

Undergraduate Medical Students' and Interns' Knowledge and Perception of Artificial Intelligence in Medicine

Nisha Jha¹, Pathiyil Ravi Shankar², Mohammed Azmi Al-Betar³,
Rupesh Mukhia⁴, Kabita Hada⁵, Subish Palaian^{6,7}

¹Department of Clinical Pharmacology and Therapeutics, KIST Medical College and Teaching Hospital, Lalitpur, Bagmati, Nepal; ²IMU Centre for Education, International Medical University, Kuala Lumpur, Kuala Lumpur Federal Territory, Malaysia; ³Artificial Intelligence Research Center (AIRC), College of Engineering and Information Technology, Ajman University, Ajman, United Arab Emirates; ⁴Department of Surgery, KIST Medical College, Lalitpur, Bagmati, Nepal; ⁵Department of General Practice and Emergency Medicine, KIST Medical College, Lalitpur, Bagmati, Nepal; ⁶Department of Clinical Sciences, College of Pharmacy and Health Sciences Ajman University, Ajman, United Arab Emirates; ⁷Center of Medical and Bio-Allied Health Sciences Research, Ajman University, Ajman, United Arab Emirates

Correspondence: Nisha Jha, Department of Clinical Pharmacology and Therapeutics, KIST Medical College and Teaching Hospital, Lalitpur, Bagmati, Nepal, Tel +977 9841602808, Email nishajha32@gmail.com; Subish Palaian, Department of Clinical Sciences, College of Pharmacy and Health Sciences, Ajman University, Ajman, United Arab Emirates, Tel +971 551322957, Email subishpalaian@gmail.com



Purpose: Artificial intelligence (AI) is playing an increasingly important role in healthcare and health professions education. This study explored medical students' and interns' knowledge of artificial intelligence (AI), perceptions of the role of AI in medicine, and preferences around the teaching of AI competencies.

Methods: In this cross-sectional study, the authors used a previously validated Canadian questionnaire and gathered responses from students and interns at KIST Medical College, Nepal. Face validity and reliability of the tool were assessed by administering the questionnaire to 20 alumni as a pilot sample (Cronbach alpha = 0.6). Survey results were analyzed quantitatively (p-value = 0.05).

Results: In total 216 students (37% response rate) participated. The median AI knowledge score was 11 (interquartile range 4), and the maximum possible score was 25. The score was higher among final year students (p = 0.006) and among those with additional training in AI (p = 0.040). Over 49% strongly agreed or agreed that AI will reduce the number of jobs for doctors. Many expect AI to impact their specialty choice, felt the Nepalese health-care system is ill-equipped to deal with the challenges of AI, and opined every student of medicine should receive training on AI competencies.

Conclusion: The lack of coverage of AI and machine learning in Nepalese medical schools has resulted in students being unaware of AI's impact on individual patients and the healthcare system. A high perceived willingness among respondents to learn about AI is a positive sign and a strong indicator of futuristic successful curricula changes. Systematic implementation of AI in the Nepalese healthcare system can be a potential tool in addressing health-care challenges related to resource and manpower constraints. Incorporating topics related to AI and machine learning in medical curricula can be a useful first step.

Keywords: artificial intelligence, healthcare, machine learning, medical students, Nepal

Introduction

The term artificial intelligence (AI) coined by John McCarthy in 1955 refers to "the ability of computers to perform tasks normally requiring human intelligence, but this does not mean they operate in the same way as human thinking and behavior".¹ The current state of AI is of technical functionality while human-like capabilities are still in the future. AI is on the verge of being able to deliver precision medicine and health.² AI can raise questions about the future of healthcare and the role of human physicians.³ AI is postulated to play a significant role in improving human decision-making and efficiency.⁴ It is already playing an important role in a range of health specialties and disease conditions, such as

radiology, neurosurgical imaging, skin lesions, tumors, chest pain, neurologic diseases such as Alzheimer's disease, and also in the diagnosis of breast cancer, drug discovery, therapy selection especially in patients with comorbid conditions and on multiple treatments, and stratified care delivery.^{5,6}

Physicians and health systems leaders should be knowledgeable about the benefits and limitations of AI and machine learning (ML) as they may already be using these or will be using them soon and are expected to play an important role in their development, testing, and integration into the clinical workflow.⁷ A lack of knowledge among physicians regarding AI and ML may translate into poorer patient outcomes due to a lack of understanding about selecting tools that add value and integrating these into patient care.⁸

AI is not commonly addressed during undergraduate medical education. Among possible reasons mentioned were current accreditation requirements do not emphasize AI, medical schools are already struggling under a heavy curriculum with periodic requests for new topics and areas of study to be added and they lack faculty with the expertise to teach this topic.⁹ Another challenge is that medical schools and educators still do not know the exact emerging role of the physician regarding AI and hence are unable to devise teaching approaches.¹⁰ However, five major focus areas for AI in the medical curriculum were suggested.³ Among these are working with and managing AI systems, exploring their ethical and legal implications, critical appraisal of AI systems, continued emphasis on the biomedical sciences, and learning to work with electronic health records. The development of AI curricula will require collaboration among data scientists, computer scientists, practicing physicians, and experts in medical education.¹¹ As AI involves multiple skills and knowledge areas, a diversity of teaching-learning strategies is suggested.

It is crucial to familiarize medical students with AI concepts and ideas so that they can begin to use these in caring for their patients, and do not get bogged down by terminology and definitions.⁹ AI courses have only recently been introduced in a few medical schools in the developed world. The Carle Illinois College of Medicine in the United States has developed a curriculum with an emphasis on mathematics and data science.¹² Queen's University in The United Kingdom and the University of Toronto in Canada also offer courses. For AI to be widely adopted in healthcare it must have regulatory approval, be integrated with Electronic Health Record systems, be standardized to a sufficient degree, taught to clinicians and medical students, be paid for by public or private payer organizations, and updated over time.¹³ The few schools that are offering courses on AI use interactive lectures, small group sessions, e-modules, and electives among other methods.¹² Embedding AI into pre-existing courses can reduce curricular overload and highlight their clinical applications.¹³

Nepal is a developing country in South Asia with several health-care problems. A recent article mentions AI can offer low-cost solutions to different health problems, help in controlling the COVID-19 pandemic, and benefit the country.⁶ With the recent penetration of AI in healthcare, it is worthwhile preparing the Nepalese healthcare system to accommodate future requirements of AI. AI can be considered as a potential tool to overcome certain challenges facing the healthcare system as it is expected to offer a cost-effective enhancement of human capabilities, easy and accurate interpretation of patient data, avenues for precision medicine, save the time of the physician, improve radiology diagnoses, among others.¹³ Nepal's health and education system should be developed to apply these developments and the country should develop local expertise. Health workers should be prepared to handle the potential challenges and threats posed by AI to harvest the benefits of AI in Nepalese healthcare. Further, to develop a curriculum tailored to the country's needs it is essential that student perceptions on this topic be studied. Hence, the present study was undertaken to study medical students' knowledge of AI, their perceptions regarding the role of AI in medicine, and preferences surrounding the integration of AI competencies into medical education.

Materials and Methods

Study Design

A cross-sectional study was done at KIST Medical College and Teaching Hospital among first year to final-year medical students and interns from 8th to 31st July 2021.

Sampling Method

All students were invited to participate. The total student population was 583 with a total of 89 medical students in the first year, 89 in the second year, 90 in the third year, 93 in the fourth year, 119 in the final year, and 103 medical interns.

Inclusion Criteria

All students from the first year to final year Bachelor of Medicine and Bachelor of Surgery (MBBS) and medical interns.

Exclusion Criteria

Those students who did not consent to participate and the Bachelor in Dental Surgery (BDS) students were excluded from the study.

Ethical Approval

Ethical approval was obtained from the Institutional Review Committee of KIST Medical College and Teaching Hospital with a reference number of 2077/78/64.

Data Collection Methods

A questionnaire used in a Canadian study was used after obtaining permission from the authors.¹¹ The questionnaire was discussed among the authors for its suitability in the Nepali context and changes in certain terminologies used in the demographic section were done. The questionnaire consisted of three sections. The first obtained certain demographic information from the participants, the second part focused on their knowledge about AI and the last part examined student perceptions about AI in medicine. Each batch of the students has their class social media group which they use to share information. The students were informed about the study through this social networking site and their emails were collected.

Consent

The study was administered online after obtaining informed consent. The study was pretested among twenty alumni of the institution. Those students who provided their consent to participate in the study were asked to complete the questionnaire. Students were also required to affirm an integrity pledge mentioning that they will not contact others about the answers to this study and will not refer to any external sources while completing the study. Each student was contacted prior to the study via email and consent was obtained. The written consent form was designed and was sent to the student's email.

Pilot Testing

The questionnaire was pretested by administering it to 20 past students (alumni). The Cronbach alpha value was 0.6.

Data Management and Analysis

Data were entered in Microsoft Excel and analyzed using IBM SPSS Version 21 for Windows, Armonk, NY. Data were presented in the form of descriptive statistics and analyzed. Free text comments were collated.

The demographic characteristics were tabulated. The median perception toward AI score was calculated by noting the respondent's degree of agreement with a set of five statements. These were scored as: strongly disagree = 1, disagree = 2, neutral = 3, agree = 4, and strongly agree = 5. The median scores were compared among different subgroups of respondents according to demographic and background characteristics. The other responses were analyzed descriptively. For the perception in the areas of individual patient care, health systems, and population health respondents were first asked the likelihood of AI performing a particular task and then the timeframe within which the respondent thinks AI will replace an average human doctor in performing this task.

Respondents' perception regarding the impact of AI on ethics and on medical education was noted by studying their agreement with a set of statements. The number of respondents who selected the responses as likely or extremely likely was low in our study. The authors decided only to include the analysis of the time within which the respondent thought AI will replace an average human doctor in performing this task if more than 20% of the total respondents had answered likely/extremely likely to the previous question. The period during which training in AI competencies should begin was also noted. Free text comments were invited.

Results

A total of 216 of the 583 students (37%) participated. Female students were in majority, 125 (57.9%), followed by males 91 (42.1%). Most participants were first-year students, 83 (38.4%), followed by interns 61 (28.2%).

The maximum number of students, 170 (91.7%) had not attended or viewed any talks or lectures on artificial intelligence. No training in programming/coding was given to 206 (95.8%) students. Most students were from the self-finance scheme, 196 (90.7%). Most students, 115 (53.2%) understood the term “artificial intelligence”.

The term “machine learning” was not understood by 92 (42.6%) of the participants. Similarly, the term “neural network” was familiar to 89 (41.2%) of the participants. Table 1 shows the demographic characteristics and the median knowledge scores of the respondents. Table 2 shows the median scores of individual statements about knowledge.

Table 1 Respondent Demographics and Median Knowledge Toward AI Score Among Different Subgroups of Respondents

Characteristic	Number (%)	Median Score	P-value
Gender			
Male	91 (42.1)	11	0.084
Female	125 (57.9)	11	
Year of study			
Year 1 (basic sciences)	83 (38.4)	11	0.006
Year 3 (basic sciences)	4 (1.9)	11	
Year 4 (clinical sciences)	23 (10.6)	11	
Year 5 (clinical sciences)	45 (20.8)	13	
Internship	61 (28.2)	11	
Additional training in AI, ML			
Yes	21 (9.7)	11	0.344
No	195 (90.3)	11	
Attended or viewed any talks or lectures on AI?			
Yes	46 (21.3)	12	0.040
No	170 (91.7)	11	
Training in programming/coding			
Yes	9 (4.2)	11	0.921
No	206 (95.8)	11	
Category			
Self-financing	196 (90.7)	11	0.881
Scholarship	20 (9.3)	11	

Note: Bold value represents statistically significant results.

Table 2 Median Scores of Individual Statements Regarding Knowledge

Statement	Median (IQR)
I understand what the term “artificial intelligence” means	1 (2)
I understand what the term “machine learning” means.	2 (2)
I understand what the term “neural network” means.	3 (2)
I understand what the term “deep learning” means.	3 (3)
I know what an algorithm is in the context of computer science.	2.5 (3)

Knowledge Toward AI

The median knowledge toward AI score was 11 (interquartile range 4). The median score was significantly higher among final-year students. The score was also higher among those who mentioned they had additional training in AI. There were no other differences according to demographic and background characteristics.

Perception Toward AI in Individual Patient Care, Health Systems, and Population Health

Table 3 shows perception regarding AI in the areas of individual patient care, health systems, and population health. Of the respondents, 64.4% (n = 139) “strongly disagreed” AI can provide patients with preventative health

Table 3 Perception Toward AI in the Areas of Individual Patient Care, Health Systems, and Population Health

Statements	Extremely Unlikely	Unlikely	Likely	Extremely Likely	Uncertain
Individual patient care					
Provide patients with preventative health recommendations (eg, exercise, diet, wellness).	139 (64.4)	65 (30.1)	9 (4.2)	0 (0)	3 (1.4)
Analyze patient information to reach diagnoses.	130 (60.2)	26 (21.3)	47 (12.5)	12 (5.6)	1 (0.5)
Analyze patient information to establish prognoses.	132 (61.1)	42 (19.4)	42 (19.4)	0 (0)	0 (0)
Read and interpret diagnostic imaging.	100 (46.3)	93 (43.1)	23 (10.6)	0 (0)	0 (0)
Evaluate when to refer patients to other health professionals.	111 (51.4)	44 (20.4)	61 (28.2)	0 (0)	0 (0)
Formulate personalized treatment plans for patients.	122 (56.5)	41 (19)	53 (24.5)	0 (0)	0 (0)
Formulate personalized medication prescriptions for patients.	99 (45.8)	69 (31.9)	48 (22.2)	0 (0)	0 (0)
Provide empathetic care to patients.	62 (28.7)	68 (31.9)	85 (39.4)	0 (0)	0 (0)
Monitor patient compliance to prescribed medications, exercise, and dietary recommendations.	128 (59.3)	56 (25.9)	32 (14.8)	0 (0)	0 (0)
Provide psychiatric/personal counselling.	112 (51.9)	38 (17.6)	63 (29.2)	0 (0)	3 (1.4)
Perform surgery (eg, robotic surgery).	118 (54.6)	72 (33.3)	26 (12)	0 (0)	0 (0)
Health systems					
Provide documentation (eg, update medical records) about patients.	104 (48.1)	105 (48.6)	7 (3.2)	0 (0)	0 (0)
Assist hospitals in capacity planning and human resource management.	147 (68.1)	46 (21.3)	21 (9.7)	0 (0)	2 (0.9)
Provide recommendations for quality improvement in practices/hospitals.	144 (66.7)	41 (19)	30 (13.9)	0 (0)	1 (0.5)
Population health					
Conduct population health surveillance and outbreak prevention.	149 (69)	29 (13.4)	33 (15.3)	0 (0)	5 (2.3)
Select the best population health interventions.	157 (72.7)	25 (11.6)	25 (11.6)	6 (2.8)	3 (1.4)

recommendations. Similarly, 60.2% (n = 130), mentioned “Extremely unlikely” that AI can analyze patient information to reach diagnoses. Of the respondents, 56.5% (n = 122) felt it was “Extremely unlikely” that AI can formulate personalized treatment plans for patients. Regarding the application of AI in health systems, 48.1% (n = 104) felt “Extremely unlikely” that AI tools can provide documentation (eg, update medical records) about patients. In relation to population health, 69% (n = 149) considered it “Extremely unlikely” that AI can conduct population health surveillance and outbreak prevention.

Perception Regarding the Impact of AI on Ethics and Medical Education

Over 49% of respondents strongly agreed or agreed that AI will reduce the number of jobs available to them. Over 65% believed the impact would be more in certain specialties compared to others and were also of the opinion that this will impact their choice of specialty. Nearly 90% agreed that AI will raise new ethical challenges. Over 70% agreed with the statements about AI raising new social and health equity challenges. Nearly 90% of respondents believed that the Nepalese health-care system is ill-equipped to deal with the challenges of AI and over 75% felt their education does not prepare them adequately to work alongside AI. Over 80% opined every medical student/trainee should receive training on AI competencies and 78% felt the training should begin as a medical student. More details are available in [Table 4](#). [Box 1](#) shows a selection of free-text comments made by the respondents.

Table 4 Respondents’ Perception Regarding the Impact of AI on Ethics and on Medical Education

Statements	Strongly Agree	Agree	Neither Agree Nor Disagree	Disagree	Strongly Disagree
Artificial Intelligence will reduce the number of jobs available to me.	82 (38.0)	24 (11.1)	58 (26.9)	41 (21.8)	5 (2.3)
Artificial Intelligence will/already did impact my choice of specialty selection.	63 (29.3)	17 (7.9)	75 (25.6)	68 (31.6)	12 (5.6)
Artificial Intelligence will reduce the number of jobs in certain medical specialties more than others.	98 (45.4)	45 (20.8)	46 (21.3)	24 (11.1)	3 (2.3)
Artificial Intelligence will/already did impact my choice of specialty selection.	98 (45.4)	45 (20.8)	46 (21.3)	24 (11.1)	3 (2.3)
AI in medicine will raise new ethical challenges.	123 (56.9)	70 (32.4)	19 (8.8)	2 (0.9)	2 (0.9)
AI in medicine will raise new social challenges.	139 (64.4)	21 (9.7)	32 (14.8)	23 (10.6)	1 (0.5)
AI in medicine will raise new challenges around health equity.	139 (64.4)	20 (9.3)	36 (16.7)	15 (6.9)	6 (2.8)
The Nepalese healthcare system is currently well prepared to deal with challenges having to do with AI.	8 (3.7)	16 (7.4)	33 (15.3)	86 (39.8)	106 (49.1)
My medical education is adequately preparing me for working alongside AI tools.	15 (6.9)	3 (1.4)	33 (15.3)	79 (36.6)	86 (39.8)
Medical training should include training on AI competencies (eg, what is AI, how will it impact us, what are the challenges it raises).	152 (70.4)	35 (16.2)	23 (10.6)	4 (1.9)	2 (0.9)
Every medical trainee should be required to receive training in AI competencies.	164 (71.3)	23 (10.6)	25 (11.6)	6 (2.8)	8 (3.7)

Box I Free-Text Comments Made by the Participants

AI has really become a matter of concern for today and even in the future.

AI is definitely a beginning of a new era in medicine. However, having said that we still have a long way to go.

Better awareness is required in this field as we have not been exposed to proper training as medical students to cope with the ever-changing and dynamic field of technology. We have not been able to curb the traditional method(s) of teaching and learning. It is not an indictment on anybody, but we have a hard time accepting the inevitable of the future.

Thank you. I hope the outcomes of this research will be brought into practice too.

Modern medicine sets a new milestone and evolving challenges so artificial intelligence is the part of medicine to gain and experience such things. AI will be prone to making bad decisions and errors at one point which might cause a direct or indirect impact on the health of the people as well as the healthcare system. Thank you!

AI will be a huge support for proficiency in the medical field in every aspect, hope will be in use soon ...

I feel awesome to be part of this.

AI should be utilized as fast as possible to reduce human errors and workload, and to increase efficiency.

Though it's a very fascinating subject to think of, it's completely irrelevant looking upon the current scenario of Nepal where there is not even a proper data management system

AI should be mandatory to face the situation like in present and will be more helpful in future.

AI will definitely be a great aid in the field of Medicine

It will be great revolution towards technological singularity, but we should use technology for benevolence and create utopian future

I think AI is not going to replace specially doctors because one ECG cannot be interpreted by machine, and we need cardiologist then how can AI can do whole thing but it may reduce the number of doctors.

Discussion

Like most developing nations, the healthcare system in Nepal also faces challenges such as a lack of trained manpower, resources, uneven distribution of facilities, and limited access to healthcare. Even with these limitations, the country has achieved significant progress in the health-care indicators¹⁴ and incorporated computer technology with most hospitals running electronic hospital databases to organize patient care and maintain electronic medical record systems. The potential benefits of AI in Nepal have been reviewed by Teijlingen et al.⁶ Being key health-care team members, physicians are expected to be key drivers of health-care transformations incorporating AI in the healthcare system of Nepal. They are also expected to resolve any anxiety, questions, or confusion, patients may have regarding AI by providing trustworthy information.¹⁵ The present study explored the medical students, the future physicians' knowledge, and perceptions toward AI in healthcare. The findings showed less understanding among medical students of AI, machine learning, and neural networks, and a poor perception of the potential roles of AI in individual patient care and the healthcare system.

Of the study respondents, only slightly over half understood the term "Artificial intelligence". In a Canadian study involving medical students, 83.3% either "agreed" or "strongly agreed" with the statement "I understood the meaning of AI".¹¹ Similarly, in the present research, only 42.6% understood the term 'machine learning and only 41.2% understood the term "neural network". Present study findings are lower than the Canadian study wherein 65.9% knew about machine learning and 42.3% about "neural networks".¹¹ In a Spanish study, 51.9% considered themselves to not clearly understand AI.¹⁶ In a survey from Germany involving three medical universities, 68% were unaware of the technologies involved in AI.¹⁷ Being a field originally more related to the application of computers and smart devices, medical students may have challenges in understanding the terminologies and technical background behind AI. It is also worth mentioning that the medical student curricula in Nepal at present do not cover AI.

Present research findings showed a poor perception among the respondents of AI as demonstrated by lower perception-related responses. The perceptions improved as students progressed to a higher year of study. A better perception may be linked with what students hear and read about AI in social media, news, and other avenues.

The contribution of AI and machine learning in individual patient care involving diagnosis and treatment is well documented in the literature.¹³ AI has proven benefits in many disease conditions such as obesity, GI diseases, oncology, cardiovascular conditions, etc. It has also proven to be beneficial in offering preventive health recommendations.¹⁸ In the

present research, only one-tenth of the respondents felt that AI can provide patients with preventative health recommendations such as exercise, diet, and wellness. Multiple published evidence supports AI applications in these conditions,¹⁹ which the responding students were not aware of. However, a review on the role of AI in diabetic retinopathy screening emphasized various challenges including medicolegal implications and ethical issues to be resolved in order to expedite the application of AI in these situations.²⁰ Of the student respondents, nearly half felt AI can analyze patient information to reach diagnoses while it is clearly documented in the literature that AI can perform as well as or better than human beings in diagnosing diseases.¹³ Students also had a poor perception of the fact that AI can analyze patient information to establish prognoses. The research findings thus clearly demonstrate that the role of AI in the clinical diagnosis of patients using patient information is not well understood by the students.

Another important highlight of the present research is that only very few (one-tenth) felt AI can read and interpret diagnostic imaging. It is clearly documented that AI algorithms have made pathbreaking improvements in image-recognition tasks and are likely to impact the practice of radiodiagnosis.²¹ While, this branch of medicine is considered a rapidly evolving field in incorporating AI, medical students from Germany viewed AI could detect pathologies in radiological examinations (83%) but not establish definite diagnoses (56%).¹⁷ In the present study, only one-quarter of the respondents felt that AI can formulate personalized treatment plans for patients and a low number of respondents felt that AI can formulate personalized medication prescriptions for patients as well as monitor patient compliance to prescribed medications, exercise, and dietary recommendations.

These findings clearly show a poor understanding among the student respondents of the potential role of AI in precision medicine. There are multiple pieces of literature confirming the role of AI in precision medicine for cardiovascular medicine,²² cancer,²³ etc. Robotic surgery is a rapidly advancing field with good precision and accuracy. Currently, robotic surgery is controlled by human surgeons who are susceptible to physical, mental, and technical variables, limiting the consistency of performance. On the other hand, surgical robots are resistant to fatigue, and tremors and offer better scalable motion and a high range of axial movement²⁴ leading to greater precision and low morbidity rates.²⁵ It is expected that AI control algorithms can offer benefits to robotic surgeries by reducing errors, and time and ultimately improving outcomes by reducing human error.²⁶ But, in the present research, only 12% of the respondents mentioned AI can perform surgery (eg, robotic surgery).

In a study from Saudi Arabia, 63.2% of medical students demonstrated a positive attitude towards robotic surgery and felt it will improve surgical outcomes though nearly half of them felt patients would not agree to robotic surgeries.²⁷ Similar to the Saudi study, even in the present research most students are unaware of robotic surgery. Considering the rapid growth of robotic surgeries, even in a hospital in Nepal (KMC Hospital),²⁸ it is important to educate medical students. However, it has been mentioned AI and robotics in healthcare may contribute to the dehumanization of medicine in the future which can reduce the human touch in treatment. In a study from Cyprus,²⁹ 54.5% of medical students felt AI and robotics in healthcare is a form of dehumanization. Though it is difficult at this point to predict dehumanization due to AI, one must consider the possibility that such technologies may dehumanize care and undermine human rights standards.³⁰

Nearly half of the respondents felt that AI will reduce the number of jobs available to them. A report from the UK suggests that 35% of jobs in the UK could be automated in the next 10–20 years.³¹ There is an argument that most of the job loss in healthcare will be related to the ones dealing with digital information, radiology, and pathology and not the ones related to direct patient contact.³² This widespread perception of possible threat to radiology and pathology jobs has led to postgraduate students showing reluctance in choosing these professions. In a Spanish study, 36.7% (of the 341) medical students surveyed expressed their concerns about the role of AI in choosing radiology as their specialty.¹⁸ In another study, 67.7% of Canadian medical students agreed that AI would reduce the demand for radiologists, and one-sixth of respondents decided not to consider radiology due to the anxiety related to AI's impact though it was otherwise their first choice.³³ In another study from UK, 49% would not prefer to consider a radiology career due to AI.³⁴ However, it is also important to note that radiologists and pathologists do many other jobs other than just reading and reporting radiology images or biopsy slides. Hence, it may be too early to conclude about the possible job threat posed by AI. Currently, in Nepal, these professions are flourishing and well-preferred by graduates while opting for their higher studies. In the present study, over one-third have mentioned that AI will impact their choice of specialty selection. AI is

also expected to enormously influence dermatology practice by improving the sensitivity and accuracy of screening skin lesions due to the abundant availability of clinical and dermatoscopic data and images. AI has found major applications in skin cancer, psoriasis, atopic dermatitis, and onychomycosis.³⁵

It is noticed that a high percentage of the respondents felt AI in medicine will raise new ethical and social challenges and affect health equity. The findings suggest students' understanding of AI in relation to ethical aspects. Ethical issues such as accountability, transparency, permission, and privacy¹³ associated with AI have been considered a major challenge in incorporating AI into healthcare. There have been guidelines governing ethical issues in AI such as Guidelines for Trustworthy AI issued by the European Union,³⁶ and Ethics and governance of artificial intelligence for health by the WHO.³⁷ The core principles on ethical issues by these organizations can be taught to medical students.

Though the extent of the impact AI will have on healthcare is not very clear, it is still worthwhile for medical students to have adequate knowledge of AI in healthcare. McCoy et al clearly described what physicians need to know about AI in a clinical context as 'use it, 'interpret it' and 'explain it'.³⁸ Colleges worldwide have implemented strategies to teach AI to medical students. It is recommended that medical education authorities incorporate AI into medical students' curricula as soon as possible. In the present research, less than 10% felt that their medical education is adequately preparing them for working alongside AI tools and over 85% wanted medical training should include training on AI competencies. Respondents also felt that it should be taught during the undergraduate level (80%). The present study finding is in concordance with the Spanish and German studies wherein most students recommended including AI in the medical school curriculum.^{16,17} A similar finding was noted in a multinational survey involving 63 countries, medical students showed a keen interest in learning about AI.³⁹ A closer look at the respondents' willingness to learn about AI gives a positive sign that potential interventions will be easily accepted by the students. There can be also concerns about "who" and "how" to train medical students. This can be more challenging in Nepal where medical schools are often understaffed, and the diversity of human resources required to teach and practice an interdisciplinary area like AI may be absent.

Limitations

The present study had a few limitations. The study included only one medical school and hence the findings may not be representative of the entire country's students.

Recommendations

Based on the research findings, authors would recommend medical schools incorporate AI into curricula. Since it can be challenging for medical schools to train students on AI, the responsibility lies in the hands of universities and the medical council to develop a task force with experts who can further train the trainers. While incorporating AI in the curriculum, ethical issues must be given due importance. The ongoing pandemic has demonstrated the feasibility of offering training online enabling Nepalese medical colleges to share scarce human resources.

Conclusion

The undergraduate medical students had a low understanding of AI and its potential implications for healthcare and were not anxious about the impact of AI in healthcare. Though respondents considered AI to have an impact on their individual careers, they were not sure of AI's impact on the individual patients and the healthcare system. The existing medical curricula in Nepal seem to provide very negligible or no inputs related to AI. A delay in teaching AI to medical students can make them ill-prepared to handle the potential threats and challenges at a personal and professional level. A perceived willingness among students to learn about AI can be considered a positive sign to harness. To explore AI as a potential solution facing the healthcare system of Nepal, it is imperative to educate future medical doctors on the subject without any further delay.

Acknowledgments

The authors would like to acknowledge Dr. Nishila Mehta from the University of Toronto, Canada for providing permission to use the questionnaire ([Supplementary Material](#)) developed by them for this study.¹¹ They thank Ajman

University, United Arab Emirates, for paying the full article processing charges. They thank all the students who participated.

Disclosure

The authors report no conflicts of interest in this work.

References

1. Webster CS. Artificial intelligence and the adoption of new technology in medical education. *Med Educ*. 2021;55(1):6–7. doi:10.1111/medu.14409
2. Obermeyer Z, Emanuel EJ. Predicting the future - big data, machine learning, and clinical. *Medicine N Engl J Med*. 2016;375(13):1216–1219. doi:10.1056/NEJMp1606181
3. Lee J, Wu AS, Li D, Kulasegaram KM. Artificial intelligence in undergraduate medical education: a scoping review. *Acad Med*. 2021;96(11S):S62–S70. doi:10.1097/ACM.00000000000004291
4. Rajkomar A, Dean J, Kohane I. Machine learning in medicine. *N Engl J Med*. 2019;380(14):1347–1358. doi:10.1056/NEJMr1814259
5. Erickson BJ, Korfiatis P, Akkus Z, Kline TL. Machine learning for medical imaging. *Radiographics*. 2017;37(2):505–515. doi:10.1148/rgr.2017160130
6. van Teijlingen A, Tuttle T, Bouchachia H, Sathian B, van Teijlingen E. Artificial intelligence and health in Nepal. *Nepal J Epidemiol*. 2020;10(3):915–918. doi:10.3126/nje.v10i3.31649
7. Pucchio A, Eisenhauer EA, Moraes FY. Medical students need artificial intelligence and machine learning training. *Nat Biotechnol*. 2021;39(3):388–389. doi:10.1038/s41587-021-00846-2
8. Yu KH, Beam AL, Kohane IS. Artificial intelligence in healthcare. *Nat Biomed Eng*. 2018;2(10):719–731. doi:10.1038/s41551-018-0305-z
9. Kolachalama VB, Garg PS. Machine learning and medical education. *NPJ Digit Med*. 2018;1:54. doi:10.1038/s41746-018-0061-1
10. Singh RP, Hom GL, Abramoff MD, Campbell JP, Chiang MF. Current challenges and barriers to real-world artificial intelligence adoption for the healthcare system, provider, and the patient. *Transl Vis Sci Technol*. 2020;9(2):45. doi:10.1167/tvst.9.2.45
11. Mehta N, Harish V, Bilimoria K, et al. Knowledge and attitudes on artificial intelligence in healthcare: a provincial survey study of medical students [version 1]. *MedEdPublish*. 2021;10:75. doi:10.15694/mep.2021.000075.1
12. Brouillette M. AI added to the curriculum for doctors-to-be. *Nat Med*. 2019;25(12):1808–1809. doi:10.1038/s41591-019-0648-3
13. Davenport T, Kalakota R. The potential for artificial intelligence in healthcare. *Future Healthc J*. 2019;6(2):94–98. doi:10.7861/futurehosp.6-2-94
14. Government of Nepal Ministry of Health and Population. Progress of the health and population sector, 2019/20. Kathmandu: National Joint Annual Review Report – 2020 (2077 BS); 2020. Available from: <http://www.nhss.org.np/Resources/HPP/NJAR%20-%20Final%20Report.pdf>. Accessed February 28, 2022.
15. Park SH, Do KH, Kim S, Park JH, Lim YS. What should medical students know about artificial intelligence in medicine? *J Educ Eval Health Prof*. 2019;16:18. doi:10.3352/jeehp.2019.16.18
16. Caparrós Galán G, Sendra Portero F. Medical students' perceptions of the impact of artificial intelligence in radiology. Percepciones de estudiantes de medicina sobre el impacto de la inteligencia artificial en radiología. *Radiologia*. 2021. doi:10.1016/j.rx.2021.03.006
17. Pinto Dos Santos D, Giese D, Brodehl S, et al. Medical students' attitude towards artificial intelligence: a multicentre survey. *Eur Radiol*. 2019;29(4):1640–1646. doi:10.1007/s00330-018-5601-1
18. Rowe JP, Lester JC. Artificial intelligence for personalized preventive adolescent healthcare. *J Adolesc Health*. 2020;67(2):S52–8. doi:10.1016/j.jadohealth.2020.02.021
19. de Moraes Lopes MH, Ferreira DD, Ferreira AC, et al. Use of artificial intelligence in precision nutrition and fitness. In: *Artificial Intelligence in Precision Health*. Academic Press; 2020:465–496.
20. Grzybowski A, Bruna P, Lim G, et al. Artificial intelligence for diabetic retinopathy screening: a review. *Eye*. 2020;34(3):451–460. doi:10.1038/s41433-019-0566-0
21. Hosny A, Parmar C, Quackenbush J, Schwartz LH, Aerts HJWL. Artificial intelligence in radiology. *Nat Rev Cancer*. 2018;18(8):500–510. doi:10.1038/s41568-018-0016-5
22. Krittanawong C, Zhang H, Wang Z, Aydar M, Kitai T. Artificial intelligence in precision cardiovascular medicine. *J Am Coll Cardiol*. 2017;69(21):2657–2664. doi:10.1016/j.jacc.2017.03.571
23. Bhinder B, Gilvary C, Madhukar NS, Elemento O. Artificial intelligence in cancer research and precision medicine. *Cancer Discov*. 2021;11(4):900–915. doi:10.1158/2159-8290.CD-21-0090
24. Lanfranco AR, Castellanos AE, Desai JP, Meyers WC. Robotic surgery. *Ann Surg*. 2004;239:14–21. doi:10.1097/01.sla.0000103020.19595.7d
25. Ramsay C, Pickard R, Robertson C. Systematic review and economic modelling of the relative clinical benefit and cost-effectiveness of laparoscopic surgery and robotic surgery for removal of the prostate in men with localised prostate cancer. *Health Technol Assess Winch Engl*. 2012;16:1–313.
26. Shademan A, Decker RS, Opfermann JD, Leonard S, Krieger A, Kim PCW. Supervised autonomous robotic soft tissue surgery. *Sci Transl Med*. 2016;8:337ra64. doi:10.1126/scitranslmed.aad9398
27. Sultan I, Bardi MF, Baatta AM, Almaghrabi S, Mohammed RA. Medical students' attitude towards robotic surgery: a cross-sectional survey. *J Med Educ Curric Dev*. 2022;9:23821205211066483. doi:10.1177/23821205211066483
28. Sunar P. My Republica KMC starts robotic surgery service for first time in Nepal; 2021. Available from: <https://myrepublica.nagariknetwork.com/news/kmc-starts-robotic-surgery-service-for-first-time-in-nepal/>. Accessed Mar 1, 2022.
29. Sassis L, Kefala-Karli P, Sassi M, Zervides C. Exploring medical students' and faculty's perception on artificial intelligence and robotics. A questionnaire survey. *J Med Artif Intell*. 2021;2(1–2):76–84. doi:10.2991/jaims.d.210617.002
30. World Health Organization. Ethics and governance of artificial intelligence for health: WHO guidance. Available from <https://apps.who.int/iris/bitstream/handle/10665/341996/9789240029200-eng.pdf>. Accessed May 13, 2022.

31. UserTesting. Healthcare chatbot apps are on the rise but the overall customer experience (cx) falls short according to a UserTesting report. San Francisco: UserTesting; 2019 Available from: <https://ir.usertesting.com/news-events/press-releases/detail/64/healthcare-chatbot-apps-are-on-The-rise-but-The-overall>. Accessed Mar 1, 2022.
32. Manyika J, Chui M, Miremadi M, et al. McKinsey Global Institute. A future that works: automation, employment, and productivity; 2017. Available from: <http://www.mckinsey.com/global-themes/digital-disruption/harnessing-automation-for-a-future-that-works>. Accessed Mar 1, 2022.
33. Gong B, Nugent JP, Guest W, et al. Influence of artificial intelligence on Canadian medical students' preference for radiology specialty: a national survey study. *Acad Radiol*. 2019;26(4):566–577. doi:10.1016/j.acra.2018.10.007
34. Sit C, Srinivasan R, Amlani A, et al. Attitudes and perceptions of UK medical students towards artificial intelligence and radiology: a multicentre survey. *Insights Imaging*. 2020;11(1):14. doi:10.1186/s13244-019-0830-7
35. De A, Sarda A, Gupta S, Das S. Use of artificial intelligence in dermatology. *Indian J Dermatol*. 2020;65(5):352–357. doi:10.4103/ijid.IJD_418_20
36. Ethics guidelines for trustworthy AI. European commission, directorate-general for communications networks, content and technology. Ethics guidelines for trustworthy AI, Publications Office; 2019. Available from: <https://data.europa.eu/doi/10.2759/177365>. Accessed Mar 1, 2022.
37. World Health Organization. Ethics and governance of artificial intelligence for health: WHO guidance; 2021.
38. McCoy LG, Nagaraj S, Morgado F, Harish V, Das S, Celi LA. What do medical students actually need to know about artificial intelligence? *NPJ Digit Med*. 2020;3:86. doi:10.1038/s41746-020-0294-7
39. Bisdas S, Topriceanu CC, Zakrzewska Z, et al. Artificial intelligence in medicine: a multinational multi-center survey on the medical and dental students' perception. *Front Public Health*. 2021;9:795284. doi:10.3389/fpubh.2021.795284

Advances in Medical Education and Practice

Dovepress

Publish your work in this journal

Advances in Medical Education and Practice is an international, peer-reviewed, open access journal that aims to present and publish research on Medical Education covering medical, dental, nursing and allied health care professional education. The journal covers undergraduate education, postgraduate training and continuing medical education including emerging trends and innovative models linking education, research, and health care services. The manuscript management system is completely online and includes a very quick and fair peer-review system. Visit <http://www.dovepress.com/testimonials.php> to read real quotes from published authors.

Submit your manuscript here: <http://www.dovepress.com/advances-in-medical-education-and-practice-journal>