

Digitalization and Big Data Analytics in Health Sector: Its Role in Promoting Sustainable Development in The Digital Economy

Dr. Guemmadi Takoua

¹ University of Mouloud Mammeri TIZI OUZOU (ALGERIA), e-mail: takoua.guemmadi@ummtto.dz ;

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المخلص:

تهدف هذه الورقة إلى دراسة دور الرقمنة وتحليلات البيانات الضخمة في تعزيز التنمية المستدامة داخل قطاع الرعاية الصحية، وخاصة في سياق الاقتصاد الرقمي. وتستخدم الدراسة منهجية وصفية تحليلية لتحليل المشهد الحالي للرقمنة وتحليلات البيانات الضخمة في الرعاية الصحية وتأثيرها المحتمل على أهداف التنمية المستدامة. ومن خلال فحص شامل للأدبيات والبيانات ذات الصلة، يسعى البحث إلى تقديم رؤى حول القوة التحويلية لهذه التقنيات وتأثيراتها على مستقبل استدامة الرعاية الصحية. وتسلط نتائج الدراسة الضوء على الإمكانيات الكبيرة للرقمنة وتحليلات البيانات الضخمة لتحسين نتائج الرعاية الصحية، وتحسين تخصيص الموارد، ودفع الابتكار، وبالتالي المساهمة في تقديم أهداف التنمية المستدامة في العصر الرقمي.

الكلمات المفتاحية: الرقمنة تحليلات البيانات الضخمة، استدامة الرعاية الصحية، أهداف التنمية المستدامة، الاقتصاد.

Abstract :

This paper aims to investigate the role of digitalization and big data analytics in promoting sustainable development within the healthcare sector, particularly in the context of the digital economy. The study employs a descriptive-analytical methodology to analyze the current landscape of digitalization and big data analytics in healthcare and their potential impact on sustainable development goals. Through a thorough examination of relevant literature and data, the research seeks to provide insights into the transformative power of these technologies and their implications for the future of healthcare sustainability. The study's findings highlight the significant potential of digitalization and big data analytics to improve healthcare outcomes, optimize resource allocation, and drive innovation, thereby contributing to the advancement of sustainable development objectives in the digital age.

Keywords: Digitalization, Big Data Analytics, Healthcare Sustainability, Sustainable Development Goals, Digital Economy.

Corresponding author: Guemmadi Takoua, e-mail: takoua.guemmadi@ummtto.dz

1. INTRODUCTION

"If I knew what you were going to use the information for, I would have done a better job of collecting it," spoken by a Migrant and Seasonal Head Start (MSHS) staff member to the MSHS director during a Community Assessment Training. This quote underscores the critical importance of understanding the purpose and intended use of collected data, reflecting a pivotal aspect in today's rapidly evolving digital landscape. In the realm of healthcare, the integration of digitalization and big data analytics stands as a beacon of progress, promising transformative impacts on sustainable development within the digital economy.

The term "big data in healthcare" refers to the use of big data analytics in the healthcare industry, which is growing at an explosive pace. According to Straits Research, the global market of big data in healthcare is projected to grow from \$33 billion in 2021 to \$106 billion in 2030 at an annual rate of 14%.

Through this research, we embark on a journey to explore the pivotal role of digitalization and big data analytics in the health sector, elucidating its profound implications in fostering sustainable development and advancing societal well-being.

2. Big Data Fundamentals

2.1 How is Data Defined?

The word Data is defined in Webster's 11th Collegiate Dictionary as "factual information (as measurements or statistics) used as a basis for reasoning, discussion, or calculation." That definition confirms what is commonly thought about data when referring to research projects. That is, "data" means the all of the information collected and generated in the course of a research project. (Responsible Conduct of Research Administrators, s.d.)

The 1996 Webster's II New Riverside Dictionary Revised Edition defines data as "information, especially information organized for analysis."

Data can be defined as such: (Migrant & Seasonal Head Start, Technical Assistance Center, 2006, p. 5)

- Data is factual information (such as measurements or statistics) used as a basis for reasoning, discussion, or calculation. For example, data can be abundant and easily accessible, like weather measurements used to predict a storm's path.
- Data is information resulting from a sensing device or sensory organ, which includes useful and irrelevant or redundant information and must be processed to be meaningful. For instance, data from a temperature sensor might include fluctuations due to environmental factors beyond what's relevant for a specific analysis.
- Data is information in numerical form that can be digitally transmitted or processed by computer devices. An example would be financial data stored in spreadsheets that can be analyzed using software to identify trends or patterns.

Taking from the above definitions, a practical approach to defining data is that data is numbers, characters, images, or other method of recording, in a form which can be assessed to make a determination or decision about a specific action. Many believe that data on its own has no meaning, only when interpreted does it take on meaning and become information. By closely examining data we can find patterns to perceive information, and then information can be used to enhance knowledge.

2.2 What is Big Data?

Big Data is a collection of data that is huge in volume, yet growing exponentially with time. It is a data with so large size and complexity that none of traditional data management tools can store it or process it efficiently. Big data is also a data but with huge size.

As Gartner defines it “Big Data are high volume, high velocity, or high-variety information assets that require new forms of processing to enable enhanced decision making, insight discovery, and process optimization”. (Gartner, s.d.)

The term ‘big data’ is self-explanatory – a collection of huge data sets that normal computing techniques cannot process.

2.3 Types of Big Data

According to IBM, the global volume of data was predicted to reach 35 zettabytes in 2020. Since it increases daily, data scientists expect that the number will hit 175 zettabytes in 2025. Picture this: 35ZB holds approximately 1 trillion hours' worth of movies. It will take 115 million years to watch all those movies. There's something even more impressive about the global data sphere. The prevailing part of data, which is 80 percent or so, is unstructured. This means structured data only has about 20 percent of all generated information. (IBM, s.d.)

Big Data is generally categorized into three different varieties. They are as shown below: (Structured vs Unstructured Data: Compared and Explained, 2020)

2.3.1 Structured Data

Structured Data owns a dedicated data model, it also has a well-defined structure, it follows a consistent order and it is designed in such a way that it can be easily accessed and used by a person or a computer. Structured data is usually stored in well-defined columns and also Databases.

Structured data examples: Structured data is familiar to most of us. Google Sheets and Microsoft Office Excel files are the first things that spring to mind concerning structured data examples. This data can comprise both text and numbers, such as employee names, contacts, ZIP codes, addresses, credit card numbers, etc.

Fig.1. The typical structured data example: Excel spreadsheet that contains information about customers and purchases

	A	B	C	D	E	F	G
1	Purchase ID	Last name	First name	Birthday	Country	Date of purchase	Amount of purchase
2	1	Davidson	Michael	04/03/1986	United States	10/12/2016	37
3	2	Vito	Jim	09/01/1994	United Kingdom	02/02/2016	85
4	3	Johnson	Tom	23/08/1972	France	02/11/2016	83
5	4	Lewis	Peter	18/10/1979	Germany	22/11/2016	27
6	5	Koenig	Edward	13/05/1983	Argentina	26/03/2015	43
7	6	Preston	Jack	16/06/1991	United States	06/11/2016	77
8	7	Smith	David	11/03/1965	Canada	15/11/2016	23
9	8	Brown	Luis	03/09/1997	Australia	03/07/2015	74
10	9	Miller	Thomas	07/01/1980	Germany	07/11/2016	13
11	10	Williams	Bill	26/07/1960	United States	20/11/2015	80
12	11	Gemini	Alexia	12/09/1995	Canada	11/03/2017	35
13	12	Bond	James	25/02/1975	United Kingdom	12/08/2017	40
14	13	Burgle	Patricia	01/12/1990	United States	18/03/2015	35
15	14	Reding	Michelle	07/04/1985	Canada	23/02/2017	28
16	15	Harvey	Billy	14/07/1973	United Kingdom	12/01/2018	41
17							

Source: <https://www.altexsoft.com/blog/structured-unstructured-data/>

2.3.2 Unstructured Data

It makes sense that if the definition of structured data implies a neat organization of components in a predetermined manner, the definition of unstructured data will be the opposite. The pieces of such data aren't structured in a pre-defined way, meaning data is stored in its native formats.

The thing with unstructured data is that traditional methods and tools can't be used to analyze and process it. One of the ways to manage unstructured data is to opt for non-relational databases, also known as NoSQL.

If there's a need to keep data in its raw native formats for further analysis, storage repositories called data lakes will be the way to go. A data lake is a storage repository or system meant to store huge volumes of data in its natural/raw formats.

Taking into account the whole variety of file formats of unstructured data, it comes as no surprise that it makes up more than 80 percent of all data. Given this, companies ignoring unstructured data are left far behind as they don't get enough valuable information.

Unstructured data examples. There is a wide array of forms that make up unstructured data such as email, text files, social media posts, video, images, audio, sensor data, and so on.

2.4 The characteristics of Big Data

Big Data is considered a significant transformation in the world of information technology and data science. These data are characterized by a unique set of features, including massive data volume, high velocity of data flow, significant diversity, and challenges of accuracy and reliability. We will take a simplified look at each of these characteristics and understand how each one impacts the use and analysis of Big Data. (Bagal, 2020)*

Fig.2. The Characteristics of Big Data



Source: <https://www.linkedin.com/pulse/big-data-what-utkarsh-bagal>

- **Volume:** refers to the unimaginable amounts of information generated every second from social media, cell phones, cars, credit cards, images, video, and whatnot. We are currently using distributed systems, to store data in several locations and brought together by a software Framework like Hadoop. Facebook alone can generate about billion messages, 4.5 billion times that the “like” button is recorded, and over 350 million new posts are uploaded each day. Such a huge amount of data can only be handled by Big Data Technologies.
- **Variety:** Big Data is generated in multiple varieties. Compared to the traditional data like phone numbers and addresses, the latest trend of data is in the form of photos, videos, and audios and many more, making about 80% of the data to be completely unstructured.
- **Veracity:** basically means the degree of reliability that the data has to offer. Since a major part of the data is unstructured, Big Data needs to find an alternate way to filter them or to translate them out as the data is crucial in business developments.
- **Value:** is the major issue that we need to concentrate on. It is not just the amount of data that we store or process. It is actually the amount of valuable, reliable and trustworthy data that needs to be stored, processed, analyzed to find insights.
- **Velocity:** plays a major role compared to the others, there is no point in investing so much to end up waiting for the data. So, the major aspect of Big Data is to provide data on demand and at a faster pace.

2.5 Data Processing Operations

In the data analysis process, we need to focus on the following data analysis operation stages: (Sushmith, 2022)

2.5.1 Data Collection: Data collection is the first step involved in the data processing cycle. It is validated by prioritizing the information resources provided, such as the company's profits and losses, user data, staff data, market net worth, and other necessary data, after acquiring the raw information from other organizations in the enterprise.

2.5.2 Data Preparation: Data preparation in the processing cycle involves the duties to prioritize the data collected and filter out the unnecessary and inaccurate data. Before the conclusion, the errors in the data, replication of the data, duplicate data, and such misleading data are corrected and filtered to guarantee the quality. Once the data quality is checked, it is then encoded for further cycle. Because of all the methods used, the term "data cleaning" is also used to describe this step of data processing.

2.5.3 The Data Input: The data input stage of data processing is where the cleaned or encoded data is transformed into inputs that can be read by machines. It is ensured that the data is in a format that can be read by a computer and processed before feeding it to the computer. At this stage of the case, the priority is to validate the data before supplying it to the computer's Central Processing Unit (CPU).

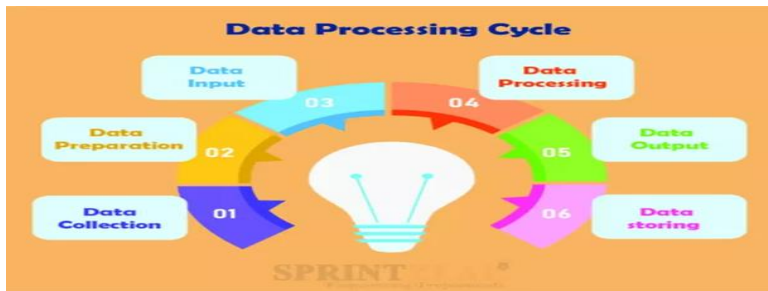
2.5.4 Data Processing: Data processing makes the data subject to various data processing methods like algorithmic and statistical calculations, depending on the tools that are being used. Most of the available tools make use of algorithms designed using machine learning and artificial intelligence for processing the cleaned data.

2.5.5 Data outputs: Data outputs are the form of data that has been processed and obtained by the previous steps. The output data obtained is then decoded which are ready to be displayed to the users. These outputs help the users immediately extract the statistics. Based on these extracted statics, the

presentation is done. For presentation, charts, reports, tables, graphs, and other such information-conveying statistics are used.

2.5.6 Storage: Storage is a major asset in any kind of data processing. The final step in the cycle is to store the decoded output data and metadata for future calibration and use. Through this, the user would be able to retrieve any particular data whenever needed. For a reliable use, the organizations buy huge amounts of memory to store all the data.

Fig.3. Data Processing Cycle



Source: <https://www.sprintzeal.com/blog/data-processing>

3. Data Analytics Basics

3.1 What are Data Analytics?

Data analytics is the collection, transformation, and organization of data in order to draw conclusions, make predictions, and drive informed decision making.

The 21st century has seen a massive increase in the generation of data from various sources such as businesses, organizations, and individuals. With the advancement of technology and the increasing availability of data, it has become imperative for organizations to make data-driven decisions. The vast amounts of data generated in the modern era require sophisticated techniques for their analysis, which is where data analytics comes into play. Data analytics is the process of examining and transforming raw data into meaningful and useful information that can be used to make informed decisions.

Data analytics has become an indispensable tool for decision making in the 21st century. Businesses and organizations rely on data analytics to

understand their customers, competitors, and market trends, and to make informed decisions that can drive growth and improve operations. To extract meaningful insights from data, however, it is important to have a systematic and structured approach to analyzing the data. This is where statistical data analysis comes into play. (Seyyed Ali Mohammadiyeh, 2023)

3.2 Applications of big data

Big Data is considered the most valuable and powerful fuel that can run the massive IT industries of the 21st Century. Big Data is being the most widespread technology that is being used in almost every business sector. Let us now check out a few as mentioned below: (Bagal, 2020)

- **Telecommunications and multimedia:** Telecommunication and Multimedia sector is one of the primary users of Big Data. There are zettabytes of getting generated every day and to handle such huge data would need nothing other than Big Data Technologies.

- **Retail:** Leading online retail platforms are wholeheartedly deploying big data throughout a customer's purchase journey, to predict trends, forecast demands, optimize pricing, and identify customer behavioral patterns. Big data is helping retailers implement clear strategies that minimize risk and maximize profit.

- **Financial Services and Insurance:** The increased ability to analyze and process big data is dramatically impacting the financial services, banking, and insurance landscape. In addition to using big data for swift detection of fraudulent transactions, lowering risks, and supercharging marketing efforts.

- **Manufacturing:** Advancements in robotics and automation technologies, modern-day manufacturers are becoming more and more data focused, heavily investing in automated factories that exploit big data to streamline production and lower operational costs. Top global manufacturers are also integrating sensors into their products, capturing big data to provide valuable insights on product performance and its usage.

- **Energy:** To combat the rising costs of oil extraction and exploration difficulties because of economic and political turmoil, the energy industry is turning toward data-driven solutions to increase profitability. Big data is optimizing every process while cutting down energy waste from drilling to exploring new reserves, production, and distribution.

. **Logistics & Transportation:** State-of-the-art warehouses use digital cameras to capture stock level data, which, when fed into algorithms, facilitates intelligent inventory management with prediction capabilities that indicate when restocking is required. In the transportation industry, leading transport companies now promote the collection and analysis of vehicle telematics data, using big data to optimize routes, driving behavior, and maintenance.

. **Government:** Cities worldwide are undergoing large-scale transformations to become “smart”, through the use of data collected from various Internet of Things (IoT) sensors. Governments are leveraging this big data to ensure good governance via the efficient management of resources and assets, which increases urban mobility, improves solid waste management, and facilitates better delivery of public utility services.

. **Healthcare:** Big data is revolutionizing the healthcare industry, especially the way medical professionals in the past diagnosed and treated diseases. In recent times, effective analysis and processing of big data by machine learning algorithms provide significant advantages for the evaluation and assimilation of complex clinical data, which prevent deaths and improve the quality of life by enabling healthcare workers to detect early warning signs and symptoms.

4. The Economic Implications and Advantages of Implementing Big Data Analytics in Healthcare

4.1 Big Data Analytics Application in Healthcare

Pharmacovigilance, privacy protection and fraud detection, public health, mental health, illness monitoring, and the monitoring of chronic conditions are the six main areas where healthcare analytics are applied. Researchers have utilized data extraction in a variety of fields, including patient management, cost reduction, resource leveraging, quality improvement, data deposition, and cloud computing. (Priyanshi & Rishabha, Challenges and opportunities of big data analytics in healthcare, 2023, pp. 3-5)

. **Disease surveillance:** It involves etiology the method by which a disease is caused—prevention, comprehension of the disease's situation, and perception. The potential for illness analysis with information from EHRs and

the Internet is enormous. The numerous surveillance techniques would assist in the establishment of health policy and practice, service planning, treatment evaluation, priority establishing, and priority setting.

- **Healthcare administration:** Healthcare providers now have access to insights made possible by big data analysis. Data warehousing, cloud computing, patient management, and other areas of healthcare have all benefited from the application of data mining techniques by researchers.

- **Patient data management:** Effective healthcare delivery and scheduling throughout patient's hospital stay are two aspects of patient data management.

- **Security of medical records and prevention of fraud:** It is essential to anonymize patient data, protect medical data privacy, and identify fraud in the healthcare industry. Data scientists must work hard to safeguard big data from hackers as a result of this. The researchers suggested a model that outperformed the conventional regarding keeping data useful without compromising data privacy, the Anonymization paradigm excels. Additionally, their system was able to handle large, multidimensional data sets.

- **Mental health:** The National Survey on Drug Use and Health found that 52.2% of Americans, in general, struggled with mental illness or drug addiction/abuse. A data analysis-focused therapy method was created by Panayiotopoulos et al. to assist medical professionals in the treatment of people with anxiety disorders. The researchers produced both static and dynamic data based on user models using both static and dynamic data. Static data included personal information such as the user's age, sex, body type, and family information. Dynamic data included stress context, weather, and symptom information. For the first three services, where correlations between a large number of complicated parameters had previously been established, the remaining parameter was mostly utilized to anticipate stress rates under different scenarios. Data gathered from 27 volunteers who were chosen using the anxiety assessment survey were used to verify this model.

- **Public health:** The detection of disease during outbreaks has also been aided by the use of data analytics. Online data based on consumer behavior patterns, media coverage of public policy issues, and expert trends of disease epidemics were analyzed by Kostkova et al. They discovered significant

elements influencing the search behaviors of experts and laypeople inside public health organizations, along with suggestions for focused communications during emergencies and outbreaks.

. **Pharmacovigilance:** To ensure patient safety, pharmacovigilance necessitates monitoring and identifying adverse drug reactions (ADRs) following product introduction. ADRs are important to the medical care system as evidenced by the estimated social cost of \$1 billion per year.

4.2 The Challenges of Healthcare System in Big Data Analytics

The healthcare system comprises a range of institutions and professionals working together to provide healthcare to patients. These institutions collect vast amounts of data from various sources such as hospitals, insurance companies, administrative offices, and government agencies. Subsequently, this data is analyzed to gain a comprehensive understanding of healthcare and improve the services provided. However, these institutions face numerous challenges in utilizing and managing this vast amount of data. We will now explore these challenges (Nikil, 2023, pp. 582-583) :

- . **Data Aggregation:** Patient and financial data are scattered across various entities, requiring extensive planning to aggregate them.
- . **Policy and Process:** Compliance with regulations like HIPAA demands robust policies and procedures to protect health information, complicating data management.
- . **Management:** Adapting to the promises of big data analytics necessitates organizational adjustments and skilled personnel.
- . **Capture:** Ensuring data cleanliness, completeness, and accuracy is an ongoing battle due to inconsistent data governance habits.
- . **Cleaning:** Data cleaning is crucial to ensure accuracy and consistency, as dirty data can disrupt analytics projects.
- . **Storage:** With the exponential growth of healthcare data, storage becomes a critical issue in terms of cost, security, and performance.

- . **Security:** Data security is paramount, given the increasing threats of breaches and cyberattacks in the healthcare sector.
- . **Querying:** Robust metadata and protocols facilitate effective data querying, but organizations must overcome various challenges to engage in meaningful analysis.
- . **Reporting:** Generating clear, accurate reports is vital for informed decision-making, but it relies heavily on data accuracy and integrity.
- . **Visualization:** Engaging data visualization aids clinicians in absorbing information effectively, enhancing patient care.
- . **Updating:** Healthcare data is dynamic and requires frequent updates to remain relevant, posing challenges for organizations in monitoring their data assets consistently.
- . **Sharing:** Data interoperability is essential for sharing information with external partners, particularly as the industry transitions towards population health management and value-based care.

4.3 The Economic Impact of Big Data Analytics in Healthcare

Big Data is a critical issue for European Union (EU) institutions, particularly concerning the availability of health-related data and its potential positive impact on medical and healthcare functions. The EU faces various changes that could affect the sustainability of its healthcare system.

By 2025, life expectancy is projected to increase further, potentially resulting in a larger population living longer but not necessarily healthier or more active lives. This demographic shift will likely increase pressure on Europe's healthcare costs and economic productivity.

The utilization of Big Data in healthcare offers several benefits across different levels, as highlighted in the European Commission's Study on Big Data in Public Health, Telemedicine, and Healthcare: (Roberta, Corrado, & Giuseppe, 2019, p. 24)

- Early diagnosis and improved treatment effectiveness and quality through the detection of early disease signals, intervention, and reduced risk of adverse reactions.

- Expanded opportunities for disease prevention by identifying risk factors.
- Enhanced pharmacovigilance and patient safety by enabling more informed medical decisions based on direct patient information delivery.
- Outcome prediction.

In addition to revolutionizing healthcare delivery and patient outcomes, the adoption of big data analytics in healthcare plays a significant role in advancing sustainable development objectives. By leveraging data-driven insights, healthcare systems can improve efficiency, optimize resource utilization, and promote preventive measures, thereby fostering a more sustainable healthcare ecosystem.

This section will explore five key benefits of big data healthcare analytics, illustrating their profound impact on healthcare management and sustainable development initiatives: (The Power of Big Data Analytics in Healthcare: Top Benefits and Challenges, 2023)

4.3.1 Cost Reduction: A more strategic utilization of big data has the potential to significantly reduce healthcare expenses. Studies suggest that leveraging big data analytics could lead to a substantial reduction of 50%–75% in wasted healthcare costs, potentially saving the U.S. healthcare system an estimated \$500 billion to \$750 billion. Through the analysis of patterns and trends, big data enables healthcare organizations to identify areas for improvement and implement cost-cutting measures. For instance, predictive analytics can accurately forecast the demand for medical supplies across various hospital departments, enabling administrators to optimize purchasing decisions and capitalize on cost-saving opportunities.

4.3.2 Minimizing Medical Errors: Applying big data analytics in healthcare can help dramatically reduce medical error rates. By analyzing data such as electronic health records (EHRs) for anomalies, data analytics solutions can flag suspicious entries for manual inspection by a healthcare professional. For example, researchers at Johns Hopkins have developed a technique to harness big data for correcting diagnostic errors, comparing patient symptoms with diseases that are frequently misdiagnosed.

4.3.3 Improving Diagnostics and Predictions: While computers aren't able

to take the place of human physicians, they can support the work and improve the care quality. Particularly, AI and machine learning algorithms can analyze healthcare provider data to predict the most likely diagnoses for a patient's condition. Besides they are also able to suggest tests to confirm a diagnosis. Meanwhile, big data analytics can pinpoint patients – the one being at the greatest risk for adverse healthcare outcomes.

4.3.4 Increasing Health Indicators: The application big data analytics has been shown to improve public health indicators across many fields, from diabetes to suicide mortality rates and mental disorders. According to a study in the *Journal of Medical Internet Research*, the use of big data analytics has been effective for use cases such as diagnosing illnesses and managing chronic diseases.

4.3.5 Enhancing Patient Experiences: Utilizing data analytics helps healthcare providers make smarter decisions about how to improve patient care and their patient experience. Thanks to big data analytics, patients can receive better care for better outcomes, and be more satisfied when interacting with healthcare professionals.

5. CONCLUSION

The Information Age has brought rapid technological advancements with an irreversible impact in our daily lives and social organizations. Advancements in computational speed and storage capacity has led our society to collect all sorts of data. This often leads to problems such as not having enough data or having too much data (big data). The end goal of data collection is to identify patterns or convert it into useful information which is then used for decision- making purposes that could have a direct or indirect impact on individuals, organizations and society.

Improving healthcare quality and achieving better health outcomes through the use of big data contributes to promoting sustainable development by enhancing the long-term health and well-being of populations. Additionally, big data analysis supports informed healthcare decision-making and reinforces preventive health measures, thereby promoting sustainability in healthcare resource utilization and reducing healthcare costs in the long run. Thus, it can be said that utilizing big data in healthcare contributes to achieving sustainable development goals.

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