Impacts and Roles of Big Data in Healthcare

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Abstract

Big data plays a crucial role in healthcare by leveraging large amounts of data to identify patterns and insights that can inform decision-making and benefit overall patient outcomes. It has revolutionized the structure of traditional healthcare to account for the dynamic changes occurring across the globe. Big data and other connected technologies continue to be vastly utilized leading to better solutions and improved quality of care.

Introduction

Analytical tools have dominated the healthcare field to quench our growing dependence on technology and demand for smart healthcare services (Garcia-Perez, 2022; Liu, 2022). It has ushered in an era of cutting-edge innovations, boosted productivity and improved efficiency to positively impact patient outcomes in the twenty-first century (Garcia-Perez, 2022; Liu, 2022; Benzidia, 2023). The quantity of data produced due to this digitization is growing exponentially (Mohapatra, 2022). As a result, storage, processing, and analysis of this data is becoming a challenge that needs to be addressed (Mohapatra, 2022). The traditional structure of healthcare is being transformed by the integration of new technology, leading to a more efficient and effective healthcare system through these data driven methods.

Big data, an analytical resource, is described as the volume, variety, veracity, and velocity of data to provide valuable insights and has a competitive edge amongst organizations

(Bag, 2023; Akter, 2022). In medical care, big data contains vast amounts of patient information including medical records, lab results, imaging studies and other clinical data in documents such as electronic health records (EHR) (Awotunde, 2022). Analysis of this data helps in furthering automation during dynamic times, providing predictive analytics, accessibility to high quality equitable services and in turn lowering cost control.

Automation

In the medical field, there has been a growing interest in using technology to improve the speed and accuracy of diagnoses. This came in approaches such as streamlining certain administrative tasks or performing procedures.

Events such as the unprecedented Corona Virus of 2019 amplified the shift of traditional to digital services, as nationwide shutdowns started occurring (Chandra, 2022). The pandemic became a catalyst to highlight significant pre-existing issues, such as the digital divide amongst certain parts of society and exacerbated limited resources as the flooding of pathology testing took place (Garcia-Perez, 2022; Chandra, 2022; Madhavan, 2021). To prevent the spread of the disease, isolation occurred where IoT solutions were utilized to continue activities previously done (Chandra, 2022). One of these being telemedicine, that allowed remote interactive two-way communication and became essential to providing personalized emergency services. This came in the form of video apps such as Zoom, Microsoft Teams, Facebook, etc. (Chandra, 2022). Big data offered a solution to analyze this data that is stored online to provide statistics regarding the pandemic (Popkova, 2021) and is a step towards automation and adaptation during times of trouble.

Aside from the pandemic, artificial intelligence (AI) in addition to big data has been widely used in technology to potentially perform autonomous surgeries sooner than expected (Wall, 2020). Additionally, it would help physicians manage the growing volume of medical literature and is not limited to the individual's capacity to remember, making this approach a valuable tool in the medical field (Wall, 2020). An example is the field of ophthalmology, where AI and big data predicted the vault and EVO-implantable collamer lens (ICL) size with an accuracy of 82.2% using the Random Forest regression model. This implies how the tool can assist ophthalmologists in improving ICL surgery's safety, strategy, and outcomes (Shen, 2023). (Wall, 2020) stated, "Big Data, AI and Automation will fundamentally change the practice of surgery in the future." Therefore, it comes as no surprise that roughly 44% of administrative tasks too, can be automated (Willis, 2020).

Predictive Analytics

Alongside improving automation, big data can be used to predict the future. The purpose of this data lies in taking an enormous dataset, analyzing it, identifying trends, and developing predictive models through data mining techniques. This technique was advantageous during COVID-19 to predict the spread amongst populations (Batko, 2022). Machine learning takes large data formed through big data to give outcomes on population level healthcare at high risk of developing adverse health outcomes and develop the necessary interventions in advance (Alanazi, 2022). Using predictive models can lead to the formation of preventative initiatives and allow patients to receive early medical attention (Krishnamoorthi, 2022).

Diabetes Mellitus, an incurable disease, is a prime example of how predictive analytics can be utilized in preventative medicine to assess patients' risk levels and offer an appropriate treatment (Srivastava, 2022). Through the various machine algorithms employed based on extensive data analysis, studies have demonstrated that there is an accuracy rate of approximately 86% in determining the likelihood of developing the disease (Krishnamoorthi, 2022; Srivastava, 2022). Similarly, in the case of heart disease, low heart rate (HR) can be contributing factor, but with monitoring systems, physicians can identify irregularities in HR and develop personalized plans to prevent or manage its progression. Utilizing heart rate time series data and machine learning techniques, a study successfully predicted future HR more accurately by incorporating accelerometers (Oyeleye, 2022).

Furthermore, this analytics plays a crucial role in pain control following knee arthroplasty surgery, as inadequate management not only delays recovery but could lead to postoperative opioid abuse. To mitigate potential complications, researchers have used factors such as preoperative opioid duration, drug abuse, and depression to predict prolonged postoperative opioid usage and identify individuals at risk (Klemt, 2022). By leveraging proactive predictive analytics within diseases such as these, which significantly impact mortality rates in populations, healthcare professionals can enhance their ability to intervene early and optimize patient outcomes.

Accessibility

In addition to predictive analytics and automation, accessibility is another challenge that big data aims to address. Accessibility has three main components: capacity, potential demand, and transport network performance of healthcare services (Chen, 2020). COVID-19 intensified the digital disparities amongst nations and urban vs. rural populations making many resources inaccessible to people (Chandra, 2022). Taxi trajectory data from Shenzhen, China, determined that the probability of reaching a desired time decreases as the targeted time gets further from the present. However, it also highlighted that if the energy required to travel is lower the probability is higher (Chen, 2020). Aside from time, proximity also plays a huge role as the number of patients by taxi decreases with an increase in distance from hospitals (Jing, 2023). Using big data to provide statistics on accessibility can aid planners and policy makers in addressing healthcare accessibility, as it helps identify areas with limited access and allocate resources accordingly. This can lead to more equitable healthcare and provide valuable insights (Chen, 2020).

Conclusion

Technology has made strides in healthcare aiming to address previously existing problems while attempting to predict future ones. Big data and its related technology show great promise of adaptability to a new system, that is modern healthcare. Over the years, practices such as automation of procedures or tasks, predictability and personalized medicine, and accessibility shows evidence of improving care and patient outcomes. These practices consider big data and analyze it to provide insights that are efficient and effective to society. There is still a long way to go for the applications of this day to day in every location. Expanding studies to different areas and getting bigger datasets of structured and unstructured data regarding diseases as well as addressing ethical and security issues would change the game for the future.

References

Akter, J. S., & Haque, S. M. (2022). INNOVATION MANAGEMENT: IS BIG DATA NECESSARILY BETTER DATA? *Management of Sustainable Development*, *14*(2), 27–33. https://doi.org/10.54989/msd-2022-0013

Alanazi, A. (2022). Using machine learning for healthcare challenges and opportunities. *Informatics in Medicine Unlocked*, *30*, 100924. https://doi.org/10.1016/j.imu.2022.100924

Awotunde, J. B., Jimoh, R. G., Ogundokun, R. O., Misra, S., & Abikoye, O. C. (2022). Big Data Analytics of IoT-Based Cloud System Framework: Smart Healthcare Monitoring Systems. *Springer EBooks*, 181–208. https://doi.org/10.1007/978-3-030-80821-1_9

Bag, S., Dhamija, P., Singh, R. K., Rahman, M. S., & Sreedharan, V. R. (2023). Big data analytics and artificial intelligence technologies based collaborative platform empowering absorptive capacity in health care supply chain: An empirical study. *Journal of Business Research*, *154*, 113315. https://doi.org/10.1016/j.jbusres.2022.113315

Batko, K., & Ślęzak, A. (2022). The use of Big Data Analytics in healthcare. *Journal of Big Data*, *9*(1). https://doi.org/10.1186/s40537-021-00553-4

Benzidia, S., Bentahar, O., Husson, J., & Makaoui, N. (2023). Big data analytics capability in healthcare operations and supply chain management: the role of green process innovation. *Annals of Operations Research*. https://doi.org/10.1007/s10479-022-05157-6

Chandra, M., Kumar, K., Thakur, P., Chattopadhyaya, S., Alam, F., & Kumar, S. (2022). Digital technologies, healthcare and Covid-19: insights from developing and emerging nations. *Health and Technology*, *12*(2). https://doi.org/10.1007/s12553-022-00650-1

Chen, B. Y., Cheng, X.-P., Kwan, M.-P., & Schwanen, T. (2020). Evaluating spatial accessibility to healthcare services under travel time uncertainty: A reliability-based floating catchment area approach. *Journal of Transport Geography*, *87*, 102794. https://doi.org/10.1016/j.jtrangeo.2020.102794

Garcia-Perez, A., Cegarra-Navarro, J. G., Sallos, M. P., Martinez-Caro, E., & Chinnaswamy, A. (2022). Resilience in healthcare systems: Cyber security and digital transformation. *Technovation*, *121*, 102583. https://doi.org/10.1016/j.technovation.2022.102583

Jing, C., Zhou, W., Qian, Y., Zheng, Z., Wang, J., & Yu, W. (2023). Trajectory big data reveals spatial disparity of healthcare accessibility at the residential neighborhood scale. *Cities*, *133*, 104127. https://doi.org/10.1016/j.cities.2022.104127

Klemt, C., Harvey, M. J., Robinson, M. G., Esposito, J. G., Yeo, I., & Kwon, Y.-M. (2022). Machine learning algorithms predict extended postoperative opioid use in primary total knee arthroplasty. *Knee Surgery, Sports Traumatology, Arthroscopy*. https://doi.org/10.1007/s00167-021-06812-4

Krishnamoorthi, R., Joshi, S., Almarzouki, H. Z., Shukla, P. K., Rizwan, A., Kalpana, C., & Tiwari, B. (2022). A Novel Diabetes Healthcare Disease Prediction Framework Using Machine Learning Techniques. *Journal of Healthcare Engineering*, *2022*, 1–10. https://doi.org/10.1155/2022/1684017

Liu, K., & Tao, D. (2022). The roles of trust, personalization, loss of privacy, and anthropomorphism in public acceptance of smart healthcare services. *Computers in Human Behavior*, *127*, 107026. https://doi.org/10.1016/j.chb.2021.107026

Madhavan, N., White, G. R. T., & Jones, P. (2021). Identifying the value of a clinical information system during the COVID-19 pandemic. *Technovation*, *120*, 102446. https://doi.org/10.1016/j.technovation.2021.102446

Mohapatra, S. K., & Mohanty, M. N. (2022). Big data classification with IoT-based application for e-health care. *Elsevier EBooks*, 147–172. https://doi.org/10.1016/b978-0-323-85117-6.00014-5

Oyeleye, M., Chen, T., Titarenko, S., & Antoniou, G. (2022). A Predictive Analysis of Heart Rates Using Machine Learning Techniques. *International Journal of Environmental Research and Public Health*, *19*(4), 2417. https://doi.org/10.3390/ijerph19042417

Popkova, E. G., & Sergi, B. S. (2021). Digital public health: Automation based on new datasets and the Internet of Things. *Socio-Economic Planning Sciences*, *80*, 101039. https://doi.org/10.1016/j.seps.2021.101039

Shen, Y., Wang, L., Jian, W., Shang, J., Wang, X., Ju, L., Li, M., Zhao, J., Chen, X., Ge, Z., Wang, X., & Zhou, X. (2023). Big-data and artificial-intelligence-assisted vault prediction and EVO-ICL size selection for myopia correction. *British Journal of Ophthalmology*, *107*(2), 201–206. https://doi.org/10.1136/bjophthalmol-2021-319618

Srivastava, R., & Rajendra Kumar Dwivedi. (2022). A Survey on Diabetes Mellitus Prediction Using Machine Learning Algorithms. *Lecture Notes in Networks and Systems*, *321*, 473–480. https://doi.org/10.1007/978-981-16-5987-4_48

Wall, J., & Krummel, T. (2020). The digital surgeon: How big data, automation, and artificial intelligence will change surgical practice. *Journal of Pediatric Surgery*, *55*, 47–50. https://doi.org/10.1016/j.jpedsurg.2019.09.008

Willis, M., Duckworth, P., Coulter, A., Meyer, E. T., & Osborne, M. (2020). Qualitative and quantitative approach to assess of the potential for automating administrative tasks in general practice. *BMJ Open*, *10*(6), e032412. https://doi.org/10.1136/bmjopen-2019-032412