QATAR UNIVERSITY

COLLEGE OF HEALTH SCIENCES

INTEGRATION OF ARTIFICIAL INTELLIGENCE INTO HEALTHCARE SERVICES : HEALTHCARE STUDENTS' PERSPECTIVES

BY

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ABSTRACT

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Title:_Integration of Artificial Intelligence into Healthcare Services: Healthcare Students' Perspectives

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Introduction: Artificial Intelligence (AI) is a rapidly expanding area in technology that is finding its place in different fields including healthcare.. AI integration has advantages such as streamlined workflow by making tasks more rapid, efficient and precise compared to human effort. AI integration also presents disadvantages such as AI's inability to provide empathetic care, the burden of data mining and preparation, the potential job replacement caused by AI as well as lack of clarity about liability. Studying the perspectives of future healthcare workers, the current healthcare students, about this topic can help to better understand the status quo and facilitate a smooth transition into a technologically enhanced healthcare sector in the nation. This study aims to study the perspectives of QU-Health students about AI in healthcare, their knowledge and perceptions about the topic and any associations that may exist among them. **Methodology:** A cross-sectional study was conducted among Qatar University Health Cluster students via an online survey. The obtained findings were analyzed statistically using SPSS software. **Results:** A total of 193 QU Health students responded to this study. A majority of participants have a positive attitude towards AI, finding it useful and reliable. The most popular advantage of AI was identified as its ability to speed up work processes and a large proportion of study participants believe AI will be most applicable in diagnostic laboratories. Around 40% of them expressed concern for their jobs due to AI and a majority of them believe that AI cannot provide sympathetic care. Significant association was found between participants knowledge about AI and their gender, as well as with their understanding of its limitations and job security.

Conclusion: With the ongoing global transition into an automated realm, this study offers insightful findings about the acceptability and hesitance towards AI integration among healthcare students. This study can be a helpful guide for policy makers in the healthcare and education sectors alike to understand and consequently improve their strategy.

DEDICATION

To everyone who believed in me and stood behind me, ready to catch me if I fall, ready to push me beyond what I think I can.

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It goes without saying that this project would not have been possible without the strength and blessings bestowed upon me by God Almighty. Despite the challenges and what life put my way, something in me had the ability to keep going and that is thanks to Him.

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CHAPTER 1: INTRODUCTION

1.1 Research Background

Artificial intelligence (AI) is a field in technology that has seen increasing attention and popularity in the recent years. It can be explained as a program or technology that is capable of carrying out tasks or making intelligent decision that are traditionally taken care of by humans. There are different approaches to AI development such as expert systems, machine learning (ML), deep learning (DL), and artificial neural networks (ANN). Some of these techniques learn from clinical information from experts while others learn from large sets of data that is fed to the program.

AI has been integrated into various sectors such as engineering, customer service, business and trade, surveillance and more. The integration of AI into healthcare dates back to the mid-twentieth century when clinical decision support systems were introduced. Today, AI has advanced enough to be utilized for triage, disease pattern prediction and image analyses. AI has been applied in the fields of gynaecology, radiology and cardiology. Integration of AI in healthcare presents opportunities to enhance the field.

The healthcare sector is currently overworked, underfunded and facing increased pressure especially during the COVID-19 pandemic. Integration of AI can tackle these challenges in the healthcare by relieving healthcare workers by aiding in some tasks, splitting them up and reducing what needs to be done, replacing human need for certain tasks and enhancing the quality and speed of tasks performed. There are different AI vendors who are currently catering to the demand for AI in healthcare. Companies offer AI applications, products, cloud storage and more services that enable healthcare organizations to integrate AI into their workflow. Although AI in healthcare seems promising, it comes with certain obstacles.

Firstly, developing effective AI programs require sufficient data that is comprehensive, clear and complete. This requires data mining and curation processes which needs suitably

skilled professionals as well as enough available data. With the integration of AI into healthcare also comes with the concern of job displacement for healthcare workers. This can lead to reduced adoptability of the technology. Since AI is a relatively new concept, the regulations about its use are not yet defined. This highlights the ethical and legal issues that may arise from AI use and the liability associated with it. AI in healthcare is a topic that needs further exploration and it is important to assess the perceptions, acceptability and concerns surrounding its integration in the field.

1.2 Significance of the study and Objectives

Identifying the perspective of key players in the health sector about AI in the field will help navigate the process in a more efficient way. As future healthcare employees, the perception of healthcare students about AI integration in healthcare is important to assess. Identifying their standpoint about the utility of AI systems, their acceptability of the technology and their fears surrounding it will help navigate the issue in a more efficient manner. Filling this gap in knowledge can guide the implementation process and will help better address the concerns that exist about AI.

This study aims to investigate the perspective of healthcare students about the integration of AI into healthcare.

Objectives:

1. To determine the participants' knowledge about AI in healthcare.
2. To evaluate the attitudes of the study participants about AI integration in healthcare.
3. To measure the perceived risks of AI integration in healthcare.
4. To determine the association between different domains in the study.

CHAPTER 2: LITERATURE REVIEW

2.1 History of Artificial Intelligence (AI)

Artificial intelligence (AI) can be defined as an automated systems that carry out tasks conventionally performed by human intelligence (Barbour et al., 2019). Evidence of AI can be traced back to Warren McCulloch and Walter Pitts' paper in the 1940s that outlined neuronal arrangements and how they can be successfully modelled using electric circuitry (McCulloch & Pitts, 1943). The world's first self-learning program was developed by Arthur Samuel in 1952 ("Samuel's Checkers Player," 2010). Arthur was a scientist working at IBM. He developed a game program that can play thousands of games with itself . The field started to expand with substantial contributions of Dr Frank Rosenblatt who developed the first artificial neural network in 1958 (Rosenblatt, 1958). Marvin Minsky, the father of AI defined AI as simply a machine that is capable of performing a task that's considered intelligent by human beings (Laï, Brian, & Mamzer, 2020). AI may also be defined as a computer program capable of making intelligent decisions (McCarthy & Hayes, 1981). By this definition, AI includes programs that run on preset rules as well as those that operate as a data-driven model.

The first AI systems operated on symbolic logic "if-then" sequences that allowed it to be developed into "expert systems" (Paton & Kobayashi, 2019). Such sequences are conditional and prescribe a specific decision or action to be carried out if the required condition is met. An example of this is how healthcare workers can triage their patients using an expert system that asks a series of questions based on patient response (Paton & Kobayashi, 2019). Another approach used in AI is using machine learning (ML) techniques with artificial neural networks (ANN). This approach paves the way for computer programs to create decision-making networks that work similarly to biological nervous system. The difference between the "expert systems" and the ML is that machine learning is formulated through automated iterative improvements whereas expert systems are designed by combining clinical knowledge from

experts with programs' expertise. Furthermore, machine learning programs rely on datasets representative of inputs such as images and symptoms that are linked to specific outcomes like diagnoses that are used to train the system to match the patterns accurately. Despite ML being in use for decades, the necessary processing power and sufficient training datasets became available only recently.

2.2 Artificial Intelligence in Healthcare

With the advancement of technology, the healthcare industry are adopting advanced systems to enhance or assist human activity. The earliest application of AI in medicine can be traced back to the mid-twentieth century, when researchers began discussing and developing clinical decision support systems (Musen, Middleton, & Greenes, 2014). The 1970s saw many successes in rule based approaches including in ECG interpretations, disease diagnoses and selection of appropriate treatments (Barbour et al., 2019). The first description of AI application was recorded in 1976, when causes of acute abdominal pain were determined using a computer algorithm (Fogel & Kvedar, 2018). Today, AI has progressed to apply machine-learning approaches that are capable of identifying characteristic patterns from large feeds of data to solve highly complexed problems. Wide range of healthcare specialties, such as cardiology, gastroenterology, haematology and radiotherapy, can benefit from applying AI. For example, AI made valuable contributions during the COVID-19 pandemic by predicting disease patterns and epidemiology with the help of machine learning based algorithms (J. Chen & See, 2020). The study conducted by Chenxi Sun and their team is a prime example of how a deep learning technique was used to predict the outcome of COVID-19 patients with an accuracy of more than 90% (Sun, Hong, Song, Li, & Wang, 2021). Currently, one of the most widely used medical application of AI is in automated medical-image analyses (Kun-Hsing, Beam, & Kohane, 2018). Surgical procedures also benefit from AI developed augmented reality, that enables enhanced

recognition of critical structures, reduces the occurrence of mistakes and complications and significantly minimizes operating time (Kolanska, Chabbert-Buffet, Daraï, & Antoine, 2021). AI has also seen its use in obstetrics and gynaecology, offering diagnostic and therapeutic benefits (Iftikhar, Kuijpers, Khayyat, Iftikhar, & DeGouvia De Sa, 2020). Time-lapse images for the best selection of in-vitro embryos and automated analysis of the fetal heartbeat are specific applications of AI in obstetrics (Fernandez et al., 2020).

The healthcare sector has been facing pressure that is hindering its optimal operations. Some of the main challenges being faced are increased demand, decreased financial support, inadequately numbered workforce and the shift in focus towards chronic disease management (Aung, Wong, & Ting, 2021). In this context, AI, particularly deep learning, has been proposed as a solution aimed at filling the existing gaps by taking over some of the workload while ensuring increased quality of care (Meskó, Hetényi, & Győrffy, 2018). Deep learning can be explained as a representative learning method whereby data representations are learned by converting the raw input data into numerous levels of abstracts (LeCun, Bengio, & Hinton, 2015). With sufficient transformed abstractions, the AI can learn very complex functions. Eggers and his team discussed potentially beneficial approaches of AI integration by asking frontline workers what aspects should be automated (Eggers et al., 2017). The business implications of their responses were assessed and Eggers and his team arrived at the four main approaches of relieving, splitting up, replacing and augmenting (Eggers et al., 2017).

The first impact of AI integration is the reduction of workload. Healthcare professionals are severely burdened and AI presents as a promising solution. The health sector has seen a recent yet expansive introduction of information technology in the form of electronic health records and other health information systems. Although its aim was to simplify patient care, the complexities in navigating the technology and the bureaucracy behind it has resulted in many healthcare workers overloaded with extra tasks (Aung et al., 2021). AI can relieve this load by

aiding in clerical duties or operating the system itself (Spencer, 2015). Moreover, AI may play a role in creating patient records and presenting a summarized version of the patient's health profile to physicians, thereby removing the need for manual screening of patient data (Dilsizian & Siegel, 2013). AI carries this out efficiently by searching through huge amounts of information faster than human ability highlighting the key outcomes.. With deep learning, AI has been able to show excellent progress in the detection of numerous medical conditions such as breast cancer (McKinney et al., 2020), arrhythmia (Attia et al., 2019), diabetic retinopathy (Ting et al., 2017) and tuberculosis (Lakhani & Sundaram, 2017). The application of AI could be utilized during the initial screening phase, in order to prioritize cases of concern which require the physician's immediate attention. One such example is Optellum (Kahn Jr, 2017), which is a tool used to automatically scan lung X-ray images to identify those of high concern. Another tool called SPECT, was developed by the American College of Cardiology where an appropriate use of the college criteria for radionuclide heart imaging to reduce number of test not meeting the criteria. The algorithm reduced the occurrence of inappropriate imaging from 10% to 5% (Saifi, Taylor, Allen, & Hendel, 2013). Integration of AI is speculated to bring about economic relief as well, by reducing the time and resources spent (Houlton, 2018; Kahn Jr, 2017).

The second benefit of AI integration discussed by Yuri M Aung is the breaking down of tasks. AI can use machine learning (ML) algorithms that split up the workload of healthcare workers and allows for a streamlined workflow (Aung et al., 2021). To this effect, AI can be utilized in avoiding unnecessary hospital admissions and thereby reducing the overall in-patient numbers. In the UK, the National Health Service (NHS) is currently trialing ML-based Babylon chatbots that aim to ask a series of questions in order to arrive at a medical diagnosis, enabling patients to be referred to the appropriate healthcare pathway (Armstrong, 2018). Aside from national initiatives, mobile phone applications based on the same principle have been developed,

either diagnosing patient symptoms, offering patient tailored medical advice, assisting the management of chronic diseases or recommending seeking further assistance from a nearby clinic (Lupton & Jutel, 2015), all before hospital admission (Stewart, Sprivulis, & Dwivedi, 2018). Although the safety and reliability of these applications are controversial, the potential AI presents in splitting off certain tasks cannot be denied.

In addition to streamlining the workflow, AI has the ability to replace healthcare professionals in certain tasks. Physicians or nurses are often burdened with many administrative jobs that are repetitive and time consuming. These may be easily handled by AI solutions. Ting et al. demonstrated that upon comparing the performance of human diagnostic graders and AI in a national diabetic retinopathy screening program, both showed comparable results, suggesting that AI could alleviate screening load by 75% (Ting et al., 2017). Dispatching AI technologies to handle such administrative and screening tasks may not only be more cost effective but can also lead to freed up time and cognitive effort for healthcare practitioners, allowing them to focus more on tasks that AI cannot fulfill, such as direct patient communication, at least for the time being.

Another benefit presented by AI, arguably the most significant one, is the reduction of human error and physician fatigue, resulting in improved quality of care. AI has the scope to not only complement healthcare workers in their job but also to extend the scope of possibilities in the field (Eggers et al., 2017). When it comes to decision making, AI can provide assistance, which can act as a second pair of eyes. In the healthcare sector, given the amount of work and stress, it is inevitable for errors to occur. These errors can lead to tragic consequences and therefore using the precision offered by AI algorithms will reduce such occurrences. The findings of Polónia et. al. on the improvement of accuracy of histological classification of breast tissue support this claim. They tested two different algorithms that aided the pathologists in classification and compared the accuracies of the pathologists on their own and when assisted

by the algorithms. The first algorithm demonstrated an improvement in average accuracy from 0.80 to o.88 while the second algorithm maintained the accuracy (Polónia et al., 2021). AI can further aid in decision making by presenting up-to-date information about clinical guidelines and regulations. Demanding schedules make it difficult for physicians to constantly stay updated about the latest developments. Considerable research has been made into determining whether AI solutions can effectively contribute to making this task easier for physicians (Jones, Golan, Hanna, & Ramachandran, 2018; Oliveira, Novais, & Neves, 2014). One such example is of IBM Watson Health, a subsidiary of the American multinational IT company called International Business Machines corporation (IBM). IBM Watson Health is a digital tool that utilizes artificial intelligence and other advanced information technology like data analytics and cloud computing for the purpose of aiding their clients in medical or clinical research as well as development of healthcare solutions(contributors, 2022). This tool utilizes machine learning to predict the ideal clinical outcome in cancer patients with 99% of the recommendations followed being from physicians (Jones et al., 2018). Quantitative skill beyond human capacity can be offered by AI with enhanced precision and details (Cheng et al., 2016). An example is that of a deep learning model called CADx. This model was designed to classify breast tumors as benign or malignant and showed higher diagnostic accuracy than previous algorithms as well as humans in the field (Cheng et al., 2016). Deep learning has also proven valuable in predicting the possibility of intracranial hemorrhage in case of stroke treatment, more specifically tissue plasminogen activator treatment (Jiang et al., 2017).

Currently, there are different company types that provide AI products and services. First type of company are those that provide Electronic Health Records (EHR). Second type are cloud platforms that help to create and manage the healthcare center's own AI and the last type includes mainly start-up companies that create specialized AI applications. (M. Chen & Decary, 2019). The EHR vendors including Cerner, Epic, Athena and Allscripts, all of which have

introduced AI features into their EHR systems by adopting ML, natural language processing (NLP), and voice dictation to support the system's operations (Davenport, Hongsermeier, & Mc Cord, 2018). Secondly, with help from big technological companies such as IBM, Apple, Google, and Microsoft, cloud platform services as well as ML algorithms are used by healthcare organizations to design, manage and distribute their own AI applications (M. Chen & Decary, 2019). Specialized healthcare products that are used by health organizations are also offered by these companies. Last but not least, mobile applications developed by companies specialized in healthcare AI, which include mainly start-up projects. These specialized applications could either be involved in telehealth, research, patient-facing services or doctor-facing services (Kuo, 2017). **Figure 1** presents a summary of the key players of AI in healthcare and the different platforms, services and products available (M. Chen & Decary, 2019).

Technology providers	AI platforms, tools, and services
EHR vendors (eg, Epic, Cerner, Allscripts, Athena, and others)	EHR vendors have started to add some AI capabilities in their EHR systems,[9] such as: • Natural language processing • Machine learning for clinical decision support • Integration with telehealth technologies • Automated imaging analytics • Voice dictation • On-line tools for engaging patients
Big tech companies (eg, Google, Microsoft, Amazon, Apple, IBM, NVIDIA, Nuance, OpenAI, and others)	Big tech companies are providing AI cloud platforms, services, and machine learning algorithms for health organizations to build, manage, deploy various AI applications with massive data, including capabilities for: • Image recognition • Natural language processing • Voice recognition • Question-answer matching • Predictive analytics • AI voice assistants: Alexa, Siri, Cortana, and Google Assistant These companies have also developed specialized products for healthcare: • IBM Watson can learn from new data and make diagnosis and treatment recommendations for cancer • Nuance offers NLP tools that can be integrated into commercial EHRs to support clinical documentation and data entry • Apple Health Records app enables consumers to enter their health data, import such data from mobile apps and devices, then exchange with their healthcare providers • Amazon offers its Comprehend Medical, a NLP tool for analyzing unstructured clinical text • Amazon's Alexa HIPAA can be used for building compliant healthcare chatbot "skills" • Google DeepMind has built a system for making diagnosis and treatment recommendations for over 50 different eye diseases • Microsoft Azure API for FHIR enables health providers to connect their existing EHR data for analytics, machine learning, and actionable intelligence • Microsoft Healthcare Bot provides healthcare intelligence, including language models to understand healthcare information and content from credible sources
Specialized AI firms in healthcare	A fast-growing number of companies, particularly start-ups, are producing both patient-facing and doctor-facing AI applications: (a) Patient-facing application: Meskó has provided an overview of such chatbots,[11] below is a list of some well-known chatbots: • Text-based chatbots: Woebot, Babylon health, Buoy health, Your.Md, Molly, Eva, Ginger, Replika, Florence, Izzy, Safedrugbot, Sensely, GYANT, Bots4Health, and others • Voice-activated chatbots: Ada health, Infermedica, Avaamo • Platforms for developing voice chatbots in healthcare: Orbita (b) Doctor-facing AI applications: • Voice dictation tools for clinical documentation: Dragon Medical Practice by Nuance • Medical NLP tools: Optum by United Health Group, MetaMap by NLM, cTakes by Mayo Clinic, Inguamatics, and CLAMP Toolkit by University of Texas

Abbreviations: API, application programming interface; EHR, Electronic Health Record; FHIR, fast healthcare interoperability resources; HIPAA, Health Insurance Portability and Accountability Act; NLP, natural language processing.

Figure 1: Key AI players, their platforms, products and services for healthcare (M. Chen & Decary, 2019)

2.3 Obstacles to AI Integration in Healthcare

Although AI is gaining high attention in medical research, implementing it in practice comes with obstacles. Achieving the proposed potential of AI in solving some of the pressing challenges worldwide demands that certain technical challenges be addressed. Three main

challenges were addressed by different experts; volume, variety and velocity (J. Chen & See, 2020; X. Chen & Lin, 2014). The challenge of volume addresses the amount of data, inputs, outputs and data attributes that are available for machine learning. Overcoming this challenge can be partially carried out by using clusters of CPUs, a data sharing system or cloud technology. The data that is available also presents the issue of variety since there are various formats of textual and visual data in circulation. The flow of data occurs in high speed, which can make it difficult to keep up with. Solutions for these challenges have been proposed, such as the development of online learning approaches. This technique records each data point at a time, which is then labelled in order to refine the learning model (Blum & Burch, 2000). This can be described as a sequential learning strategy and is notably effective in handling big data.

The problems surrounding available data for machine learning do not end there. Firstly, providing continuous data to teach AI model can be a long and tedious process. Jiang et. al. reports less than 20% of the world's medical data to be available in AI and ML format (Jiang et al., 2017). One of the main obstacles in mining data is the problem of missing data. Missing data points is very often encountered during the process of data mining and could be attributed to the data being incomplete, inconsistent or inaccurate (Botsis, Hartvigsen, Chen, & Weng, 2010; Sterne et al., 2009). Filling this gap using prediction techniques may be a solution, although it poses its own challenges . The MICE algorithm is one such standardized technique that has been proposed to address this issue (White, Royston, & Wood, 2011). Other challenges in mining patient data include the constantly changing and inadequately documented data mining protocols, policies and reimbursement rules, which affect the insurance coverage and consequently, the kind of care and treatment sought out by patients (Noorbakhsh-Sabet, Zand, Zhang, & Abedi, 2019). Another important consideration is that the mined data should be representative of all the possible medical cases that may be encountered by the algorithm. This means that sufficient and comprehensive data must be curated. Data curation can be a hurdle in

the face of strict laws surrounding the protection of patient data. The demand for clinicians or scientists who can commit their time and expertise to this process is difficult to meet due to the global shortage in healthcare workers. Alongside the need for adequately qualified healthcare workers for appropriate data selection is pressing, many tasks that were previously handled by humans will be dealt with by algorithms (Erickson, Korfiatis, Akkus, & Kline, 2017). This can have two implications, the first one is the potential deskilling of physicians which can have a long term impact on the ability of physicians to make well-informed decision based on presented signs and symptoms. This phenomenon was observed in Tsai and colleagues' study which showed a reduced diagnostic accuracy by residents when electrocardiograms were wrongly annotated by a computer-supported system (Tsai, Fridsma, & Gatti, 2003). The integration of AI into healthcare also has the potential to displace some healthcare workers, mainly radiologists and anatomical pathologists (Noorbakhsh-Sabet et al., 2019) and thereafter restructure the workforce (Kun-Hsing et al., 2018). This concern could lead to low acceptability rates of AI integration in healthcare workers.

Another obstacle facing AI integration in healthcare is its regulatory aspect. AI systems should be certified before being deployed on large-scale clinical applications. Currently, there are no well-established standards to measure the safety and efficacy of AI systems for clinical use. Since AI is a newly introduced and popularized advancement in the healthcare sector, regulations and other control protocols are not mature yet. This is another obstacle that needs to be overcome before achieving a smooth integration of AI in healthcare. In the US, the Food and Drug Administration (FDA) has made attempts to guide the assessment of AI before implementing it on a large scale (Graham, 2016) . Subsequently, AI systems have been identified as 'general wellness products'. This means that as long as they present low risk to consumers, they require only loose regulations. Regulation protocols governing the integration of AI in healthcare in other countries are yet to be well defined. An example of an AI system

failing to get popularized is demonstrated by two systems that were developed in the US in the recent years for the purpose of automated detection and diagnosis of diabetic retinopathy (Gulshan et al., 2016). Both these systems faced limitations with regards to external validation, integration into the clinical setting and the attitude of clinicians toward it and therefore was not easily popularized. (Keane & Topol, 2018; Stead, 2018).

The ethical and legal dilemma surrounding AI is another major concern about its implementation in healthcare. AI plays the role of a physician and would be held to the same ethical standards and expectations as human physicians (Kluge, 2019). This means that requirements such as informed consent, confidentiality, privacy and decision-making should be ethically fulfilled by the AI systems. Privacy related to patient data is at the center of most of the discourse around the ethics of AI. The Universal Declaration of Human Rights defined privacy as a basic human right during the 1948 United Nations General Assembly (Azencott, 2018; Floridi & Taddeo, 2016). With the large amounts of data that is collected and shared for effective machine learning, the concern about privacy becomes increasingly relevant (Azencott, 2018). Some approaches that have been adopted to enhance privacy preservation include de-identification processes before sharing clinical data or performing data analysis in-house prior to contributing the findings with external institutions (Noorbakhsh-Sabet et al., 2019). Questions about where the liability lies in cases of medical negligence due to AI complexities or malpractice involving AI applications are yet to be answered. The medical regulations in place today are not comprehensive enough to clearly outline the lines of responsibilities in case of medical errors. This lack of clarity is more severe when applied to the partial or complete involvement of AI platforms, products or services in the delivery of healthcare services (Kingston, 2016). According to the "Digital Health Software Precertification (Pre-Cert) Program, the legal system of each country carries the responsibility of clearly outlining who holds accountability for mistakes arising from AI systems (Lee & Kesselheim, 2018). This area

needs further definition and should be carried out following close consultation with stakeholders including clinicians and software developers (Reddy, Fox, & Purohit, 2019). Hands-on healthcare involves a patient-physician relationship interlaced with many ethical considerations, the most important of which is the patient's trust that their best interest is always considered by the physician (Oh et al., 2019). The ability of AI applications to make ethically sound decisions that are appropriate for every individual case is limited. Another important consideration is the potential loss of an empathetic touch due to computer-based service (Kassam & Kassam, 2019). Considering patient feelings and personal situations in order to adequately tailor treatment options is one of the many human characteristics possessed by conventional physicians. Whether AI will be able to learn such behavior is another uncertainty.

2.4 Qatar's Healthcare Sector

The healthcare sector in Qatar is continuously growing and making technological advancements. Qatar National Vision 2030 focuses on establishing advanced health systems in their first pillar of human development. Qatar also aims to be an active hub of scientific research and intellectual activity. Integration of AI into Qatar's healthcare sector is in line with the 2030 National Vision. In the face of COVID-19 pandemic, Qatar introduced many automated services including automated reminders for appointments, test bookings and receipt of results. Hamad General Hospital, Qatar's only tertiary facility of vascular surgery service, included telemedicine technology for urgent consultations ("Hamad Medical Corporation. New HMC Urgent Consultation Service Providing Patients with Access to Hospital-Level Care Across 14 Specialties via Telemed," 2020). Patients were able to have virtual consultations, receive medical advice, obtain official sick leaves and get their medication delivered via this service. A study conducted by Hassan Al-Thani and his team showed that there was an increase in telemedicine use during the peak of the COVID-19 pandemic. They observed a 95% decline in

physical visits at the clinic and a 25 fold climb in telemedicine encounters (Al-Thani et al., 2021).

CHAPTER 3: METHODOLOGY

3.1 Ethical Approval

An ethical approval from the Qatar University Institutional Review Board (IRB) was obtained (Reference number QU-IRB 1570-E/21) (Appendix A) prior to the study initiation. Participation in the study is voluntary and participant consent has been obtained electronically.

3.2 Study Participants

The participants included in this study are students who are currently enrolled in Qatar University in any of the QU-Health cluster study programs. This includes undergraduate and postgraduate students of Medicine, Dentistry, Physiotherapy, Pharmacy, Human Nutrition, Public Health and Biomedical Sciences. This group was selected since it is very representative of the different fields in the healthcare sector.

3.3 Study Design and Setting

This study utilizes an online descriptive cross-sectional survey conducted among Qatar University (QU) healthcare students. A previously validated and published survey was adapted for the purpose of this study (Oh et al., 2019). The survey was built using *www.kobotoolbox.org*, an online open source initiative developed by the Harvard Humanitarian Initiative that offers different data collection tools. A link to the online survey was distributed through the QU email announcements to QU-Health students (Appendix B).

3.4 Questionnaire

The survey questionnaire (Appendix C) was designed to gather basic demographic information of the participants including their age range, gender and study program . The questions in the survey have been divided into six sections:

Section 1: Demographics (6 questions)

This section aims to collect demographic data about the participants including age, gender, nationality, qualification being pursued, academic year and the program they're enrolled in.

Section 2 : Attitude (6 questions)

In this section, questions are designed to evaluate the participants' attitude towards the integration of AI in healthcare. The participants are asked how they feel about AI's usefulness, reliability and its diagnostic ability.

Section 3 : Application (7 questions)

This section intends to assess the applicability of AI in different sectors and stages of healthcare. It reviews what the participants think will be the effects of AI integration, the areas where it can be applied best and the advantages of AI integration.

Section 4 : Risks (4 questions)

In this section, participants were asked about the main concerns in AI integration in the healthcare sector. It covered topics of medical errors, possibility of unethical use and liability.

Section 5 : Perception (4 questions)

The participants' perception about how familiar they are with AI skills and limitations is assessed in this section.

Section 6 : Knowledge (8 questions)

In this section, participants were asked questions to understand how knowledgeable they are about AI in healthcare and about different tools associated with AI.

Some of the questions in the survey have Likert scale questions and multiple choice questions. Likert scales are practical and accessible to use for data collection (Bhandari, 2020). They are useful in simplifying abstract concepts into recordable responses and enable statistical testing of the hypotheses. Due to their close-ended nature, participants are able to fill them out faster, enabling adequate data to be collected from large samples.

3.3 Data Analysis

The results obtained from the survey were analyzed using the Statistical Package for the Social Sciences (SPSS) program, version 28 (IBM Corporation, New York, NY, United States). Descriptive statistics were performed for all obtained data. Cross tabulation using Chi-Square test and p-values with CI 95% was used to study for significant association between participant demographics and their perception of AI integration in healthcare. Chi-squared tests was also used to assess categorical variables like risks and knowledge associated with AI integration.

CHAPTER 4: RESULTS

4.1 Participant Demographics (Section 1)

Out of 684 QU Health students at QU, a total of 193 responded to our survey, which represent 28.2% of total student number. 63.6% of them were non-Qatari students and the remaining 36.4% were Qatari students. Although the questionnaire was distributed among both male and female students via the university email announcements, however, we more female students responded compared to male students, 79.3% and 20.7% respectively. The gender distribution across different QU-Health academic programs is discussed in **Table 2.** The highest proportion of male students are from biomedical science and medicine programs while among female students, most of them are from biomedical science, nutrition and medicine programs. Most of the study participants were bachelor's students (75.6%), followed by master's students (20.2%) and the least responses were from PhD students (4.1%). The academic program with the most participants was Biomedical Sciences (41.1%) while the least was Dentistry (0.6%). The detailed demographic data is outlined in **Table 1**.

Table 1: Demographic Data of the Study Participants

Variable	**Total**	**Percentage (%)**
Gender (n=193)		
Male	40	20.7
Female	153	79.3
Age (n=193)		
18-20	51	26.4
21-23	58	30.1
24+	84	43.5
Nationality (n=184)		
Qatari	67	36.4
Non-Qatari	117	63.6
Qualification (n=193)		
Bachelor's	146	75.6
Master's	39	20.2
PhD	8	4.1

Variable	Total	Percentage (%)
Academic Program (n=175)		
Pharmacy	12	6.9
Biomedical Sc	72	41.1
Medicine	27	15.4
Public Health	26	14.9
Physiotherapy	13	7.4
Human Nutrition	24	13.7
Dentistry	1	0.6
Academic Year (n=179)		
Freshman	27	15.1
Sophomore	27	15.1
Junior	22	12.3
Senior	39	21.8
Graduate Student	64	35.8

Table 2: Gender Distribution across Varios Academic Programs

Academic programs	Male students		Female students	
	n	**%**	**n**	**%**
Biomedical Science	14	38.9	58	41.7
Dentistry	1	2.8	0	0.0
Nutrition	1	2.8	23	16.5
Medicine	10	27.8	17	12.2
Pharmacy	1	2.8	11	7.9
Physiotherapy	4	11.1	9	6.5
Public Health	5	13.9	21	15.1
Total	**36**	**100.0**	**139**	**100.0**

4.2 Attitude (Section 2)

Figure 2 shows participants' attitude towards the integration of AI into healthcare. Majority of the participants agree that AI has useful applications in the medical field (62.2% agree, 31.4% somewhat agree) and only 2.2% disagree with that statement and 4.3% have a neutral opinion about it. Almost half of the participants agree (17.3% agree, 30.8% somewhat agree) that AI has a more superior diagnostic ability compared to humans, 23.8% neither agree nor disagree and 28.1% believe that humans are more superior in this area (21.1% somewhat

disagree, 7.0% disagree). The healthcare students' attitude towards AI's ability to replace their jobs is noteworthy with more students disagreeing with this possibility (22.2% somewhat disagree, 21.1% disagree) than agreeing (14.6% agree, 24.3% somewhat agree). 17.8% neither agree nor disagree that AI will replace human jobs. A clear majority of respondents consider AI in healthcare to be reliable (73.0%) and that it can help relieve the stress faced by healthcare workers (26.5% agree, 58.9% somewhat agree). 43.8% agree that they would always use AI in decision-making, 28.6% are neutral about it and 27.6% disagree with doing so. In general, the responses collected in the attitude section reflect an accepting attitude towards AI in healthcare.

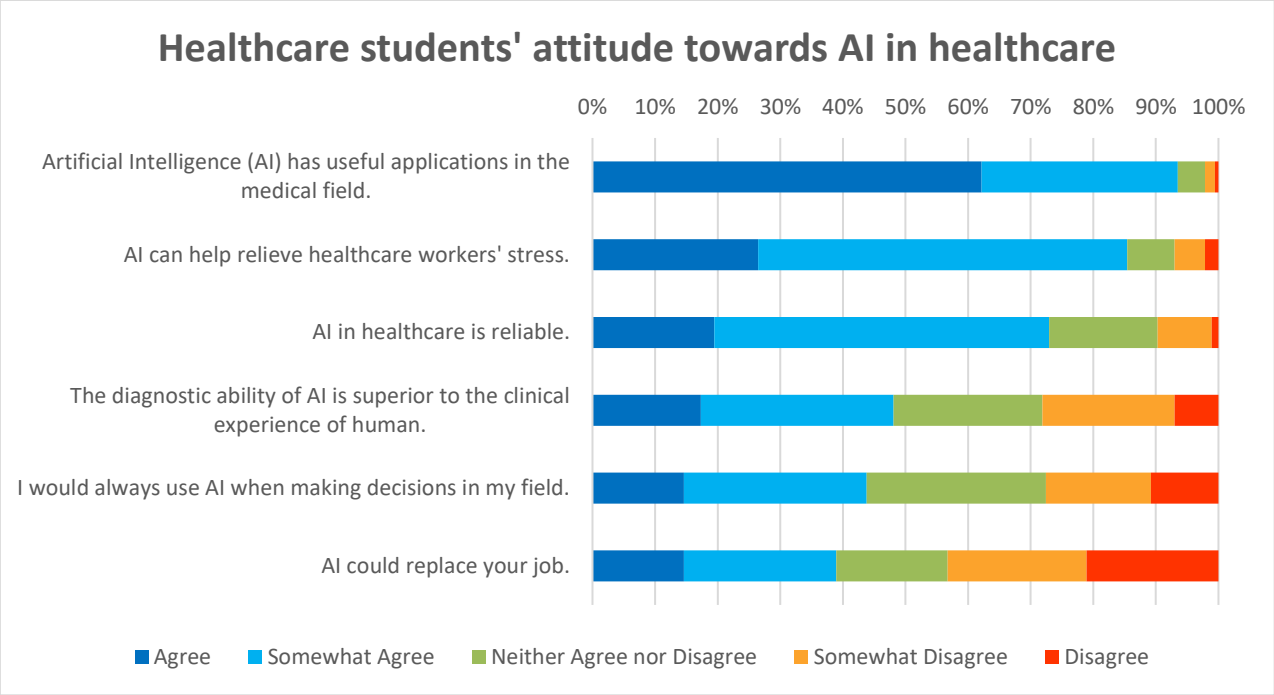

Figure 2: Participants' attitude towards the integration of AI into healthcare.

A significant association was determined between participants' attitude towards AI's superior diagnostic ability and AI replacing their jobs (**Table 3**). Majority of participants who agreed that AI's diagnostic ability is superior to that of humans also agreed that AI could replace their job, while those who disagreed that AI has a more superior diagnostic ability disagreed

that AI could replace their job (p = 0.005).

Table 3: Association between Attitude towards AI's Superior Diagnostic Ability and AI Replacing Jobs

		The diagnostic ability of AI is superior to the clinical experience of human			Chi Square Tests		
		Agree	**Neither agree nor disagree**	**Disagree**	**Chi square**	**df**	**p-value**
AI could replace your job	Agree	40(44.9%)	16(36.4%)	16(30.8%)	14.920	4	0.005
	Neither agree nor disagree	19(21.3%)	11(25.0%)	3(5.8%)			
	Disagree	30(33.8%)	17(38.6%)	33(63.4%)			
	Total	**100.0%**	**100.0%**	**100.0%**			

4.3 Applications (Section 3)

In this section, participants were asked about which areas of healthcare AI can be applied and about the extent of AI application in healthcare. When asked about whether AI will be applicable in evaluating the need for referring a patient from one healthcare professional to another, 52.4% agreed (18.9% agree, 33.5% somewhat agree), 18.9% neither agreed nor disagreed while 28.6% disagreed. Majority of the respondents agree that AI can provide personalized medication for patients (18.4% agree, 35.1% somewhat agree). When asked about applying AI in providing sympathetic care to patients, most respondents disagreed that AI will be able to do so (16.8% somewhat disagree, 41.1% disagree). Only 22.7% agreed that AI will be able to provide sympathetic care while 19.5% neither agreed nor disagreed **(Figure 3)**. An important finding from this section is that a significant majority of respondents (82.2%) agree

that the results obtained by AI must be verified by a human professional, and only 6.5% disagree.

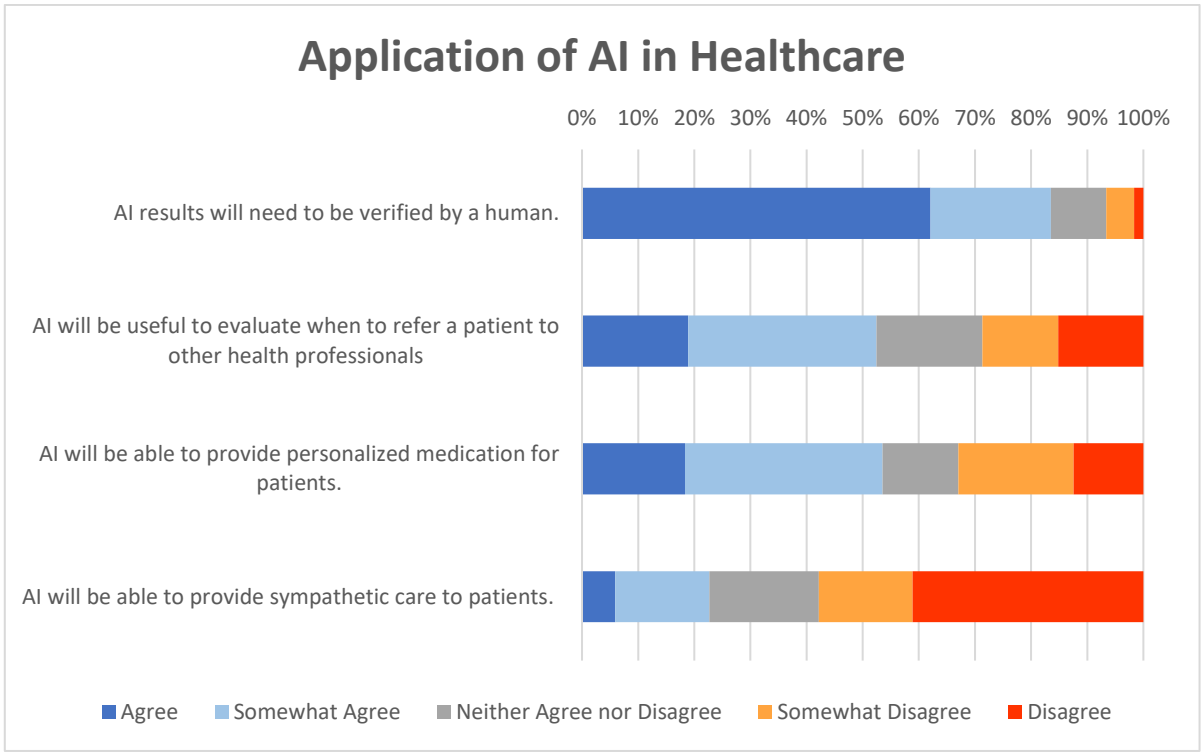

Figure 3: Participants' perception on how applicable AI in healthcare is (Section 3 in the questionnaire).

In this section, participants were also asked about what areas of healthcare will mostly benefit from AI integration. This question allowed participants to choose multiple answers. Diagnostic laboratories was the most selected area of AI integration with 113 votes. The area in healthcare where AI would be least applicable, according to survey participants, was in making treatment decisions (48 responses) **(Figure 4)**.

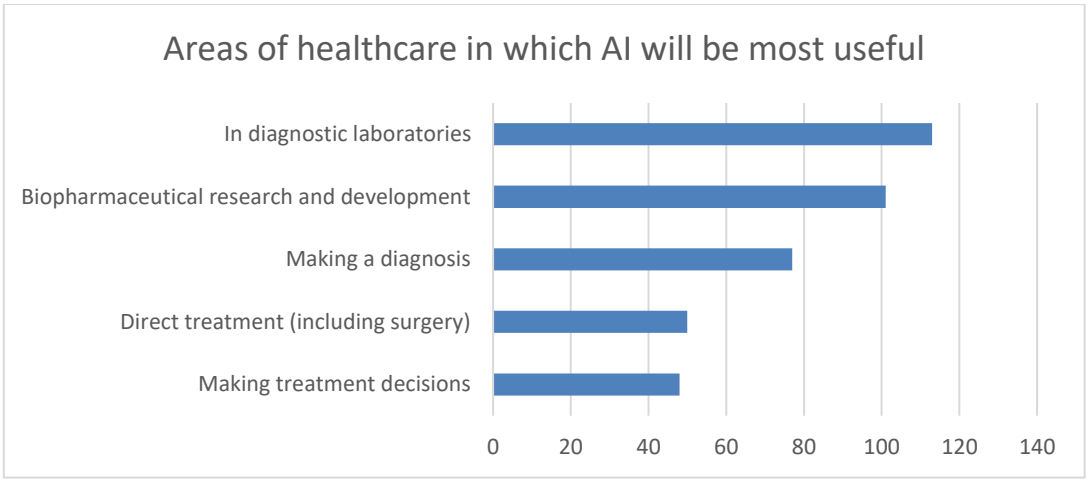

Figure 4: Participant opinion on area of healthcare in which AI integration will be most useful (Q11, Section 3).

Most of the study participants (69 responses) believe that the healthcare sector which is most likely to integrate AI first is diagnostic laboratories, followed by university hospitals (38), pharmaceuticals (32), specialized clinics (31) and the least likely is in primary care centers (13) **(Figure 5).**

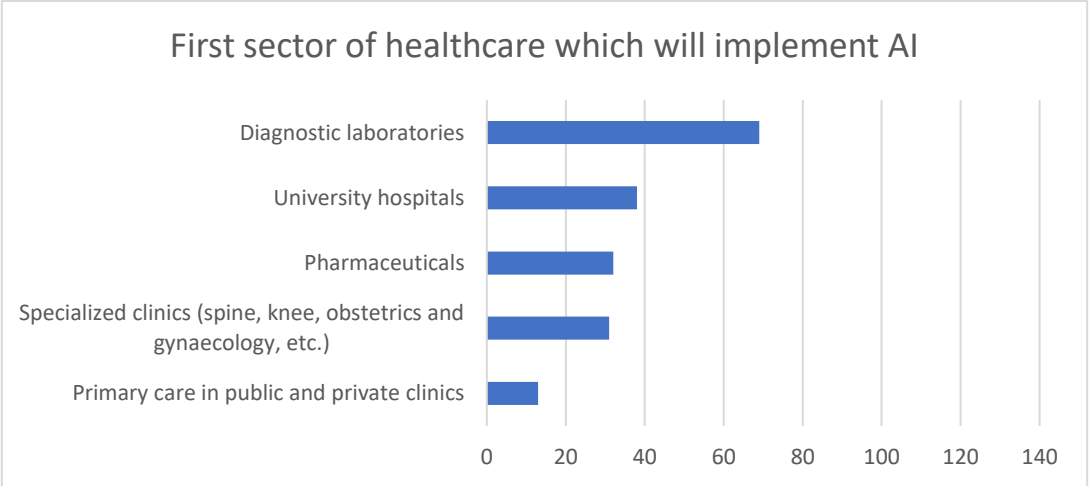

Figure 5: Participants' response on which sector in healthcare will be the first to implement AI (Q12, Section 3).

Regarding the advantages of AI application, most participants' agreed that speeding up the process is an advantage of AI integration (129 responses). The other advantages of AI integration in order of popularity were reduction of medical errors (115 responses), delivering large amounts of clinically relevant high-quality data (101), having no physical or emotional exhaustion (74) and having no space-time constraint (45) **(Figure 6)**.

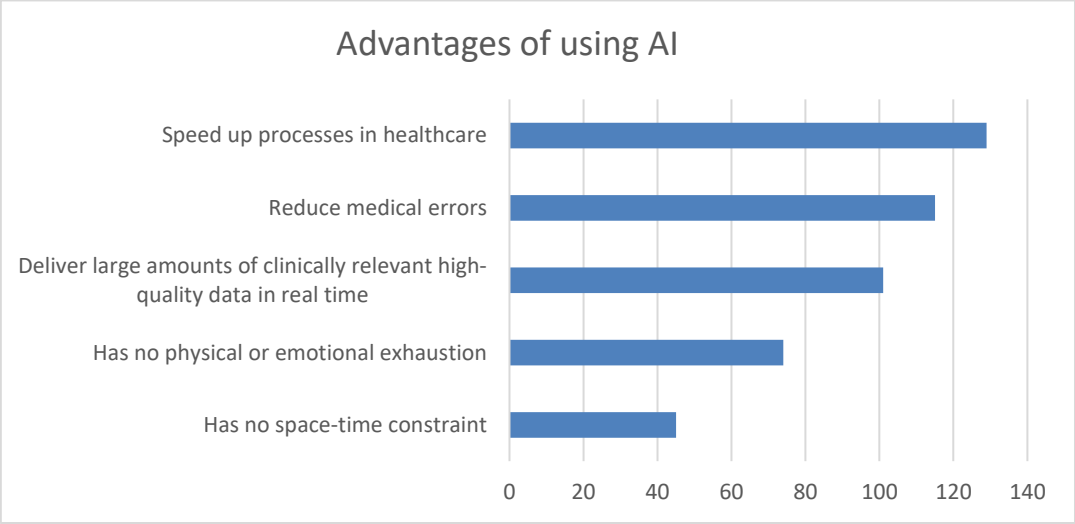

Figure 6: Participant responses about the possible advantages of using AI in healthcare (Q13, Section 3).

An association was found between the participants' nationality and their responses about the role AI could play. Participant nationality showed a significant association with whether their jobs could be replaced by AI or not ($p = 0.007$) (**Table 4**). A higher proportion of Qatari participants (46.3%) agreed that AI could replace their job while more non-Qatari study respondents disagreed with this possibility. Similarly, an association was shown between nationality and AI's usefulness in making decisions and referring patients to other professionals. More non-Qataris agreed that AI will be useful to evaluate when to refer a patient to other health professionals (59.0%) ($p = 0.004$) as well as with using AI when making decisions in their field

(47.0%) (p = 0.012)(**Table 4**).

Table 4: Association between Nationality and Other Variables

		Nationality		Chi Square Tests		
		Qatari	**Non-Qatari**	**Chi square**	**df**	**p-value**
AI could replace my job.	Agree	31(46.3%)	41(35.0%)	9.837	2	0.007
	Neither agree nor disagree	17(25.3%)	16(13.7%)			
	Disagree	19(28.4%)	60(51.3%)			
	Total	**100.0%**	**100.0%**			
AI will be useful to evaluate when to refer a patient to other health professionals	Agree	27(40.3%)	69(59.0%)	10.893	2	0.004
	Neither agree nor disagree	11(16.4%)	24(20.5%)			
	Disagree	29(43.3%)	24(20.5%)			
	Total	**100.0%**	**100.0%**			
I would always use AI when making decisions in my field	Agree	25(37.3%)	55(47.0%)	8.860	2	0.012
	Neither agree nor disagree	28(41.8%)	25(21.4%)			
	Disagree	14(20.9%)	37(31.6%)			
	Total	**100.0%**	**100.0%**			

Table 5 shows the significant associations between participants understanding the limitations of AI and their opinion on whether AI's diagnostic ability is superior to human experience (p = 0.052) and whether the participants will use AI in deciding when to refer a patient to another professional (0.004). Most of the respondents who agree that they have an understanding of AI's limitations (57.0%) also agree that AI's diagnostic ability is superior to the clinical experience of human. Similarly, a higher proportion of participants who agreed that they understand the limitations (64%) also agreed that AI will be useful to assess when a patient needs to be referred to another health professional.

Table 5: Association between Understanding of AI Limitations and AI's Applications

		I have an understanding of the limitations of AI			Chi Square Tests		
		Agree	**Neither agree nor disagree**	**Disagree**	**Chi square**	**df**	**p-value**
The diagnostic ability of AI is superior to the clinical experience of human	Agree	57(57.0%)	13(32.5%)	18(40.9%)	9.385	4	0.052
	Neither agree nor disagree	17(17.0%)	13(32.5%)	14(31.8%)			
	Disagree	26(26.0%)	14(35.0%)	12(27.3%)			
	Total	**100.0%**	**100.0%**	**100.0%**			
AI will be useful to evaluate when to refer a patient to other health professionals	Agree	64(64.0%)	15(37.5%)	18(40.9%)	15.605	4	0.004
	Neither agree nor disagree	15(15.0%)	13(32.5%)	7(15.9%)			
	Disagree	21(21.0%)	12(30.0%)	19(43.2%)			
	Total	**100.0%**	**100.0%**	**100.0%**			

4.4 Risks (Section 4)

The fourth section evaluated participants' perception about the risks involved in AI integration in healthcare. When asked about the main concerns about applying AI in healthcare (**Figure 7**), the option with the most responses (125 responses) was AI's low ability to sympathize with and consider the emotional well-being of the patient. This was followed by the concern about not being able to use AI for opinions in unpredicted situations due to inadequate information (91 responses). The other concerns in order of the number of responses were that AI is not flexible enough to applied to all cases (75 responses), AI is difficult to apply to controversial subjects (69 responses) and that AI is developed by specialists who have little clinical experience in the field (55 responses).

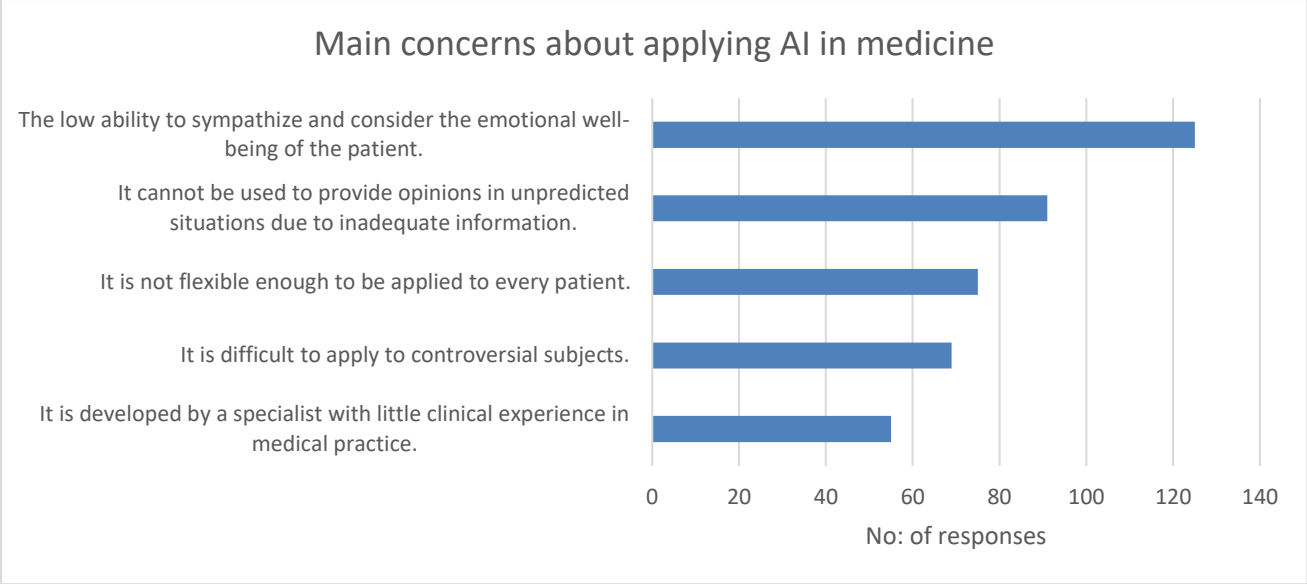

Figure 7: Major concerns surrounding AI application in medicine (Q14, Section 4).

This section also aimed to compare the participants' perceived risks associated with AI in healthcare against risks associated with traditional practice (**Figure 8**). When asked about the risk of medical errors associated with AI compared to the risk during traditional practice, the response rate for the risk being low (37.8%; 30.1% low, 7.7% very low) was very closely followed by those who said it's the same likelihood as traditional practice (35.0%). Only 27.3% responded that the possibility of medical errors associated with AI is high (17.5% high, 9.8% very high). Majority of the participants said that the possibility of unethical use is higher (28.6% high, 36.3% very high) with AI use compared to traditional medical practice. Very few (11.5%) are of the opinion that the possibility of unethical data use is low with AI (9.3% low, 2.2% very low). Another major concern when it comes to AI integration in healthcare is who the liability falls on in case of legal issues.

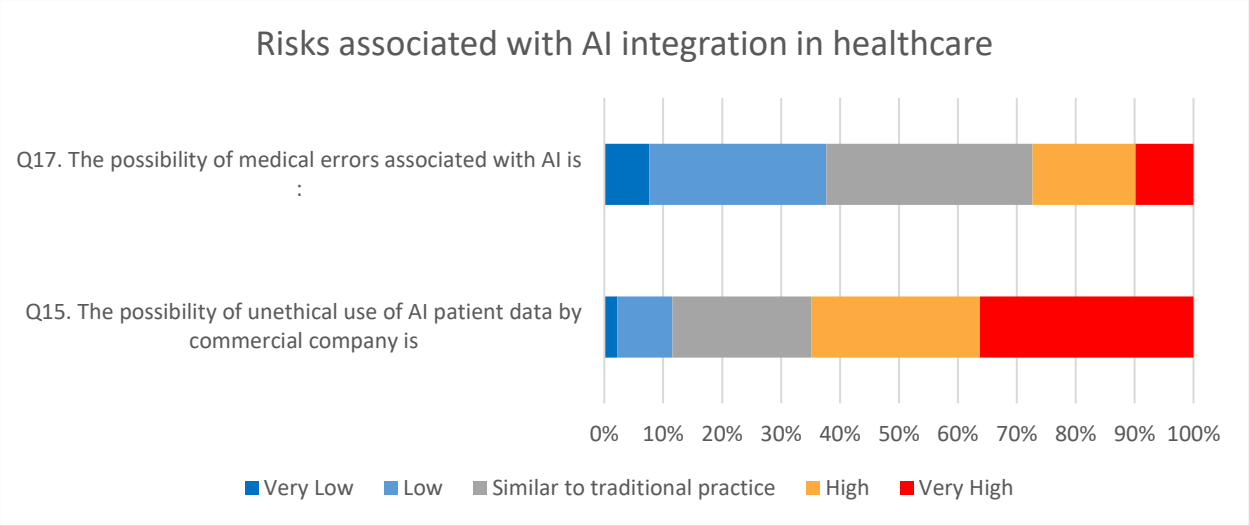

Figure 8: Risks associated with integrating AI in healthcare compared to traditional practice (Section 4 in the questionnaire).

Participants were asked who would be most liable in case of legal problems (**Figure 9**) and the response rate was similar for both the company that created the AI (92 responses) and the healthcare worker in charge of the AI (87 responses). Only 14 respondents held the consenting patient as most liable. A similar trend was observed when asked who would be held less liable; AI developing company (81 responses), healthcare worker (83 responses), consenting patient (29 responses). The choice of who is the least liable party in case of legal problems was the consenting patient with 150 responses. The developer company and the healthcare worker in charge had very few responses (20 for the developing company, 23 for the healthcare worker) to be held least liable.

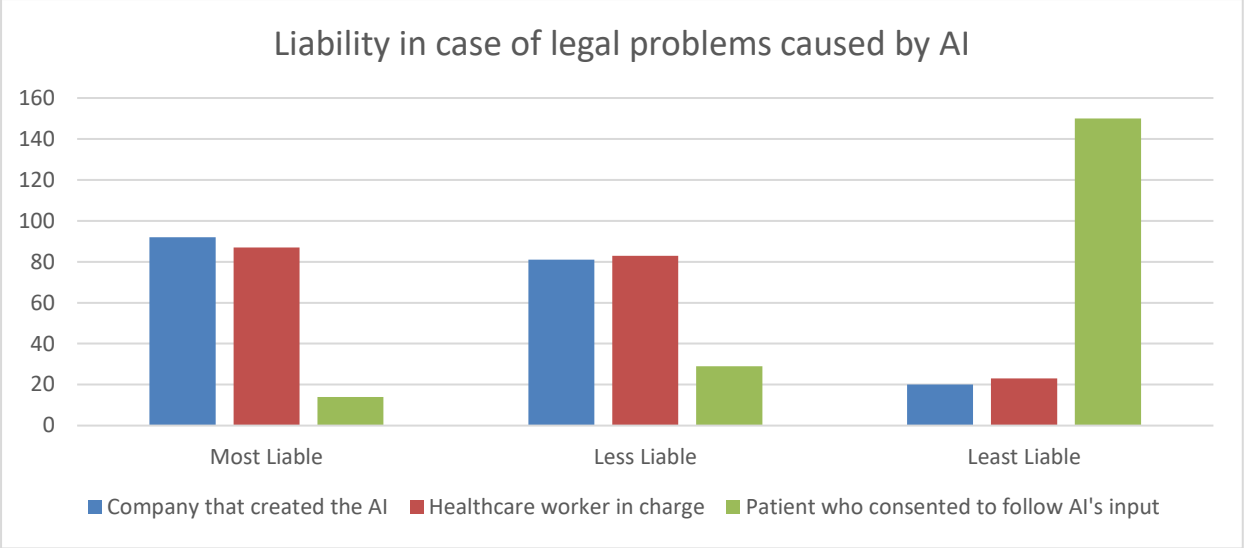

Figure 9: Participants' opinion about the liability of key players in case of legal problems that arise due to AI integration (Q16, Section 4)

4.5 Perceptions (Section 5)

This section assesses the participants' perception about AI in healthcare (**Figure 10**). Participants were asked about being familiar with basic computational principles of AI. Most of them agree that they are familiar (9.9% agree, 30.2% slightly agree). 32.4% disagree with this and 27.5% neither agree nor disagree with the statement. 51.6% of the respondents agree that they are familiar with common terminology related to AI, 23.1% feel neutral about it and 25.3% disagree. Majority of the study participants disagree with the statement "I have relevant skills in AI" (18.7% slightly disagree, 21.4% disagree). 24.2% neither agree nor disagree while 35.7% agree. Participants were also asked about their perception about limitations of AI. Most of them (54.4%) agree that they have an understanding of AI's limitations, 24.2% claim they do not have an understanding while 21.4% are neutral about this statement.

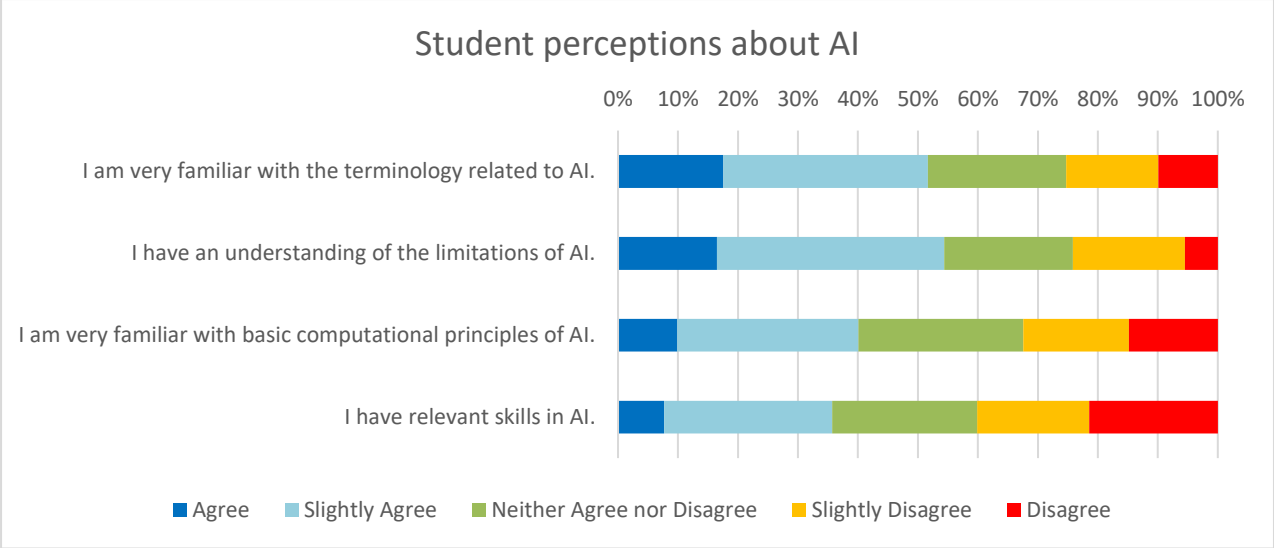

Figure 10: Perceptions of healthcare students about AI (Section 5 in questionnaire).

Gender was shown to have a significant association with participants' perceptions about AI. More male participants agreed that they have relevant skills in AI (p = 0.004) and that they have an understanding of the limitations of AI (p = 0.051) (**Table 6**).

Table 6: Association between Gender and Perceptions of AI

		Gender		Chi Square Tests		
		Male	**Female**	**Chi square**	**df**	**p-value**
I have relevant skills in AI	Agree	22(57.9%)	43(29.5%)	10.861	2	0.004
	Neither agree nor disagree	5(13.2%)	39(26.7%)			
	Disagree	11(28.9%)	64(43.8%)			
	Total	**100.0%**	**100.0%**			
I have an understanding of the limitations of AI	Agree	26(66.7%)	74(51.0%)	5.936	2	0.051
	Neither agree nor disagree	3(7.7%)	37(25.5%)			
	Disagree	10(25.6%)	34(23.5%)			
	Total	**100.0%**	**100.0%**			

4.6 Knowledge (Section 6)

The last section of the questionnaire evaluated the participants' knowledge level about AI in healthcare. The participants were asked whether they have read about AI and its role in healthcare. 63.4% of them answered yes while 36.6% said they haven't. Most participants (73.0%) said that they have not received any training or attended any courses about AI in healthcare. Only 27.0% answered that they had participated in such training sessions. Although most participants hadn't received training, 53.8% of the participants said that they have relevant knowledge that can help them understand AI. 46.2% answered that they don't have the relevant knowledge (**Figure 11**). Participants showed that they had some experience with AI applications in their field, although limited. Majority of them (40.3%) said they had come across one AI application and only 9.7% had come across more than four applications. 12.7% answered that they had had no previous exposure to such applications. Students were asked about their knowledge of the difference between deep learning and machine learning and a vast majority of 40.1% said they did not know this at all. Only 18.1% were familiar with both terms and the difference between them.

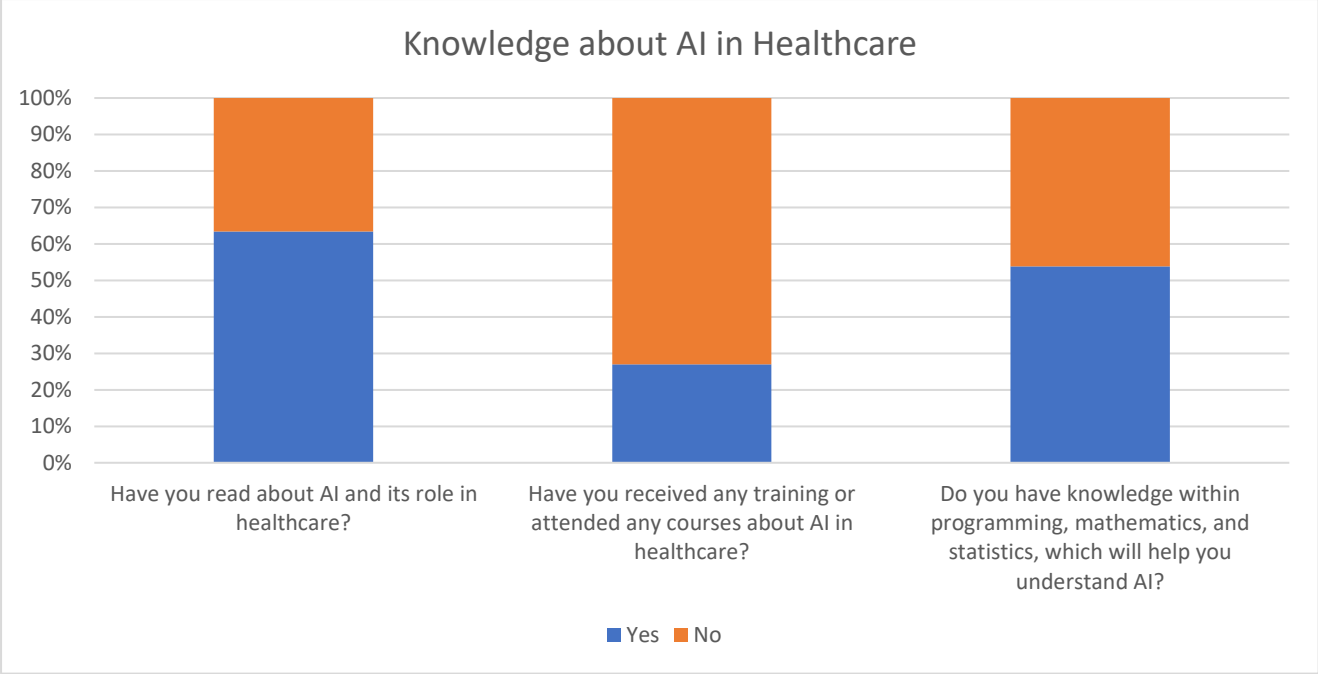

Figure 11: Knowledge levels among healthcare students about AI in healthcare (Section 6 in questionnaire)

To further assess the knowledge about AI among students, they were asked where they acquired their skills in AI from (**Figure 12**). Most students (31%) said they have no relevant knowledge or skills about AI. 30% of the participants said that they are self-taught. Only 19% claim to have acquired their skills via university courses while 14% obtained them through external workshops. The least popular source (6%) of AI relevant skills was postgraduate training. This section also gathered information about barriers that student face in learning about AI. The most common barrier was the lack of mentorship or guidance from experts in the field (26%). This was followed by the lack of dedicated courses and learning materials about AI in healthcare (17%) and the lack of funding or investment put into new AI technologies (16%). The next prevalently cited barrier was the lack of time students have to learn about AI (13%). The fear of the unknown surrounding AI as well as the lack of evidence about AI improved clinical outcomes followed with 10% of the participants choosing each of them as the barriers they face. The least popular barrier against learning about AI is the lack of motivation for change

or lack of interest to learn (8%).

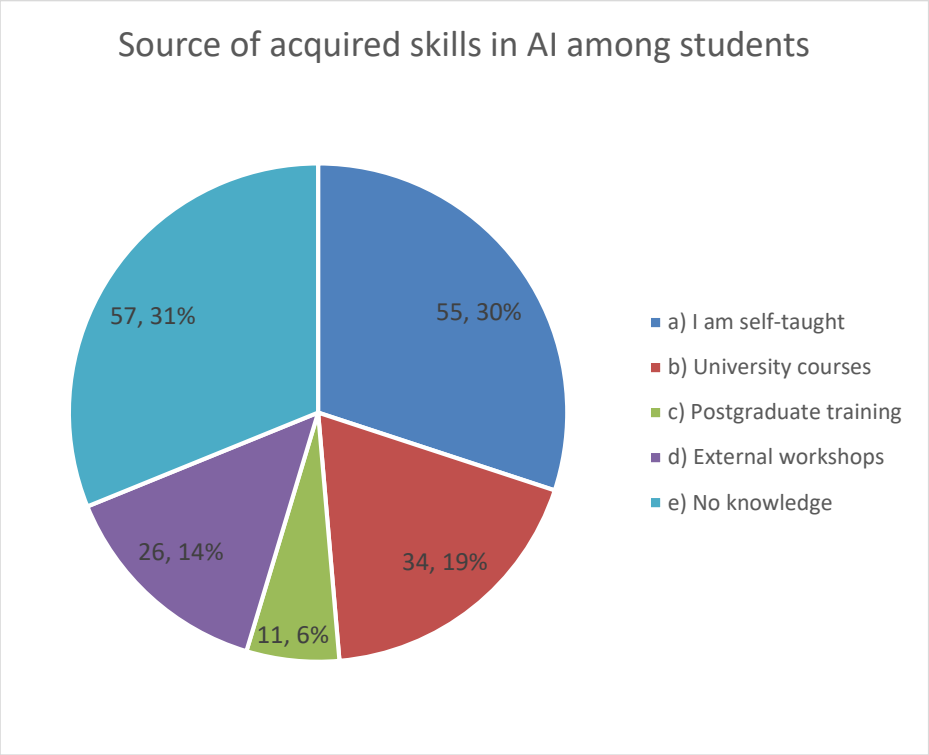

Figure 12: Sources from where students acquired their skills in AI (Q25,Section 6)

The participants' responses in the knowledge section were cross tabulated with their demographics and significant association was found between gender and some of the questions, as outlined in **Table 7**. Male respondents answered more positively about the questions. 79.5% males had read about AI and its role in healthcare and 71.8% of them answered that they had knowledge within programming, mathematics and statistics to help understand AI. When asked whether the students had received training about AI in healthcare, majority of both genders answered no but the difference in male students who had received the training or attended courses and those who had not was minimal (46.2% Yes, 53.8% No).

Table 7: Association between Participants' Gender and their Knowledge about AI

		Gender		Chi Square Tests		
		Male	**Female**	**Chi square**	**df**	**p-value**
Have you read about AI and its role in healthcare?	Yes	79.5%	59.6%	5.275	1	0.022
	No	20.5%	40.4%			
	Total	**100.0%**	**100.0%**			
Have you received any training or attended nay courses about AI in healthcare?	Yes	46.2%	23.3%	7.964	1	0.005
	No	53.8%	76.7%			
	Total	**100.0%**	**100.0%**			
Do you have knowledge within programming, mathematics and statistics which will help understand AI?	Yes	71.8%	49.0%	6.444	1	0.011
	No	28.2%	51.0%			
	Total	**100.0%**	**100.0%**			

CHAPTER 5: DISCUSSION

5.1 Attitude towards AI integration

When students' attitude towards AI integration was assessed, most of the study participants responded that AI integration can be useful (93.6%), reliable (73.0%) and that it can relieve healthcare workers' stress (85.4%). This shows an overall positive and accepting attitude towards the integration of AI in healthcare. However, it is important to address the remaining proportion of the study participants who do not view AI with the same attitude. It may be due to unfamiliarity about AI and the consequent fears about AI that these participants seem to view AI negatively. Almost 50% of the study participants agreed that AI has superior diagnostic ability compared to that of a human. A similar study conducted by Sarwar et. al. also concluded that most people believed that AI can enhance diagnostic efficiency (Sarwar et al., 2019).

A noteworthy finding is that 38.9% of the participants expressed concern for their job in case of AI integration. 43.3% of the students disagreed that AI could replace their job. 17.8% of them neither agreed nor disagreed with the statement. Although there is no overwhelming majority in the responses, more students disagree that AI can replace their job. These findings can be supported by the findings of Oh et al. who concluded that doctors do not expect to be replaced by AI (Oh et al., 2019). A study from Germany by Pinto dos Santos et al. also demonstrated that the cohort of students did not believe that AI would replace radiologists (Pinto Dos Santos et al., 2019). In contrast, a study conducted among radiology students in the UK showed that 48.3% believe that jobs in certain specialties would be affected by AI (Sit et al., 2020). A similar conclusion was arrived at by a study conducted among employees including doctors, nurses and technicians in the Saudi health care sector where most participants expressed concern that they could lose their jobs (Abdullah & Fakieh, 2020). It is reassuring that the concern about job security among Qatar University healthcare students is not a majority. This

presents a somewhat promising scenario for AI integration and acceptability in the health sector in the country. However, the approximate 40% of participants who express concern for their jobs cannot be ignored. If this percentage of future healthcare workers still feel the same, introducing AI in the workplace may face a lot of resistance. These findings should be taken into consideration by policy makers so that they may aim to re-engineer jobs instead of replacing or displacing employees from their positions.

In this study, there was a significant association between agreeing with AI's superior diagnostic ability and its ability to replace jobs. Most of the participants who agreed that AI's diagnostic ability is more superior to that of humans also agreed that AI could replace their jobs. Most of those who disagreed that AI has a more superior diagnostic ability disagreed that AI integration could be a threat to their job. It may be that the participants' perception that AI has better diagnostic ability than humans convinces them about the possibility that AI could replace them in their jobs.

5.2 Applications of AI in healthcare

Although the general usefulness that AI presents was agreed with, the scope of AI needed more exploration (Figure 2). Whether AI's integration can provide sympathetic care and personalized medication is an important question to assess. When the study participants were asked about it, more than half of them agreed that AI can provide personalized medication.

Most students disagree that AI will provide sympathetic care to patients. Only 22.7% of the respondents agree that AI will be capable of providing sympathetic care and 57.8% disagree that this is a possibility. This shows the necessity of human intervention in the field. Specific health conditions require specific attention from physicians and this ability seems uniquely human (Gurovich et al., 2019). A significant association was determined between participants' understanding of the limitations of AI and whether they see AI's diagnostic ability as superior to the human experience ($p = 0.052$) and whether AI will be useful to decide when to refer a

patient to another healthcare professional ($p = 0.004$). More participants who agreed that they understand the limitations of AI also agreed to AI having superior diagnostic ability and being useful in evaluating when to refer patients. Despite the perceived positive attributes of AI, 82.2% of the participants believe that the results produced by AI must be verified by human. This further stresses that AI integration cannot replace the human experience within the clinical field. These findings are supported by Sarwar et. al.'s study in which most respondents firmly believed that humans should predominantly make diagnostic decisions if not equally carried out with the help of AI tools (Sarwar et al., 2019). The survey gathered participants' input about the area in healthcare where AI would be most used. The most selected answer was diagnostic laboratories, followed by biopharmaceutical research and development. Participants answered that AI will be least used in conducting direct treatment such as surgeries and in making those decisions. This may be explained by the any mistrust participants may have about using AI for precise and invasive procedures such as surgeries. Similarly, diagnostic laboratories was answered most as the field that will implement AI first. Diagnostic laboratory settings present numerous opportunities for AI integration such as data entry, test selection, microscopy image analysis and result verification. This may explain why a majority of the participants see high possibility for diagnostic laboratories to implement AI first. Participant responses show that primary care in the public and private clinics are the least likely to be the first to implement AI.

In this section, the common advantages that AI integration can cause were also explored. Most respondents chose AI's ability to speed up healthcare response as the advantage presented by AI, closely followed by AI's ability to reduce medical errors. The least selected advantage was that AI is not bound by space-time constraints. These results are in accordance with Abdullah & Fakieh's findings that identified speeding up health care as the main advantage of AI integration. This was also supported by previous studies that discuss AI's ability to process large amounts of data with accuracy, efficiency and rapidness (Alsharqi et al., 2018; Shameer,

Johnson, Glicksberg, Dudley, & Sengupta, 2018).

5.3 Risks of AI integration

According to majority of the study participants, the main concern when integrating AI into healthcare is AI's low ability to sympathize with the patient and consider their emotional well-being. This is a recurring finding in this study and emphasizes on the need for AI developers to consider the AI's sympathetic ability in order to enhance the technology available in the market. The next main concern was not being able to use AI in unpredicted cases due to the lack of sufficient information to accurately teach the AI program. The concern of the smallest proportion of respondents is that AI is developed by personnel who have minimal clinical experience. These findings are different from that of Oh et al and Abdullah & Fakieh, both of whom found from their surveys that applying AI to controversial subjects was the most commonly perceived problem with AI integration. The least identified concern was the inability to use AI in unexpected situations (Abdullah & Fakieh, 2020; Oh et al., 2019).

Once the potential risks of AI integration were identified, the likelihood of these risks occurring with AI use compared to traditional medicine was evaluated. Most participants said that the medical risks associated with AI use is less possible than they are with traditional medicine. However, the participants' response about the likelihood of unethical use of patient data by commercial AI company is drastically different. More participants said that AI integration paves the way for more cases of unethical use by commercial companies. There seems to be a need for AI developer companies to ensure data privacy and for regulatory bodies to introduce strict guidelines on the proper use of data and the legal consequences for misuse.

An important question frequently asked about AI integration is where the liability falls in case of legal mishaps. According to the study, a significant proportion of the participants would place liability first on the company that created the AI, followed by the healthcare worker operating it. Patients who consent to the use of AI were considered to be the least liable in these

scenarios. Sarwar and his team's findings from their study was that 43.7% of the study participants believed that both the AI platform vendor and the pathologist who operated the AI should be held equally liable. 50.2% of them placed responsibility on the human operator and only 6.1% placed it primarily on the platform vendor (Sarwar et al., 2019). These contrasting opinions indicate the need for resolving the medico-legal conundrums before integrating AI into practice.

5.4 Perceptions of AI in healthcare

Overall, most participants in this study claimed to be familiar with the concepts of AI and say they understand its limitations. Majority of the respondents agreed that they are familiar with the basic computational principles of AI and with the terminology associated with AI. However, when asked about having relevant skills in the field, more respondents said they didn't have the skills compared to those who said they did. This shows that the students included in our study have more theoretical information about the field than practical skills. This may be due to exposure to information regarding AI through course materials or the internet but a lack of hands-on education about it.

Upon looking for any associations, gender was found to have a significant association with having relevant skills in AI ($p = 0.004$) and with understanding the limitations of AI ($p = 0.051$). More males responded that they had the skills and understanding than female participants. This may be due to a higher innate interest in technology among males than in females. Our findings are similar to Oh et al.'s conclusions in their study where healthcare professional's perception of AI was above the means (Oh et al., 2019). It is to be remembered that the male representation in this study is primarily from biomedical science and medicine students.

5.5 Knowledge about AI in healthcare

Assessing the knowledge about AI among the study participants provides an insight into the current status of the QU Health students and the areas where improvement is needed. Most

of the respondents said they have read about AI and its role in healthcare and that they have knowledge in areas that will help them understand AI. This means that a majority of them said they have mathematics, statistics and programming knowledge relevant to AI. A strong association was found between gender and knowledge among participants, with male students having read more about AI and having more knowledge. However, 73% of the study participants have not received formal training or attended any courses related to AI. When asked about the source of the participants' knowledge about AI, 31% of them answered that they had no relevant knowledge. Following this, the most common source of the participants' knowledge about AI was self-teaching. Only 19% of the participants obtained their information from university courses. This points to a concerning lack of university provided education about AI that must be brought to the attention of educators.

Participants cited the lack of mentorship from experts as the main barrier to them obtaining knowledge about AI. This was followed by lack of dedicated courses and proper funding for AI education. The least common barrier for learning about AI was the lack of motivation or interest for it. This reflects that although students have keen interest in the field, they need more structured educational materials and guidance from experts in the area in order to increase in knowledge. University programs can utilize these findings to customize the study plans in such a way that these gaps are filled.

A lack of understanding or knowledge about AI among healthcare students could be a reason for negative receptivity of it. Unfamiliarity with the up and coming technologies and their scope in the healthcare sector can lead to hesitation among students and future employees towards its use. It is important that educational institutions provide resources and guidance to university students as well as healthcare professionals about AI and its role in the field. An educated student population will fulfill the role of an empowered society in the future. This mindset can also be extended to the general public, resulting in an overall improved outlook on

AI.

CHAPTER 6: LIMITATIONS, CONCLUSION AND RECOMMEDATIONS

6.1 Limitations

This study presents some limitations. Firstly, the cross sectional study design, although it serves objective of the study, limits the findings to Qatar University Health Cluster students only and cannot be applied to all healthcare students in the country. To improve the representation, future studies including participants from different universities may be conducted. This study also had fewer responses than originally anticipated, which affected the correlation tests. Many questions had a large number of responses for the neutral option "neither agree nor disagree". This reflects a central tendency bias for many questions where the participant avoids forming an opinion and limits the comprehension of the study findings.

6.2 Conclusion

To conclude, AI has a strong potential role to play in healthcare. In general, QU Health students showed a positive attitude towards AI integration. Most participants agreed that AI can be superior in diagnostic ability, useful, reliable and stress-alleviating when used alongside human experience. Contrary to what was expected, most participants were not concerned about their jobs being threatened by AI and claimed to have good understanding of its limitations. Although AI shows the ability to speed up processes, its inability to provide sympathetic care remains a major concern. The medico-legal questions surrounding AI needs authoritative resolutions and is something that the regulatory boards of each country implementing it need to look into. Students in this study claimed to have an above average familiarity with the concepts and knowledge related to AI but said they do not have the relevant skills in the field. Lack of dedicated courses and expert mentorship was identified as major barriers to learning more about AI in healthcare. Significant association was found between student knowledge and perceptions about AI, and their gender. Associations were also found between other student perspectives such as AI's superior diagnostic ability and it potentially replacing jobs. There is a lot of scope for AI in healthcare but a successful integration requires certain steps to be taken.

6.3 Recommendations

There is a mentionable gap in structured education about AI and incorporating this into the syllabi of QU Health students can significantly enhance their understanding and expertise in the field. A collaborative effort between the Ministry of Public Health, Ministry of Education and Qatar University, to make these subjects more accessible to students can pave the way to AI-integrated, efficiently run healthcare system in the nation. This study may also be expanded upon by including healthcare students across other universities in the country to obtain a more comprehensive and accurately reflective picture.

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APPENDICES

APPENDIX A: ETHICAL APPROVAL

Qatar University Institutional Review Board **QU-IRB**

QU-IRB Registration: IRB-QU-2020-096, QU-IRB, Assurance: IRB-A-QU-2019-0009

DATE:	August 3, 2021
TO:	Atiyeh Abdalah, PhD
FROM:	Qatar University Institutional Review Board (QU-IRB)
PROJECT TITLE:	1748441-1Integration of Artificial Intelligence into Healthcare Services; Students Perspectives
QU-IRB REFERENCE #:	QU-IRB 1570-E/21
SUBMISSION TYPE:	New Project
ACTION:	DETERMINATION OF EXEMPT STATUS
DECISION DATE:	August 3, 2021
REVIEW CATEGORY:	Exemption category # 4

Thank you for your submission of New Project materials for this project. The Qatar University Institutional Review Board (QU-IRB) has determined this project is EXEMPT FROM IRB REVIEW according to Qatar Ministry of Public Health regulations. Please note that exempted proposals do not require renewals however, any changes/modifications to the original submitted protocol should be reported to the committee to seek approval prior to continuation.

We will retain a copy of this correspondence within our records.

Documents Reviewed:

- Action Plan - AI IRB Research Proposal.docx (UPLOADED: 04/25/2021)
- Consent Form - Informed Consent (UPLOADED: 06/14/2021)
- Consent Form - Informed consent.docx (UPLOADED: 05/8/2021)
- Consent Form - Informed Consent (UPLOADED: 04/25/2021)
- Other - Updated - QU-IRB Check List.pdf (UPLOADED: 05/8/2021)
- Qatar University - IRB Application - Qatar University - IRB Application (UPLOADED: 05/8/2021)
- Qatar University - IRB Application - Qatar University - IRB Application (UPLOADED: 05/8/2021)
- Qatar University - IRB Application - Qatar University - IRB Application (UPLOADED: 04/25/2021)
- Questionnaire/Survey - Questionnaire (UPLOADED: 04/25/2021)

If you have any questions, please contact QU-IRB at 4403 5307 or qu-irb@qu.edu.qa. Please include your project title and reference number in all correspondence with this committee.

Best wishes,

Dr. Ahmed Awaisu
Chairperson, QU-IRB

Institutional Review Board
(IRB)
Office Of Academic Research

APPENDIX B: ONLINE INFORMED CONSENT AND SURVEY

Dear participant, You are invited to participate in a research study entitled: The integration of artificial intelligence into healthcare, approved by the QU-IRB board (1570-E/21). If you have any question related to ethical compliance of the study you may contact them at QU-IRB@qu.edu.qa. The aim of the study is to identify the attitude and perspective of QU-Health Cluster students about AI in healthcare. The procedure involves filling a self-administered online questionnaire. The survey will take approximately 10-15 minutes to complete. Your valuable input is essential to the completion of my study. There is no any foreseen risk from completing the survey and no direct benefit, but you may benefit from the outcome of the study by enhancing your understanding of the motivational factors for using AI in healthcare. Your participation is voluntary and anonymous. Unwillingness to participate or withdrawal from the study will not in any way interfere with the student-instructor relationship or affect student's course grades. The information collected will be kept confidential. You may withdraw from this study at any time and skip any question. The data will be deleted permanently after 5 years. If you have any questions, you may contact: Graduate Student: Muna Ahmed, Master's in Biomedical Sciences, email: ma1507488@qu.edu.qa, Tel: 33268008 Research Supervisor: Dr Atiyeh Abdallah, email: aabdallah@qu.edu.qa, Tel: 4403-7578	عزيزي المشارك، أنت مدعو للمشاركة في دراسة بحثية بعنوان: منظور طلاب الرعاية الصحية بجامعة قطر حول دمج الذكاء الاصطناعي في الرعاية الصحية تم أخذ الموافقة لهذا البحث من مجلس مراجعة البحوث في جامعة قطر تحت رقم: 1570 E/21-إذا كان لديك أي أسئلة، يمكنك التواصل معهم على البريد الإلكتروني QU-IRB@qu.edu.qa. الهدف من الدراسة البحثية: تقييم مدى قبول وتقييم مخاوف طلاب الرعاية الصحية بجامعة قطر حول دمج الذكاء الاصطناعي في الرعاية الصحية الآلية تتضمن تعبئة استبيان عبر الإنترنت. سيستغرق الاستبيان حوالي 15 دقيقه. تشمل المشاركين في هذا البحث طلاب القطاع الصحي في جامعة قطر المخاطر والفوائد: لا تفيدك المشاركة في هذه الدراسة بشكل مباشر، ولكنها ستساعدنا في توضيح وجهات النظر السائدة حول فائدة أنظمة الذكاء الاصطناعي، وقبول التكنولوجيا والمخاوف المحيطة بدمجها في قطاع الرعاية الصحية في قطر لديك الحق في الانسحاب من الدراسة البحثية في أي وقت، أو يمكنك تخطي أي سؤال. عدم الرغبة في المشاركة أو المشاركة أو الانسحاب من الدراسة لن يتعارض بأي شكل من الأشكال مع العلاقة بين الطالب والمدرس أو يؤثر على تقييم درجات المقرر الدراسي للطالب. السرية: ستكون جميع الردود المقدمة من قبل المُشترك سرية تمامًا، ولا نقوم بجمع أي معلومات شخصية مثل الاسم أو عنوان البريد الإلكتروني .سيتم تخزين سجلات البحث أو البيانات إلكترونيًا على جهاز كمبيوتر محمي بكلمة مرور وسيتم إتلاف جميع السجلات بعد 5 سنوات. التواصل: إذا كان لديك أي أسئلة يمكنك التواصل معنا على الآتي: طالبة الدراسات العليا: منى احمد ma1507488@qu.edu.qa 33268008 المشرف: د. عطية عبد الله

Please, if you are 18 years old or above and you would like to participate, kindly click on survey link. https://ee.kobotoolbox.org/single/057f7216583894d7da93f8d47fe904d6	aabdallah@qu.edu.qa الرقم 44037578 يشير النقر فوق الزر "موافقة" أدناه إلى ما يلي: • وتوافق بطواعية على المشاركة في الدراسة • لقد قرأت وفهمت المعلومات المذكورة أعلاه • عمرك لا يقل عن 18 عامًا يرجى العثور على رابط الاستبيان أدناه: https://ee.kobotoolbox.org/single/057f7216583894d7da93f8d47fe904d6

APPENDIX C: SURVEY QUESTIONNAIRE

Demographics:

Q1. What is your age?

18-20

21-23

24+

Q2. What is your gender

Male

Female

Q3. What is the qualification you are pursuing?

Bachelor's degree

Master's degree

PhD

Q4. What program are you currently enrolled in?

Human Nutrition

Biomedical Sciences

Public Health

Physiotherapy

Dentistry

Medicine

Pharmacy

Q5. Which academic year are you currently in?

Freshman

Sophomore

Junior

Senior

Graduate student

Section 1 : Attitude
Q1. Artificial intelligence (AI) has useful applications in the **medical field?**
Disagree Somewhat disagree Neither agree nor disagree Somewhat agree Agree
Q2. The diagnostic ability of AI is superior to the clinical experience of human.
Disagree Somewhat disagree Neither agree nor disagree Somewhat agree Agree
Q3. AI could replace your job
Disagree Somewhat disagree Neither agree nor disagree Somewhat agree

Agree
Q4. I would always use AI when making decisions in my field
Disagree Somewhat disagree Neither agree nor disagree Somewhat agree Agree
Q5. AI in healthcare is reliable
Disagree Somewhat disagree Neither agree nor disagree Somewhat agree Agree
Q6. AI can help relieve healthcare workers' stress
Disagree Somewhat disagree Neither agree nor disagree Somewhat agree Agree

Section 2 : Application
Q7. AI will be useful to evaluate when to refer a patient to other health professionals
Disagree Somewhat disagree Neither agree nor disagree Somewhat agree Agree
Q8. AI will be able to formulate personalized medication for patients
Disagree Somewhat disagree Neither agree nor disagree Somewhat agree Agree
Q9. AI will be able to provide empathetic care to patients
Disagree Somewhat disagree Neither agree nor disagree Somewhat agree Agree
Q10. AI results will need to be verified by a human
Disagree Somewhat disagree Neither agree nor disagree Somewhat agree Agree

Q11. In which areas of healthcare do you think AI will be most useful?
Making a diagnosis Making treatment decisions Direct treatment (including surgery) Biopharmaceutical research and development Providing medical assistance in underserved areas Development of social insurance program
Q12. Which sector of healthcare do you think will be the first to commercialize AI?
Primary care in public and private clinics Specialized clinics (spine, knee, obstetrics and gynecology, etc.) University hospitals Diagnostic Laboratories Pharmaceuticals
Q13. What are the advantages of using AI?
AI can speed up processes in healthcare AI can help reduce medical errors. AI can deliver vast amounts of clinically relevant high-quality data in real time AI has no space-time constraint AI has no emotional exhaustion nor physical limitation
Section 3 : Risks

Q14. What do you think are concerns about application of AI in medicine?
It cannot be used to provide opinions in unpredicted situations due to inadequate information It is not flexible enough to be applied to every patient It is difficult to apply to controversial subjects The low ability to sympathize and consider the emotional well-being of the patient It is developed by a specialist with little clinical experience in medical practice
Q15. How high do you think the possibility of unethical use of patient data for commercial use would be with AI tools compared to traditional healthcare practice?
Very high High Same rate of errors as traditional practice Low Very low
Q16. Who do you think will be liable for legal problems caused by AI?
Healthcare worker in charge Company that created the AI Patient who consented to follow AI's input
Q17. How high would you say the possibility of errors associated with AI technologies

in healthcare compared to traditional healthcare practice is?
Very high High Same rate of errors as traditional practice Low Very low
Section 4 : Perception
Q18. I am familiar with basic computational principles of AI.
Disagree Slightly disagree Neither agree nor disagree Slightly agree Agree
Q19. I am familiar with the terminology related to AI.
Disagree Slightly disagree Neither agree nor disagree

Slightly agree Agree
Q20. I have relevant skills in AI.
Disagree Slightly disagree Neither agree nor disagree Slightly agree Agree
Q21. I have an understanding of the limitations of AI.
Disagree Slightly disagree Neither agree nor disagree Slightly agree Agree
<u>Section 5 : Knowledge</u>
Q22. Have you read or heard about AI and its role in healthcare?
Yes

No
Q23. Have you received any training or attended any courses about artificial intelligence in healthcare?
Yes No
Q24. Do you have relevant knowledge within programming, mathematics, and statistics, which will help you understand scientific literature on AI in healthcare?
Yes No
Q25. My skills in AI have been acquired through:
I am self-taught University courses Postgraduate training External workshops No knowledge
Q26. How many applications of AI have you come across in your field?
None

One Two to four More than four
Q27. Do you know the difference between machine learning and deep learning?
Not at all I only know one term I know both terms but the difference is not clear to me I know both terms and the difference is clear to me
Q28. How often do you use speech recognition or transcription applications?
Never Rarely Weekly On a daily basis
Q29. What are the main barriers to you in learning about AI?
Lack of dedicated courses and learning materials Lack of mentorship, guidance and support from "experts" Lack of evidence based material and proof of improved clinical outcomes

Lack of time to learn new technologies

Lack of funding/ investment for new technologies

Lack of motivation for change and interest to learn

Fear of the unknown