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Chinese colposcopists' attitudes toward the colposcopic artificial intelligence auxiliary diagnostic system (CAIADS): A nation-wide, multi-center survey

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Abstract

Objective: The objective of this study was to assess the attitudes toward the Colposcopic Artificial Intelligence Auxiliary Diagnostic System (CAIADS) of colposcopists working in mainland China.

Methods: A questionnaire was developed to collect participants' sociodemographic information and assess their awareness, attitudes, and acceptance toward the CAIADS.

Results: There were 284 respondents from 24 provinces across mainland China, with 55% working in primary care institutions. Participant data were divided into two subgroups based on their colposcopy case load per year (i.e. ≥50 cases; <50 cases). The analysis showed that participants with higher loads had more experience working with CAIADS and were more knowledgeable about CAIADS and AI systems. Overall, in both groups, about half of the participants understood the potential applications of big data and AI-assisted diagnostic systems in medicine. Although less than one-third of the participants were knowledgeable about CAIADS and its latest developments, more than 90% of the participants were open with the idea of using CAIADS.

Conclusions: While a related lack of acknowledgement of CAIADS exists, the participants in general had an open attitude toward CAIADS. Practical experience with colposcopy or CAIADS contributed to participants' awareness and positive attitudes. The promotion of AI tools like CAIADS could help address regional health inequities to improve women's well-being, especially in low- and middle-income countries.

Keywords

Artificial intelligence, cervical cancer, attitude, colposcopy, quantitative

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Introduction

The high mortality rate due to cervical cancer (CC) underscores the urgent need for the uses of advanced technologies to improve case detection (348,874 in 2022).[1,2] Cervical cancer was ranked among the top causes of cancer-related deaths in women with approximately 85% of all cases occurring in low- and middle-income countries (LMICs).[1,3] In response, the World Health Organization announced the Global Strategy for Accelerating the Elimination of Cervical Cancer in November 2020, which emphasized the need to improve screening, vaccination programs, and delivering treatments.[4] For underserved countries or regions, where elimination of CC is extremely challenging due to limited healthcare resources and scarcity of qualified professionals, there is an urgent need to find new methods and technologies to accomplish this goal.

Colposcopy is commonly used to identify high-grade squamous intraepithelial lesions and to guide biopsy for women who have abnormal cytology, human papillomavirus infections, and clinical symptoms of suspected cervical diseases.[5–7] However, the diagnostic performance of colposcopy relies greatly on the operators' experience which varies in sensitivity (44–77%) and specificity (85–90%).[8] Especially in LMICs, the lack of experienced colposcopists, which leads to missed or misdiagnoses and delayed in treating patients.[9–12] While colposcopy training courses can be effective in improving colposcopists' diagnostic proficiency, the implementation of these courses may face feasibility challenges, limiting the immediate enhancement of overall diagnostic performance.[13–15] Fortunately, the Colposcopic Artificial Intelligence Auxiliary Diagnostic System (CAIADS) may offer a promising alternative to aid doctors in diagnoses. Xue et al. discovered that CAIADS performs almost as well as the gold standard pathological test in both diagnosing cervical lesions and providing guidance for biopsies, outperforming even senior colposcopists.[16] This suggests that CAIADS could serves as a more equitably diagnostic tool for colposcopy, which could present a chance to aid in improving the quality of CC screening, especially in LMICs such as China. However, the use of CAIADS in clinical practice is limited, and there is uncertainty regarding Chinese healthcare professionals' attitudes toward this system that could hinder the adoption of the system.

Given colposcopists play a key role in the adoption of CAIADS, it is crucial to understand their knowledge about AI systems and their attitudes, perceptions, concerns, and willingness to use it.[17–19] Assessing their attitudes will help identify barriers and challenges to integrate the system into their daily workflows.[20,21] Additionally, colposcopists' attitudes about CAIADS may influence education and the development of training programs using AI systems.[22] Therefore, understanding the end-users' (i.e. colposcopists) needs and concerns toward AI systems can guide the successful adoption of this intervention. To date, studies have primarily focused on physicians' attitudes about AI in developed countries[23] with limited work comparing and contrasting attitudes from physicians in LMICs. The goal here is to understand colposcopists' attitudes toward CAIADS across China to facilitate the future adoption of medical AI systems in LMICs.

Materials and methods

Questionnaire development and distribution

An online questionnaire was developed and distributed to clinicians across mainland China in October 2022. For representative selection of the study population, the questionnaire was sent to more than 100 hospitals of different sizes in seven regions of mainland China and completed by gynecologists responsible for interpreting colposcopy results. The questionnaire was designed to assess awareness and attitudes, and to understand behavioral tendencies around CAIADS and human–AI interactions. The questionnaire had three sections:

1. *Demographic information.* Demographic information, the awareness, attitude, and acceptance toward CAIADS, and the interaction between colposcopists and CAIADS. The demographic information included level of education, job title, amount of practical CAIADS experience, and annual number of colposcopies. Please refer to Section One of the Appendix for more details.
2. *Awareness, attitudes, toward CAIADS.* Additionally, respondents were asked to disclose their knowledge about specific aspects of clinical AI or colposcopy-based AI applications. Respondents were asked to indicate their level of agreement with each statement on a 5-point Likert scale, ranging from "strongly disagree" to "strongly agree." Please refer to Section Two of the Appendix for more details.
3. *Interaction between CAIADS and colposcopists.* The final section provides participants with an opportunity to describe the advantages and challenges associated with CAIADS, including shortcomings and ethical concerns. Please refer to Section Three of the Appendix for more details.

Prior to administering the study, the questionnaire was piloted with 30 colposcopists and the feedback from the pilot was used to refine the structure and focus of each question.

Participation in the study was voluntary and informed consent was required. All responses were anonymized to encourage honest feedback and completion. This study was approved by the Research Ethics Committee in the

Table 1. Sociodemographic characteristics and professional experience.

Characteristics	*N* (%)	Characteristics	*N* (%)
Age		Years of experience in OB/GYN	
Mean (SD)	41.1 (8.3)	Mean (SD)	15.9 (9.3)
<30	34 (12.0)	<10	78 (27.5)
30–39	87 (30.6)	10–14	52 (18.3)
40–49	123 (43.3)	15–19	58 (20.4)
≥50	40 (14.1)	≥20	96 (33.8)
Gender		Years doing colposcopy	
Male	6 (2.1)	Mean (SD)	5.3 (5.3)
Female	278 (97.9)	<1	56 (19.7)
Ethnicity		1–4	103 (36.3)
Han	251 (88.4)	5–9	64 (22.5)
Others	33 (11.6)	≥10	61 (21.5)
Education level		Number of colposcopy examinations per year	
College degree or below	21 (7.4)	<50	148 (52.1)
Bachelor degree	192 (67.6)	≥50	136 (47.9)
Master degree or above	71 (25.0)	Number of colposcopies with abnormal diagnosis per year	
Hospital level			
Primary or secondary hospital	155 (54.6)	<50	203 (71.5)
Tertiary hospital	129 (45.4)	≥50	81 (28.5)
Title		Have used CAIADS before	
Resident physician	60 (21.1)	Yes	49 (17.3)
Attending physician	102 (35.9)	No	235 (82.7)
(Associate) chief physician	122 (43.0)		
Colposcopy specialist			
No	193 (68.0)		
Yes	91 (32.0)		

CAIADS, Colposcopic Artificial Intelligence Auxiliary Diagnostic System; OB/GYN, obstetrics and gynecology.

Chinese Academy of Medical Sciences and Peking Union Medical College (No. CAMS and PUMC-IEC-2022-022). Before answering the questionnaire, participants were asked to watch an introductory video about CAIADS.

Statistical analysis

The primary outcome was the distribution of all participants' responses to the questionnaire. To evaluate the attitudes toward CAIADS of colposcopists with varying levels of experience based on the annual colposcopy examination number and prior experience with the system. For the purpose of this study, participants were divided into two subgroups: (1) ≥50 colposcopies per year and (2) <50 colposcopies per year. This threshold of 50 colposcopies per year was selected based on the standard of European Federation for Colposcopy (EFC).[24] This criterion was used as the cutoff to stratify colposcopists' experience in a study evaluating curriculum effectiveness that was developed by the EFC.[14]

Continuous variables were presented as means (M) with standard deviations (SD). The 5-point Likert scale was viewed as an ordinal variable. Subgroup differences were assessed using nonparametric tests (Mann–Whitney's *U* test) for non-normal data. All analyses were conducted using Stata (version 17.0).

Results

Demographic information

Of the 350 responses received, four did not complete the survey after watching the introductory video. An additional 66 questionnaires were excluded due to inappropriate responses. The final sample included 284 participants from seven different geographic regions across 24 provinces (out of the 34 provinces, autonomous and special administrative regions of China). The mean age of respondents was 41.1 years and the majority were female (98%, $n = 278$). Approximately, 55% ($n = 155$) were practicing physicians in primary care hospitals. Additional details about the participants' demographic information and their geographic distribution can be found in Table 1.

Knowledge related to CAIADS

The knowledge questions were used to assess the colposcopists' knowledge about big data, AI systems, and CAIADS overall. Figure 1 shows the distribution of responses for each of these questions (A1–A4). Sixty percent of the participants had a good knowledge of the application of big data, and 53% of AI assisted systems, however, only 31% had a good working knowledge of CAIADS, and 24% kept up with the latest research on CAIADS. The results of subgroup in Figure 2 showed the annual examination number and used experience with the system may influence the awareness and knowledge related to CAIADS. The colposcopists with more than 50 colposcopy cases exposure had a better knowledge of CAIADS's general information ($p = .0183$) and were more willing to keep up with the latest research ($p = .0015$). The colposcopists who used the system early had a better awareness in the application of big data analysis in medicine ($p = .0017$), the application of AI-assisted diagnostic system ($p = .000$), the general information about CAIADS ($p < .001$), and were more willing to keep up with the latest research in CAIADS ($p < .001$).

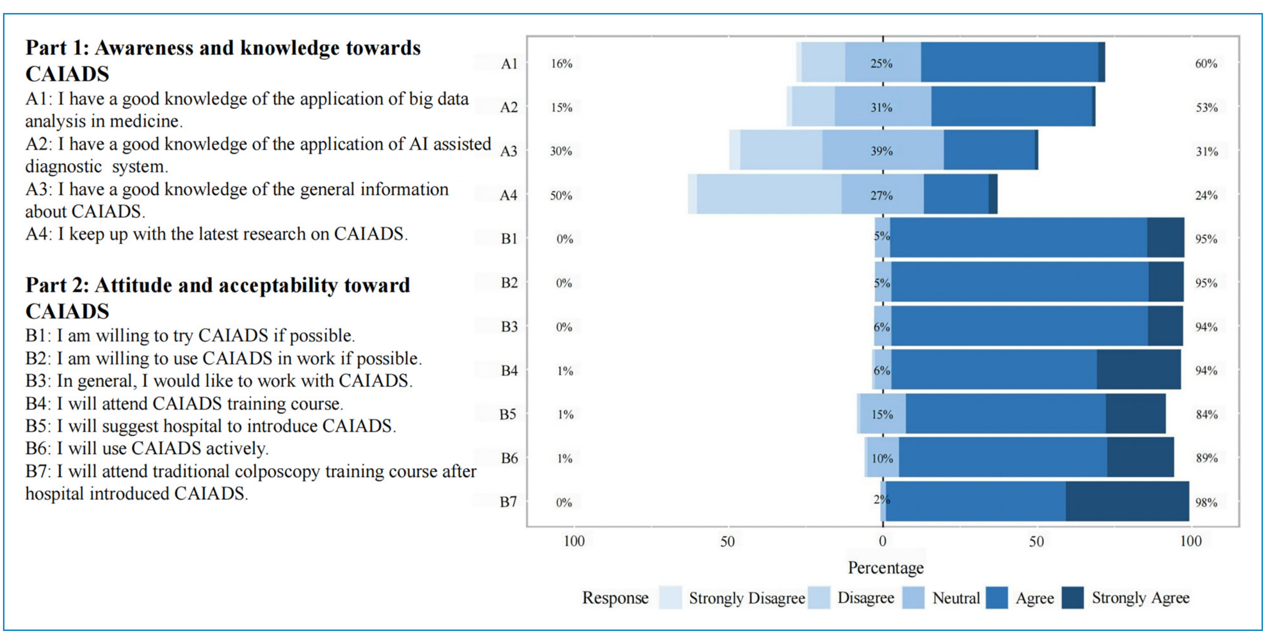

Figure 1. The distribution of respondent perspectives toward CAIADS.

The responses on question A7 showed that over 60% of the participants knew about the efficacy and operation of CAIADS. Colposcopists were also asked if they were aware of other uses of CAIADS in question A8, and over 90% stated that they were aware of other uses, such as annotating lesions, giving colposcopic impressions, determining biopsies, and indicating biopsy sites (Figure 3).

Attitude and acceptance related to CAIADS

As shown in Figures 1 and 2, over 90% of the participants expressed positive attitudes and are willing to use CAIADS (questions B1–B7). They believed that the diagnostic performance of AI was superior to colposcopists with regard to its knowledge and confidence in its output. After receiving information about the superior performance of AI-based colposcopy compared to colposcopists in pathology findings (with means of 82.2% vs. 65.9%, $p < .001$) and about its accuracy in predicting biopsy sites (75.8% overlap between predicted and actual sites), all 284 participants reached a consensus. They agreed that their confidence would be enhanced if judgments matched those of CAIADS (Refer to question B9 and B11, B9 is for the diagnosis of lesions, B11 is for biopsy sites). Additionally, almost 90% showed a willingness to seek a second opinion from CAIADS. The subgroup analysis showed the participants who had prior experience with the system were more willing to use the CAIADS in work ($p = .003$).

From the responses to question B11–B13, 60–80% of all participants believed that CAIADS had a higher diagnosis

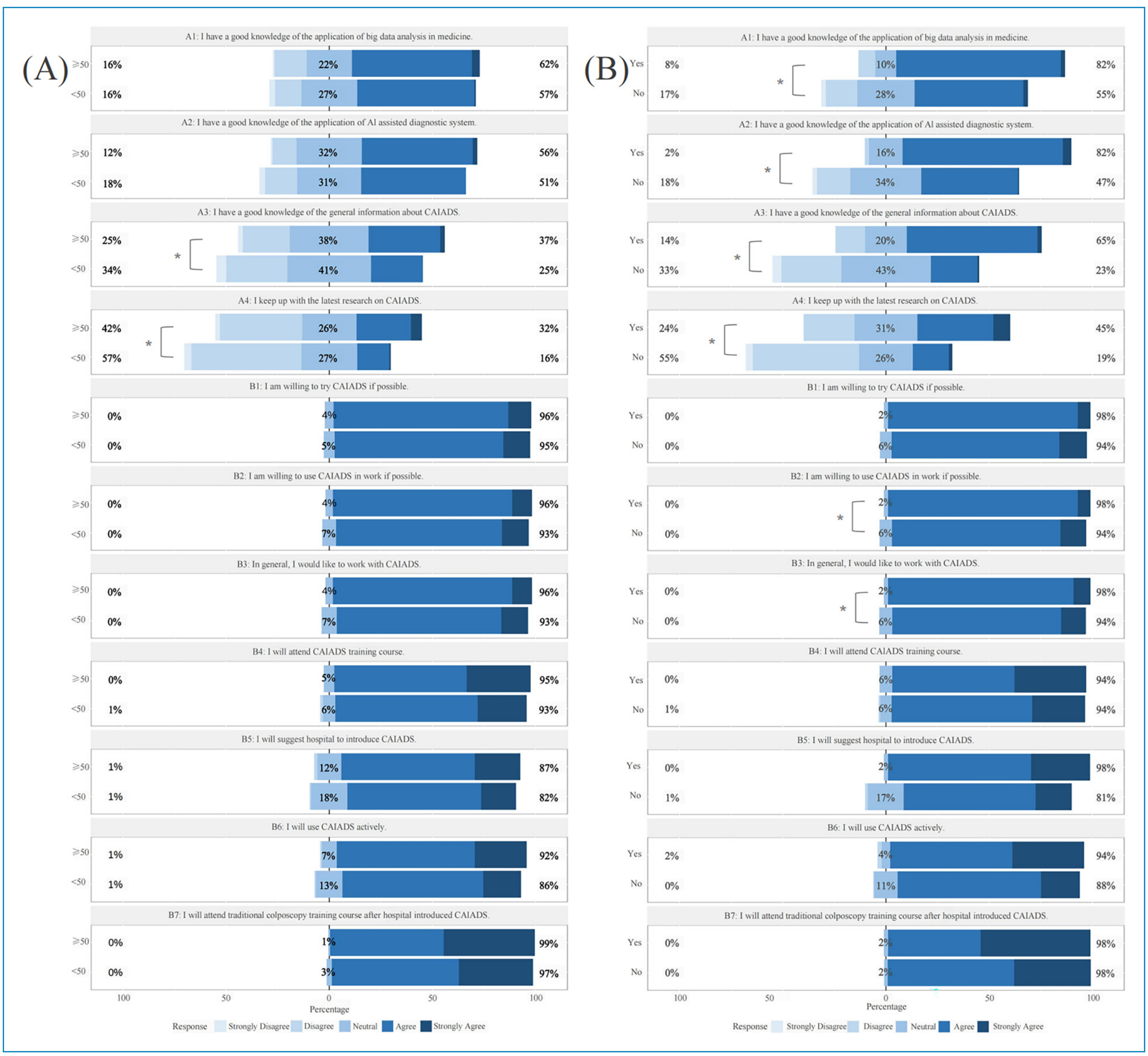

Figure 2. Detailed statements of knowledge, attitude and behavior related to CAIADS.

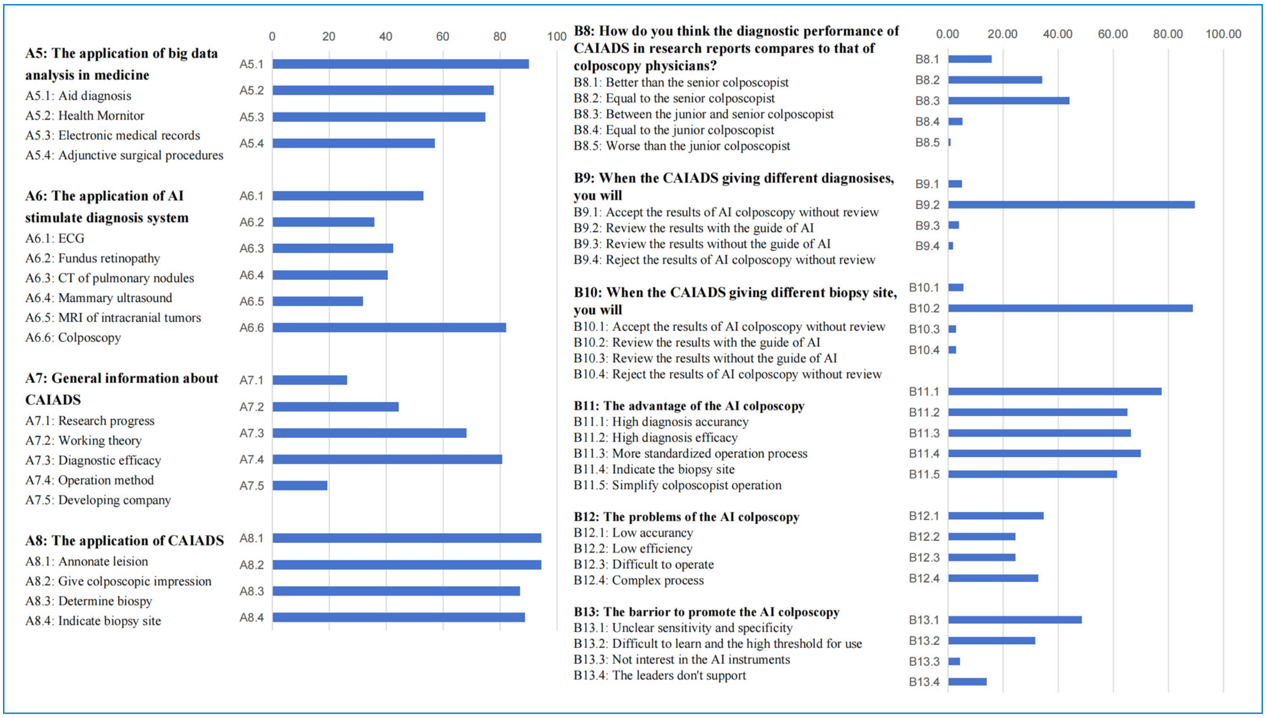

Figure 3. The sub-group distribution of respondent perspectives toward CAIADS.

accuracy and efficacy, a more standard and simpler operation process, and could locate potential biopsy sites. However, 30% of the participants with prior CAIADS experience felt that it required further refinement in the accuracy of its output, efficacy of use, and procedure embedding it into the colposcopists' existing workflow. Nearly 50% of the participants highlighted unclear sensitivity and specificity as hindrances to the wider adoption of CAIADS. Over 30% found that there was a high learning cost associated with the CAIADS (Figure 3).

Expectation and responsibility for CAIADS in clinical practice

The answers to question C1 indicated that more than 70% of the participants' workplace have not yet implemented CAIADS. More than three quarters of participants believed that their workplace would adopt CAIADS within 10 years (Table 2). For question C4: "After the introduction of CAIADS equipment in the hospital, what should be the process for colposcopy interpretation?," 82.4% of participants ($n = 234$) held the opinion that colposcopists should take the lead role in the diagnostic process, and CAIADS should only play a supporting role. The responses to C4 echoed the results of responses to C3: 83.5% of participants ($n = 237$) concerned about the misdiagnosis made by CAIADS, and the mean degree of concern is 51 on a 100-point scale, showcased a medium concern.

For question C5: "If CAIADS makes a diagnostic error, who do you think should be responsible?," participants identified the following parties that would be responsible (in ranked order): colposcopists ($n = 190$, 66.9%), CAIADS development companies ($n = 183$, 64.4%), and hospitals ($n = 65$, 22.9%). In addition to the three responsible parties identified, six colposcopists mentioned that due to individual differences and the actual clinical characterizations, misdiagnosis is unavoidable naturally and none of the parties should be liable.

In response to the open-ended question C6, "What are your expectations/suggestions regarding the development of CAIADS?" nearly all the physicians expressed a desire to enhance the diagnostic accuracy and lower costs. When asked the open question C7: "What issues may you encounter when applying CAIADS in clinical work?," most participants expressed concerns about insufficient accuracy, high costs, limited patient acceptance, and the potential for overreliance on CAIADS leading to degradation of their professional skills. Additionally, some physicians pointed out that CAIADS may have difficulty detecting lesions in specific locations, particularly those sited in the vaginal vault and wall. Mechanical failures of CAIADS and dependence on network conditions were also envisioned as potential challenges in the future application of CAIADS. Furthermore, one participant raised the issue of AI development having a potential lag, as it may take an extended period to update the software system after feeding the data to the machine learning model, whereas the pace of physicians' self-learning may be much faster.

Table 2. The interaction between colposcopists and CAIADS.

Characteristics	*N* (%)	Characteristics	*N* (%)
Have AI-assisted diagnostic equipment in hospital		When CAIADS makes a diagnostic error:	
		1. Should the hospital be responsible?	
Yes	60 (21.13)	Primary responsible.	23 (8.10)
No	201 (70.77)	Nonprimary responsible.	43 (15.14)
Not sure	23 (8.10)	None responsible.	218 (76.76)
Your hospital will introduce CAIADS in the future		2. Should the colposcopists be responsible?	
		Primary responsible.	135 (47.54)
Yes, in 5 years	118 (41.55)	Nonprimary responsible.	54 (19.01)
Yes, in 5–10 years	101 (35.57)	None responsible.	95 (33.45)
Yes, more than 10 years later	54 (19.01)	3. Should the CAIADS company be responsible?	
No	11 (3.87)	Primary responsible.	112 (39.44)
Concern the misdiagnosis made by CAIADS		Nonprimary responsible.	64 (22.53)
Yes	237 (83.45)	None responsible.	108 (38.03)
No	47 (16.55)		
The degree of concern (0–100) (Mean (SD)) (*N* = 237)	51.83 (17.73)		
The process when read a colposcopy image			
Colposcopist reads the image individually			4 (1.41)
Colposcopist reads the image with the supplement of CAIADS			234 (82.40)
CAIADS reads the image with the supervision of colposcopist			44 (15.49)
CAIADS reads the image individually			2 (0.70)

CAIADS, Colposcopic Artificial Intelligence Auxiliary Diagnostic System.

Discussion

This multicenter survey was conducted to gain colposcopists' attitudes toward CAIADS across China in order to facilitate the implementation of this system in clinical practice. The study population was selected from a colposcopy training program and involved participants from 24 provinces within China. Selection ensured a broad and balanced geographic distribution, as well as comparable demographic information.[19] While only 2.1% of participants were male, this is in line with the higher proportion of female colposcopists in clinical practice. In contrast to a previous study focusing on ethnically Han physicians,[25] this study included 11.6% minority physicians, providing a more accurate reflection of the actual situation in the central-western and southwestern regions of China.[26,27] Of the participants in this study, 17.3% had previous experience using AI systems. These are comparable to the percentage of radiologists with experience using AI systems in Saudi Arabia, a comparable LMIC.[28] The inclusion of minority physicians and the maintenance of balanced demographic information further enhance the validity of this study.

The second part of the questionnaire contained questions regarding awareness, attitudes, and acceptance toward

CAIADS. Additionally, over 90% of participants had a willingness to attend training sessions of CAIADS, and 98% remained interested in colposcopy training even after CAIADS implementation. This indicated that participants were open to the new tool and desired to improve their diagnostic capabilities.[19,27] Although the participants' knowledge in AI was limited, only 31% of participants stated they knew about the CAIADS system, most respondents' attitudes and acceptance of CAIADS were remarkably positive. Moreover, the subgroup analysis showed that participants with higher exposure to colposcopy examinations or those who had used CAIADS before had a better awareness of related knowledge and held a more positive attitude toward its clinical usage. Therefore, it suggested that colposcopists should have more opportunities for continuing medical education to learn about colposcopy and CAIADS, which would promote the acceptability toward this system. In general, additional training around AI could help physicians improve their comprehension and application of AI technology and foster the wider adoption of AI devices.[27,29,30]

Our findings did highlight an ethical dilemma in using CAIADS. While 77% of our participants did not believe that hospitals should be responsible for CAIADS misdiagnosis, Maliha et al. argue that hospitals should be jointly liable, emphasizing the importance of adequate regulatory oversight.[31] Previous studies have highlighted challenges in determining responsibility for diagnostic results, and there are concerns about how to maintain human control and autonomy when moving toward the mass adoption of AI products.[23,32–34] The questionnaire used in this study allowed the allocation of responsibility, but in reality, AI devices are generally accepted as tools that assist doctors in diagnosis, and primary responsibility for errors in AI devices would lie with doctors who rely upon them.[29,35] This highlights the need for regulatory oversight and ethical guidelines to ensure the safe and responsible implementation of AI technologies in clinical practice.[36,37]

This study presents the first multicenter survey of the awareness and attitudes toward CAIADS among obstetricians and gynecologists in mainland China. The survey included participants with comparable demographic characteristics and examined their knowledge, attitudes, and acceptance toward the system, as well as their interaction with it. Additionally, the survey investigated the support and resistance in the promotion of CAIADS, providing a valuable reference for product development and improvement.

There are limitations of this study. First, the survey only profiled the current situation of participants without qualitative research or an exploration of the underlying reasons. Future studies should expand the sample size, particularly for primary care physicians in underserved areas, and include focused and targeted interview studies to obtain more in-depth findings. There is an urgent need to provide more training on colposcopy or CAIADS to colposcopists and increase the number of images read to boost confidence and awareness for AI and its capabilities. Future research should aim to overcome these limitations by conducting institutional research on healthcare institutions, including the investigation of the distribution of colposcopists and identifying how many institutions can carry out colposcopy examinations, as well as determining the number of institutions with qualified colposcopists. We suggest that experts from all relevant parties engage in discussions to establish ethical guidelines for the application of AI systems in clinical situation. This will promote the use of CAIADS and other AI assistance systems in primary healthcare institutes.

Conclusion

Our survey showed that although there was relatively low knowledge of CAIADS, there was a high acceptance of potentially using CAIADS and similar AI technologies. Prior working experience with the system and an exposure of at least 50 annual colposcopy examinations per year had a positive effect on colposcopists' understanding and acceptance toward CAIADS, highlighting the significance of practical experience in shaping colposcopists' perspectives on the system. Establishing ethical guidelines, bridging knowledge gaps, and fostering understanding of CAIADS among colposcopists can not only promote the widespread adoption of CAIADS in clinical environments but in turn can improve women's health and mitigate health inequalities.

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Data availability statement: The data used in this study will be safely stored following the principles of research ethics. Upon completion of the study, data may be made available by the corresponding authors upon request with justification.

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