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Empirical Investigation of Artificial Intelligence and Data Science in Healthcare Management and Administration

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ABSTRACT

The present research analyses the importance of AI technology and Data science implementation in the healthcare system. These two technologies are extensively used in present days and hold high value in the medical and healthcare industries. From disease detection to strategy prediction, these technologies have placed their influence. Through effective patient data analysis and disease monitoring, these technologies have enhanced their popularity. The research focuses on describing the role, challenges, and advantages associated with AI and data science. The research has been conducted with a survey-based statistical analysis and critical justification of survey analysis has been done with supportive articles of the last five years. Findings showed that AI approaches are mostly used in the administrative and data science fields in the National Health Service (NHS UK). AI technology is further categorised into three types: Rule-based, Machine Learning (ML) and Deep Learning (DL) which are being used in the healthcare sector. The research suggested that Deep Learning is the recent demand due to its greater performance and low update cost. However, the major challenge in these AI technologies is large datasets, inaccuracy and security issues which have been addressed in this paper. Lastly, possible solutions have been described for these empirical findings.

Keywords: *Machine Learning, Artificial Intelligence, Healthcare, Survey, NHS UK*

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INTRODUCTION

Artificial intelligence (AI) nowadays is extensively used in healthcare due to its vast application and advantage. AI technology is used both in administration and in patient care. Different types of AI technology such as "Machine Learning", "Neural Language Processing" and "Rule-Based expert systems" are used in hospitals and healthcare organisations for disease diagnostics and administrative purposes. Machine Learning is one of the most common and well-known practises of AI technology. The wide range of applications and advantages of this technology enables healthcare professionals and experts in determining the best treatment and diagnostic method for their patients. NLP of the "Neural Language Processing" on the other hand is effective in "speech recognition" and proper "clinical documentation". NLPs are effective in a better-quality understanding of patient behaviour and thus provide a significantly better and improved result for the patients. The "rule-based expert system" is somewhat a more traditional approach to AI technology. This technology works with a set of "if-then" rules and is often not suitable for large data analysis. Especially in clinical documentation, where large patient datasets are often generated which is required for proper treatment. Data science on the contrary helps to manage the large dataset of healthcare industries which usually contains "demographic data of patients", medical treatment plans and test results etcetera. Data science helps individuals in proper analysis, documentation, assimilation, and management of large datasets with both "structured" and "unstructured" data. In the healthcare industry, data science is used for proper data cleaning, effective data analysis, and proper data mining process. This helps medical and healthcare professionals in making

different strategic decisions regarding the treatment procedure. Moreover, data science also enhances the overall treatment quality through an effective diagnosis of disease and proper analysis of patient data [1]. Both AI and data science improve the treatment procedure and quality of patients and help in effective patient data management. The present research focuses on analysing the impact of AI and data science in data management in healthcare industries. The research also focuses on demonstrating the role of these two data analysis methods in improving the treatment quality.

LITERATURE REVIEW

The AI technology is extensively used in hospitals and healthcare organisations to develop different computer algorithms that can help in "clinical diagnostics", "healthcare management", "therapeutics application" and "administration" [2]. AI technologies can be used to analyse patient information that can be further used for making effective clinical decisions. Apart from that AI technology can effectively reduce the number of medical and diagnostic errors and can improve the treatment quality. This technology can also effectively stratify the disease and can help in proper risk assessment. AI technology can also be used for proper diagnosis generation and effective therapy selection. This way AI technology helps in improving the overall treatment productivity and quality [3].

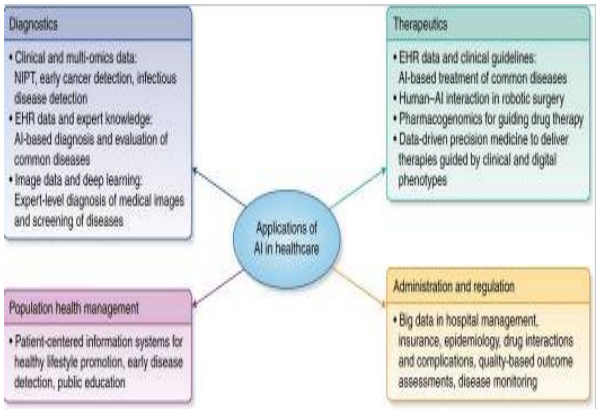

Figure 1. Role of different AI technology in hospitals and healthcare industries[3]

In diagnosis AI technology is used to analyse different "clinical" and "multi-omics" data such as NIPT or "Non-invasive perinatal testing", detection of oncogenes in the body (cancer detection) etcetera [4]. AI is also used for detecting non-infectious and infectious diseases. The EHR or "Electronic Health Record" data generated through AI technology is extensively used for medical diagnosis. Deep learning methods of AI technology are used for describing different medical images and analysing disease screening processes [5].

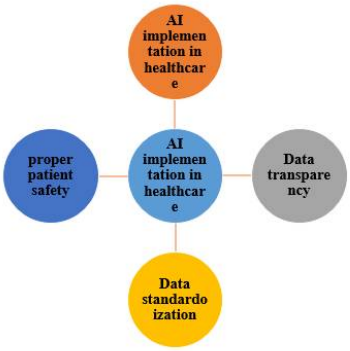

Figure 2. The data implementation process of AI technology in the healthcare industry

AI technology is used for promoting a healthy lifestyle to patients by analysing their medical records and data. This technology is also used for different disease detection and "public education".AI technology is used in the treatment of various common diseases and effective “Human-AI” interaction is used for performing robotic surgery. Apart from that effective “pharmacogenomics” is used for different drug delivery. AI is used in hospital sectors for managing and analysing big data of patient insurance, disease epidemiology, different drug interactions, proper disease monitoring etcetera [6]. Data sharing is required for proper data analysis, data validation, and improvement of "AI algorithm". Data sharing can

be done with different medical databases and biobanks. For example, the "UK biobank", "cardiac atlas project" etcetera". These shared data are used for "calibration" and creation of different anonymous datasets of benchmarking. Data transparency helps individuals in understanding the way AI analyses the patient dataset and predicts results. Data transparency also helps in understanding technical errors and keeps the technology free from any "algorithmic" or "characteristics" biasness. Data standardization can be done by "DICOM" or "Digital Imaging and Communications in Medicine" standard and through this effective data storage and data security can be maintained. Confidentiality is the key to maintaining patient safety that is maintained in AI technology [7]. Data science is used for big data analysis, management, and effective distribution. Different processes are used for analysing the large dataset generated in healthcare (such as treatment data, demographic data, insurance data, test results, drug interactions etcetera).

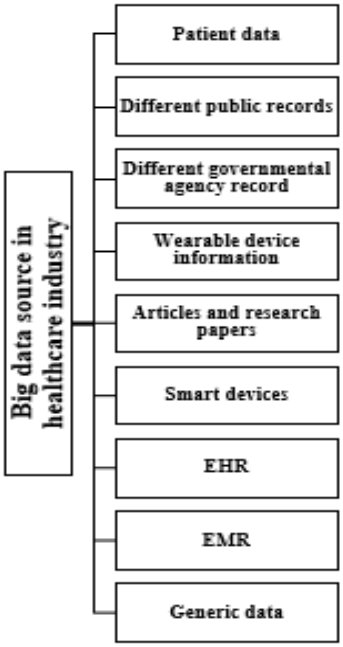

Figure 3. Source of big data in the different healthcare industry

Data analysis is usually performed in data science with different types of tools such as "Apache Hadoop", "Apache Cassandra '', "Apache storm" etcetera (Table 1). These tools can effectively analyse, store and validate the clinical dataset [8].The "Electronic Health Records" and "Electronic medical records" generated in healthcare industries are often analysed by data mining processes. This process is used for data clustering, data fragmentation, data sourcing, effectively analysing, and proper distribution [9]. NLP-based algorithms are used in the data mining process which effectively detects disease and helps in the "early detection" of several oncogenes. Data science is used for effective image processing in healthcare industries through which patient anatomy and health conditions can be analysed. Image processing is essential in visualising "organ delineation", tumours, "spinal deformities", "arterial stenosis" etcetera. The images are analysed through effective segmentation, proper enhancement, and proper noise reduction. Disease monitoring can be done using the patient EMR and EHR data. Disease monitoring helps medical professionals in understanding the spread rate and dominance of disease [10].

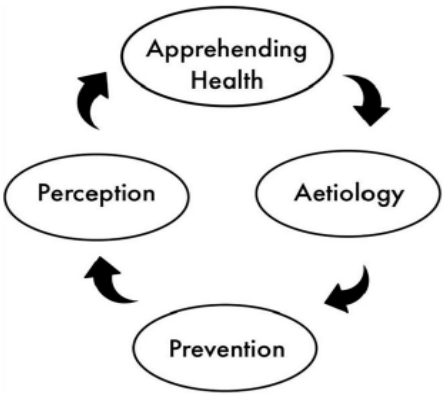

Figure 4. Disease analysis and monitoring through data science[10]

Data mining technique is usually used in healthcare administration for large data analysis. Apart from that cloud computing can also be used for effective data analysis and data storage. The patient EMR and EHR data are stored by data mining and cloud computing. The overall quality and patient handling capability are improved by implementing data science.

MATERIAL AND METHODS

A purposive sampling technique has been done in this research to demonstrate the advantage and impact of data science and AI technology in healthcare. This sampling technique has been used as this effectively demonstrates the main characteristics of the research dataset [11]. In the present research, this sampling technique has been used to observe the impact and characteristics of data science and AI implementation in healthcare sectors. A survey-based analysis has been done in which 5 consecutive surveys have been performed with 50 participants. The survey participants were chosen from the "National Health Service" organisation of the UK. The survey-based analysis helps researchers in analysing the importance of AI and data science from other individuals' (in this case surveyors) perspectives. By following this way, the researcher can analyse the advantage and disadvantages of these technologies and also can assess their impact on medical and healthcare professionals. A "Deductive research approach" has been taken for this research. This research approach helps to critically test the importance and impact of AI and data science in the health sectors [12]. Whereas other research approaches such as the inductive research approach do not describe the importance of these technologies rather it focuses on demonstrating the future implementation of AI and data science in healthcare. A mixed research strategy has been applied in which both quantitative and qualitative data have been analysed. A mixed research strategy helps the researcher in critically assessing the dominance of AI and data science. The quantitative data has been analysed from survey-based questionnaires and the qualitative data has been analysed from the argumentative analysis. The primary data has been taken from five online surveys which have been done by generating a google form. Due to the covid-19 pandemic, the survey has been done online via google forms. The argumentative or critical analysis has been done by taking secondary data. This data has been taken from google scholar and journals of the last five years were taken to support the research objective. Statistical analysis has been done with the primary data and critical analysis of that primary data has been done with the help of secondary data. Through statistical data analysis, the impact of AI and data science can be demonstrated. The research also focuses on critical analysis which has been done through supportive articles and journals taken from google scholar. The present research also critically assesses the advantages and challenges that are associated with AI technology and data science implementation. Moreover, the research also analyses the impact of these advantages and challenges on the lives and wellbeing of medical and healthcare professionals.

Research questions

What are the impacts of AI and Data science algorithms in the healthcare system?

What challenges and advantages are posed by AI technology and data science on healthcare professionals?

ANALYSIS AND INTERPRETATION

In this section, the relevant and essential questions asked in the google survey have been presented and analysed. During the online survey, names, gender, age and work experiences were also collected which were excluded from this analysis as that information seem to be irrelevant. The required questions and responses are following

Q1: Where do you think the AI, ML and NLP are used the most in your healthcare sector (in terms of administration and diagnosis)?

Responses:

TABLE 2. RESPONSES OF FIRST SURVEY QUESTION

Options provided	Total respondents	Collected responses	Percentile
Administration	50	16	32%
Radiology	50	9	18%
Robotic surgery	50	5	10%
Discovery of biomarker	50	6	12%
Interpretation of Genome	50	6	12%
Pathology	50	4	8%
Dermatology	50	4	8%

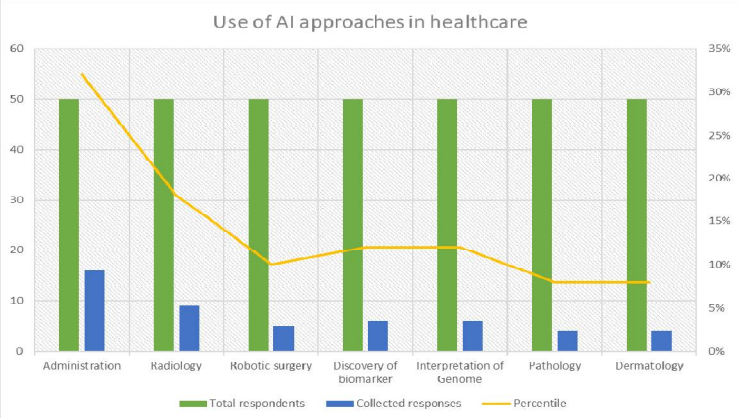

Figure 5. Graphical representation of first survey question

The first survey question responses (Table 2, figure 5) show that AI technologies are used mostly in the administration department for keeping the medical records and analysing the medical data (32%). Thereafter, 18% of the respondents agreed that AI approaches are being used in the radiology departments followed by Robotic surgery (10%), Bio-marker discovery (12%), Interpretation of Genome (12%), Dermatology (8%) and Pathology (8%). Therefore, AI technologies are used mostly in the administrative departments for clinical record-keeping and scheduling the clinician's timings.

Q2: What do you think are the most used approaches in your healthcare sector?

Responses:

TABLE 3. RESPONSES OF SECOND SURVEY QUESTION

Options provided	Total respondents	Collected responses	Percentile
Human Evaluation	50	21	42%
Machine Learning methods	50	10	20%
Deep Learning Techniques	50	13	26%
Rule-based Algorithm	50	6	12%

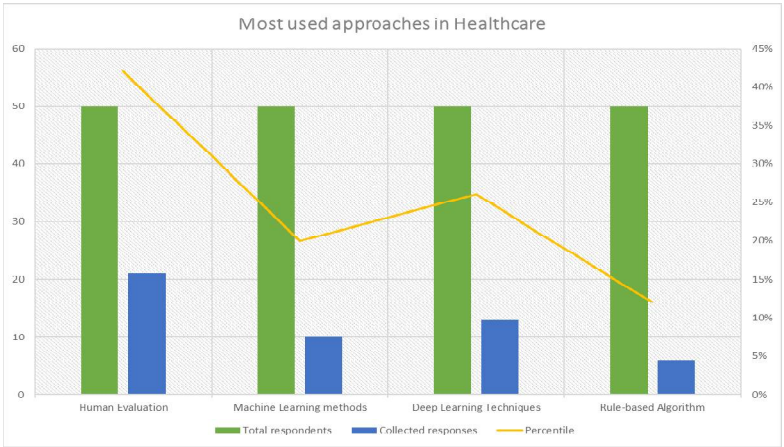

Figure 6. Graphical representation of second survey question(Source: Self-created)

Survey response of question 2 (table 3, figure 6) shows that most of the works are accomplished by human evaluation (42%) and few are accomplished by Rule-based algorithms (12%). However, deep learning and machine learning are used in an average manner. In this case, the DL is winning among the other AI technologies. The discussion section will explain the reason behind the use of DL mostly.

Q3: What do you think is the best AI approach among the following approaches?

Responses:

TABLE 4. RESPONSES OF THIRD SURVEY QUESTION

Options provided	Total respondents	Collected responses	Percentile
Machine Learning	50	14	28%
Deep learning	50	26	52%
Rule-based algorithms	50	10	20%

Survey question 3 is related to the previous question where the respondents were asked which is the best AI approach among the three approaches. 52% of the respondents agreed that DL is the best approach followed by ML and Rule-based algorithms (Table 4). The DL has been discussed a little in the previous sections and the discussion of this analysis will be accomplished in the next section.

Q4: Do you think your AI approach truly benefits the healthcare administration and data science works (For example, medical record-keeping, accurate administration in clinical records, scheduled tasks, data analysis)?

Responses:

TABLE 5. RESPONSES OF FOURTH SURVEY QUESTION

Options provided	Total respondents	Collected responses	Percentile
Highly Agree	50	25	50%
Agree	50	10	20%
Neutral	50	6	12%
Disagree	50	7	14%
Highly Disagree	50	2	4%

The fourth survey question is related to the research topic where the healthcare sectors responded whether AI has benefitted their administrative and data science works. A total of 70% of respondents agreed with this question. 12% were neutral and 18% have disagreed with this question (Table 5). The reason behind this disagreement will be explained in the discussion part.

Q5: What do you think can be a challenge in this AI technology?

Responses:

TABLE 6. RESPONSES OF FIFTH SURVEY QUESTION

Options provided	Total respondents	Collected responses	Percentile
Huge amount of training data	50	14	28%
AI Noise and Bias	50	2	4%
Social challenges when during AI deployment	50	4	8%
Issues in replacing the healthcare professional's work	50	3	6%
Inaccuracy and lack of human-driven diagnostic	50	8	16%
Privacy and Security issues	50	10	20%
Job loss	50	9	18%

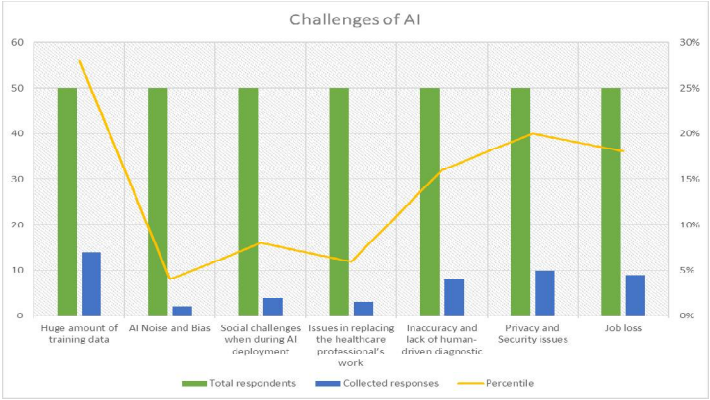

Figure 7. Graphical representation of fourth survey question

(Source: Self-created)

The last survey question responses (table 6, figure 7) are based on the present and future challenges of AI technologies in healthcare. 28% of the respondents stated that AI technology, especially DL and ML,

require huge amounts of data for the training which becomes impossible sometimes. 20% of the respondents agreed that Privacy and Security are present and future concerns that will lead to clinical data leakage. 18% agreed that job loss will become a problem; inaccuracy is another concern (16%) followed by AI noise and bias, social challenge and clinician replacement.

RESULTS AND DISCUSSION

The survey question analyses have stated various information related to the advantages and challenges of AI in healthcare sectors. AI is beneficial in terms of administration, data science and clinical methods [13]. Concerning this, Spruit and colleagues stated that data mining and data discovery is accomplished by implementing AI technology [14]. The survey responses suggested that the healthcare sectors started using the AI approach in administration and data science (Table 2). Therefore, it can be stated that healthcare sectors are using this technology to discover data, analyse big data, analyse domain information and clinical data for providing better care. The domain data and other clinical data are analysed by data scientists to bring insightful information [15]. The survey responses stated that DL is the most used approach and Nosratabadi and co-workers defined that hybrid machine learning and DL are the most used techniques to achieve effective data analytics [16]. The survey responses stated that AI technology may cause job loss in healthcare sectors as the administrative works will be replaced by AI (Table 6). However, Spruit and colleagues argued that AI technology alone cannot accomplish this process. Clinical researchers, expert data scientists and business analysts are required to organise the entire data into meaningful insight. Thus, the machines are used for bringing new opportunities and profits in healthcare, rather than replacing humans [17].Survey responses stated that most of the respondents agreed that AI helps the data science and administration department to conduct medical record-keeping, clinical data analysis and clinician scheduling (Table 5). It suggests that delivering effective and timely care became difficult for most of the healthcare sectors. In this evidence, Reddy and others also explained that the healthcare sectors are having a human-driven administration process which results in low-accuracy treatment scheduling. After the implementation of AI, the treatment schedule has been accomplished accurately [18]. Therefore, the entire task of a clinician is being scheduled in terms of urgency and unimportance [19]. However, issues may arrive during the integration of ML/DL with conventional record systems and data labelling. Thus, Transfer Learning is an alternative technology for integrating the conventional methods with new approaches [20]. Apart from these, respondents highlighted that privacy-related issues are some major concerns in AI. The privacy-related issues include data breaching which may result in reputational and psychological harm to the patients. Therefore, before storing and sharing the patient data, the patient needs to be informed and consent is required [21]. Other solutions include educating the healthcare professionals on transparency, accountability and unbiasedness. Table 5 stated that social issues may occur which include replacing the works of healthcare professionals with other clinicians by following the scheduled tasks. Therefore, the works will reshape the clinician's roles in the sectors [22]. More research is required in this to address the challenges [23].Tables 3 and 4 suggested that DL is the demanding approach in healthcare sectors to carry out various tasks related to radiology, diagnosis and administration. Mostly, the DL is used due to its high performance [24, 25]. Yu and colleagues suggested that DL, ML and rule-based algorithms are the most used technologies where these three technologies are equally productive [26]. However, the updating cost of DL is much lower than ML and rule-based techniques [27]. Moreover, DL algorithms have higher performance than human-driven, rule-based and ML algorithms [28]. The DL has been reported and surveyed that it requires a large amount of data for training purposes; otherwise, the inaccurate output will result in inappropriate treatment and social violence [29, 30]. Other future challenges are also predictable and need to be addressed further.

CONCLUSION

The research paper discussed the AI approaches in NHS UK by a quantitative survey method. The AI approaches are mostly used in Data Science to generate new data, analyse the data and bring insightful information. The study suggested that healthcare sectors (particularly NHS) implement the AI, ML and DL technologies in administration works, diagnosis and other departmental works. In administration, the AI helps to schedule the treatment times, clinician's routine and manage data which were previously difficult by human-driven processes. Therefore, the AI approaches have benefitted the healthcare sectors in terms of clinician routine development, treatment scheduling, patient report justification, profitable business data generation and many more. However, several present and future challenges have been addressed during this survey which includes privacy issues, inaccuracy, job loss and so on. This research can be extended further for exploring new solutions to the current challenges.

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