Artificial intelligence enhancing the quality of healthcare services

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ABSTRACT
This paper aims to propose that the applications of Artificial Intelligence in healthcare improve the quality of healthcare services. Through theoretical analysis of existing literature of the applications of AI in healthcare, then descriptive data analysis of a questionnaire distributed among healthcare professionals in six countries to validate the theoretical analysis. As a result of the descriptive analysis, it is proved that the applications of artificial intelligence in healthcare are enhancers of the six dimensions of quality healthcare services defined by the Institute of Medicine (IOM) as defining dimensions of healthcare quality globally.

Keywords: artificial intelligence, knowledge management, quality healthcare.

1 INTRODUCTION
Healthcare is a service industry serving the world population of approximately eight billion people (UNFPA, 2020). Health as stated by the World Health Organisation (WHO) is a fundamental human right (WHO, 2017).

As we are witnessing through the global crisis of Covid-19; health crisis transforms into economic crisis, food crisis, housing crisis and political crisis (Gates and Gates, 2020). Unfortunately, challenges within the global healthcare before the current pandemic have caused a lot of pressure and call for actions revolving around universality of healthcare and quality of healthcare services (World Health Organization, World Bank Group, 2018).
The quality of healthcare is an intrinsic crucial part of healthcare delivery that does not come automatically; it requires planning, identification and clarifications with transparency and focus upon the patients and work force supported by leadership and healthcare organisation culture (World Health Organization, World Bank Group, 2018).

The institute of medicine (IOM) defines quality healthcare as: “the degree to which healthcare services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge” (AHRQ, 2012). Healthcare quality dimensions have been identified and developed starting with the work of Donabedian in the late 1980s (Walshe and Smith, 2011) arriving at the six dimensions of quality healthcare defined by the IOM which are effectiveness, safety, people centeredness, timeliness, equity and efficiency (Dunn, 2006; AHRQ, 2012; World Health Organization, World Bank Group, 2018) and are defined as below:

- **Effectiveness**: delivering healthcare that is compiled and aligned with the evidence base healthcare and results in improved healthcare outcomes for the specific needs of individuals and communities.
- **Safety**: Delivering healthcare while minimising risks and harms to the service users who are the patients.
- **People centeredness**: delivering healthcare with people preferences, aspirations, communities, and cultures being the drivers.
- **Timeliness**: delivering healthcare that is accessible in time with ease when exactly needed with the minimum delays possible.
- **Equity**: to deliver a healthcare service without any disparity whether due to personal related issues like gender, race, ethnicity, geographical location, or socioeconomic status.
- **Efficiency**: delivering healthcare while maximising the utilisation of resources and minimising wastage.

The healthcare industry characterised by its innovative nature and continuous challenges have evolved immensely in the last 20 years, starting from medical products (equipment, hardware and consumables), then to medical platforms due to the informatics booming era (wearables, big data and health analytics) then reaching the era of medical solutions which is characterised by the incentive of technological adaptation like robotics, artificial intelligence (AI) and augmented reality (PWC, 2017). It is important to mention that informatics have participated hugely in improving healthcare quality (Otokiti, 2019) yet also resulted in overload of information in healthcare that is needed to be transformed into knowledge (Nicolini *et al.*, 2008).

Knowledge management has been proved through research as an important element in healthcare decision making support (Sibte and Abidi, 2001) as the healthcare industry is a knowledge based
community depending in connection between hospitals, clinics, pharmacies and patients (customers) in sharing knowledge (Bose, 2003) and thus high knowledge management tools effect positively in any healthcare facility competitive advantage while enhancing the organisation continuous learning (Kothari et al., 2011).

In innovative industries like the healthcare industry, knowledge management practices also proved to enhance innovation (Donate and Guadamillas, 2010, 2015). And in different other industries, knowledge management also have proved to increase productivity (Avalos et al., 2021).

Artificial intelligence (AI) defined as the branch of computer science focused in stimulating intelligent behaviour in computers to imitate intelligent human behaviour (RADICK, 2017). Artificial Intelligence in other words is a computer system ability to interpret external data correctly, to learn from the data and to use those learnings to achieve specific goals and tasks (Haenlein and Kaplan, 2019). AI is also a tool of knowledge embodiment that works in the powerful transformation of knowledge into valuable form (Pee, Pan and Cui, 2019).

Artificial intelligence has proven significant results in the healthcare field through its different subfields like: expert rule-based systems utilising neural networks to stimulate the expert level capacities of knowledge-based decision making, robotic process automation, natural language processing (NLP) and machine learning (Wiljer and Hakim, 2019).

Image and signal processing AI is considered for some researchers a subfield (Cossy-Gantner et al., 2018) due to the huge amount of data available in healthcare as medical images and to availability of signals as data through physiological devices thus leading many companies to invest in this subfield of AI (Faggella, 2019). AI has proven its ability to extract and detect information from medical images to help in diagnosing cancer and eye diseases (Jiang et al., 2017), cardiac diseases (Esposito, 2018) and cerebral aneurysm in brain (Jiang et al., 2017).

Artificial intelligence plays a huge role in prediction and prognosis in healthcare like predicting health outbreaks or sepsis in hospitals by measuring the frequency of symptoms. In the other hand, utilising AI algorithms to teach robots have impacted positively in minimum invasive surgeries (RADICK, 2017). Those robots can also be utilised as surgical assistants and trainers for junior surgeons in the future. It could be soon that the vision of Ray Kurzweil of nano robots which can target specific issues in the human body including fixing immunity issues or provide internal blood monitoring (Bedsol, 2017; Technology Trends, 2019).

Precision medicine is yet another potential area of AI in healthcare with huge promise of great transformation in this field; which is the manufacturing of medicines based on the personalised genome of the patient which holds the promise of delivering tailored medicine to patients (Lindsay Holst, 2015; Barlow, 2016).
In the pharmaceuticals industry, the applications of artificial intelligence are used in clinical trials as means to reduction of costs and lowering the probabilities of mistakes in the process of drug discovery including enhancing the process of finding candidates for the clinical trials (Cheson, 2009; Woo, 2019). The promise of huge costs saving in clinical trials using NLP algorithms and even robotics in clinical experiments (Clinical Trials Arena, 2018; Woo, 2019).

In medical research, just like clinical trials AI provides an important tool for analysing and identifying patterns in large complex data as a navigating tool also with high promise in medical genomics research (Rees, 2019; SRG Blog, 2019).

In public health, just as its promise in precision medicine, AI carries huge possibilities in precision public health which provides the right intervention to the right population at the right time (Khoury, Iademarco and Riley, 2016). Also, in epidemiology as we witnessed during the Covid-19 pandemic, AI algorithms can help in prediction and management whether in the outbreaks or the vaccines development and management (WHO department of Digital Health and Innovation, 2021). At the same time; AI can support bridging disparities through learning from countries data and sharing expertise in countries where there are scarcity in experts (SRG Blog, 2019) this point in itself is part of the sustainable development goals of the World Health Organisation (WHO, 2019).

In healthcare facilities, AI can be leveraged as a great operation enhancement tool (Lass and Orr, 2019). Prediction analysis in managing patients visits and analysing patients logistics and flow data which impacts hugely in operation costs of hospitals (Sukel, 2019). An added benefit is utilising AI in managing the prediction of pharmaceuticals expiration dates which can also save huge costs to hospitals (RADICK, 2017).

In any hospital department that requires repetitive tasks, labour intensive tackling of high volume of documentation, AI algorithms help cutting time cost and human mistakes (Lass and Orr, 2019). An interesting report published in 2018 in the United Kingdom, predicted that the National Health Services (NHS) can save more than 10 percentage of its running costs with outsourcing repetitive tasks to AI (Kerasidou, 2020).

Many would argue that healthcare currently is in huge need for empathy and increasing available time for patients is one way to increase empathy in healthcare services.

2 OBJECTIVES

More than a year and a half after the Covid-19 pandemic, and it is obvious that the healthcare industry has been put under the microscope of the quality of its performance globally.
As we have already entered the era of the highest technological evolvements as stated above; there is still ambiguity around what can those high technological advancements achieve in the healthcare sector as tools for enhancements.

Artificial intelligence (AI) is a technology that carry huge possibilities of improving quality healthcare according to the six quality dimensions as these are stated: Effectiveness, safety, people centeredness, timeliness, equity, and efficiency.

This paper aims to highlight through theoretical and descriptive analysis evidence that the applications of artificial intelligence in healthcare have huge possibilities in enhancing the six quality dimensions of IOM.

3 THEORETICAL ANALYSIS

From the introduction section above the applications of artificial intelligence carry huge possibilities in the healthcare sector. Here those possibilities are connected to the definitions of the six dimensions of quality healthcare of IOM.

**Effectiveness**: delivering healthcare complied and aligned with the evidence base healthcare and results in improved healthcare outcomes for the specific needs of individuals and communities.

Artificial Intelligence algorithms basically are built upon analysing current existing medical data, learning from these data, building experience through these learnings, then creating solutions or projections for better healthcare services. Examples for how the AI applications can enhance the effectiveness in healthcare:

- Medical diagnostics and enhancing early diseases detection.
- Medical treatment whether through nano robotics or through specific software that allows better applied treatments.
- Surgical robotics: using AI algorithms as teaching algorithms for the robots enhancing accuracy and possibility of the current and future medical surgeries.

**Safety**: delivering healthcare while minimising risks and harms to the service users who are the patients.

Again, as AI algorithms are based on learning from existing medical data, enhancement of accuracy in delivering solutions based on those systems experiences increase safer solutions and lower risks.

- Precision medicine which addresses the needs for safe and precise tailored medicines according to the genetics of the individuals or population groups. This approach can maximise the suitability and efficiency of medicines minimising side effects and increasing beneficial output.
Lowering the load of administrative repetitive tasks for healthcare professionals, lower stress and accordingly the medical errors due to this stress; enhancing safety of delivery.

- Spending less time in hospitals through using AI prediction algorithms guarantee less time spent in hospitals which also lower the risk of taking an infection from the hospital and thus increasing the safety.

_People centeredness:_ delivering healthcare with people preferences, aspirations, communities, and cultures being the drivers for healthcare solutions.

AI solutions are driven from health data, those health data are from patients and addressed towards helping patients; driven by the specificity of people’s needs and diseases. Clear examples are witnessed in:

- Precision medicine: manufacturing medicine based on the personalised genome of the person, moving medicines from the approach “fits all healthcare” to a personalised tailored approach.
- Predicting (tailoring) patient’s treatment plans using AI algorithms based on the patients’ needs.
- Saving the physicians time through using AI algorithms, which can then guarantee more time for the physicians for the patients enhancing empathy and compassion during the healthcare service delivery.

_Timeliness:_ delivering healthcare that is accessible in time with ease when exactly needed with the minimum delays possible.

AI can help in creating faster responses which then facilitate achieving the healthcare service in the right time for the patient. Examples are:

- Prediction and prognosis: in population health using AI as an early detection method for diseases which allows fast reliable strong responses as early as needed. This early detection is highly beneficial to delivery of the service in the right time for the patients. At the same time, it saves more of the health professional times which also increase time of the patient care.
- Can be used as a strong prediction tool for future outbreaks.

_Equity:_ it to deliver a healthcare service without any disparity whether due to personal related issues like gender, race, ethnicity, geographical location, or socioeconomic status.

AI can help bridge disparities as a public health tool allowing for sharing health expertise in poor health settings or while also helping in diagnosing and treatment plans through using this AI expertise.

- Precision public health: providing the right interventions to the right population at the right time.
• Precision medicine: the tailoring manufacturing approach of medicines address the lack of suitability of medications based on biased made on clinical trials.

• AI solutions and telemedicine as a method for sharing health solutions between different locations and allowing the health expertise with less disparities once these technologies are available.

Efficiency: delivering healthcare while maximising the utilisation of resources and minimising wastage.

AI targets utilising available medical resource in forms of data for enhancing the healthcare solutions for patients, its principles are based upon raising the efficiency in healthcare along with that; minimising the costs of healthcare is a huge aspect of AI interventions. This is clarified in different healthcare industries, or inside the healthcare organisations.

• Accuracy in manufacturing industry minimising the wastage of time and resource.

• Inside the healthcare facility, logistics resources saving and healthcare professionals time saving, along with managing patients’ arrivals and departures predictions enhancing the flow of the healthcare organisation operations and saving a lot of the pharmaceutical wastage inside healthcare facilities.

• Using AI NLP algorithms for saving time when selecting candidates for clinical trials saving a lot of cost in the very expensive research industry in healthcare.

• Saving a lot of time and resource using AI in protocol design in the pharmaceutical industry and in analysing complex data in medical research.

4 METHODOLOGY

The study included reading, analyzing, and relating medical and managerial literature about the applications of artificial intelligence in healthcare. After that evidence was collected from research and industry reports about the applications of artificial intelligence in healthcare and how can these applications enhance each dimension of the six quality healthcare dimensions.

Then a questionnaire was designed and distributed (using google forms) among healthcare professionals in different countries in relation to how the applications of artificial intelligence can enhance the six dimensions of quality healthcare and 72 responses were gathered and analyzed.

The answers were collected from individuals that are healthcare professionals from different seven countries which are: Ireland, United Kingdom, United states of America, Spain, South Africa, Thailand, and Kingdom of Saudi Arabia.
5 DESCRIPTIVE ANALYSIS

This part of the study aimed to validate and collect opinions of healthcare professionals about the theoretical assumptions stated above and the questionnaire contained questions related to each dimension of the quality healthcare dimensions.

The questionnaire was designed and distributed among healthcare professional in different countries which were selected with the purpose of having different varieties of responses yet from healthcare professional working in countries where the applications of artificial intelligence are already established or growing.

Professionals responded from six countries which are: The United States of America, United Kingdom, Ireland, Spain, Thailand, South Africa, and Kingdom of Saudi Arabia. These countries cover Europe, North America, Africa, Asia, and the Middle east.

Table 1 below indicates responses collected from questions related to how the applications of AI increase and enhance each quality dimension:

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Don't Have Information</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effectiveness</td>
<td>32%</td>
<td>39%</td>
<td>26%</td>
<td>2%</td>
<td>0%</td>
</tr>
<tr>
<td>Safety</td>
<td>38%</td>
<td>48%</td>
<td>12%</td>
<td>2%</td>
<td>0%</td>
</tr>
<tr>
<td>People centeredness</td>
<td>40%</td>
<td>47%</td>
<td>11%</td>
<td>1%</td>
<td>0%</td>
</tr>
<tr>
<td>Timeliness</td>
<td>44%</td>
<td>39%</td>
<td>14%</td>
<td>3%</td>
<td>0%</td>
</tr>
<tr>
<td>Equity</td>
<td>31%</td>
<td>52%</td>
<td>15%</td>
<td>1%</td>
<td>0%</td>
</tr>
<tr>
<td>Efficiency</td>
<td>45%</td>
<td>48%</td>
<td>6%</td>
<td>1%</td>
<td>0%</td>
</tr>
</tbody>
</table>

From calculating of the percentages of the answers of “I agree” and “I strongly agree” among the six IOM dimensions it is obvious that AI in healthcare is perceived positively among healthcare professionals.

Effectiveness has the lowest percentage though among the other five dimensions with a sum of 71 percentage; not surprising maybe with parts of the questions addressing robotics and their future potential in surgical procedures while there is a form of an unspoken fear concerning surgical robotics as replacement of doctors and one question addressed the new concept of the future of medical treatments and nanorobotics with 26 percentage of participants not having information.

Efficiency in the other hand, received the highest number of positive answers concerning the applications of AI.

This could be an indicator confirming the high concerns of time wastage and medical wastage being a huge hold in healthcare and the need for tools to enhance that and AI being hugely acceptable also in these measures. Positive responses are highlighted in figure 1.
6 RESULTS

Quality is what defines good healthcare delivery and technological innovations efforts could have more positive effects once applied with focus to enhance the quality of healthcare.

According to the study, the applications of Artificial Intelligence enhancing the quality dimensions of healthcare through the theoretical analysis followed by descriptive analysis has proved positive. According to the study each dimension of the six quality healthcare dimensions can be enhanced through the applications of AI in healthcare. (Table1 and Figure1) both highlights this clearly.

7 CONCLUSIONS AND LIMITATIONS

The study represents evidence of the huge potentiality of the applications of Artificial Intelligence in healthcare today.

The study didn’t include factors of hindrances of leveraging AI in healthcare or complexity of its adaptation in such a sensitive field, factors like data privacy and interoperability or the complex healthcare organisation culture also influence hugely the adaptation of AI in healthcare and must be also considered in future research.

The study demonstrates that AI carries within its layers and evolved advancement many possibilities for enhancing and improving the six quality healthcare dimensions which are always the goals behind each healthcare practice specially in the current time today where technological advancements are well utilised in many other sectors like the banking sector. The study in this way provides a proof for encouragement of applying technology in healthcare, a field that is highly burdened and in need of continuous improving solutions.
The main limitation is the study only provide a descriptive analysis. Further empirical studies are recommended.
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