness such organizational knowledge is big data analytics. Figure 1 depicts the use of big data analytics in knowledge creation (11–15).

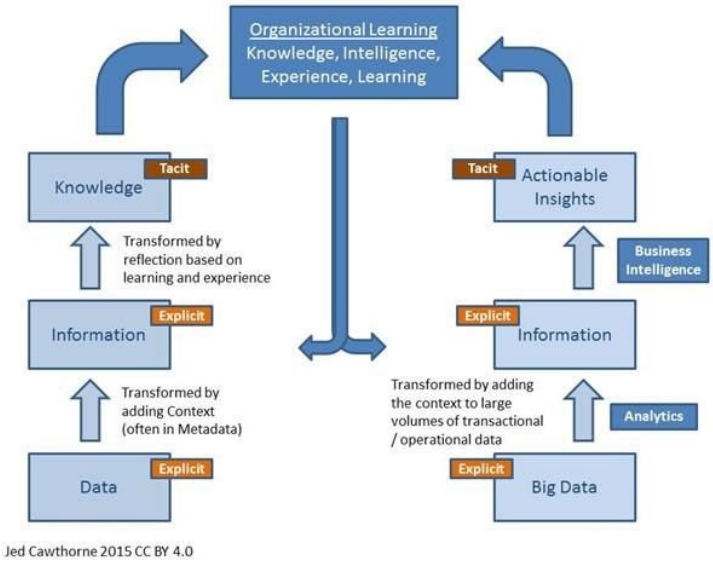

Figure 1: A representation of knowledge creation using Big Data Analytics.

This lays the basis for a model for the relationship of big data to knowledge creation.

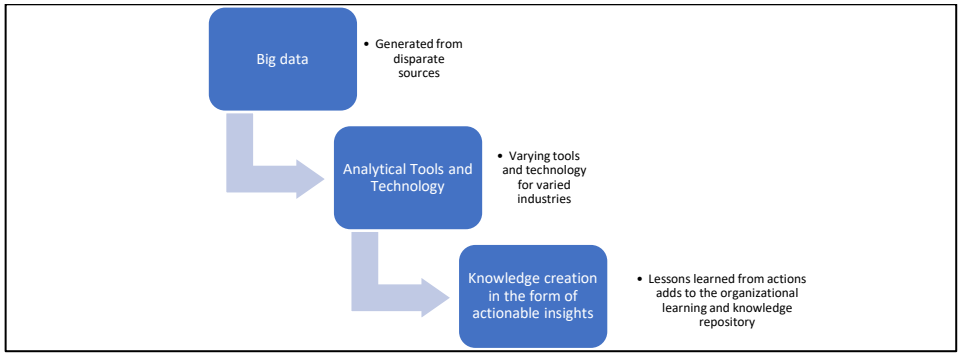

Figure 2: From big data to knowledge creation.

The domain of healthcare and its institutions are multi-dimensional systems, comprising different constituents namely the healthcare professionals such as the nurses and physicians, the treatment facilities, the management offices, and other staff in these offices (16). These institutions are a knowledge-based community for sharing knowledge between its different constituents to manage better the administrative costs and the quality of care provided. It is therefore clear that these organizations can only succeed when there is a seamless creation and transfer of knowledge within the different entities of these institutions (17). The trend of digitizing healthcare workflows resulted in the creation of bulk quantities of electronic data every day from patient records, clinical processes, treatment plans, laboratory records, insurance details, and many other data sources (18) The huge amounts of data generated in these healthcare institutions can be categorized as big data due to the volume that is produced, its velocity of generation and its variety (19). This data if analyzed using appropriate methods, can result in cost savings and most importantly in astute decision-making. Big data analytics can be used effectively as a technique for knowledge management in the healthcare sector.

Higher education institutions similarly have huge amounts of data generated from all its stakeholders including students, faculty, and staff. These institutions are constantly engaged in knowledge management processes including the creation, dissemination, and application of knowledge (20). Further, these institutions are faced with changing environmental factors such as the student population, industry needs, and available funding. These organizations generate huge amounts of academic data such as details of courses offered and programs of study in addition to the data required for the daily running of the institutions. Analyzing this large volume of data can benefit these institutions as well, by providing valuable insights to improve teaching and learning processes. Big data analytics is similarly not restricted to healthcare or education sectors alone. Most other organizations that generate huge amounts of data can also benefit from big data analytics.

Healthcare organizations have been known to use big data analytics not just to improve their organizational performance, but also to provide better treatment options for patients. Research into the use of data analytics in healthcare organizations has further identified the areas of use in risk and disease management, precision medicine, preventing emergencies for patients, and predicting pandemics, to name a few. The healthcare sector even though producing bulk amounts of structured and unstructured data, has been one of the leaders in using big data analytics.

1. Literature Review

1.1 Knowledge Management

It is well understood that globally there is an information overload. So much data and information become available in the smallest unit of time. From all this information, the actionable part is what we call knowledge. This knowledge is exemplified in the work practices, theories, skills, processes, and heuristics of the employees, students, patients, and other people involved in these sources of knowledge (21). The systematic coordination of an organization's people, organizational structure, processes, and

technology for adding value to the organization through reuse and innovation can be attributed to the definition of knowledge management (21). To achieve this coordination there is a need to thoroughly create, share, and apply knowledge and also feed the lessons learned and the best practices back into the organization to continue with the organizational learning (21). Knowledge management requires the use of special techniques, methodologies, and tools and techniques depending on the area of application. In any industry, robust bodies of knowledge need to be created or discovered using suitable methods and practices that work with and for knowledge (22). So, industries that generate data need to use techniques that enable knowledge to be discovered from this data.

1.2 Big Data Analytics

The origin of the term big data is disputed (23). There is a mention of the term as early as the 1990s by (24) who defined it as data that was so large and complex that it needed special computing mechanisms. Gartner glossary defines big data as "high-volume, high-velocity and/or high-variety information assets that demand cost-effective, innovative forms of information processing that enable enhanced insight, decision making, and process automation." (25). This definition stresses the 3 Vs that characterize big data and points to the need for special computational methods to process such data to derive useful insights from it. Oxford English Dictionary defines big data as "Computing data of a very large size, typically to the extent that its manipulation and management present significant logistical challenges." Manyica et al., 2019 refer to data sets whose size is beyond the ability of the typical database software tools to capture, store, manage and analyze." Both these definitions emphasize the need for special methods and technology to process big data. Many other definitions exist where the authors depict big data as subjective and capable of growing further with the passing years. Many other researchers also convey the need to employ special computational methods in big data analysis for delivering value to organizations and other stakeholders involved in generating this data.

It is because of this that big data analytics has been widely researched and applied in various industries for the past decade and later. Some areas where it has been implemented in our business intelligence, crime prevention, improving travel facilities, urban informatics, meteorology, genomics, healthcare, and environmental research among other areas (26). In the healthcare sector specifically, insights gained from analyzing big data can be used to not only improve the health of individuals but also to boost the performance of the system itself (27,28). Groves et al., (2016) point out that health sector data grows exponentially, due to the use of computer-based systems and also mainly due to population increase. It is therefore all the more pertinent that healthcare professionals begin using big data to its fullest capacity. The growing needs of the healthcare sector is well supported by ICT and big data analytics to provide quick data analysis and decision support in its various functions.

It is known that the data in healthcare is very complex as it is generated from various sources such as research, clinicians' case

notes, patient data in hospitals including admission and discharge notes, records from pharmacies, insurance companies, laboratories, wearable, and other devices, genomics, social media as well as research articles (29). Data in the higher education setting is also complex to some extent, as it is similarly obtained from various sources such as student data, examinations, or assessment data. The successful use of big data analytics in healthcare sets a precedent for similar use in higher educational organizations.

1.3 Healthcare sector and Big Data

Big data analytics opened up a wide range of opportunities for the healthcare sector to deliver better healthcare for all (30). This includes harnessing the technology of Hadoop clusters to store bulk amounts of data economically or employing improved techniques and better technologists to make sense of data that meets the condition of the five Vs- volume, veracity, velocity, variety, and value (31). In clinical practices, effective decision-making is a critical factor for the successful treatment of patients. The advent of big data analytics and its effective use helps to provide patient-specific health assessments and recommendations using evidence-based decisions rather than ad-hoc decisions by clinicians (31). Big data analytics thus makes the clinical decision-making process easier and cost-effective for both the healthcare facility and the patients as it allows relatively effortless use of data recorded from various sources such as patients themselves, wearable devices, and genomics (32). Big data analytics allows clinicians to identify those who are at high risk of developing chronic illnesses and helps to treat a disease even before it surfaces. This helps in unnecessary, extensive hospitalization, thus cutting down on expenses for all stakeholders including the patient and the insurance company.

To enable big data analytics in the health sector, suitable predictive models are used for improving the outcomes in all areas at once. The areas in the health sector where big data analytics brings potential benefits were identified by Mckinsey and Company as clinical care, population health, and research and development (33).

Various predictive models are used to provide insights into these three areas. In clinical care, the data generated from lab testing, biometrics, insurance claims, and patient health, can be used to create risk scores. These risk scores can be used to predict the services to be rendered or to plan wellness activities for individuals (34). Another case in Alabama Huntsville Hospital combined predictive analytics and clinical decision support tools to reduce sepsis mortality in patients by more than half. Duke University studied that electronic health records (EHRs) and patient registration data can be used in predictive analytics to predict patient no-shows thus enabling a better organization of the clinician's schedule. Using the EHR data and a standard questionnaire for predictive analytics, Kaiser Permanente, a prominent health research Institute in the US, identified with accuracy, individuals at high risk for suicide attempt. At the level of the hospital executives, predictive tools help to determine and reduce variations in the ordering of supplies and their utilization. This however is at a low utilization level at the healthcare institutions (34). Kaiser Permanente medical network is

also a case in point of how the healthcare sector manages big data as it manages the data of more than 9 million members (18). Sophia Genetics a global leader in data-driven medicine uses analytics and artificial intelligence for several clinical needs such as identifying disease-causing mutations in genomic profiles of patients and suggesting suitable and effective care. Sophia has been adopted across many countries and regions globally (18).

1.4 Big Data Analytics in other domains

Business organizations of all sizes use analytics to support core business functions, such as sales and marketing, merchandising, and risk management (35). There is a dramatic data explosion in various industries as a result of the use of devices including embedded sensors, smartphones, and tablet computers that are used in conducting the daily activities of these industries. This data should be able to provide the required knowledge to improve the activities in different industries such as oil and gas, surveillance, finance, and others (36). In any domain, the data possessed are considered big data when the characteristics of volume, variety, and velocity are large for that specific domain, irrespective of whether it may be considered small in other domains (37). Therefore big data may vary from domain to domain and its size would range from megabytes to petabytes. Irrespective of the domain, the challenge is to be able to analyze the data for decision-making and process improvement (37).

The use of Big Data in healthcare may contribute at different levels such as in "*increasing early diagnosis and giving effective and quality treatments* with early discovery of likely symptoms or signals, early intervention and reduced probability of adverse reactions or increasing the *prevention of diseases* by identification of risk factors or making more informed decisions for *patient health and safety* or the early *prediction of undesirable outcomes"* as reported by the Study on Big Data in Public Health, Telemedicine, and Healthcare of the European Commission (27).

1.5 Big Data Analytics in higher educational institutions

Higher educational institutions have a humongous amount of data being generated regularly due to the ever-increasing digitalization of educational methods, processes, and policies. A variety of data in different formats such as audio, video, pictures, and text get stored in multiple platforms like student information systems, online data repositories including learning management systems, and other systems for administrative purposes (38). Data, therefore, is vast and is produced from disparate, multiple sources. This data when consolidated and analyzed can provide useful information for various processes and individual performance improvement (39). Big data analytics has been employed in certain higher educational institutions in the field of administrative decision-making, resource allocation, early identification of at-risk students, improving teaching and learning techniques, and using the data gathered regularly from the LMSs, social networks, and the learning activities to transform the curriculum (40).

A prominent area in which big data analytics can be usefully employed is in curriculum improvement in Higher educational

institutions (41,42). Besides, universities can improve student retention and thus minimize the loss of revenue from tuition and fees (35).

Data analytics in higher educational institutions fall under different categories. Institutional analytics is performed on institutional data to improve performance in various organizational areas. IT analytics helps to analyze other critical data which may include data about student access to IT systems. Academic analytics analyses data at a programmer level giving useful information about the resource utilization and other administrative functions of the programmers. Learning analytics provide insights into the student learning process and is useful for improving student retention and student academic performance (38). Attaran, Stark and Stotler, (2018), explored several successful analytics platforms in several universities in the United States with different objectives including identification and support of at-risk students, intrusive advising, identification of students missing assignments or classes, student retention and graduation, identification of possible donors to the university funds etc. These cases clearly show limited use of data analytics in these higher educational institutions where the focus is on solving either one or at most two problems. There is a gap in the integrated use of data analytics in the different areas or departments in the organization. A University needs a well-designed analytics platform that integrates data from all the different departments in the organization. This will help to easily discover and dispense insightful information for the benefit of the whole organization (43). Higher educational

institutions are also varied in the percentage use of data analytics. A survey conducted by KPMG revealed limited use of big data analytics in various decision-making processes (44).

1.6 Knowledge gap

A bibliometric mapping analysis of the current literature on big data in the two sectors of healthcare and higher education was conducted to identify the research gap through the use of the VOS viewer tool. A total of 78 articles were located in the titles using the keywords “Big Data in higher education” or “Big Data in healthcare” through a search on the Scopus database. The bibliometric analysis results as in figure 1 indicate that big data analytics in healthcare was more prominent than big data in higher education. The link strength and the number of keywords in healthcare analytics was a lot more than those of higher education analytics as shown in figure 2. This indicates that healthcare big data analytics is much more researched than big data analytics in higher educational institutions. It is clear that due to the need to offer the best solutions for their patients, the healthcare sector has more readily embraced cutting edge technology such as the big data analytics in different spaces within these entities.

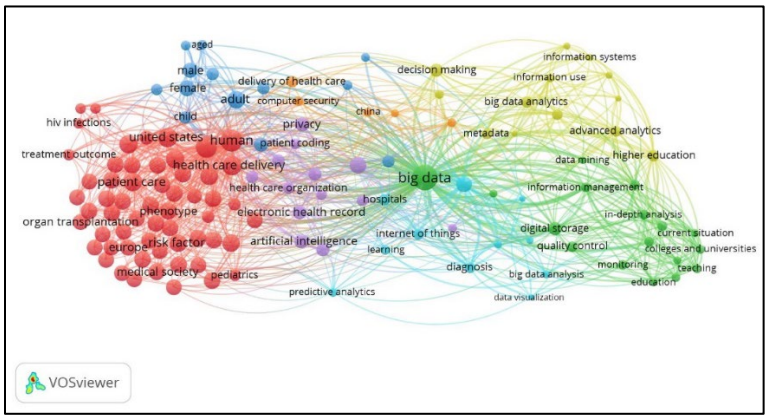

Figure 3: Keywords in existing literature for Big Data in Healthcare and Higher educational institutions.

Further, it was observed that prominent keywords in the researched areas connecting big data and Higher education were "digital storage", "advanced analytics", "data analytics", "teaching", "information use", "information management", "data analytics", "conceptual frameworks" and "computing". Most of these keywords indicate the research direction involving learning analytics that involves performance improvement of students and at-risk prediction of student performance.

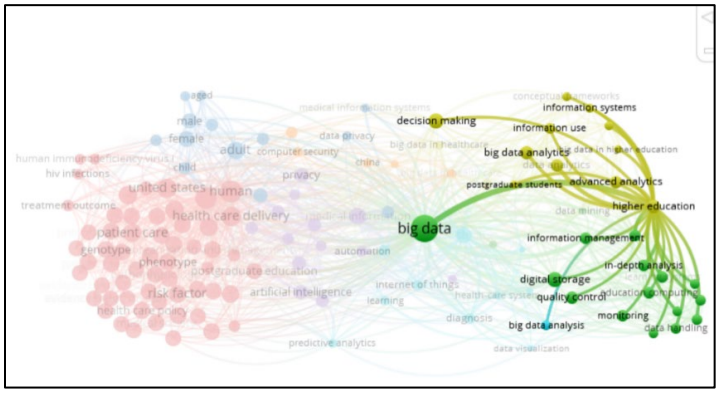

Figure 4: Keywords in existing literature for big data and higher educatio

A google scholar search showed some more research areas involving big data implementation platforms or architecture such as Hadoop, MapReduce, NoSQL, Spark, etc., learning analytics tools for collaborative and interactive learning, personalized learning, social learning, etc., predictive analytics for course selection, student performance prediction, dropout prediction, etc. and data sources for big data such as LMS, MOOCs etc.

However, a gap was noticed in an integrated approach to big data analytics as well as in suggestions for the best tools and techniques used for an integrated approach. Research in to the international standards and governance that is needed for the adoption and implementation of big data analytics across the board in all higher educational institutions is necessary for such institutions to accept this tool and technology.

2. PROBLEM STATEMENT AND SOLUTION

2.1 Identification and Analysis

Though big data analytics is employed in higher educational institutions to a varying extent, it has still not been extensively adopted across all higher educational institutions. The cost and the time required to establish the infrastructure to implement big data analytics, the necessity to employ specialist analysts to execute big data analytics and the lack of analytical knowledge among some or higher educational institutions employees are some of the reasons for the hesitancy in adopting big data analytics in higher educational institutions (45).

The practical reason for the lack of implementation of the applications of big data analytics in higher education is the many different challenges that they face. These challenges need to be addressed in order for the adoption of big data analytics on a larger scale in higher education. One of the challenges is that many higher education institutions lack the appropriate technology and skills for implementing analytics and even if implemented, there is a lack of internal resources to interpret and take the data-driven insights (35). Due to this they either use outsourced analytics support or, do not leverage the insights that the data or information possessed within their systems (35).

However, it is seen that the healthcare sector uses big data analytics more rigorously to make informed decisions than higher educational institutions. In Europe, many different solutions are available that have the potential to improve the health of individuals and also improve the outcomes of healthcare institutions. One of these, the big data analytics for precision medicine can only succeed with appropriate data acquisition and timely data analysis for detecting and preventing diseases. In most parts of the world, the healthcare sector similarly employs big data analytics to a great extent. It is also stated that big data analytics when employed requires effective and proportionate governance of health-related data and appropriate collaboration from stakeholders to modify the design and presentation of their systems to achieve the maximum potential (27). It is therefore essential to have international standards and also develop newer methods for making use of the ever-growing big data besides making the information easily available and accessible to healthcare professionals (27).

Healthcare sector data and higher education data are comparable due to their similarities in the disparate nature of data, the unstructured type of data, and also the bulk or volume of data generated daily. Therefore, similarities can also be observed in the problems that exist in healthcare and in higher education. Solutions to the problems seen in healthcare can then be adapted to the higher education sector. There is a need to enhance the use of big data analytics in higher educational institutions. The commonalities in healthcare data and higher education institutions' data make it a possibility for comparing the methods used in healthcare big data analytics to be adapted to big data analytics in higher educational institutions. The areas of use of big data analytics in healthcare can therefore guide big data analytics in higher educational institutions. For this to succeed, there is a strict need to

formulate international standards and appropriate governance for the adoption of big data in higher education. There is also the need to identify the best tools and platforms for each area of big data analytics in higher education institutions.

2.2 Possible Solutions

A comparison of areas of use of big data analytics in healthcare and higher education institutions provides a direction for adopting big data analytics more in higher educational institutions. The Healthcare sector even though is considerably larger in dimension compared to the higher education sector, has been more successfully adopted and thrives on big data analytics. Several big companies have developed solutions for health data analytics and provide this on a commercial basis. IBM's Watson Health, Flatiron Health's technology-based cancer research, MedeAnalytics' performance management solutions, and Apixio's cognitive health computing platforms for analyzing clinical data are some popular commercial data analytics platforms(16). Besides these some specific applications exist for clinical decision support such as the HELP system namely the health evaluation through the logical processing system, or the QMR system for supporting physicians (46). All these research and existing applications can therefore serve as a guide for higher educational institutions in deciding their organizational policies for the adoption of big data analytics. A comparative study of the use of big data analytics in different areas of healthcare and higher education indicates that this is possible. Table 1 shows the results of this comparative study.

Table 1: Comparative study of the use of big data analytics in different areas of healthcare and higher education.

Level of action	**Criteria**	**Healthcare Sector**	**Higher Educational Institution**
At the customer level	Risk aversion through early prediction	Early patient-centered disease prediction	Prediction of academic failure through identification of at-risk students.
	Personalized services for Customer	Personalized patient care and health management plans	Personalized management plans for student academic success
	Re-admission management	Monitor and follow up on patient health and use precision medicine to minimize re-admission	Predict student drop-out accurately and intervene early to avoid students retaking courses or entire programs.
	Recommendation system	Precision medicine recommendation or healthcare provider recommendation	Personalized recommendation for the type of academic materials, course selection etc.
At the Organization level	Transparency and Compliance with regulations.	Transparency in hospital management, and health records handling through well-defined analytical tools.	Transparency in institutional management, academic, financial, and other organizational records handling.
	Accreditation standards	Maintenance of global healthcare standards.	Benchmarking and meeting accreditation requirements.
	Resource Optimization	Resource management – healthcare professionals, equipment, space, etc.	Resource management – faculty, space, tools, technology, etc.

	Security and risk management	Secure organizational networks and patient health records from unauthorized access. Release of medical records only by following strict organizational and international standards.	Prevent unauthorized handling of student and institutional data. Secure the release of student data.

3. DISCUSSION AND CONCLUSION

The healthcare sector is a more willing adopter of big data technological tools for harnessing insightful information. This is essential for the sector to stay ahead in the field and to provide an enhanced service to its stakeholders. The domain of healthcare can be used to pave the way for other businesses that generate similar types of fragmented data to use big data analytics. Higher education is somewhat comparable to healthcare due to the huge amounts of structured and unstructured data that is produced. This is why the methods used in healthcare for data analytics can be used in higher education as well. A comparative study of the processes in healthcare and higher education data shows many areas requiring similar attention with appropriate revisions and adaptations, knowledge, or insightful actions; therefore, the analytical methods are adaptable from the former to the latter. Better management of big data analytics applications to higher education will help to improve transparency in all areas, improve educational quality and experience of all stakeholders and therefore improve the organizational stature and business value. Table 2 shows some applications of big data in higher educational settings (47). These applications are all comparable to the analytics implemented in the healthcare sector (48-49). It is therefore plausible to adapt the analytics technology and tools from healthcare to higher education.

Table 2: Application of Big Data in Higher Education Institutions.

Criteria			
Predictive analytics	**Reporting and compliance**	**Analysis and visualization**	**Security and risk mitigation**
• Predicting at-risk students and intervening early. • Predicting and preventing student dropout from courses and programs of study. • Predicting more accurately the applicant levels for enrolment or recruitment to programs of study. • Predicting employability of students on graduation • Understanding student behavior for recruitment, retention and engagement, strategic planning, etc.	• Meeting accreditation requirements • Benchmarking for competitiveness • Transparency enhancement through publishing information and making information accessible • Compliance to regulations	• Various kinds of report generation periodically • Resource optimization • Improving campus services	• Securing institutional network and data cost-effective security

4. LIMITATIONS AND FUTURE STUDIES

This article has discussed a comparative study of implementing big data analytics in higher education institutions from the successful implementations that happen in the healthcare sector. In a future study, it is recommended to identify suitable tools that will be used for each of the applications suggested for the higher educational institutions in the comparative study. This will help in the actual testing and verification of the process. Also, it is recommended that a future study will suggest with clarity the appropriate infrastructure to implement an integrated big data analytics tool for higher-education institutions. A quantitative study to verify the adoption of healthcare big data analytical tools and techniques in higher education will strengthen and provide clearer evidence for the feasibility of the suggested models in this study.

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