



Attitudes towards medical artificial intelligence talent cultivation: an online survey study

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Background: To investigate the attitude and formal suggestions on talent cultivation in the field of medical artificial intelligence (AI).

Methods: An electronic questionnaire was sent to both medical-related field or non-medical field population using the WenJuanXing web-application via social media. The questionnaire was designed to collect: (I) demographic information; (II) perception of medical AI; (III) willingness to participate in the medical AI related teaching activities; (IV) teaching content of medical AI; (V) the role of medical AI teaching; (VI) future career planning. Respondents' anonymity was ensured.

Results: A total of 710 respondents provided valid answers to the questionnaire (57.75% medical related, 42.25% non-medical). About 73.8% of respondents acquired related information from network and social platform. More than half the respondents had basic perception of AI applicational scenarios and specialties in medicine, meanwhile were willing to participate in related general science activities (conference and lectures). Respondents from medical healthcare related fields, with high academic qualifications of male ones demonstrated showed significant better understanding and stronger willingness ($P < 0.05$). The majority agreed medical AI courses should be set as major elective (42.82%) during undergraduate stages (89.58%) involving medical and computer science contents. An overwhelming majority of respondents (>80%) acknowledged the potential roles of medical AI teaching. Surgeon, ophthalmologist, physicians and researchers are the top tier considerations for ideal career regardless of AI influence. Radiology and clinical laboratory subjects are more preferred considering the development of medical AI ($P > 0.05$).

Conclusions: The potential role of medical AI talent cultivation is widely acknowledged by public. Medical related professions demonstrated higher level of perception and stronger willingness for medical AI educational events. Merging subjects as radiology and clinical laboratory subjects are preferred with broad talents demands and bright prospects.

Keywords: Medical artificial intelligence (Medical AI); talent cultivation; survey study

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Introduction

Artificial intelligence (AI) holds great promise for the improvement of medicine. Medical AI has moved from theory toward application in real clinical practice in recent years (1,2). The advantages of medical AI include reduction of medical costs and improvement of diagnostic and therapeutic efficiency (3,4). AI can assist in the establishment of precise diagnoses and proper treatment strategy, presented as Watson (5) or Google's DeepMind (5) providing advice on the best treatments for cancer and conducting genome analyses. Furthermore, AI has been used to predict genetic variations in low-grade gliomas (6), identify genetic phenotypes in small cell lung carcinoma (7), and automatically perform bone age assessment (8). These examples demonstrate the application of AI will be further extended to other areas in the future, leading to fundamental changes in the role of physicians and the way they practice medicine. Meanwhile, the development and utilization of AI programs in the medical field are currently entering the stage of commercialization calling for involvement of diverse academic backgrounds and occupations (9).

Talent cultivation, especially the specialized education in colleges and universities forms the footstone on the way towards the age of medical AI (10). Medical AI is rapidly emerging as a multidisciplinary branch of science, which involves foundational biomedical sciences, computer sciences, relevant laws and ethics, etc. The medical school curriculum as well as the graduate medical education within academic hospitals have not yet come to grips with educating students and trainees on this emerging technology around the world (11). Several opinions have pointed to the benefits and limitations associated with the use of AI in medicine (12,13), but the aspect related to formally educating the young generation has not been openly discussed. Some science and engineering institutes have set up independent AI college (14), however, fundamental medical courses and clinical application scenarios are still absent in the curriculum arrangements. A realistic and well-accepted scheme for talent cultivation on medical AI remains to be established.

Heated debates are maintained on educational reform concerning medical AI among educational, medical and

relevant subject scholars. Recent reports have shown the interests, as well as concerns for career planning from medical students (15) and physicians (16) accompanied by development of AI. To date, no comprehensive survey was published to focus on the attitudes and formal suggestions on medical AI talent cultivation. Therefore, in this study, we conducted an on-line survey for both the medical and nonmedical public, to investigate their perception, willingness, understanding of the role for the issue. The respondents are also asked to provide detailed suggestions on course content and express their opinion on career planning. The information conveyed in the survey will be conducive to expand the talent pool effectively and accelerate the translational progress of AI in medicine.

Methods

Study design

The survey was designed to find out the intention and suggestion of medical AI teaching, as medical AI is considered as the promising application prospect while the talent cultivation and teaching plan remain uncertain. An electronic questionnaire was sent out using the WenJuanXing web-application (web link: www.wjx.cn) via social media. The questionnaire consisted of 7 items, including single-choice questions, multiple-choice questions, 3-point and 5-point Likert scale items, ranking question, and a narrative comment. Questions were designed to collect: (I) demographic information; (II) perception of medical AI; (III) willingness to participate in the medical AI related teaching activities; (IV) teaching content of medical AI; (V) the role of medical AI teaching; (VI) future career planning. According to the respondents' profession (medical-related field or non-medical field), the questions were designed differently (<http://cdn.amegroups.com/static/application/f96fac204f567830f0f4c54990650073/atm.2019.12.149-1.pdf>).

The respondents were informed that the information and results of questionnaire would be used to conduct statistical analysis and scientific publish. The anonymity of respondents was guaranteed. Once the respondents started to fill out the questionnaire, they had to answer all the questions, except the last narrative comment, to submit the survey.

Statistical analysis

Statistical analyses were performed by using distribution description, χ^2 test and McNemar test. For the distribution description, we described demographic information of respondents, channels of knowing medical AI, the course type that medical AI should be set to, and the stage that medical AI should be involved in. When computing the proportion of multiple-choice question, the total number of respondents was divided by the number of each option. Besides, for the ranking questions, the ranking score was calculated by the total number of respondents multiplying the corresponding score (1st rank score: 3, 2nd rank score: 2, 3rd rank score: 1). For instance, if 80 respondents choose A as 1st option, the 1st rank score of A will be $80 \times 3 = 240$.

For the χ^2 test, we reassign the respondents based on their education background, for those were “primary school and below”, “junior high school”, “high school”, “Specialized college”, or “Undergraduate/bachelor’s degree”, they were grouped to “Undergraduate or below”, and the rests were grouped to “Graduate or Phd”. Then we conducted three tests for each Likert scale to see if profession (“Medical-related”, “Non-medical”), gender (male, female), and education background (Undergraduate or below, Graduate or Phd) would have the significant difference.

For McNemar test, we tested the choice of future career if considering the influence of medical AI or not considering the influence for significant difference.

For all the tests, a $P < 0.05$ was regarded as statistically significant. All analyses were performed using R 3.6.1.

Results

Over a 4-week period (Jul 13th, 2019–Aug 6th, 2019), a total of 714 students and professionals responded to the questionnaire. Of these, 4 respondents refused to upload their information and data to analyze, so the total number of analyzed respondents is 710. The proportion of respondents in the “Non-medical” group (42.25%) is approximate to the one in the “Medical-related” group (57.75%). As we targeted at students and professionals who were interested in medical AI, almost half of the respondents (49.58%) were at undergraduate level. Demographic characteristics of the Respondents was shown in *Table 1*, [http://cdn.amegroups.](http://cdn.amegroups.cn/static/application/804b63ed0646e190ee5d2a438323fd48/atm.2019.12.149-2.pdf)

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Perception of medical AI

To access the level of respondents’ perception of medical AI, respondents were asked to rate their agreement with 6 statements on 3-point Likert scale. When the perception level of medical AI increased, from “heard of the concept” to “been involved in the research”, the corresponding proportion of respondents in favor of “disagreement” became bigger, from 3.52% to 70.85% (<http://cdn.amegroups.cn/static/application/804b63ed0646e190ee5d2a438323fd48/atm.2019.12.149-2.pdf>). However, there was a significant difference between different education background when respondents rated their agreement (<http://cdn.amegroups.cn/static/application/804b63ed0646e190ee5d2a438323fd48/atm.2019.12.149-2.pdf>). As shown in *Figure 1*, the respondents in the “Undergraduate and below” group tended to disagree the statements while the rest tended to agree, as the level was increased. In the last statement, there was 35% of respondents in favor of “been involved in research on medical AI” in the “Graduate and Phd” group while only 11% agreement in the “Undergraduate and below” group. It is reasonable as most students will be involved in scientific research at their graduate or PhD stage. Moreover, when asked “I know medical AI through the following options”, there are 73.8% of respondents chose “Information from network and social platform” (<http://cdn.amegroups.cn/static/application/804b63ed0646e190ee5d2a438323fd48/atm.2019.12.149-2.pdf>). We might conclude that most of the respondents knew “medical AI” through internet and social platform thus lack of systematically study.

Willingness to participate in medical AI related activities

To access the level of respondents’ willingness to participate in medical AI related activities, the respondents were also asked to rate their agreement with 7 statements on 5-point Likert scale. As illustrated in *Figure 2* and <http://cdn.amegroups.cn/static/application/804b63ed0646e190ee5d2a438323fd48/atm.2019.12.149-2.pdf>, as the level progressed, from “I am interested in medical AI” to “I believe that my current knowledge can support the study of medical

Table 1 Demographic characteristics of the respondents

Category	N	Medical related field, N (%)	Non-medical field, N (%)
Profession	710	410 (57.75)	300 (42.25)
Country			
China	704	407 (57.32)	297 (41.83)
Other countries in Asia	1	1 (0.14)	0
US	3	2 (0.28)	1 (0.14)
Canada	1	0	1 (0.14)
Africa	0	0	0
Europe	0	0	0
Australia	0	0	0
Others	1	0	1 (0.14)
Gender			
Male	288	160 (22.54)	128 (18.03)
Female	422	250 (35.21)	172 (24.23)
Age			
<18	6	1 (0.14)	5 (0.70)
18–25	238	142 (20.00)	96 (13.52)
26–30	146	81 (11.41)	65 (9.15)
31–40	194	103 (14.51)	91 (12.82)
41–50	82	52 (7.32)	30 (4.23)
51–60	38	29 (4.08)	9 (1.27)
>60	6	2 (0.28)	4 (0.56)
Academic qualification			
Primary school and below	0	0	0
Junior high school	2	0	2 (0.28)
High school	80	56 (7.89)	24 (3.38)
Specialized college	43	19 (2.68)	24 (3.38)
Undergraduate/ bachelor's degree	352	156 (21.97)	196 (27.61)
Master's degree	117	73 (10.28)	44 (6.20)
Doctor's degree	116	106 (14.93)	10 (1.41)

AI”, more respondents tended to be in favor of disagree. Noticeably, before the fourth question “I am willing to undertake or assist in the education reform and related work on medical intelligence tutoring system”, the ratios of “agree” (combined the proportion of “strongly agree” and “somewhat agree”) were over 80%. When it came to

the last question, “I believe that my current knowledge can support the study of medical AI courses”, the ratio of “agree” dropped to 56%. Besides, “Lack of teachers in the field of medical AI” was most selected in both “Medical-related” group (73.66%) and “Non-medical” group (62%) (<http://cdn.amegroups.cn/static/application/804b63ed0646e190>

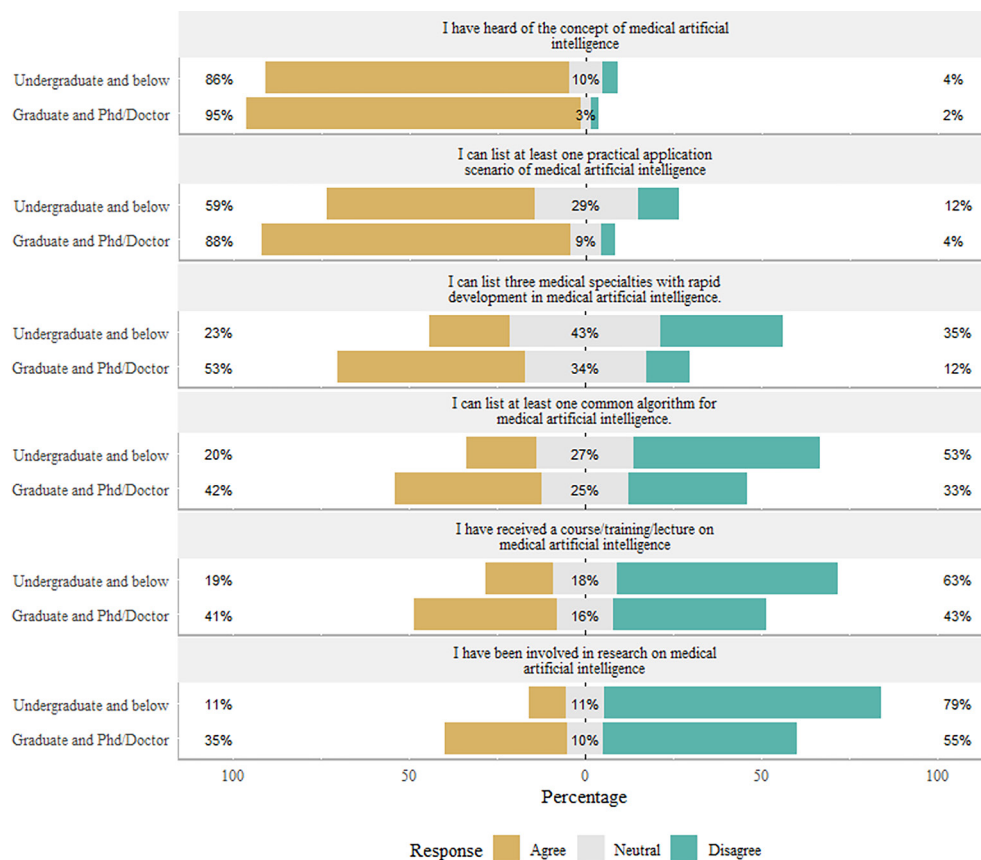


Figure 1 Perception of respondents with two groups comparison. Based on the education background, the respondents were divided into two groups: Undergraduate and below/Graduate and PhD.

ee5d2a438323fd48/atm.2019.12.149-2.pdf). It seems that there was an urge for sophisticated lecturers regarding the medical AI.

Teaching form/content

Since most respondents were in favor of statements, only a few statements showed the significance difference between “Medical-related” group and “Non-Medical” group (<http://cdn.amegroups.cn/static/application/804b63ed0646e190ee5d2a438323fd48/atm.2019.12.149-2.pdf>). As illustrated in *Figure 3*, the questions were designed to further explore the possible course type and the appropriate stage to introduce medical AI. Panel A showed that most of the respondents chose the “major elective course” as the proper course type. Panel B showed that “undergraduate” would be the appropriate stage to introduce the “medical AI”. Specifically, the undergraduate stage of medical-

related group consisted of two parts: one is “after medical major courses” (with more votes), and the other is “before medical major courses”. On panel C, “AI application scenarios in the medical field” won more attention from both “Medical-related” group and “Non-medical” group. Despite respondents preferred to introduce the medical AI course sooner at the undergraduate stage as the major elective course, but most of respondents in the “Medical-related” group preferred that it should be arrange after medical major course. Furthermore, the practical content with application scenarios was most favored.

The role of medical AI teaching

More than half of the respondents disagreed that “Medical AI related content has been covered in other courses”, combining the proportion of “Strongly disagree” and “Somewhat disagree”. From *Table 2*, over 80% of

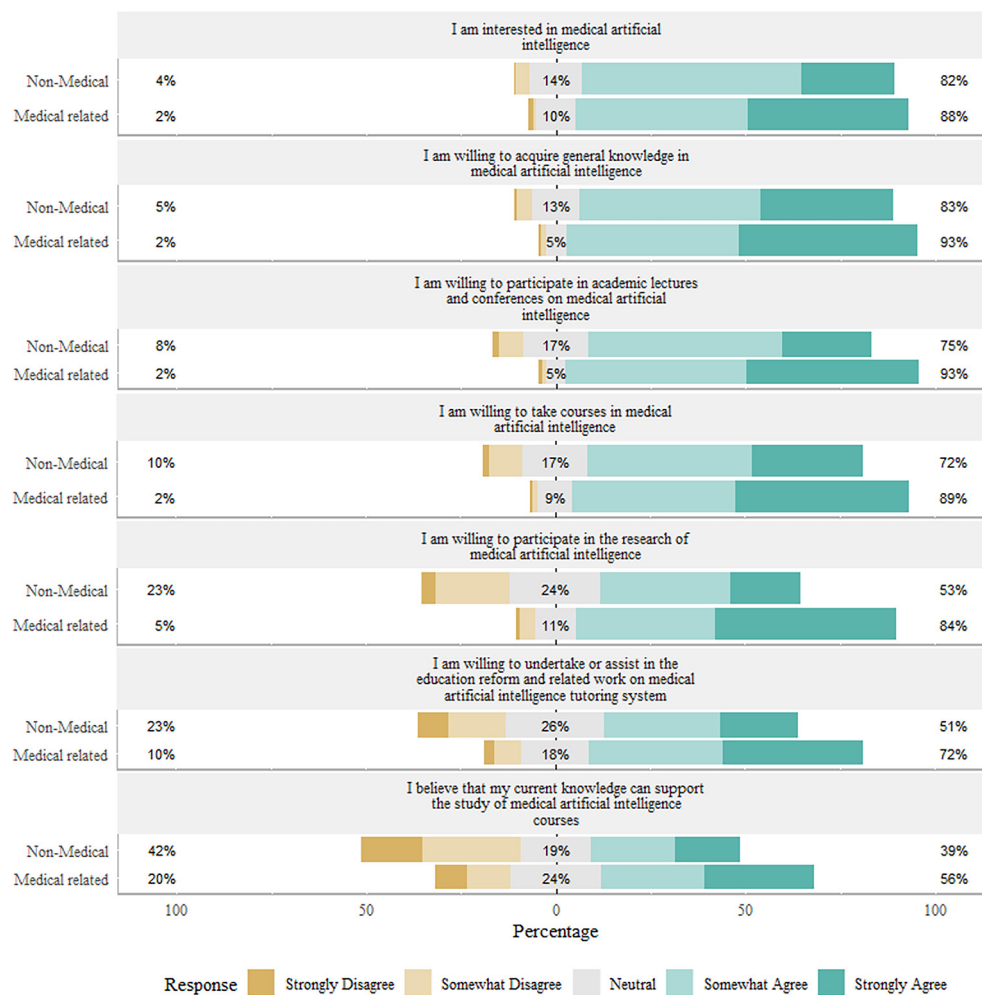


Figure 2 Willingness of respondents with two groups comparison. Based on their professions, the respondents were divided into two groups: Medical-related field or Non-medical field.

respondents recognized the medical AI as “Conducive to promoting the development of medical AI diagnosis system” and “Effectively promote health care reform” (combining the proportion of “strong agree” and “Somewhat agree”).

Career planning regrading medical AI

As shown in the *Figure 4*, <http://cdn.amegroups.com/static/application/804b63ed0646e190ee5d2a438323fd48/atm.2019.12.149-2.pdf>, respondents showed tendency to work in the field of medical AI especially for those in the “Medical-related” group (61% for working full-time, 80% for engaging in some work related to the field). It is interesting to find out that although most respondents

(58% in the “Non-medical” group, 78% in the “Medical-related” group) were in favor of the statement “AI can only play a supporting role in the future”, there were still certain respondents that remained the approval attitudes (34% in the “Non-medical” group, “33%” in the “Medical-related” group) when asked if they agreed on the statement “AI will replace human beings”. As illustrated in the *Figure 5*, “Surgeon” and “Ophthalmologist” remained the top 2 ranking place for ideal profession regardless of if the influence of medical AI was taken into account. Nevertheless, after taking the influence of medical AI into account, the score of conventionally considered as “most affected” profession increased such as “Clinical service guiding, care workers”, “Medical imaging doctor” and “Pharmacist”.

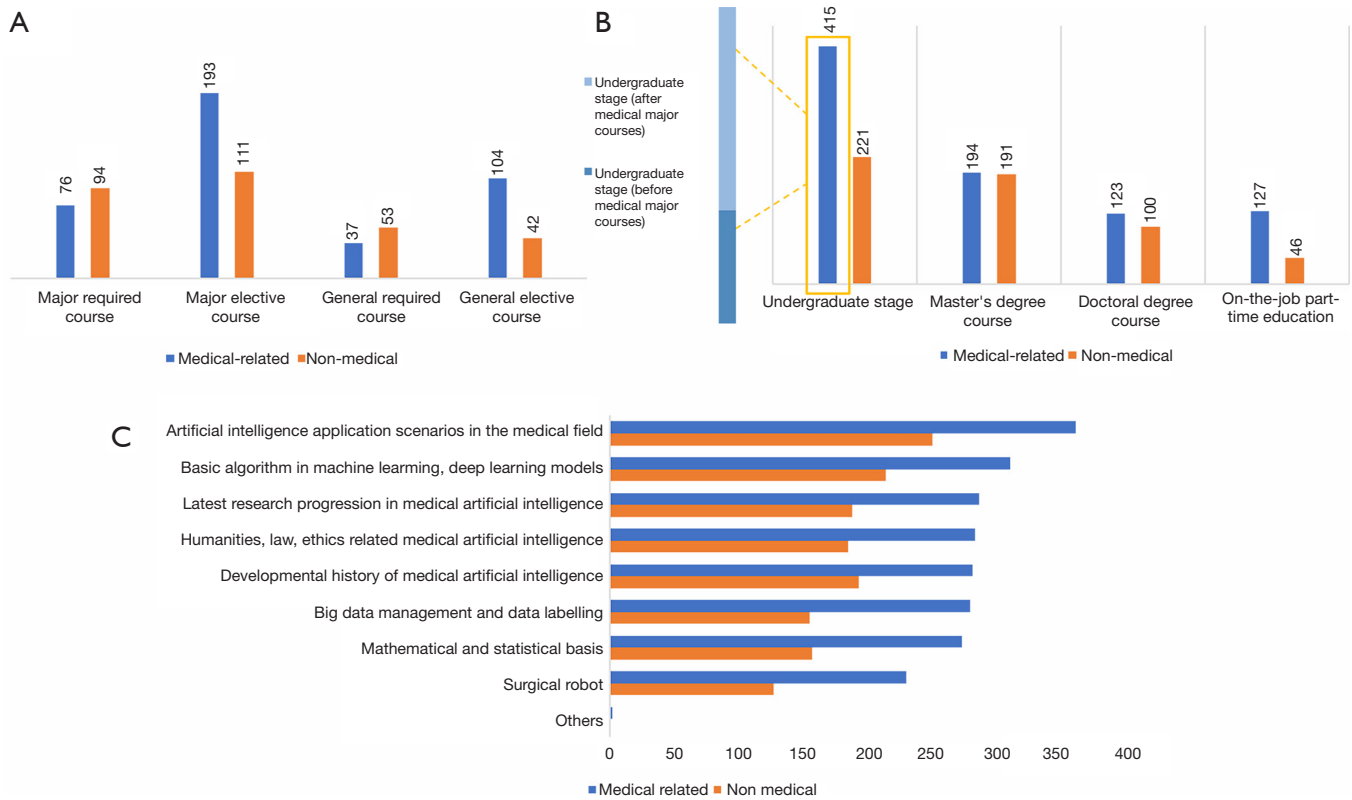


Figure 3 Medical artificial intelligence course type/stage/content with respondents from medical-related field and non-medical field. (A) How respondents set the course type; (B) stage the medical artificial intelligence courses should be involved; (C) content the respondents were interested in. Noticeably, in the panel B, the “medical-related” bar in the undergraduate stage contains two parts (undergraduate stage after medical major courses, undergraduate stage before medical major courses).

Table 2 The role of medical artificial intelligence teaching

	Strongly disagree, N (%)	Somewhat disagree, N (%)	Neutral, N (%)	Somewhat agree, N (%)	Strongly agree, N (%)
Medical artificial intelligence related content has been covered in other courses	81 (11.41)	329 (46.34)	144 (20.28)	103 (14.51)	53 (7.46)
Conducive to the cultivation of talents in the medical artificial intelligence	3 (0.42)	8 (1.13)	57 (8.03)	408 (57.46)	234 (32.96)
Conducive to promoting the development of medical artificial intelligence diagnosis system	2 (0.28)	8 (1.13)	45 (6.34)	374 (52.68)	282 (39.72)
Help artificial intelligence technology to be applied in medical field	4 (0.56)	9 (1.27)	49 (6.90)	356 (50.14)	292 (41.13)
Improve the level of medical diagnosis, treatment and service capabilities	4 (0.56)	11 (1.55)	68 (9.58)	348 (49.01)	281 (39.58)
Broaden research ideas	2 (0.28)	8 (1.13)	57 (8.03)	363 (51.13)	281 (39.58)
Effectively promote health care reform	5 (0.70)	17 (2.39)	120 (16.90)	313 (44.08)	255 (35.92)

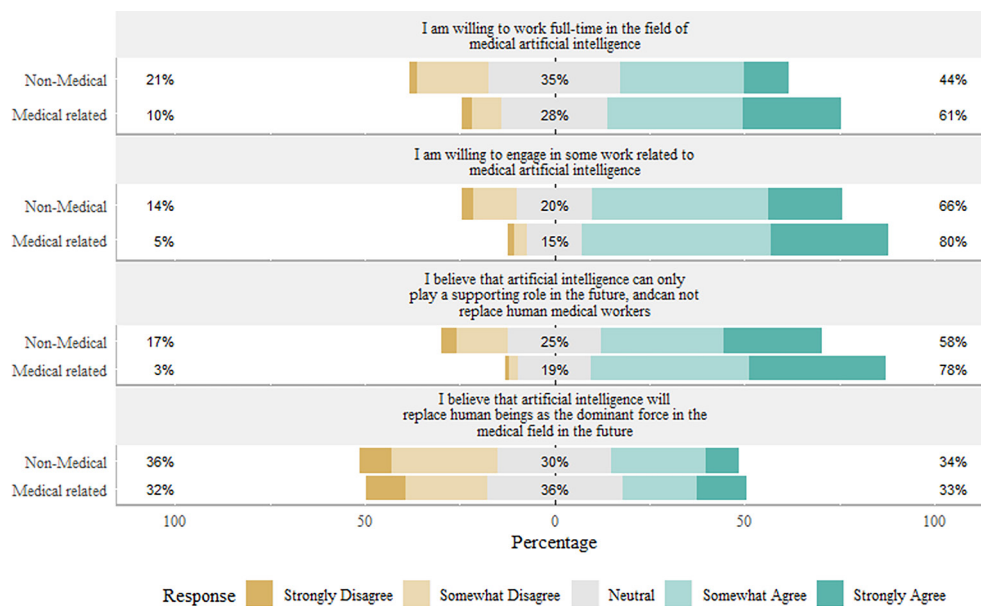


Figure 4 Career planning considering the role of medical artificial intelligence. Based on their profession, the respondents were divided into two groups: Medical-related field or Non-medical field.

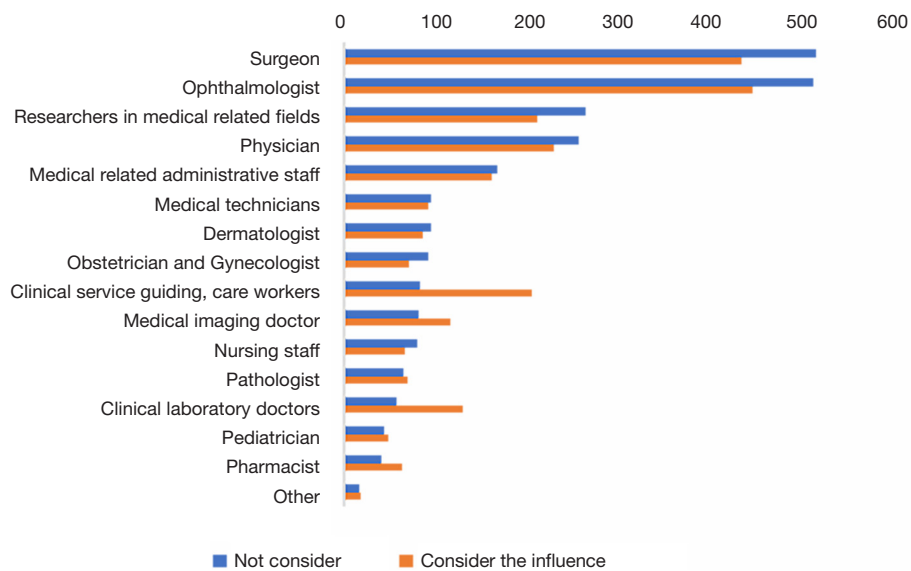


Figure 5 Score bar plot of ranking top 3 professions out of 16 options.

Perhaps, those “most affected” profession might also have more medical AI application scenarios and those who would work in the profession, might have more chance to expose to the medical AI practice.

Narrative comment

As an optional question, the respondents were asked to provide additional comments on the implementation of medical AI. A total of 87 comments were received. Some respondents mentioned that medical AI is inevitable trend and more related scientific knowledge should be popularized. Besides, many commented that medical AI would bring an efficient and effective experience and reformation beyond imagination. A few respondents commented that the implementation of medical AI should cooperate with government for certain funding or companies for technical support. Several comments touched upon the importance of medical AI applications on telemedicine using augmented reality technology.

Discussion

AI, the core of the fourth revolution of science and technology, provides an opportunity to achieve personalized medicine and precision public health (17). Even though an increasing number of colleges students became aware of the development trend and involved in lectures, courses or research fields on AI in medicine, the curriculum system of medical AI subject has not yet been established, nor an independent subject been set up. In this study, an on-line survey was designed for both the medical related and non-medical field professions, involving diverse academic qualifications, job positions, and majors. The main part of the questionnaire contains 5 matrix scales with progressive investigations from respondents on their perception on the issue, the willingness to participate, the understanding of the role, their advice for the course curriculum and the relationship between their career planning and medical AI. Taken together, this survey aims to provide an integrated analysis on the attitudes towards medical AI talent cultivation.

An overwhelming majority of respondents acknowledged the potential roles of medical AI teaching as was demonstrated in *Table 2*, nevertheless, their perception level (*Figure 1*) and

willingness to participate (*Figure 2*) medical AI events varies especially considering profession, education background and gender. More than half the respondents were shown equipped with basic knowledge of AI applicational scenarios and specialties in medicine, meanwhile were willing to participate in related general science activities (conference and lectures). The results emphasized on the feasibility and necessity for medical AI educational propagation. Further, although most respondent showed interest for medical AI in professional perspectives (courses, research or teaching), far less of them had the experience or trained with the specialized concepts/skills. Respondents from medical healthcare related fields, with high academic qualifications of male ones demonstrated better understanding (<http://cdn.amegroups.cn/static/application/804b63ed0646e190ee5d2a438323fd48/atm.2019.12.149-2.pdf>) and stronger willingness for medical AI area (<http://cdn.amegroups.cn/static/application/804b63ed0646e190ee5d2a438323fd48/atm.2019.12.149-2.pdf>). This trend calls for the establishment of academic curriculum and research platform in colleges and universities; medical college might be an ideal scene for pilot regarding the highly relevant theoretical backgrounds and applicational demand in the future.

There is no doubt that, noteworthy changes with era of AI are coming to the practice of medicine and healthcare system in general (18). Topics arose at various medical fields, especially where AI pioneered to achieve rapid development, that doctors and healthcare related staff might be substituted and lose their jobs in the foreseeable future (19,20). Despite previous reports confirmed the anxiety from medical students and physicians on the subjects including radiology and pathology (15,21), there has not been a systematic survey amongst public on the attitude alteration of career planning regarding development of medical AI. In this survey, respondents from medical related fields chose surgeon, ophthalmologist, physicians and researchers with high considerations in top tier, regardless of the boosting development of AI (*Figure 5*). Interestingly, the respondents tend more to choose clinical service guiding, radiology or clinical laboratory subjects. They possibly look to further increase of challenges and opportunities brought by tight combination with AI and multidisciplinary fusion.

The limitations of our research should also be considered. The participants are mainly Chinese, and the data from

other countries are limited; therefore, the perceptions and demands of other countries require additional study to ensure accuracy. Moreover, the online survey is only accessible by computer and mobile phones with internet access, and thus some people fail to participate because of insufficient access. Further studies are warranted to investigate the factors that influence the public perceptions and the variation of demands with the medical AI education. How to teach students to practice successfully in a health care environment transformed by AI applications should be a central focus of educational reform today. As the mainstream agreed on the trends, AI cannot substitute doctors as a whole, but doctors with no concept of AI will lose their stage in the near future (22). New skills and expertise will be required as we move to an age of AI, including better use of the findings of cognitive psychology, closer alignment of humans and machines in education, and enhanced use of simulations focused on the integration of machines in care delivery and on patients as active collaborators in their career.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Supplementary

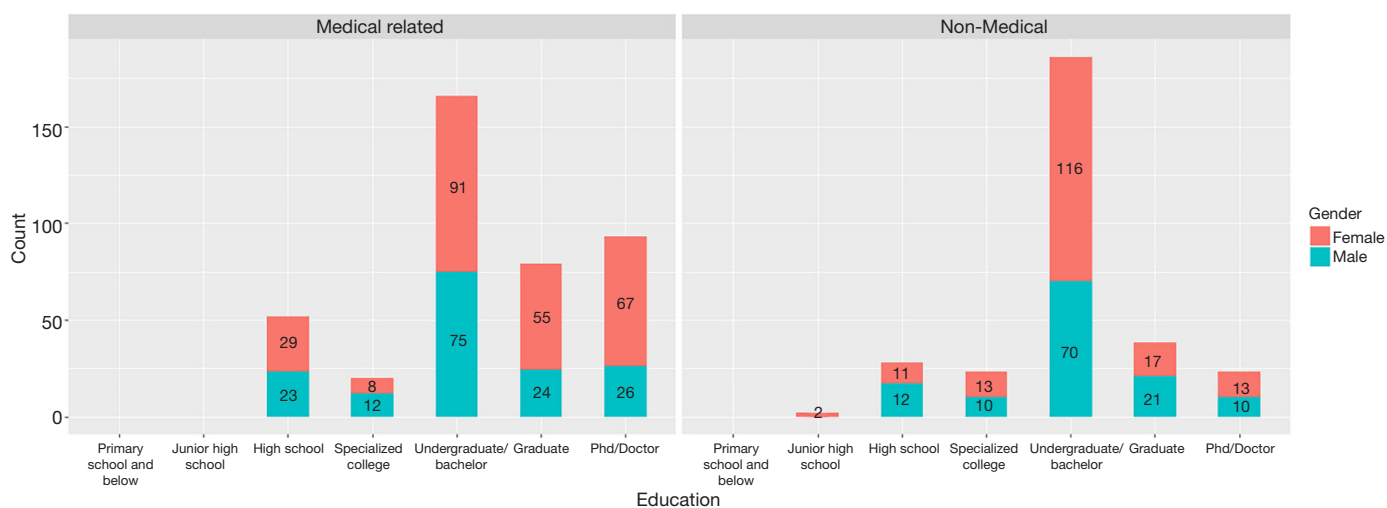


Figure S1 The distribution of education with Medical related field and non-medical related field.