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AI-assisted diagnosis of renal cell carcinoma: educational needs and cognitive assessment based on the WHO classification 2022

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Abstract
This study explored medical students' perceptions, educational needs, and cognitive biases toward Artificial Intelligence-assisted (AI-assisted) renal cell carcinoma (RCC) diagnosis, using the World Health Organization (WHO) 2022 classification. A cross-sectional survey of 249 students examined their familiarity with AI tools, trust in AI-based pathology, and understanding of diagnostic criteria. While most students acknowledged AI's potential to boost diagnostic accuracy, especially for subtyping, over half voiced significant concerns about risks such as over-reliance and automation bias. A key finding was the knowledge gap around the WHO 2022 standards; urology students had a 66.7% self-reported awareness compared to just 7.7% among other majors' students. Nearly 70% of the participants called for mandatory AI training in curricula, with a focus on the rigorous clinical validation of AI tools, supported by over 70% of the pathology students. These results highlight the need to integrate AI innovations with stronger validation protocols and curricular updates to address challenges such as technical limitations, data standardization, and ethical issues. Future studies should align AI development with educational reforms and ethical frameworks to advance precise RCC diagnosis.

Keywords Renal cell carcinoma, Artificial intelligence, Medical education, Pathology diagnosis, Cross-sectional study

Introduction

Renal cell carcinoma (RCC) represents approximately 90% of primary kidney cancer and poses considerable diagnostic difficulties due to its histologic heterogeneity and evolving classification system [1, 2]. The World Health Organization (WHO) 2022 classification introduced molecularly defined renal tumor subtypes such as FH-deficient RCC, SMARCB1-deficient medullary carcinoma, TFE3 rearrangements, TFEB alterations, ALK rearrangements, ELOC mutations, etc [3–8]. This classification diagnostic demand significantly complicates the definitive diagnosis of RCC. Given the heterogeneity of RCC, it is often difficult for a single method to provide comprehensive diagnostic information [9]. Therefore, comprehensively considering the molecular, radiological, clinical, and morphological features, which are evaluated using light microscopy and immunohistochemistry techniques, is necessary to accurately diagnose RCC [3, 9–11].

Artificial intelligence (AI), particularly deep learning algorithms, has demonstrated transformative potential in the field of oncological pathology by improving

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diagnostic accuracy, reducing differences among observers, and deep learning algorithms excel in pathology image analysis to predict the molecular subtypes and prognosis of cancers, such as breast, prostate, and brain tumors, from conventional pathology slides [12–16]. For example, Niazi et al. (2019) employed transfer learning to automate Ki67-positive cell quantification in pancreatic neuroendocrine tumors, reducing the inter-observer variability in prognostic evaluations [17]. Similarly, Cruz-Roa et al. (2019) demonstrated the robustness of AI in detecting invasive breast cancer across diverse datasets using adaptive sampling, achieving a DICE coefficient of 76% [17]. These developments demonstrate that AI can convert conventional slides into tools for predicting molecular subtypes and prognosis. This aids in the progress of personalized oncology and reduces biases that depend on humans.

However, AI models typically perform well on specific datasets but have a limited ability to generalize across different patient populations or healthcare settings [18, 19]. An AI model may perform well in specific age groups, ethnicities, or disease types, but cannot be generalized effectively to other groups [20]. Furthermore, there are numerous cases of AI systems inadvertently inheriting, perpetuating, and amplifying multidimensional biases, such as race and gender, owing to flaws or a lack of representation in training datasets [21].

Our survey investigated the perceptions, educational needs, and challenges faced by medical students regarding AI-assisted RCC diagnosis within the context of the WHO 2022 framework. By conducting a survey of 249 students from different majors and educational stages, we assessed their familiarity with AI applications, trust levels regarding AI-assisted pathology diagnosis, and understanding of the new classification standards for RCC.

Methods

This descriptive cross-sectional study used a purpose-designed online questionnaire as the data collection instrument. The questionnaire measured self-reported familiarity and attitude. The questions were refined and tailored to better assess medical students' familiarity of the use of AI technology in the diagnosis of RCC, the new subtypes in the WHO Classification of RCC 2022, and their interest in education related to AI-assisted diagnosis.

The final questionnaire comprised 16 items scored on a 5-point Likert scale and five questions about the respondents' basic information. 16 Likert-scale questions were divided into the following four categories: perception of AI technology, understanding of the WHO 2022 classification, views on AI-assisted diagnosis of RCC, and educational needs for AI-assisted diagnosis. The following scoring options were used: strongly disagree = 1; disagree = 2; neutral (neither agree nor disagree) = 3; agree = 4; and strongly agree = 5. The other five questions concerned major, degree, gender, age, and experience with RCC diagnosis.

An online questionnaire (Supplementary File 1) was administered to medical students with different majors at West China Hospital of Sichuan University, and the respondents were all adults when they completed the questionnaire. The survey followed a randomized, anonymous, and voluntary design, ensuring that no personally identifiable information was collected.

The questionnaire was distributed through an online platform, completed anonymously, and lasted four weeks. Descriptive statistical methods were used to analyze the frequency distribution and proportion of each question, and differences were assessed using between-group comparisons (e.g., differences in majors and degrees).

Statistical analyses

To examine the differences between student groups, mean scores and standard deviations were calculated for each item across both groups, and a one-way Analysis of Variance (ANOVA) (F-test) was conducted for differential analysis in three different student groups. For items that showed significant differences ($P < 0.05$) in the ANOVA test, we further performed Tukey's Honestly Significant Difference (HSD) post hoc multiple comparison test to identify specific group differences (Supplementary Tables S1-S8). Statistical significance was set at $P < 0.05$ for all inferential tests. All the analyses were performed using SPSS version 27.

Results

Basic information

The age distribution of the respondents in this survey was concentrated between 23 and 26 years old (49.4%), and most of them were resident physicians (graduate degrees) and doctoral students, and most of them were pathology students and urology students (Table 1). Among the respondents, 80% of pathology students had practical experience in RCC diagnosis, while only 37% (30/81) of urology students had this experience, and none of the other majors had any relevant experience.

Perception of AI technology

The results of the questionnaire regarding the perception of AI among all participants and students from different majors are presented in Table 2. In the self-assessment of the urology students, 74.1% (60/81) of the respondents indicated some level of familiarity with the application of AI technology in the medical field (44.4%; "3", 22.2%; "4", 7.4%; "5", Fig. 1A). Over 70% of respondents expressed a positive attitude towards the potential application value of AI technology in pathology diagnosis, only 14.82%

Table 1 Basic information

	Urology (%)	Pathology (%)	Other major (%)	Total (%)
Undergraduate	3 (3.7)	9 (10)	33 (42.3)	45 (18.1)
Resident physician (Undergraduate degree)	3 (3.7)	9 (10)	6 (7.7)	18 (7.2)
Resident physician (Graduate degree)	15 (18.5)	33 (36.7)	6 (7.7)	54 (21.7)
Master's student	27 (33.3)	24 (26.7)	12 (15.4)	63 (25.3)
Doctoral student	18 (22.2)	3 (3.3)	12 (15.4)	33 (13.3)
8-year clinical medical student	15 (18.5)	12 (13.3)	9 (11.5)	36 (14.5)
Other	0 (0)	0 (0)	0 (0)	0 (0)
Total	81 (100)	90 (100)	78 (100)	249 (100)

(7.4%; "1", 7.4%; "2") of urology students were less likely to agree with this view, with an average score of 3.89 for Item 2, compared with 0% of pathology and other majors who gave lower approval to its potential application value, with statistically significance ($P=0.032$) (Fig. 1B) (Table 2, Item 2).

More than half of the respondents believed that AI could assist pathologists in identifying RCC subtypes. In addition, most respondents expressed concerns that AI would cause pathologists to rely excessively on technology, only 9.6% (24/249) of the respondents expressed no concern about this issue. About 33.3% (24/72) and 38.9% (26/67) of master's and doctoral students, respectively, expressed some concern, while almost no resident physicians (bachelor's degrees) expressed concern.

Perception of WHO 2022 classification

The questionnaire results regarding the perceptions of the WHO 2022 classification among all students and students from different majors are presented in Table 3. In terms of self-reported familiarity, most urology students (29.6%; "4", 37%; "5") indicated relatively high familiarity with the new classification subtypes. Among the pathology students surveyed, half of them chose to be neutral on this issue. In other majors, no one considered themselves extremely familiar with the new classification subtypes (0%; "5" Fig. 2A).

Moreover, compared with students from other majors (7.7%; "5"), the view that "the refinement of WHO 2022 classification put forward higher demands for pathology diagnosis" received stronger acceptance in pathology students (53.3%; "5", Fig. 2B). The average score of the students in urology is 4.11, that of the students in pathology is 4.33, and the average score of students in other majors is 2.96, with statistically significant difference among three majors ($P<0.001$) (Table 3, Item 7). Among doctoral students, 55.6% chose "5" to show they hold a positive view on the refinement of the WHO 2022 classification in pathology diagnosis; undergraduates had a lower recognition, and only 20% chose "5". A total of 56.6% (141/249) of respondents had difficulty distinguishing subtypes in clinical practice (28.9%; "5", 27.7%; "4", Fig. 2C); especially in urology, the proportion of "4" and "5" reached 66.7% (54/81). Master's and doctoral students also experienced difficulties distinguishing RCC subtypes. A total of 37.5% (27/72) of the master's respondents chose "4", while 44.4% of the doctoral respondents chose "5". In total, over 69% of the respondents showed a positive attitude to learn the new diagnostic criteria and hoped to learn the criteria according to the WHO 2022 classification (38.6%; "5", 31.3%; "4", Fig. 2D).

Views about AI-assisted RCC diagnosis

The questionnaire results regarding views on AI-assisted RCC diagnosis among all students and students from different majors are presented in Table 4. On the issue of AI helping pathologists complete the diagnosis of RCC more efficiently, a majority of participants expressed a positive attitude. Among the respondents majoring in urology, many students acknowledged the efficiency of AI-assisted diagnosis. Among urology students, 41% (33/81) believed that AI could improve diagnostic accuracy and significantly reduce RCC misdiagnosis rate. Notably, 54.2% (135/249) of the respondents believed that the application of AI technology in pathology requires clinical verification. This perception showed statistically significant differences among the three groups ($P=0.001$) (Table 4, Item12).

Educational needs for AI-Assisted diagnosis

The questionnaire results regarding the educational needs for AI-assisted RCC diagnosis among all students and students from different majors are presented in Table 5. Among all the respondents, the training of AI-assisted diagnosis was generally perceived as beneficial for pathology diagnosis (42.2%; "5", 34.9%; "4", Fig. 3A). The students from the different majors all had a high level of agreement on this view, and their average scores were all above 4. Most of the respondents supported the integration of AI into pathology teaching (27.7%; "4", 42.2%; "5", Fig. 3B), particularly urology students (40.7%; "4", 33.3%; "5"). "Integration of AI into pathology teaching" refers to the use of AI tools to assist in teaching. Simultaneously, the majority of respondents expressed interest in learning the diagnostic methods of new RCC subtypes in the WHO 2022 classification through AI technology

(47%; "5", 31.3%; "4", Fig. 3C) and desired to learn a combination of AI and morphological analysis (45.8%; "5", 30.1%; "4"), of which urology (44.4%, "5") and pathology students (53.3%, "5", Fig. 3D) had a stronger demand for learning to combine AI tools with morphological analysis.

Discussion

The results of this study revealed differences in the application of AI technology, familiarity with the WHO 2022 RCC classification, and educational needs of students with different professional backgrounds in the medical field. Most surveyed students acknowledged the potential of AI to enhance diagnostic efficiency and facilitate subtype identification. However, there were significant concerns about technological dependence and automation biases. Differences in professional backgrounds affected the level of understanding of the new WHO 2022 classification standards, underscoring the urgency for interdisciplinary knowledge integration. Most students advocated for enhanced clinical validation protocols for AI tools and emphasized the need to incorporate AI technology into medical curricula to be updated with evolving disease classification standards.

In our study there were differences in the self-assessment of the familiarity with the new subtype among students from different majors. While a greater proportion of urology students selected the highest ratings, pathology students were more likely to select "neutral," and fewer provided either strong agreement or disagreement. Firstly, we acknowledge that the meaning of the "neutral" option is ambiguous, which limits the accuracy of the conclusion. Secondly, this different phenomenon might be caused by the differences in teaching purposes among different majors, which leading to different self-assessment standards and resulted in different outcomes. The teaching purpose for pathology students is to accurately diagnose different types of RCC. Their rigorous professional training prompts them to be cautious when assessing "familiarity". In contrast, since the teaching purpose of students in the urology is how to treat different types of RCC, that have been diagnosed, which may lead them to be less rigorous in their self-assessment of familiarity with details of histopathologic diagnosis when assessing their own familiarity with the new classification. Furthermore, it is also possible that these respondents were only familiar with a part of the new subtypes, thus maintaining a relatively cautious attitude when making their choices. Or it could also have contributed to personal traits that they were relatively less confident when evaluating themselves. Besides, our survey did not require an exact meaning of this choice.

Our research indicated that there was a noticeable discrepancy between students' self-reported familiarity

Table 2 Results on the perception of AI technology among all students and students from different majors

Item	All, Mean (SD) ($n=249$)	Urology students, Mean (SD) ($n=81$)	Pathology students, Mean (SD) ($n=90$)	Students of other majors, Mean (SD) ($n=78$)	F-test	P-value
Item 1. I have a certain understanding of the application of artificial intelligence (AI) technology in the medical field.	3.05 ± 1.14	3.00 ± 1.06	3.10 ± 1.23	3.04 ± 1.13	0.17	0.847
Item 2. I believe that AI technology has potential application value in pathological diagnosis.	4.06 ± 0.92	3.89 ± 1.20	4.03 ± 0.71	4.27 ± 0.77	3.49	0.032*
Item 3. I am interested in the specific applications of AI in pathology (such as molecular feature identification including gene mutations).	4.00 ± 0.95	4.22 ± 0.88	3.73 ± 1.00	4.08 ± 0.88	6.33	0.002*
Item 4. I believe that AI can assist pathologists in identifying subtypes of renal cell carcinoma.	4.00 ± 0.95	3.93 ± 0.98	4.20 ± 0.84	3.85 ± 0.99	3.35	0.037*
Item 5. I am concerned that AI might lead pathologists to rely excessively on technology.	2.95 ± 1.10	3.11 ± 1.07	2.77 ± 1.09	3.00 ± 1.12	2.23	0.110

*$p<0.05$

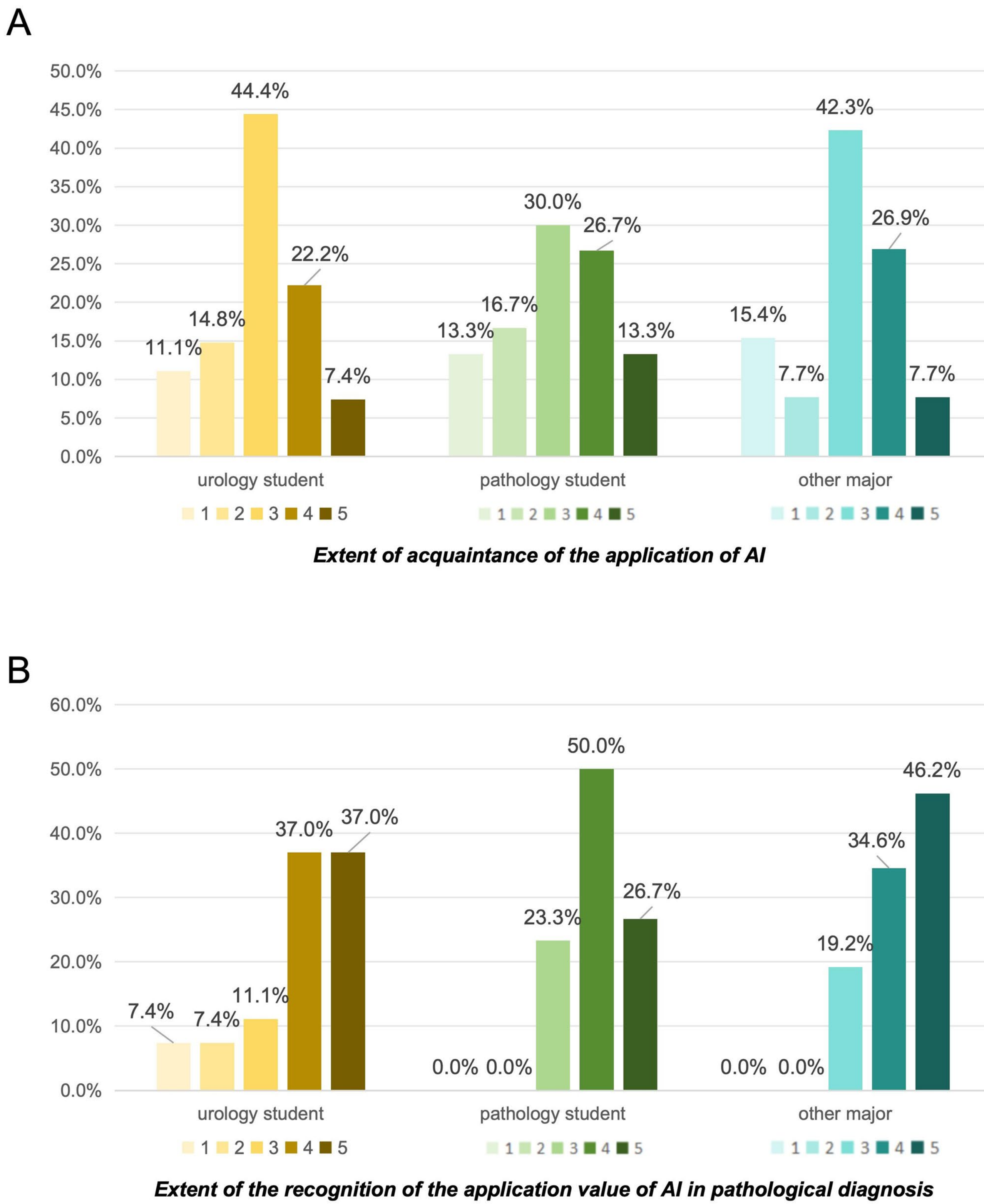

Fig. 1 Perception of AI technology.**A** Perceptions of the application of AI in the medical field among students from different majors ranging from 1 (extremely ignorant) to 5 (extremely acquainted). **B** Attitudes towards the prospects of AI in RCC diagnosis among students of different majors (strongly disagree = 1, disagree = 2, neutral = 3, agree = 4, strongly agree = 5) *AI*, *Artificial Intelligence; RCC*, *Renal Cell Carcinoma*

Table 3 Results on the Understanding of the WHO 2022 classification among all students and students from different majors

Item	All, Mean (SD) (n = 249)	Urology students, Mean (SD) (n = 81)	Pathology students, Mean (SD) (n = 90)	Students of other majors, Mean (SD) (n = 78)	F-test	P-value
Item 6. I am familiar with the new subtypes of renal cell carcinoma introduced in the WHO 2022 classification (e.g., FH-deficient RCC, ESC RCC, ALK-RCC, ELOC-RCC, etc.).	2.92 ± 1.41	3.74 ± 1.30	3.30 ± 1.01	1.62 ± 0.93	84.11	< 0.001
Item 7. I believe that the refinement of the WHO 2022 classification imposes higher requirements on pathological diagnosis.	3.83 ± 1.21	4.11 ± 1.23	4.33 ± 0.83	2.96 ± 1.10	39.11	< 0.001
Item 8. I have encountered difficulties in distinguishing subtypes of renal cell carcinoma in clinical practice.	3.41 ± 1.43	3.67 ± 1.31	4.00 ± 1.16	2.46 ± 1.37	32.58	< 0.001
Item 9. I hope to master the diagnostic criteria for new subtypes in the WHO 2022 classification through further learning.	4.00 ± 1.00	4.19 ± 0.87	4.47 ± 0.67	3.27 ± 1.03	43.28	< 0.001

*p < 0.05

with the WHO 2022 classification and their belief that it imposes higher requirements for pathological diagnosis. This trend was particularly evident in the pathology group (53.6% strongly agreed that the classification increased diagnostic demands, yet only 13.3% strongly agreed they were familiar with it). This phenomenon may be attributed to the complexity of pathological classification; on the other hand, it could also reflect a sense of difficulty or intimidation caused by a lack of understanding. In either case, these findings suggested a potential need for providing targeted instruction to student groups unfamiliar with the new classification to alleviate their sense of intimidation. It also underscored the need for more multidimensional teaching approaches to address the complexity of the classification system, including the potential integration of AI-assisted education.

Over 70% of respondents expressed optimism regarding the application prospects of AI for pathological diagnosis. Recent research indicates that the subtype classification of brain tumors poses diagnostic challenges; however, using sequencing to conduct machine learning with tumor DNA methylation patterns can markedly enhance classification accuracy compared to traditional histopathological methods [22]. Notably, over 60% of the respondents were concerned that pathologists would rely too much on AI technology, resulting in automation bias; that is, doctors relying excessively on AI diagnostic tools, much like drivers who uncritically depend on navigation and cease proactive verification; this approach poses the risk of overlooking diagnostic errors and eroding independent thinking skills [23]. This automation bias could potentially arise from two key factors. First, the combination of AI and clinical diagnosis does not guarantee a 100% disease diagnosis rate. Although AI is widely used in medical diagnostics, there are still false positives and diagnostic errors. For example, a 2018 study showed that when diagnosing melanoma, an AI program made incorrect diagnoses in over 30% patients [24]. Coincidentally, a study conducted in 2020 also showed that the artificial intelligence system used to classify COVID-19 patients had a false-negative rate of over 90% [24]. Second, the development of AI models requires large-scale datasets, but sharing medical data is strictly restricted by privacy protection regulations; therefore, the medical field faces greater challenges in terms of obtaining high-quality and standardized data than other fields [25]. Particularly in the case of rare diseases, limited patient numbers lead to a data scarcity, which directly affects the training and accuracy of AI models [26]. Furthermore, the complexity of rare diseases manifests in the diversity of symptoms and the complexity of causes, which requires AI models to handle more complex features and patterns [26].

Over half (50%) of the respondents in this survey emphasized the need for rigorous clinical validation of

Fig. 2 (See legend on next page.)

(See figure on previous page.)

Fig. 2 Perception of WHO 2022 Classification.**A** The perception of the new types of WHO 2022 RCC among students of different majors ranging from 1 (extremely ignorant) to 5 (extremely acquainted). **B** Degree of agreement among students from different majors concerning the increased requirement for pathological diagnosis posed by the new RCC classification (strongly disagree = 1, disagree = 2, neutral = 3, agree = 4, strongly agree = 5). **C** Level of agreement among all respondents that they had experienced difficulties in diagnosing RCC (strongly disagree = 1, disagree = 2, neutral = 3, agree = 4, strongly agree = 5). **D** Respondents' support for learning new diagnostic criteria (strongly opposed = 1, opposed = 2, neutral = 3, supported = 4, strongly support = 5) *WHO*, *The World Health Organization; RCC*, *Renal Cell Carcinoma*

AI tools, which aligned with recent literature, considering the complexity and potential risks of AI in practical applications. Adding an additional early limited clinical evaluation link after the completion of algorithm development and before large-scale clinical trials is necessary to ensure the efficacy and safety of the algorithm in large-scale clinical trials [27]. Pilot clinical evaluations, such as patient/clinician-centered (dual-centered) AI randomized controlled trials (DC-AI RCTs), can validate the efficacy and applicability of AI models prior to large-scale clinical trials. This approach not only reduces resource waste but also ensures the reliability and safety of AI models in real-world clinical settings [28].

The results indicated that the pathology students were more strongly in agreement regarding the necessity for clinical validation. This tendency may be attributable to that they had more opportunities to engage in pathological diagnosis, deeper understanding of the complexity of the diagnosis, and a more detailed comprehension of the risks involved in AI integration. This may also help explain why pathology students had a more cautious assessment of their own familiarity compared to those majoring in urology, as mentioned previously.

A key finding of our study points to a considerable educational need for AI-assisted diagnostic training. Our survey clearly shows that nearly 70% of students express a strong interest in incorporating AI training into their medical curricula. For example, when a student with no experience in diagnosis encounters a pathological diagnosis for the first time, they may find themselves at a loss. At this time, AI can assist them in learning how to interpret pathology, helping them quickly accumulate experience and shorten their learning curve. Currently, most medical practitioners only have a basic grasp of AI; therefore, they urgently need systematic training for its effective use. There were 27 studies consistently highlighted the current state of education and training for healthcare personnel as a major barrier to the application of AI in healthcare scenarios [23]. To date, knowledge of the potential of AI in healthcare and actual operation logic is limited, and large-scale AI education and training is urgently required [23].

To address this problem, medical education may need to focus on two key aspects. First, it could be beneficial to provide students with a solid foundation for RCC classification learning (integrating molecular and morphological standards) through structured modules such as virtual simulation platforms. For instance, when students learn about pathological sections, AI could be used to interpret the observed cell and tissue features in time, helping them deepen their understanding of the knowledge points immediately [29]. Incorporating such technologies into instructional settings might offer students a more immersive learning experience. Second, students can be provided professional training on the practical functions of AI tools through interdisciplinary seminars (organizing collaborative exchanges among clinicians, pathologists, and AI developers) and offering specialized elective courses in AI pathology. For instance, Duke University offered a training course titled "Machine Learning School" for medical school students, highlighting the value of AI-assisted medical education [30].

The main limitation of our research is that the sample was from a single medical institution; it may lack representativeness and have selection bias. Additionally, we didn't conduct pairwise comparisons in our study. In the future, multicenter studies involving institutions from different regions and types are needed to enhance the reliability and universality of the conclusions.

To effectively apply AI in RCC diagnosis, we need to boost technological innovation, improve education, and ensure ethical governance. By dealing with technological, educational, and ethical problems, the medical field can fully utilize AI in precision medicine. This is very important as the disease classification criteria continue to change.

Conclusion

This study demonstrates that the application of AI in renal cell carcinoma diagnosis is promising, but technical, educational, and ethical challenges need to be addressed. Medical professionals generally recognize the assistive value of AI, but have concerns about technical dependence, data quality, and ethical issues. In the future, it will be necessary to promote the in-depth integration of AI technology and traditional pathology through virtual case simulation training, clinical validation, and the construction of ethical norms to realize the goal of precision medicine.

Table 4 Results on the views about AI-assisted diagnosis of RCC among all students and students from different majors

Item	All, Mean (SD) ($n=249$)	Urology students, Mean (SD) ($n=81$)	Pathology students, Mean (SD) ($n=90$)	Students of other majors, Mean (SD) ($n=78$)	F-test	P-value
Item 10. I believe that AI can help pathologists complete the diagnosis of renal cell carcinoma more efficiently.	4.05 ± 0.81	4.04 ± 0.93	4.00 ± 0.78	4.12 ± 0.70	0.44	0.647
Item 11. I trust that AI can reduce the misdiagnosis rate in renal cell carcinoma diagnosis.	3.89 ± 0.89	3.96 ± 0.89	3.83 ± 0.90	3.88 ± 0.90	0.45	0.638
Item 12. I believe that the application of AI technology in pathology requires more clinical validation.	4.35 ± 0.83	4.26 ± 0.75	4.60 ± 0.72	4.15 ± 0.95	7.09	0.001

*$p < 0.05$

Table 5 Results on the educational needs for AI-Assisted diagnosis of RCC among all students and students from different majors

Item	All, Mean (SD) ($n=249$)	Urology students, Mean (SD) ($n=81$)	Pathology students, Mean (SD) ($n=90$)	Students of other majors, Mean (SD) ($n=78$)	F-test	*P*-value
Item 13. I believe that training in AI-assisted diagnosis can improve my pathology diagnostic ability.	4.18 ± 0.81	4.33 ± 0.72	4.17 ± 0.86	4.04 ± 0.81	2.69	0.070
Item 14. AI should be integrated into pathology education (e.g., through virtual case simulation training).	4.01 ± 1.05	3.93 ± 1.06	4.17 ± 1.04	3.92 ± 1.04	1.54	0.217
Item 15. I hope to learn the diagnostic methods for new subtypes in the WHO 2022 classification through AI technology.	4.20 ± 0.90	4.15 ± 0.94	4.37 ± 0.80	4.08 ± 0.96	2.41	0.092
Item 16. I would like to learn how to combine AI tools with morphological analysis for diagnosis.	4.16 ± 0.93	4.19 ± 0.87	4.27 ± 0.90	4.00 ± 1.01	1.80	0.168

*$p<0.05$

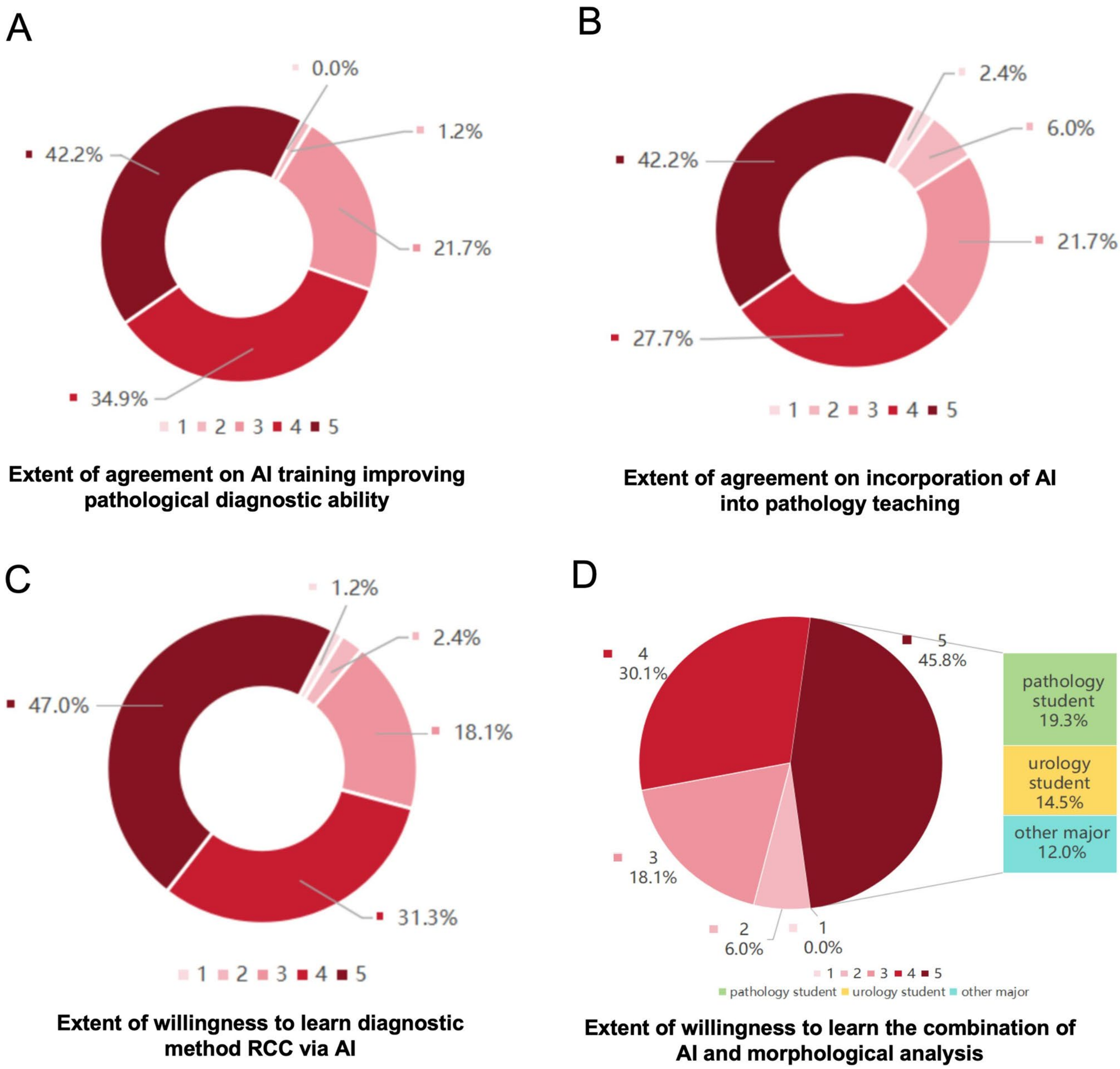

Fig. 3 Educational needs and views about AI-assisted diagnosis. **A** Attitudes regarding the incorporation of AI into pathology teaching (strongly disagree = 1, disagree = 2, neutral = 3, agree = 4, strongly agree = 5). **B** Attitudes towards AI training to improve pathological diagnostic ability (strongly disagree = 1, disagree = 2, neutral = 3, agree = 4, strongly agree = 5). **C** Willingness to learn diagnostic methods for new RCC subtypes - through AI (strongly disagree = 1, disagree = 2, neutral = 3, agree = 4, and strongly agree = 5). **D** Willingness to learn a combination of AI and morphological analysis (strongly disagree = 1, disagree = 2, neutral = 3, agree = 4, and strongly agree = 5); among the students who expressed a strong desire to learn ("5"), 19.3% were urology students, 14.5% were pathology students, and 12% were from other majors *AI*, *Artificial Intelligence; RCC*, *Renal Cell Carcinoma*

Abbreviations

AI	Artificial intelligence
RCC	Renal cell carcinoma
WHO	World health organization

Supplementary Information

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Supplementary Material 1.

Supplementary Material 2.

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Authors' contributions

The questionnaire design was carried out by XMZ, HYX and XXY. Data collection and analysis were the responsibility of YXH and XXY. YXH took charge of drafting the initial version of this manuscript. The results were interpreted, and the final version of this article was written by YXH and XYY. QW and XS assisted in formatting the final manuscript. Methodological guidance and crucial revisions for this article were provided by XMZ, who also serves as the corresponding author of this paper. All authors reviewed and gave their approval to the final manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

The Biomedical Ethics Review Committee of West China Hospital reviewed and exempted the study from formal review; informed consent was obtained as required by the same committee.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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