Research Article

Bridging the Gap: Understanding of Application, Education and Ethical Consideration of Artificial Intelligence in Medical Students of Punjab,

Hafiz Muhammad Ehsan Arshad,[1] Dua Kashif,[2] Hafiz Muhammad Haris Waris,[3] Dilawaiz Faisal,[4] Beenish Tahir,[5] Muhammad Awais,[6]

[1-6]*Mayo Hospital/King Edward Medical University, Lahore, Pakistan;*

Abstract

Introduction: Taking into account the extensive availability and integration of AI in medicine, the growing concern regarding its inclusion in undergraduate medical curricula worldwide, and a lack of scientific literature directly addressing these subjects in Pakistani institutes,

Objective: This research aimed to explore how medical students of Pakistan perceive the implementation of artificial intelligence within medicine, as well as the formal education of its utilization and ethical concerns related to its use.

Methods: This cross-sectional survey was conducted across the medical institutes of Punjab and used a validated web-based pre-developed study including 53 items across 6 sections. Descriptive statistics (median, mode, IQR, totals and sub-totals, and percentages) were derived and analysis utilized either the Mann-Whitney U or the chi-square tests, as appropriate.

Results: 332 students with a majority from public sector colleges (77.7%), participated. 308/332 participants had prior experience with these language models and other tools but only a fraction received any formal education regarding its ethical concerns (72/332). The majority had a positive perception of its implementation. Despite varied prior use, 76.2% of participants acknowledged a positive impact of AI and had widespread consensus (74.4%) on the inclusion of ethics instruction in medical education, with a significantly higher figure (P=0.02) in participants with prior experience. Regarding its contents, all the proposed AI ethics topics were rated as highly relevant.

Conclusions: Despite the extensive AI technology use, only a fraction of the students had received formal AI ethics education, revealing an important shortcoming in the current medical curricula. This necessitates the re-evaluation of medical curricula regarding the incorporation of AI and AI ethics education.

Keywords | Artificial Intelligence, Ethics, Medicine, AI-based language models.

Corresponding Author | Muhammad Awais email: awaisgill68@gmail.com

Introduction

Although the origins of artificial intelligence (AI) can be traced back to the latter part of the previous century, the recent availability of highly advanced large language models like Microsoft Co-pilot and Google Gemini, which can be openly accessed and used by the public, has generated significant interest from both the public and scientific communities.[1,2] Despite the considerable ambiguity in its definition, there is agreement on the differentiation between "Artificial general intelligence" (or "Strong-AI" for short), and "Artificial narrow intelligence" (or "Weak-AI" for short).[3] This classification is based on the capabilities and applications of AI. Strong-AI, characterized by its intellectual abilities and knowledge equivalent to those of humans, is distinct from the weak-AI, which generally refers to the simple algorithms that efficiently accomplish repetitive yet highly specific tasks such as "statistical AI" and "symbolic AI".[3] In contrast, artificial general intelligence encompasses complex algorithms such as machine- and deep-learning, which form the basis of large language models like Microsoft Co-pilot and Google Gemini.[3] The field of medicine has long been an active and ever-evolving area of research for the

integration of AI and AI-based technologies.[4] With the potential of AI-based applications, various research articles have already demonstrated its capacity for disease information, clinical diagnosis, scientific research article writing, and patient communication.[5,6]

A recent study, conducted in 2022 in Pakistan, showed that 74% of doctors and 68.8% of medical students had a basic knowledge and understanding of AI but only 27.3% of doctors and 19.4% of students were aware of its medical applications.[7] Taking into account the extensive availability and integration of AI in medicine, its growing use in medicine and medical students is predictable.[8] Therefore, it is critical to understand the perceptions, concerns, and expectations of medical students as this insight can uncover potential gaps and shortcomings within their knowledge and skillets, allowing their instructors and policymakers to plan and implement changes and interventions, which are better suited to their needs.[9] A growing body of studies in different countries has already acknowledged the increasing need for the inclusion of formal education concerning the utilization of artificial general intelligence-based language models and other tools in undergraduate medical curricula.[10,11] However, as of now, there is a lack of scientific literature directly addressing these subjects in Pakistani institutes. Therefore, this research aims to evaluate the perception of medical students in Pakistan regarding the use of artificial intelligence and its application in medical practice, and the perceived relevance of AI ethics instructions within the formal medical curriculum. This includes evaluating their attitudes towards formal teaching of AI content topics as part of the curriculum and whether these attitudes were influenced by their prior experience with AI. These results will be useful for improving the current medical curriculum as to incorporate the use of the latest AI-based technologies while making sure that ethical issues are fully taken into consideration. Furthermore, the findings of this research can help the educators and legislators understand the necessary reforms and the support required for successful AI integration in medical training.

Methodology

This cross-sectional survey was conducted across the private and public sector medical colleges of Punjab, Pakistan, from June 01 to July 15, 2024, and the Institutional Review Board of King Edward Medical University granted the ethical approval for the conduction of this research. The Sample size of 332 students was estimated by using the Confidence interval of 95% (Z=1.96), absolute precision (d)=5%, and prevalence (p)=68.6% (7) using the Cochran's sample size formula.

The convenient sampling technique was used to collect the data. Participants were deemed eligible if they fulfilled following inclusion criteria: Undergraduate medical students of MBBS enrolled in any private or public sector medical colleges of Punjab, undergraduate medical students of MBBS from 1st to 5th year, the students who gave consent to participate in the survey, the students who are able to understand and respond to the study questionnaire, and the students who are fluent in English language, in which the study is conducted. Furthermore, the participants were excluded from the study if they fell under at least one of the following exclusion criteria: The medical students who dropped out of medical colleges, all those students who are absent from college for an extended period of time; or the students who did not complete all the sections of the questionnaire.

The questionnaire used for data collection of this study was developed and validated by Weidener et al. 2024.[12] After ethical approval, an online survey-based consent form and questionnaire were distributed to the 332 participants full filling our eligible criteria. Informed consent was taken from the partici- pants using a standardized form. The data were collected in the preformed questionnaire form to assess the perception of AI use, and perceived relevance of AI ethics education in medical practice using "Google forms". The modified questionnaire used consisted of 53 items including both questions and statements, and was divided into 6 sections. The first section collected information on the demographic characteristics and educational background of the participants. The second section gathered information regarding the partici- pants' previous experiences with AI-based (chat) applications and consisted of four dichotomous and two multiple-response questions based on the time and type of usage. The third section rated the degree of agreement on 12 statements concerning the use of artificial intelligence in medicine, the fourth section rated the degree of agreement on 8 statements teaching AI, and the fifth section evaluated 8 statements on the importance of AI ethics education. Lastly, the perceived relevance of the teaching of potentially important ethics content related to the implementation of AI within medicine was evaluated in the sixth section. A 5-point Likert scale was used to measure the responses for all the statements in sections 3 to 6, and was later re-coded into a numerical format for analysis ("I strongly disagree" = 1, "I disagree" = 2, "undecided" = 3, "I agree" = 4, "I strongly agree" = 5). The data of variables was collected as per operational definitions.

The collected data variables were analysed by SPSS version 27.10; IBM, corp. The descriptive statistics were derived for all the relevant variables, which included median, interquartile ranges (IQR), total number, and percentage agreed. The participants who selected either 4 or 5 on the Likert scale were considered to have agreed with the statement. In order

to assess the impact of prior use of AI-based applications, participants were segregated into two subgroups depending on their usage (as indicated in section 2 of the questionnaire), and the statistical comparison of these two distinct groups was conducted using the appropriate statistical test (Mann-Whitney U). A significance level of $\alpha = 0.05$ was established for all statistical tests, and a P value of less than 0.05 was deemed to be statistically significant.

Results

The survey revealed that the majority of participating medical students were female, accounting for 71.1% (236 out of 332, 71.1%), followed by men at 27.7% (92 out of 332, 27.7%). Additionally, 1.2% (4 out of 332) of the participants chose not to disclose their gender identity. The largest demographic age group consisted of participants from 20 to 25 years of age (274/332, 82.5%), and most students participated from public sector medical colleges (258/332, 77.7%). There was a fairly even distribution of students (Chi2 P value = 0.289) with 66 students enrolled in the 1st year, 66 in the 2nd, 72 in the 3rd, 76 in the 4th, and 52 in the 5th year of MBBS. When asked regarding their educational backgrounds in ethics instructions, 173 out of 332 (52.1%), and 209 out of 332 (63.0%) participants reported having received formal ethics education within and outside of their medical curriculum, respectively. However, a notably smaller proportion of participants claimed to have received specifically AI ethics education both as part of their formal medical curriculum (72/332, 21.7%) as well as outside the medical curriculum (96/332, 28.9%). The most extensively covered topic in AI ethics instructions were informed consent (49/332, 14.7% within and 35/332, 10.5% outside regular studies) and Responsibility for AI-generated content (45/332, 13.43% within and 35/332, 10.5% outside regular studies). A complete description of the demographic characteristics and the participants' educational background is given in the first half of Table 1.

Concerning the utilization of artificial general intelligence-based language models such as Gemini (Google, Inc.), Bing Co-pilot (Microsoft, Inc.), ChatGPT (Open-AI), and Jasper Chat (Jasper AI, Inc.), an overwhelming majority of participants (308/332, 92.8%) reported prior use of these platforms. Conversely, only a fraction of participants (57/332, 17.2%) indicated that they knowingly used AI-based medical tools (such as visual-based diagnostic applications in radiological fields). Of the total 332 participants, 310 (93.4%) were interested in its future use and among those who reported that they had used AI-based apps (308), more than half had used these applications for less than 1 hour over the past week (165/308, 53.57%). 256 out of 332 participants (77.1%) reported the usage in the medical context (e.g., for explaining

medical conditions/ questions) and more than two-thirds of them (184/256, 71.8%) used them for querying medical knowledge. The results of the AI use are summarized in the second half of Table 1.

The third and fourth sections of the questionnaire examined the participants' attitudes toward the role of artificial intelligence within medicine, and AI-based applications education in medical curricula, respectively (Q1 to Q20). Out of the 332 participants, 76.2% (n = 253) agreed with the statement that

Table 3: *Participant demographics and use of AI-based language models amd pther tolls applications*

Section 1, Demographics and the educational background of the respondents	
Character	**Number of students (%)**
Gender	
Woman	236 (71.1%)
Man	92 (27.7%)
Preferred not to say	4 (1.2%)
Age (years)	
<20	58 (17.5%)
20-25	274 (82.5%)
Year of Study	
1st year	66 (19.9%)
2nd year	66 (19.9%)
3rd year	72 (21.7%)
4th year	76 (22.9%)
5th year	52 (15.7%)
College of enrolment	
Public Sector	258 (77.7%)
Private Sector	74 (22.3%)
Education within the field of ethics	
Received as a part of the medical curriculum	173 out of 332 (52.1%)
Received outside of their formal medical curricula (In the form of additional workshops/ trainings, or as their own research, etc.)	209 out of 332 (63.0%)
Education regarding AI ethics	
Received as a part of the medical curriculum	72 out of 332 (21.7%)
Received outside of their formal medical curricula (In the form of additional workshops/ trainings, or as their own research, etc.)	96 out of 332 (28.9%)
AI ethics content covered as a part of their formal education.	
Informed consent	49 (14.7%)
Bias	28 (8.43%)
Data privacy	43 (12.9%)
Explainability	21 (6.3%)
Safety (of AI-based applications)	18 (5.42%)
Fairness	27 (8.13%)
Autonomy	27 (8.13%)
Responsibility	45 (13.55%)

AI ethics contents covered outside of the formal medical curriculum (In the form of additional training, or as their own research, etc.)	
Informed consent	35 (10.54%)
Bias	21 (6.3%)
Data privacy	35 (10.54%)
Explainability	27 (8.13%)
Safety (of AI-based applications)	23 (6.92%)
Fairness	33 (9.93%)
Autonomy	23 (6.92%)
Responsibility	35 (10.54%)

Section 2, the use of AI-based language models among the participants	
Question	**Number of Participants (%)**
Had used AI-based language models (such as Gemini/Bard, or Co-pilot)	308 (92.8%)
Knowingly used artificial intelligence-based medical tools (such as visuals-based diagnostic applications in radiological fields)	57 (17.2%)
Had Interest in using AI-based medical applications in the future	310 (93.4)
Approximate hours of AI-based application use in the last seven days (out of 308)	
Less than 1 hour	165 (53.57%)
1 to 3 hours	84 (27.27)
4 to 6 hours	46 (14.9%)
7 to 9 hours	23 (7.2%)
10 to 12 hours	12 (3.89%)
More than 12 hours	2 (0.6%)
Have used AI-based applications in specific context (e.g., for explaining medical field related questions/ conditions/ scenarios)	256 (77.1%)
Objectives of AI-based application use in the medical context (multiple selection possible)	
For diagnostic support	55 (21.48%)
For therapy suggestions	12 (4.6%)
For querying medicine related knowledge	184 (71.8%)
For explanation of pathologies	28 (10.9%)

the increased utilization of AI within medicine would result in positive changes (Q1), and 86.1% (n=286) believed that Artificial intelligence would find practical applications (Q2) within medicine. The responses of those who had used these language models before significantly differed from those who did not (S1: P=<0.01; S2: P=.003), with their z scores indicating that the participants who had previously used these language models displayed higher levels of agreement (z for Q1 = 4.401; z for Q2 = 2.932). Both groups had similar responses regarding its effect on their choice of specialization within medicine and the potential job reduction statements (Q3: P=0.42; Q4: P=0.22). However, marked differences were noted in the collective attitudes concerning potential

improvement in quality of patient care (Q5: P=0.001), process of diagnosis (Q6: P<0.001), and therapy selection process (Q7: P<0.001), with the z-score of Mann Whitney U test indicating greater agreement with the previous use of AI-based applications (z for Q5 = 3.265; z for Q6 = 4.34; z for Q7 =3.48).

43.9% of participants believed that the use of artificial intelligence with medicine would lead to the dehumanization of medicine and negatively affect the doctor-patient relationship (Q8 and Q9), 23.5% believed that it would negatively affect the patients' autonomy (Q10), and 34.5% believed that it would negatively affect the autonomy of medical staff (Q11). Lastly, 78% of the participants believed that this would bring new ethical challenges in medicine. Both groups displayed comparable levels of agreement for these statements with no statistically significant difference for any of the statements. The complete results of the statistical analyses of the third section of the questionnaire are presented in in the first part of Table 2.

79.8% (n = 265) of the participants agreed or strongly agreed with the incorporation of AI into the formal medical curriculum (Q13), with a statistically significant difference between the two groups based on the prior use of AI-based applications (P=0.02) and the z-score indicating higher agreement with the previous use. Less than half of the participants (40.3%) believed that the current AI instructions in current medical curriculum are sufficient (Q14), with no statistically significant difference across the two groups. The majority of participants agreed that AI education should consist of practical content (Q15; 72.9%), be based on case studies and scenarios (Q16; 77.7%), be an important prerequisite for medical practice (Q17; 58.4%), be available to the medical staff (Q18; 83.8%), and be regularly updated (Q19; 87.9%). Both groups had similar levels of agreement with these statements (Q14 to Q19) and no statistically significant difference was observed (see Table 2). Lastly, 72% of the participants reported that the teaching of Artificial intelligence utilization and implementations is of interest to them (Q20). Subgroups based on the previous use of AI-based applications indicated a statistically significant difference (P<0.001), with the z-score indicating a much higher degree of agreement among the subgroup with previous use (z score for Q20 = 4.26). The complete results of the statistical analyses of the fourth section of the questionnaire are presented in the second half of Table 2.

74.4% of medical students agreed that AI ethics education should be a part of the formal medical curriculum (S1), and nearly two-thirds of the total (65.1%) agreed that the current instructions regarding artificial intelligence ethics in the medical curriculum are adequate (S2). A significant propor-

Table 2: *The results of the perception of respondents concerning the utilization, and the teaching of AI-based language models and other tools in medicine.*

Section 3, the perceptions of respondents concerning the use of AI-based language models and other tools within medicine.

Question		previous use of AI)	without previous use of AI)	U test z-score)
The utilization of artificial intelligence within medicine...				
Q1: ...will positively improve the field of medicine	76.2%	4 (4-5)	3 (2-4)	<0.01 (z = 4.401)
Q2: ...will find useful applications in medicine	86.1%	4 (4-5)	4 (3-4)	0.003 (z = 2.936)
Q3: ...influence the choice of my medical specialization	44.6%	3 (3-4)	3 (2.5-4)	0.420 (z = 0.806)
Q4: ...will decrease the number of jobs for medical staff	46.4%	3 (3-4)	3 (2-4)	0.220 (z = 1.227)
Q5: ...will improve the quality of patient care	66.3%	4 (3-4)	3 (2-4)	0.001 (z = 3.265)
Q6: ...will improve the process of diagnosis	80.7%	4 (4-5)	3 (2.5-4)	<0.001 (z = 4.34)
Q7: ...will improve the process of therapy selection	86.8%	4 (4-4)	3.5 (3-4)	<0.001 (z = 3.48)
Q8: ...will negatively affect the doctor-patient relationship	43.9%	3 (2-4)	3 (2.5-4)	0.742 (z= -0.329)
Q9: ...will lead to a dehumanization of medicine	43.9%	3 (2-4)	3 (1.5-4)	0.229 (z= 1.203)
Q10: ...will negatively affect patient autonomy	23.5%	3 (2-3)	3 (2.5-4)	0.118 (z= -1.562)
Q11: ...negatively affect the autonomy of medical staff	34.3%	3 (2-4)	3 (2.5-4)	0.525 (z = -.636)
Q12: ...bring new ethical challenges	78%	4 (4-4)	4 (3.5-4.5)	0.994 (z = 0.007)
Section 4, the perception of participants concerning the tutoring of AI-based applications within medicine.				

Question		previous use of AI)	without previous use of AI)	U test z-score)
The teaching of AI and AI -based applications...				
Q13: ...should be a part of the formal curriculum	79.8%	4 (4-4)	4 (2.5-4)	0.020 (z = 2.328)
Q14: ...in the current curriculum is adequate	40.3%	4 (2-4)	4 (2.5-4)	0.571 (z= -0.566)
Q15: ...should include practical content alongside its theoretical aspects	72.9%	3 (3-4)	3.5 (2-4)	0.011 (z= 2.544)
Q16: ...based on real-life case studies and practical scenarios	77.7%	4 (4-4)	4 (3-4)	0.055 (z = 1.918)
Q17: ...is an important prerequisite for medical practice	58.4%	4 (3-4)	4 (1.5-4)	0.355 (z = 0.926)
Q18: ...should be made available for the staff even after their graduation	83.8%	4 (4-5)	3 (2.5-4)	0.597 (z = 0.528)
Q19: ... be updated continuously in order to reflect future advances in the field	87.9%	4 (4-5)	4 (3.5-5)	0.350 (z = 0.934)
Q20: ...is of interest to me	72%	4 (3-4)	3 (1.5-4)	<0.001 (z = 4.26)

tion of participating medical students reported agreement with the statements that teaching AI ethics education: 1) be based on real-life case studies and practical scenarios (S3; 77.4%); 2) contributes to raising awareness towards ethical issues (S4; 75.3%); 3) is an important prerequisite (S5; 59.8%); 4) be available to the staff even after graduation (S6; 70.1%); and 5) be taught by experts from various fields (S7; 81.9%). Both groups had similar levels of agreement regarding these statements with Mann Whitney U test showing no significant difference (See Table 3). The statement "the teaching of AI ethics is of interest to me" (S8) had a statistically significant difference (P=0.0047) between the two groups based on the previous use of these language models, with the z-score

indicating notably higher levels of interest in ethics education regarding artificial intelligence in participants who had used these language models in comparison to those who had not. The complete results of the statistical analyses of the fifth section of the questionnaire are presented in the first half of Table 3.

Lastly, Regarding the perceptions of medical students towards the relevance of the AI ethics topics within the medical curriculum, the majority of participants deemed them highly relevant ("quite relevant" and "very relevant") with 1) Informed consent = 56.6%; 2) Bias = 62.9%; 3) Data privacy = 74.1%; 4) Explainability = 68.1%; 5) Safety of using AI-based applications = 75.3%; 6) Fairness = 80.1%; 7) Autonomy = 65.3%;

and 8) Responsibility = 76.2%. There was no statistically significant difference in the responses based on the previous use of these application for these statements except for the "Informed consent" (P=0.002), where the z-score of Mann Whitney U indicated the participants with prior experience of language models and other medicine related tools deemed "informed consent" to be more relevant than those without any experience (z-score = 3.024). The complete results of the statistical analyses of the sixth section of the questionnaire are presented in the second half of Table 3.

Discussion

This cross-sectional study aimed to comprehensively evaluate the perception of using AI and its application in medical practice in medical students of Pakistan and to determine the perceived relevance of AI ethics in medical students for using AI in medical education. A considerable proportion (308/332, 92.8%) of the participants acknowledged prior use of these language models or some other AI-based tools, which is significantly raised as compared to 68.8% reported by a similar study conducted on a similar population two

Table 3: *The results of the perception of participants concerning the tutoring of AI ethics within medical curricula, and the perceived relevance of (proposed) AI-ethics teaching content..*

Section 5, the perceptions of respondents concerning the tutoring of AI ethics within medical curricula.				
Question	**Percentage agreed**	**Median (IQR) (Subgroup with previous use of AI)**	**Median (IQR) (Subgroup without previous use of AI)**	**P value (Mann-Whitney U test z-score)**
AI ethics education...				
S1. ... should be part of the medical curriculum.	74.4%	4 (4-5)	3.5 (3-5)	0.161 (z=1.397)
S2. ... in medical studies is adequate.	45.1%	3 (2-4)	3 (2-3.5)	0.130 (z=1.516)
S3. ... should be based upon real-life case studies and practical scenarios.	77.4%	4 (4-4)	4 (3-5)	0.514 (z=0.653)
S4. ... contributes to raising awareness for ethical issues in clinical everyday life.	75.3%	4 (4-4)	4 (3-4.5)	0.897 (z=0.129)
S5. ... is an important prerequisite for medical practice.	59.7%	4 (3-4)	4 (1.5-4)	0.685 (z=0.406)
S6. ... be made available for the staff even after their graduation.	70.1%	4 (4-4)	4 (3.5-4.5)	0.652 (z=0.451)
S7. ... should involve experts from different fields of expertise to ensure a multi-disciplinary perspective on ethical concerns regarding AI.	81.9%	4 (4-5)	4 (3.5-5)	0.792 (z=0.263)
S8. ... is of interest to me.	74.1%	4 (4-4)	4 (2-4)	0.047 (z=1.988)
Section 6, the results of the perceived relevance of (proposed) AI -ethics teaching content.				
Question	**Percentage that deemed it relevant**	**Median (IQR) For group 1 (previous use of AI)**	**Median (IQR) For group 2 (no previous use of AI)**	**P value (Mann-Whitney U test z-score)**
The relevance of the AI ethics topics within medical university studies:				
Informed consent	56.6%	4 (3-4)	3 (2-4)	0.002 (z=3.024)
Bias	62.9%	4 (3-4)	4 (2.5-4.5)	0.651(z=-0.452)
Data privacy	74.1%	4 (3-4)	4 (2.5-4.5)	0.593 (z=0.535)
Explainability	68.1%	4 (3-4)	4 (3-4)	0.551 (z=0.596)
Safety of using AI-based applications	75.3%	4 (4-5)	4 (3.5-4.5)	0.532 (z=0.625)
Fairness	80.1%	4 (4-4)	4 (3.5-4.5)	0.988 (z=0.15)
Autonomy	65.3%	4 (3-4)	4 (3-4)	0.831(z=-0.213)
Responsibility	76.2%	4 (4-4)	4 (3.5-4)	0.791 (z=0.265)

years ago.[7] It is noteworthy that some of these chat applications were not as easily available back then as they are now. For instance, Co-Pilot/ Bing was not broadly accessible until May 2023.[13] However, academic literature on the directed use of these language models and other tools among medical personnel is still limited and a more detailed evaluation is necessary given that the data suggests many of these students might be using AI without any well-directed orientation (only 17.1% of participants reported goal-oriented use, such as image-based diagnostic tools, as compared to the toa of 92.8%. Moreover, this also highlights the necessity of taking active steps in designing curricula, so that the understanding of AI tools in medical and research contexts could be improved.

Despite the significant engagement of students with these language models and other AI-based tools, only a small fraction (21.1%) reported to have received formal AI ethics education, although more than a two-thirds majority of the participants agreed that the AI ethics education should be part of the formal medicine curricula. This disparity underscores a critical gap between the evolving learning tools and the academic guidance addressing the subsequent ethical and technical concerns regarding their use. Concerning the implementation of artificial intelligence within medicine, the findings suggest a significant contrast between the utilizing of AI and optimism toward AI, as the response to the inclusion of AI in medical curriculum in the subgroup with prior use was statistically significantly higher than that of without a previous use (P=0.02). However, Caution is warranted in this case as there might have been an overly optimistic view of its potential benefits due to the current hype surrounding this topic, that could have overlooked its fundamental shortcomings as well as ethical implications that may arise with its use.[14]

Remarkably, nearly a four-fifth majority (78%) acknowledged that the increasing use of artificial intelligence within medicine will pose novel ethical challenges, which resonates with pre-existing international research.[12,15,16] However, there seem to be limited studies in Pakistan addressing this issue, as highlighted by a recently published editorial[17]. The majority of participants perceived the proposed AI ethics topics as fairly relevant (see Table 3), which were suggested for teaching as potentially important ethics content concerning the implementation AI, in the current medical literature.[14,18–20]

Interestingly, a statistically significant difference was observed for the term "informed consent" between the subgroups based on the prior use of AI (P = 0.002), suggesting that the actual use of AI-based technology may have broadened the understanding of its ethical dimensions. Although this study was aimed to address the current perceptions of AI and education concerning its ethics with respect to medical curricula,

it is also important to note that the use of artificial intelligence and AI-based tools in medicine is currently not authorized and endorsed widely, mainly due to the safety and privacy issues related to its use.[20–22] Nonetheless, the overwhelmingly positive perception of the potential utilization and implications of artificial intelligence, as demonstrated in this research, highlights the necessity for institutions and educational boards to react proactively. Keeping these results in view, balancing the speed of technological advances in AI with the integrated thoughtful and comprehensive curriculum will likely be a key challenge for medical education in the upcoming years.

Being a cross-sectional study, it had several limitations. Firstly, the survey being web-based may have led to the selection-bias, with tech-savvy students being more likely to participate, potentially impacting the results. Secondly, the use of convenience sampling due to the large geographical coverage (all medical institutes in Punjab) could limit generalizability to the entire population. Thirdly, due to the cross-sectional design, the findings may not capture the changing attitudes and competencies with future advancements in these AI-based technologies. Finally, self-reported outcomes in the responses may be affected by recall bias, misinterpretations of questions, or due to social-desirability bias, i.e., the respondents may have attributed the use of AI to a "good-behaviour".

Conclusions

The survey findings show that there is generally a positive view of the impact of AI on the field of medicine in Punjab, Pakistan. There is also a recognition of the importance of integrating the AI utilization instructions as well as relevant ethics education into the formal medical curriculum. However, there is a notable disparity between the use of artificial intelligence-based tools by students and the level of education provided on ethics concerning its use within their formal medical curriculum, i.e., despite the majority of students using AI technology, only a small minority have been formally educated on the ethical considerations of AI. This highlights a significant disparity within the current medical curricula and emphasizes the need to reassess the existing medical curricula and consider integrating AI and AI ethics education into the curriculum to ensure that future medical professionals are adequately prepared to address the challenges and opportunities posed by the incorporation of artificial intelligence in medicine. Future research is necessary to find effective strategies for integrating AI ethics and practical use of AI guidelines in their courses for better use of AI in medicine.

public, commercial or not-for-profit organization.

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