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General public's cognition on the application of artificial intelligence in healthcare: a qualitative Meta-synthesis

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General public's cognition on the application of artificial intelligence in healthcare: a qualitative Meta-synthesis

Title page

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ABSTRACT

Objectives Medical artificial intelligence has been widely used, bringing convenience and innovation, but there are also policy and regulatory issues such as credibility, responsibility sharing mechanism and ethics, and it is necessary to understand the public's understanding and views on medical artificial intelligence.A meta synthesis was conducted to analyze and summarize the public's understanding of the application of artificial intelligence in the medical and health field in order to provide recommendations for the application and management of artificial intelligence in nursing practice.

Design We conducted a meta-synthesis of qualitative studies.

Method Electronic databases were systematically searched with date from the inception to 25 December 2021. Meta-aggregation synthesis methodology was used to summarize the findings from qualitative studies which focus on the public's attitudes towards the application of artificial intelligence in healthcare field were carried out.

Results Of the 5128 researches screened, a total of 12 studies met the inclusion criteria and were included. Three synthesized findings were concluded: advantages of artificial intelligence in medical field from public perspective; potential ethical problems with artificial intelligence in healthcare from public perspective; public suggestions on medical artificial intelligence applications.

Conclusion Medical artificial intelligence has its unique advantages, and its wide application will be the general trend. The application of medical artificial intelligence also brings corresponding social ethical problems and challenges, reasonable supervision and standard application of medical artificial intelligence is the key to ensure its real role.Based on the public perspective, this paper provides enlightenment and suggestions for medical and nursing managers on how to implement and apply medical artificial intelligence smoothly and safely in healthcare practice.

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Strengths and limitations of this study

- This meta-synthesis of qualitative studies conducts in accordance with the Joanna Briggs Institute methodology for meta-aggregation approach to identify the general public ' s

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cognition on the application of artificial intelligence in healthcare

- The JBI Qualitative Critical Appraisal Checklist was used to evaluate the quality of the included studies.
- These syntheses of the included studies relied on the availability of direct quotes from the public with experiences of using AI applications in the healthcare field.
- A limitation of this study is only the publication in English and Chinese were included in this meta-synthesis and there may be some language bias.

Introduction

Artificial intelligence (AI), as a new technical science for simulating and expanding human intelligence, refers to a branch of computer science that involves creating machines with the aim to replicate human intelligence[1]. In recent years,medical technology and artificial intelligence technology have gradually integrated development. Intelligent clinical assisted diagnosis and treatment applications[2-3], medical robots[4], intelligent public health management applications[5] and other AI technologies have been widely applied in the field of medical and health. The technological innovation and high-quality supply of AI can lead, create and meet new medical needs. As a result, medical AI is and will continue to be innovative and rapidly growing. Although medical AI has brought great convenience to disease diagnosis, health management, etc., the application of AI in medical health is still in its infancy, and its promotion and application still face many challenges.

At present, most of the researches on medical AI are conducted from the perspective of professionals, focusing on technological development and application prospects.Some scholars have also carried out qualitative studies on the public's views and concerns about AI application in the medical field, but the results of single qualitative studies cannot fully understand the public's cognition of medical AI. Based on this, this study integrates a number of qualitative studies on the public's views and opinions on medical AI, in order to provide a new perspective for the healthy development of medical AI.

METHODS

Meta-aggregation approach developed by Joanna Briggs Institution(JBI) was used in this systematic review and qualitative meta-synthesis. This research work was carried out between September 2021 to January 2022. The entire search process guided by PRISMA[6].

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Search strategy

The following three-step method was utilized in this review: firstly, an initial limited search of Medline and CINAHL was conducted , followed by an text word analysis of the title, abstract, and index terms used to describe the article. A second extensive search is then performed across all included database (MEDLINE, CINAHL, Web of science, Cochrane library, Embase, PsycINFO, CNKI, Wangfang and VIP)using all identified keywords and index terms. Lastly, the references list of all identified reports and articles was searched for additional studies. The studies published in English and Chinese were considered in this review and there was no restriction in the publish date. The search strings and the titles extracted from each database are shown in the online supplemental file 1.

Inclusion criteria

The inclusion criteria of this systematic review are as follows: (a) qualitative study, including the qualitative component of mixed-methods studies; (b) the context was the application of AI in the field of healthcare; (c) the phenomenon of interest was the is the public attitude, concern and perception of AI application in health care and so on. We excluded articles published in languages other than English or Chinese, and mixed studies in which quantitative results could not be separated.

The initially retrieved articles were imported into Endnote X9 software, and the repeated literature were removed. Literature that did not meet the inclusion criteria was then deleted by reading titles and abstracts. Finally, the quality of the included literature was evaluated by reading full text. The screening process was undertaken by two reviewers.

Assessment of methodological quality

The methodological validity of the retrieved qualitative research paper was assessed by two reviewer using JBI Qualitative Critical Appraisal Checklist, which contain ten criteria to ensure the appropriateness of the methodological approach,the method application and the representation of the voice of participants in studies. Each criteria has three levels of “yes ”, “no” and “unclear”, the papers below six “yes” were excluded to ensure quality. All disagreement between two reviewers were resolved through discussion, or with a third reviewer.

Data extraction

Two investigators(CXW and XYC) screened all the records independently and read the titles and

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abstracts to exclude literature which were not fill the inclusion criteria obviously. And then read full texts to definite which studies could be adopted into our study. If there were divergent literature, we would invite the third researcher to join into discussion and make judgement. The authors, regions, research objects, research methods, phenomenons of interest and main research results were the information we need extract.

Data synthesis

Qualitative data were extracted from papers included in the review using the Nvivo 2021 software. We analyzed contained qualitative researches by using techniques of integrative qualitative meta-synthesis[7,8], which summarizes researches with the purpose to get new findings from integrating multiple original studies. In the process of integration, we need sure the results reflect range of findings that exist based on retaining the original meaning. And then through comparing and contrasting findings across studies, a new integrative interpretation of the phenomenon be produced[9].

Patient and public involvement statement

There were no patients or the public were involved in this research.

Result

A total of 12 papers were included in this study, including 5 grounded theory studies,6 descriptive qualitative studies, and 1 phenomenological study. Literature screening process and results are shown in Figure 1.

Study characteristics and quality of studies

The characteristics of the included literature are shown in Table 1. All the quality appraisal results of researches we adopt are B grade. The details are as follows: research questions, research objectives, methodology selection, data collection, data analysis, interpretation of results are explained clearly in all studies. But when it comes to the consistency of methodology and philosophical basis and interpretation of ethical review, the explanation of some original literature are incomplete. In addition, the most don't explain the researcher's own situation and the influence of the research on the researcher or the researcher's influence on the research from the perspective of values and cultural background. The results of the quality assessment were presented in the Table 2.

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Table1 Study characteristics

Study	Country	Methodology	Participants（n）	Phenomenon of interest	Main results
Haan, Marieke 2019[10]	Netherlands	Grounded theory	Patients（20）	Patients' view on the use of AI in radiology.	Six themes：①Proof of technology about efficacy and reliability of AI；②Procedural knowledge is about understanding how AI will be implemented in the current radiological practice；③The capability of AI to produce reliable results；④Efficiency of the scanning process；④Personal interaction between patients and doctors；⑤The responsibility of humans when computers make mistakes.
Thenral M 2020[11]	India	Grounded theory	Patients（14）	The perceive challenges of building, deploying, and using AI-enabled Telepsychiatr for clinical practice from the perspectives of patients.	Four themes：①Ethical, legal, accountability, and regulatory problems of AI；②Financial issues；③Technology problems of AI；④Clinical-practice problems of AI
Chao Bian 2021[12]	Canada	Descriptive qualitative study	Old people（15）	Older adults' perceptions And preferences of technologies that can potentially assess frailty at home.	Four themes：①General attitude towards using the technologies；②Conditions for accepting certain technologies；③Existing living habits or patterns related to using the technologies；④Constructive suggestions related to the technologies.
Zhan Zhang 2021[13]	America	Descriptive qualitative study	Patients（13）	Patients' perceptions and acceptance of using AI technology to interpret their radiology reports.	There themes：①General perceptions of using AI tools to interpret diagnostic results；②Concerns；③Increasing acceptability and trustworthy of AI-based systems in communicating radiology report findings.
L.E. Sangers 2021[14]	Netherlands	Drounded theory	General public（27）	The perceived barriers and facilitators towards mHealth apps for skin cancer screening among the Dutch general population.	Two themes：①Barriers to using mHealth skin cancer screening apps；②Facilitators of mHealth use.
Melissa D 2020[15]	Canada	Descriptive qualitative study	General public（41）	The perspectives of the general public regarding the use of health data in AI research.	Five themes：①Mixed, mostly negative views about artificial intelligence (AI) in general；②Hopes and perceived benefits of health artificial intelligence (AI) research scenarios；③Fears and perceived drawbacks of health AI research scenarios；④Conditions under which health AI research scenarios are more acceptable；⑤Educational effect of realistic health AI research scenarios.

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Melissa D 2020[16]	Canada	Descriptive qualitative study	Patients（18）	Current perspectives of patients on ethical issues surrounding AI in health care.	Four themes：①Protection of health data；②Skepticism regarding accountability mechanisms；③Computer-based predictions；④Trust and confidentiality.
Mandemeulebr 2019[17]	Belgium	Grounded theory	Old people（59）	Community-dwelling older adults perceive as ethical issues of socially assistive robots(SARs) in aged care.	There themes：①SARs as components of a techno-societal evolution；② SARs' embeddedness in aged-care dynamics,；③ SARs as embodiments of ethical considerations
Caroline A. 2020[18]	America	Grounded theory	Patients with skin cancer（48）	How patients perceive the use of AI for skin cancer screening.	Five themes：①AI benefits；② AI risks；③AI strengths；④AI weaknesses；⑤AI implementation；
Jordan P. 2021[19]	America	Descriptive qualitative study	Patients（87）	How patients view the use of AI in their healthcare.	Five themes：①Participants were excited about healthcare AI but wanted assurances about safety；②Patients expect their clinicians to ensure AI safety；③Preservation of patient choice and autonomy；④Concerns about healthcare costs and insurance coverage；⑤Ensuring data integrity；⑥Risks of technology-dependent systems.
Ding Ping 2016[20]	China	Phenomenology	Patients（12）	Perioperative psychological experience of patients undergoing DaVinci robotic surgery	Four themes：①Patients have a gradual psychological acceptance process for robotic surgery；②Most patients need knowledge about robotic surgery and postoperative rehabilitation guidance；③Most patients are confident about robotic surgery；④Most patients are worried about the cost of robotic surgery.
Anne Müller 2021[21]	Germany	Descriptive qualitative study	Patients（5）	how all these different factors may act as barriers or enablers to implement AI in care	Three themes：①Enablers for patients；②Conflicting Themes for patients；③Barriers for patients

Table 2 Quality assessment of included studies

Citation	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Score
Haan et al. (2019)	Y	Y	N	Y	Y	Y	Y	Y	N	Y	8
Thenral & Annamalai (2020)	Y	Y	N	Y	Y	Y	Y	Y	N	Y	8
Bian et al. (2021)	Y	Y	N	Y	Y	U	Y	Y	Y	Y	8
Zhang et al. (2021)	Y	Y	N	Y	Y	U	Y	Y	Y	Y	8
Sangers et al. (2021)	Y	Y	N	Y	Y	Y	Y	Y	N	Y	8

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McCradden et al. (2020)	Y	Y	N	Y	Y	N	Y	Y	Y	N	8
McCradden, Sarker & Paprica (2020)	Y	Y	Y	Y	Y	N	Y	Y	N	Y	8
Topol (2019)	Y	Y	N	Y	Y	Y	Y	Y	N	Y	8
Nelson et al.(2020)	Y	Y	N	Y	Y	Y	Y	Y	N	Y	8
Richardson et al. (2021)	Y	Y	N	Y	Y	U	Y	Y	N	Y	7
Ding et al. (2016)	Y	Y	N	Y	Y	Y	Y	Y	N	Y	8
Müller et al. (2021)	Y	Y	N	Y	Y	U	Y	Y	N	Y	7

Q1:Is there congruity between the research methodology and the research questions or objectives?

Q2:Is there congruity between the research methodology and the representation and analysis of data ?

Q3:Is there a statement locating the researcher culturally or theoretically?

Q4:Are participants and their voices adequately represented?

Q5:Do the conclusions drawn from the research report flow from the analysis or interpretation of the data?

Q6:Is there congruity between the stated philosophical perspective and the research methodology?

Q7:Is there congruity between the research methodology and the data collection methods?

Q8:Is there congruity between the research methodology and the interpretation of results?

Q9:Is the influence of the researcher on the research, and vice- versa, addressed?

Q10:Is the research ethical according to current criteria or, for recent studies, and is there evidence of ethical approval by an appropriate body?

Appraisal result: "Y": Yes; "N": No; "U": Unclear.

Meta-synthesis

In our study, a total of 40 clear research results were extracted, and similar results were summarized into 12 categories, then 3 synthesized findings were obtained.Three new synthesized findings reflected the public's cognition about the using of AI in healthcare fields: 1) Advantages of medical AI from public perspective; 2) Potential ethical problems with medical AI from public perspective; 3) Public suggestions on medical AI applications.

Synthesized finding 1: Advantages of medical AI from public perspective.

The first theme integrated from included studies was that medical AI had its advantages in public views: AI's advantage of huge data storage, accompanying with the remarkable efficiency, it can helps monitor and promote health in real time.

Category 1: AI has the advantage of huge data storage.

The public described the role of AI's huge data storage advantage in meeting their medical needs. They stated that they can use the AI system to "seek more personalized and actionable information"[13].Through the medical AI system, more medical information that is easy to be understand can be obtained, and the comparison between medical information or data can be

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realized to provide more reference suggestions and the public could "get a second opinion from another dentist"[21]. Besides, the large amount of medical data possessed by AI also becomes an important aid to make accurate diagnosis. AI probably has more information and more intelligence to work with to try to come up with a proper diagnosis. "I don't think you will cure a lot of diseases without that advanced intellect."[19].

> *"participants discussed the possibility of using AI systems to evaluate and compare different opinions received from their physicians : 'I could get a second opinion because I found my doctors interpret my results differently. Maybe it could look into that"*[13].

Category 2: AI is remarkably efficient.

High efficiency is considered to be one of the outstanding advantages of AI technology applied to the healthcare industry.The application of AI can save precious treatment time for patients and reduce their medical expenses.They express that "AI will allow more scans to be analyzed in a shorter amount of time" so as to have consequences for being assisted sooner and that this will help reduce costs,too[10]. In addition to improving the efficiency of diagnosis and treatment of the medical system itself, medical AI still has the strong ability to deal with huge data. Through high-speed calculation and processing of data, medical AI can indicate possible abnormalities, improve the speed of patients' treatment and prevent the deterioration of their condition. Because "If the APP says, 'You probably have melanoma—go see your doctor'" , they might actually get in the hospital sooner and be lifesaving[18].

> *"When you can reach out and have a sample size of a group of ten million people and to be able to extract data from that ... a team of researchers can't do that. You need AI"*[12].

Category 3: AI helps monitor and promote health in real time.

In public's view, the application of medical AI not only realizes the tracking and recording the changes of health status by "comparing the data collected by the technologies at different times"[12], but also provides suggestions for potential health problems identified through the comparison and analysis of health data, for example, they may "be positive about the possibility of monitoring skin lesions over time from an APP"[14].In addition, providing the basis for medical staff to make medical decisions is another advantage of medical AI.

> *" Three other participants believed the data collected and interpreted by the technologies*

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would be useful for both older adults themselves and clinicians to understand their health better and make a more informed decision "[12].

Synthesized finding 2*: Potential ethical problems with medical AI from public perspective*

The second theme concluded was that public's views about the potential ethical problems with medical AI. First, they tend to worry about the reliability and usability of AI and then the data security and privacy protection are also not guaranteed. Besides, the responsibilities and rights in medical AI application are still not clear, and they think that owning to the applying of the medical AI, the communication between people, like doctor and patients, will be affected. If a healthcare staff rely on the AI technology too much, the public concern that their ability will be affected. In the end, the expense on the medical AI can also cause public's worries.

Category 4:Concerns about reliability and usability of AI.

The public expressed their doubts about the accuracy and reliability of health data recorded by AI systems and "cited personal experiences with errors they had found in their own health records"[19]. More, they indicated that didn't know if the medical staffs could find the possible malfunctions of AI and "be able to correct them"[21].Besides, the general public believed that human beings have autonomy and their health status is dynamically developing, which would lead to the inconsistency between the AI data and the actual situation.

"Before [the brain tumour], I might [have said] yes, because I would say ⋯ it's the survival of the fittest. ⋯ But you can never underestimate the fight ⋯ in a person, even with a disease. And [a patient] can far surpass the expectations that are set out in these kinds of statistics."[16]

Category 5:Concerns about data security and privacy protection.

The public concerns that medical AI has dangers of data being hacked and trafficked, which may "be used to against themselves"[11,15,18], and the personal privacy is monitored and recorded and is violated. Some public have also expressed concern about medical apps sharing personal data for disease diagnosis.

"Participants expressed concerns about the sharing of personal data with mHealth apps for skin cancer screening. While some participants considered an image of a skin lesion to be nonintrusive personal data, others saw this as a reason not to use an app."[14]

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Category 6:Responsibilities and rights in AI application.

For the public, they usually worried about the the ownership of the data collected by the AI. “Does it belong to the patient alone? if it belongs to the patient, what is the level of access that can be granted to the developers or service providers?” [11]. These questions are still unclear now. Besides, they also want to know “who can be held responsible for errors made by computers”[10]. All above has reflected the lack of oversight of the use of medical AI.

Category 7: AI may affect communication.

In public’s perspective, their medical needs can only be met when someone knows what they're expressing. But sometimes they think they may be treated indiscriminately by AI machines’ depersonalized procedures in which “patients become numbers”[10]. Similarly, AI cannot understand patients' emotions during communication so as to “the responses given by AI were seen as depersonalized and inhuman”, because of telling a cancer patient that “you’re going to die”[13]. Besides, AI has a negative impact on interpersonal communication as “people don't relate to each other” under the atmosphere of artificial intelligence and “the human component even if it's just emotional” becomes what public are still seeking from AI[18]. Finally, communicating with the AI can be inefficient no matter for patients or physicians who like the face-to-face communication better.

> *“patients and psychiatrists who prefer an in-person consultation feel the lacuna while using online services.”*[11]

Category 8: over-reliance on AI may affect the ability of health staffs.

Although the medical AI can be a assistance of all medical staffs to improve the efficiency, the public also wants to know if all these doctors who are accustomed to deal with all the information by artificial intelligence, “they don’t have the skill of reading it, then what happens?”[19]. There is no doubt that over-reliance on AI could affect the ability training of medical staff. Besides, relying on the AI programs or algorithms too much can reduce insight for medical staff, which may mean the loss of some their “soft skills” and even that “can’t function without it” and be unable to withdrawal[15,19]. All the expression about public’s concerns of over-reliance on AI indicate the public’s thinking on the role of AI in medical practice, they prefer that AI should only be an auxiliary tool.

Category 9: Economic concerns.

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Finally, public describe how the economic burden caused by medical AI could bring about their concerns. From their perspective, we can find that they are care about that medical AI may increase the healthcare costs which would "be passed on to patients"[19]. This has something to do with the insurance reimbursement of medical AI machines. Like the robotic surgery, "there are no charging standards and medical security policies for robotic surgery in our province, and patients have great psychological pressure in economy"[20]. In additional to the obvious expense, the operation of AI devices has requirement to technology and internet that low-income people may not be able to afford. The above economic problems brought by medical AI are one of the key points that must be solved in its promotion and use.

> *All these devices, technology, AI, etc., require high-speed internet ... patients who have basic livelihood issues cannot afford a device or internet.*[11]

Synthesized finding 3: Public suggestions on medical AI applications

The third theme summarized was about some suggestions provided by the public to the application of medical AI. During the process of applying the AI, they suggest that medical AI should meet individual needs and respect the autonomy of the public at first. And then improve the transparency and credibility of medical AI, and identify the role of AI in healthcare activities as a feature-rich auxiliary tool.

Category 10: medical AI should meet individual needs and respect the autonomy of the public.

Medical AI has many types and targets different groups of people, but if AI wants to bring its superiority into full play, taking the specific health needs into account could be essential, "such as a necklace sensor or ankle sensor might be more appropriate for a particular older population to accommodate their special conditions such as dermatitis"[12]. Apart from fulfilling the special health needs, choosing when and whether to use the medical AI is the reflection of respecting public's autonomy[19].

> *"I would like her [the SAR "Alice"] (robot) in my environment . . . For when something has been spilled and she cleans it up and other things ... But I decide when she meddles with me."*[17].

Category 11: improve the transparency and credibility of medical AI.

Enormous medical data is the important basic of medical artificial intelligence technology, so the

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public claim that " each person must consent to allow his or her data to be used in research"[15]. Similarly, some patients also expressed the necessity of "knowing how AI systems generate medical information" in order that they can make judgement about whether to trust the "medical-related recommendations"[13]. Medical AI as a valuable technology is developing prosperously, but it also needs priori validation and "extensive regulatory validation" to ensure the care offered by AI is "well-tested and accurate"[19,21] and "an independent group of experts from multiple academic institutions" can enhance public trustworthiness in medical AI,too[14] .

Category 12: identify the role of AI in healthcare activities as a feature-rich auxiliary tool. With the wide application of artificial intelligence in medical field, public stressed the AI's role in healthcare activities. Of course,they confirm AI is "a useful tool for the doctor to make diagnosis", but the "human element" shouldn't be removed from the healthcare process. In other words, medical AI should only be be an auxiliary tool for making medical decisions, and the "doctor to make the final decision" is still needed[13]. The public also mentioned that the information provided by AI is for reference only, not for determination, "as long as the doctor is making the call, and it's not a computer telling the doctor what to do"[15].Finally, they hope medical AI could be rich in assistive functions in order to find more worthy information except what they what to know mainly.

> *"They report that they would like to receive results not only of findings based on the questions of the referring physician (ie, the primary aims of the scans) but also of incidental or unrequested findings that can be extracted from the scan."*[12]

Discussion

This meta-synthesis concluded the public's cognition on the application of AI in healthcare. The included 12 papers in the meta-synthesis resulted in 40 findings that were summarized into 12 categories and further concluded as 3 synthesized findings: advantages of AI in healthcare from public perspective, potential problems with AI in healthcare from public perspective, and public suggestions on medical AI applications, these themes reveal the recognition and concerns about medical AI from the perspective of the public, which can provide reference and guidance for the research and development, promotion and application of medical AI. After all, the public is the largest audience of medical AI.

Medical AI has prominent advantages and is an emerging means to improve the level of

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medical services and comprehensively protect public health

The researches included in this paper involves the application of AI in disease screening, diagnosis, risk warning, adjuvant therapy and intelligent health care etc.. In addition, AI is increasingly being used in the research and development of new drugs[22], as well as the prevention and treatment of COVID-19[23]. Medical AI takes huge data, mature deep learning algorithms and GPU computing power as the core support[24-26]. With the accumulation of massive medical data and the improvement of hardware computing power, medical AI has built a data-driven deep learning system[27]. From early screening and accurate diagnosis of diseases to curative effect prediction, prognosis assessment and health management, medical AI provides emerging technological means to efficiently and qualitatively meet the public's medical and health needs. In present study, the public also fully affirmed the advantages of medical AI. As a strategic technology leading the frontier of science and technology, medical AI is showing a trend of rapid growth and innovative development.

The construction of medical AI related policies and regulations should be improved and strengthened to create a safe and healthy AI application environment

Both literature review and the results of this study indicate that currently, due to the imperfect system of relevant policies and regulations[28], there are still many hidden dangers in medical AI in aspects of medical security, privacy protection, attribution of rights and responsibilities, medical expenses and reimbursement.In terms of medical security, AI systems can cause medical security accidents due to malicious attacks by hackers[29], system loopholes[30], algorithm differences[31] and other factors, and damage the life safety of patients. In terms of privacy protection, the formation of medical AI requires the collection of a wide-range health data from environment[32], resulting in varying degrees of security risks to the public in physical privacy, information privacy and decision-making right privacy ect.. A study shows that 59.72% of the public are concerned about the privacy disclosure during the application of medical AI[33].Personal privacy information may be obtained, spread and utilized by illegal personnel through network means, resulting in personal privacy disclosure. Other information derived from artificial intelligence learning and analysis has also become one of the important ways of privacy disclosure[34].At the same time, the emergence of AI has created a fuzzy zone between academic research and clinical application of privacy, making the public wary of the conversion of their private information between commercial and

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non-commercial. After all, according to a study of four thousand American adults,only 11% were willing to share health data with tech companies, versus 72% with physicians[35].In terms of rights and responsibilities, public health data is an important basis for AI, but the ownership of data management has always been controversial, conflicts of interest between data source subjects and data processors continue to exist, and how to guarantee the informed consent of the public in the process of using medical data is an urgent problem to be solved.In addition, medical AI is increasingly involved in medical and health services. However, when AI poses a threat to public medical security or causes an accident, the definition of the subject of responsibility is still unclear, whether it is medical staff, AI producers or AI itself... , there is no unified view at present. In terms of expense, medical AI, as an emerging technology, often needs the support of expensive equipment, network and other hardware or software facilities. This, coupled with the current immature insurance reimbursement system for medical AI expenses, may increase the financial burden on the public of medical AI application.

To sum up, the establishment and improvement of medical AI policy and regulation system is the key issue to be solved in the process of its promotion and application. First of all,relevant departments should formulate a quality evaluation system for medical AI application, improve it's admittance criterion and regulatory regulations, enhance it's service and protection performance,so as to maximize the protection of public life and health safety.Secondly, the standardized management of medical data and other private information should be strengthened, and the management system should be improved to ensure the privacy security of public information in the whole process from the development, application and destruction of medical AI.Thirdly, a sound responsibility supervision system and rights protection mechanism should be established to clarify the rights and responsibilities of medical AI, so that AI technology can be better developed and supervised, adverse events can be avoided, and public trust in medical AI can be improved.Finally, relevant regulation and control regulations should be formulated to reasonably control the expenses caused by medical AI and improve the insurance reimbursement system. Through the above measures, a good environment will be created for the promotion and application of medical AI.

Establish the concept of "people-oriented" and practice the principles of medical ethics in the application of medical AI

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In addition to the application environment,ethical issues such as problems of social contact caused by AI, over-reliance on AI and the role position of AI have also attracted widespread attention. While medical AI has broadened the channels of communication between the public and healthcare workers, it has often caused problems such as conflicting medical advice. Information asymmetry not only leads to public distrust of medical staff, but also makes the public anxious and worried about their own health conditions. Besides, the current AI products are basically programmed mechanical devices, which may leads to the absence of humanized therapies[36,37]. The application of medical AI may deprive the public of autonomy and weaken the emotional support between people. This problem is particularly evident in the application of AI in the field of elderly care[17] and psychotherapy[38]. In addition, the public believes that both themselves and medical staffs are over-dependent on AI, and there is a risk that their skills and knowledge will be deprived by AI.

Such concerns suggest that the role of medical AI in healthcare practice is still not clearly defined.From the perspective of the public, they only want AI to exist as an auxiliary tool. Therefore, the concept of "people-oriented" and the corresponding ethical principles should be implemented throughout the application of medical AI. The research, development and application of medical AI should be patient-centered and follow the medical ethical principles of “putting patients' interests first, respecting patients and being fair”. As medical AI is increasingly widely used, various fields have made attempts on its ethical governance. For example,in the fields of nuclear medicine and molecular imaging, there have proposed 16 ethical principles to guide the development and implementation of AI[39], like “ common good and benefit”, “first do no harm”, “patient safety and quality of care” ect. To sum up, ethical considerations should be taken into account in the development of medical AI, so that ethical values can give it new life and color to maximize human well-being.

Conclusions

Through meta integration, present study reveals the double-edged sword trend of the development of medical AI from public perspective, and illustrates that medical AI has greatly promoted the development of modern medical and health care, but also brought many social ethical issues and challenges. Public is one of the important audience of medical AI, while taking the public's perception of the advantages of medical AI as the driving force for its development, the public's

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concerns about AI should also be used as a reference perspective to promote the continuous development and improvement of medical AI.We should strengthen the management of AI from both legal governance and ethical constraints, solve the problems existing in the application of medical AI, give full play to its advantages, and maintain the social values of security, fairness and justice.

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Authors' contributions

CXW conceived the study idea,participated in study design and method development, screened titles, abstracts and full text articles,carried out the data extraction and quality appraisal of included articles, coded the extracted findings and performed the data synthesis. CXW wrote the manuscript.DXB independently screened the titles, abstracts and full texts of the retrieved articles to ensure that they met the inclusion criteria, and contributed to the writing of the manuscript. XYC applied for regulatory approval, independently extracted data from the included articles , evaluated their qualities and coded the extracted results, contributed to the final synthesis of the data.JG was involved in designing the study, developing the methods, contributed to the synthesis of the extracted findings.XLJ was involved in study design and research method development, contributed to the writing of the subsequent revision of the manuscript.All authors read and approved the final manuscript.

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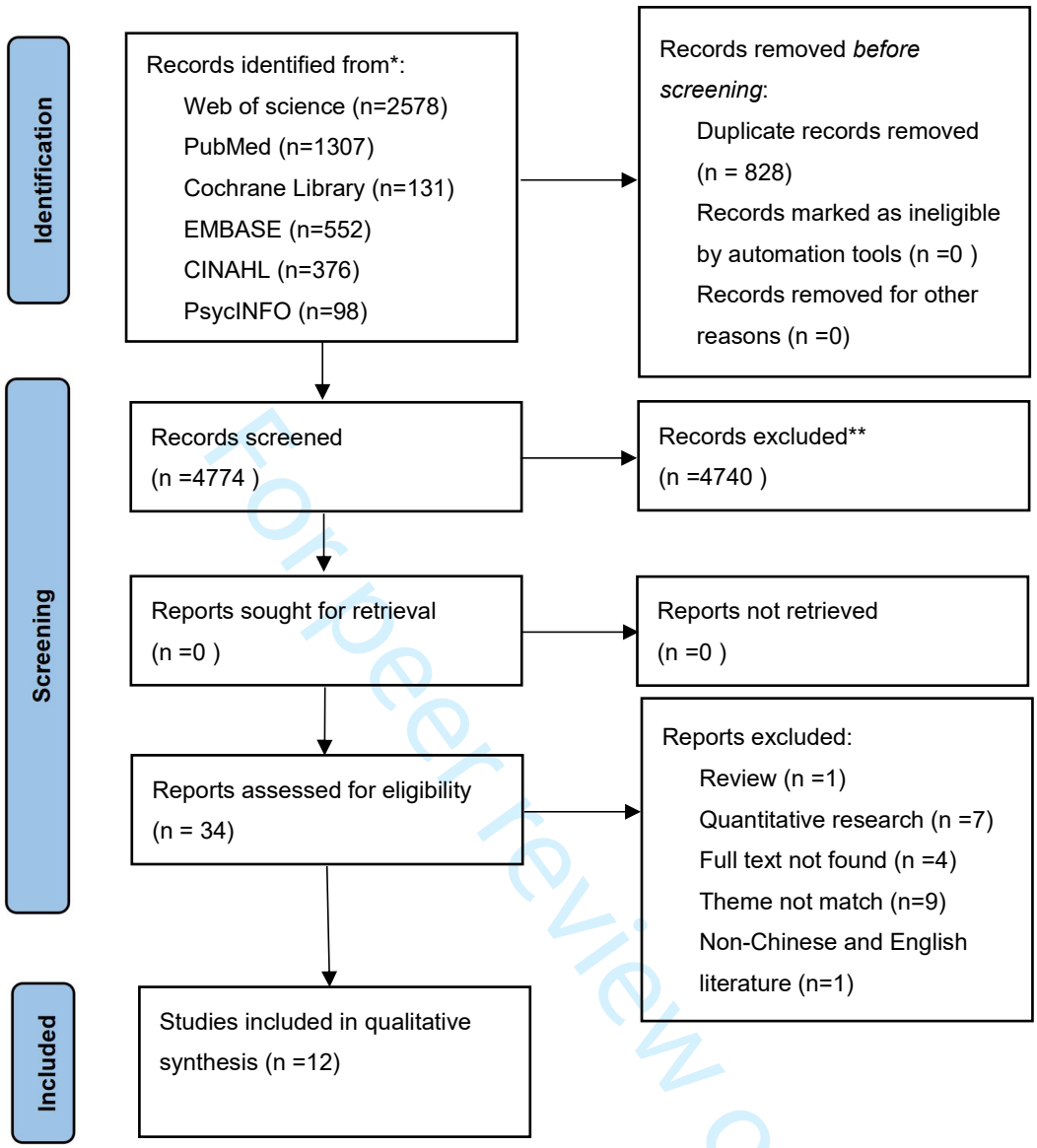

Figure 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow

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Supplemental File 1

Search strategies used for finding qualitative research articles about public's attitudes towards the application of artificial intelligence in healthcare field. Number of retrieved articles is given in the right-hand column.

CNKI

S1	人工智能 + 医疗大数据 + 机器人 + 医疗数据共享 + AI + "Artificial intelligence" + "medical big data" + "healthcare data" + "data sharing"[SU]	
S2	质性研究 + 质性访谈 + 观点 + 看法 + "qualitative study" + "qualitative research" + "qualitative inquiry" + interview + perception + attitude + view[SU]	
S3	医疗 + 护理 + medicine + nurse + nursing + medical [SU]	
S4	S1 AND S2 AND S3	393

VIP

S1	人工智能 + 医疗大数据 + 机器人 + 医疗数据共享 + AI + "Artificial intelligence" + "medical big data" + "healthcare data" + "data sharing"[题目或关键词]	
S2	质性研究 + 质性访谈 + 观点 + 看法 + "qualitative study" + "qualitative research" + "qualitative inquiry" + interview + perception + attitude + view[题目或关键词]	
S3	医疗 + 护理 + medicine + nurse + nursing + medical[题目或关键词]	
S4	S1 AND S2 AND S3	21

WanFang

S1	人工智能 OR 医疗大数据 OR 机器人 OR 医疗数据共享 OR AI OR Artificial intelligence OR medical big data OR healthcare data OR data sharing[题目或关键词]	
S2	质性研究 OR 质性访谈 OR 观点 OR 看法 OR qualitative study	

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	OR qualitative research OR qualitative inquiry OR interview OR perception OR attitude OR view[题目或关键词]	
S3	医疗 OR 护理 OR medicine OR nurse OR nursing OR medical[主题]	
S4	S1 AND S2 AND S3	146

Web of science

S1	AI OR “Artificial intelligence” OR “medical big data” OR “healthcare data” OR “data sharing”[主题]	
S2	"qualitative study" OR "qualitative research" OR "qualitative inquiry" OR interview OR perception OR attitude OR view[主题]	
S3	medicine OR nurse OR nursing OR medical[主题]	
S4	S1 AND S2 AND S3	2,578

PubMed

S1	Artificial intelligence[Mesh, ti, ab] OR "AI"[Title/Abstract] OR "Artificial intelligence"[Title/Abstract] OR "medical big data"[Title/Abstract] OR "healthcare data"[Title/Abstract] OR "data sharing"[Title/Abstract]	
S2	"qualitative study"[Title/Abstract] OR "qualitative research"[Title/Abstract] OR "qualitative inquiry"[Title/Abstract] OR "interview"[Title/Abstract] OR "perception"[Title/Abstract] OR "attitude"[Title/Abstract] OR "view"[Title/Abstract] OR "qualitative research"[MeSH Terms]	
S3	"medicine"[Title/Abstract] OR "nurse"[Title/Abstract] OR "nursing"[Title/Abstract] OR "medical"[Title/Abstract] OR "medicine"[MeSH Terms] OR "nurses"[MeSH Terms]	
S4	S1 AND S2 AND S3	1,307

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Cochrane Library

S1	AI OR “Artificial intelligence” OR “medical big data” OR “healthcare data” OR “data sharing”[Title Abstract Keyword]	
S2	’qualitative study’ OR ‘qualitative research’ OR ‘qualitative inquiry’ OR interview OR perception OR attitude OR view[Title Abstract Keyword]	
S3	medicine OR nurse OR nursing OR medical[Title Abstract Keyword]	
S4	S1 AND S2 AND S3	131

EMBASE

S1	'artificial intelligence' OR 'healthcare data' OR 'medical big data' OR 'data sharing' OR AI[ti, ab]	
S2	’qualitative study’ OR ‘qualitative research’ OR ‘qualitative inquiry’ OR interview OR perception OR attitude OR view[ti, ab]	
S3	medicine OR nurse OR nursing OR medical[ti, ab]	
S4	S1 AND S2 AND S3	552

CINAHL

S1	'artificial intelligence' OR 'healthcare data' OR 'medical big data' OR 'data sharing' OR AI[ti, ab,su]	
S2	’qualitative study’ OR ‘qualitative research’ OR ‘qualitative inquiry’ OR interview OR perception OR attitude OR view[ti, ab,su]	
S3	medicine OR nurse OR nursing OR medical[ti, ab,su]	
S4	S1 AND S2 AND S3	376

PsycINFO

S1	'artificial intelligence' OR 'healthcare data' OR 'medical big data' OR 'data sharing' OR AI[ti, ab,mh]	
S2	’qualitative study’ OR ‘qualitative research’ OR ‘qualitative inquiry’ OR	

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	interview OR perception OR attitude OR view[ti, ab,mh]	
S3	medicine OR nurse OR nursing OR medical[ti, ab,mh]	
S4	S1 AND S2 AND S3	98

TOTAL FOUND: 5602

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PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	2
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	2
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	3
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	3
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	3
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	4
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	4
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	4
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	4
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	3
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	4
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	4
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	

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PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	4
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	4
Study characteristics	17	Cite each included study and present its characteristics.	5
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	7
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	4
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	7-12
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	12-15
	23b	Discuss any limitations of the evidence included in the review.	
	23c	Discuss any limitations of the review processes used.	
	23d	Discuss implications of the results for practice, policy, and future research.	
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	1
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	16
Competing interests	26	Declare any competing interests of review authors.	16
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	17

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

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PRISMA 2020 for Abstracts Checklist

Section and Topic	Item #	Checklist item	Reported (Yes/No)
TITLE			
Title	1	Identify the report as a systematic review.	YES
BACKGROUND			
Objectives	2	Provide an explicit statement of the main objective(s) or question(s) the review addresses.	YES
METHODS			
Eligibility criteria	3	Specify the inclusion and exclusion criteria for the review.	YES
Information sources	4	Specify the information sources (e.g. databases, registers) used to identify studies and the date when each was last searched.	YES
Risk of bias	5	Specify the methods used to assess risk of bias in the included studies.	NO
Synthesis of results	6	Specify the methods used to present and synthesise results.	YES
RESULTS			
Included studies	7	Give the total number of included studies and participants and summarise relevant characteristics of studies.	YES
Synthesis of results	8	Present results for main outcomes, preferably indicating the number of included studies and participants for each. If meta-analysis was done, report the summary estimate and confidence/credible interval. If comparing groups, indicate the direction of the effect (i.e. which group is favoured).	NO
DISCUSSION			
Limitations of evidence	9	Provide a brief summary of the limitations of the evidence included in the review (e.g. study risk of bias, inconsistency and imprecision).	NO
Interpretation	10	Provide a general interpretation of the results and important implications.	YES
OTHER			
Funding	11	Specify the primary source of funding for the review.	NO
Registration	12	Provide the register name and registration number.	YES

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

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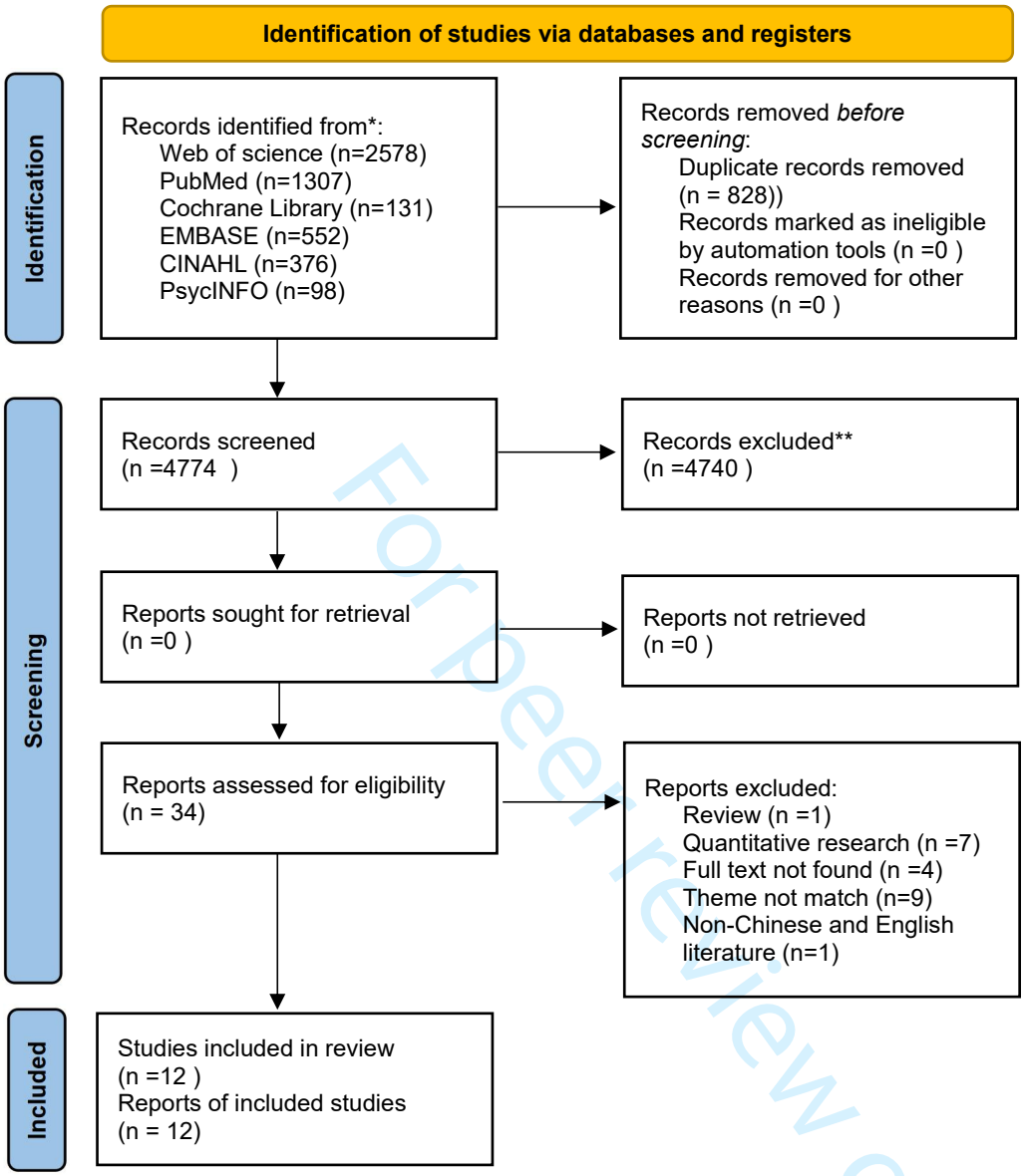
PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only



*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers).

**If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

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Perceptions of the public on the application of artificial intelligence in healthcare: A qualitative Meta-synthesis

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Perceptions of the public on the application of artificial intelligence in healthcare: A qualitative Meta-synthesis

Title page

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Perceptions of the public on the application of artificial intelligence in healthcare: A qualitative Meta-synthesis

ABSTRACT

Objectives Medical artificial intelligence (AI) has been used widely, bringing convenience and innovation. However, there are policy and regulatory issues such as credibility, sharing of responsibility and ethics. It is therefore necessary to understand the general public's understanding and views on medical artificial intelligence. Herein, a meta synthesis was conducted to analyze and summarize the public's understanding of the application of artificial intelligence in the medical and healthcare field, to provide recommendations for the use and management of artificial intelligence in medical practice.

Design This was a meta-synthesis of qualitative studies.

Method A search of English and Chinese qualitative studies was performed using the following databases: MEDLINE, CINAHL, Web of science, Cochrane library, Embase, PsycINFO, CNKI, Wanfang and VIP. Retrieval time was from inception to 25th December 2021. The meta-aggregation approach of JBI was used to summarize findings from qualitative studies, focusing on the public's perception of the application of artificial intelligence in healthcare.

Results Of the 5128 studies screened, a total of 12 met the inclusion criteria, hence incorporated into the study further analysis. Three synthesized findings were used as he basis of our conclusions, including advantages of medical AI from the public's perspective, ethical and legal concerns about medical AI from the public's perspective, and public suggestions on the application of medical AI.

Conclusion This study identified that the public can perceive the unique advantages and convenience of medical artificial intelligence, meanwhile there are many concerns about medical AI, most of which involve ethical and legal issues. Standard application and reasonable supervision of medical artificial intelligence is key to ensuring effective utilization. Based on the public's perspective, this analysis provides insights and suggestions for health managers on how to implement and apply medical artificial intelligence smoothly, while ensuring safety in healthcare practice.

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Strengths and limitations of this study

- This meta-synthesis of qualitative studies was conducted in accordance with the Joanna Briggs Institute (JBI) methodology for meta-aggregation, to identify the public's perception on the application of artificial intelligence in healthcare.
- The JBI Qualitative Critical Appraisal Checklist was used to evaluate the quality of the included studies.
- Synthesis of the included studies relied on the availability of direct quotes to the views or perceptions held by the public about the application of AI to healthcare.
- A limitation of this study is that only publications in English and Chinese were considered in this meta-synthesis resulting in possible language bias.
- The participants in each study varied in the experience with medical AI, future studies should consider this as a variable to explore the perceptions of medical AI among different participants.

Introduction

Artificial intelligence (AI) is currently one of the most controversial topics,[1] especially since there is no consensus in its definition. Professor John McCarthy, one of the founders of AI, defines it as "the science and engineering of making intelligent machines".[2] In another monograph, AI was referred to the development of computer algorithms to accomplish tasks traditionally associated with human intelligence, such as the ability to learn and solve problems.[3] In recent years, AI has been increasingly applied in the field of medical and health care, the integration of AI in health care is growing. For example, in radiology, with the help of big data and deep learning technologies, AI imaging applications not only improve the accuracy of diagnosis, but also facilitate timely diagnoses.[4] Another widely used healthcare AI system is medical robots,[5] and the advantages of the Da Vinci robotic surgery system in reducing intraoperative bleeding and shortening the operation time are well known.[6-7] In addition, during the COVID-19 outbreak, use of such aids as UV-disinfectants and social robots was found to be effective in managing disease, treating patients, and most importantly ensuring the safety of healthcare workers.[8] Artificial intelligence can also be used in public health management, for instance use of mobile health apps in the rehabilitation of patients with chronic diseases[9] such as diabetes,[10] and stroke.[11] Moreover, there are studies focusing on the application of AI in diet,[12] sports[13] and emotional management.[14] In fact, some scholars believe that AI is likely reshape and re-orient clinical medical practice in the next few years.[15] Moreover, it is estimated that by 2026, the global expenditure on healthcare AI technologies will reach up to US $45 billion.[16] Nonetheless, although AI for healthcare has been greatly convenient for disease diagnosis and management, compared with the application of AI in other industry, such as engineering of smart devices, its use in health care is still at its infancy, and its promotion and application still faces many uncertainties and challenges. According to Choudhury,[17] these challenges may manifest evidently at the macro, technical and individual levels. At the macro level, there are still regulatory and policy difficulties for AI, according to a recent survey of 265 clinicians actively practicing in the United States. The survey revealed that lack of AI accountability is a significant

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barrier to its adoption in health care.[10] At the technical level, since the performance of healthcare AI systems depends heavily on the data they are trained on, AI integrations that do not address data quality issues could exacerbate biases in healthcare due to the biased data storage inventories that are in existence.[12] For example, an algorithm that is mostly trained on Caucasian patients is not expected to have the same accuracy when applied to minorities.[18] In addition, many developers for health care AI apps are not the end users. As such, developers have primarily focused on AI's analytic capabilities, accuracy, speed, and data handling, with little attention to the human perspective,[19] leading to poorly designed apps. In fact, most AI tools that have shown good performance in literature are impractical in clinical practice,[20] and according to a survey published on the BBC in 2020, 80% of health care AI apps fail to meet the National Health Service(NHS) standards.[21] Challenges at the individual level mainly refer to issues around the awareness and trust of individuals in AI.[16,22] In his research, Choudhury[10] derived a framework that focuses on the interaction between AI and clinicians. This framework can be used to explain how interactions between clinicians and AI vary according to human factors such as expectations, workload, trust, cognitive variables related to absorptive capacity and bounded rationality, and concerns about patient safety. Moreover, as additional potential users of healthcare AI, what are the public's attitudes, requirements, and expectations towards the tool? Here, the term "public" refers to both patients and healthy individuals, because research on health care AI relies on large data sets, which should contain information from both patients who may benefit from the study, as well as people who with no health conditions and/or cannot benefit directly.[23] Therefore, a comprehensive understanding of the public's perspective can provide a more representative picture for future development of healthcare AI.[24]

Current research mostly involves qualitative studies that have explored the public's awareness and views towards healthcare AI.[25-27] However, results from a single qualitative study may not fully present the public's perception, in a holistic manner. Accordingly, this study integrated several qualitative studies on the public's perceptions and views on healthcare AI, in order to provide guidance for its development.

METHODS

A meta-aggregation approach developed by the Joanna Briggs Institution (JBI) was used in this systematic review and qualitative meta-synthesis. The study was conducted between September 2021 and January 2022, according to the recommendations of PRISMA.[28]

Search strategy

The following three-step method was utilized in this review: Firstly, an initial limited search in Medline and CINAHL was conducted, followed by a text word analysis of the title, abstract, and index terms used to describe the articles. A second extensive search was then performed across all the included databases (MEDLINE, CINAHL, Web of science, Cochrane library, Embase, PsycINFO, CNKI, Wanfang and VIP) using all the identified keywords and index terms. Lastly, the reference lists of all the identified reports and articles were searched for additional studies. Only studies published in English and Chinese were considered in this review, with no restriction for publication date. The search strings and titles extracted from each database are shown in the online **Supplemental File 1**.

Inclusion and exclusion criteria

► The following were the inclusion criteria for the study:

(a) Population: Members of the public, regardless of age, gender, health status, or history of medical AI use etc.

(b) Phenomenon of interest: The public's perceptions about the use of AI in healthcare.

(c) Setting: Hospitals, homes, or nursing homes, where healthcare AI was applied.

(d) Design: Qualitative or a mixed-methods study design.

(e) Language: English or Chinese.

► The Exclusion criteria included:

(a) Design: Studies that did not use a qualitative approach.

(b) Study types: Conference papers, editorials, letters or general-comment articles.

(c) Language: Studies published in neither English nor Chinese.

(d) Studies for which we couldn't get either the full text or the data collection and analysis methods were not reported.

Study section

The initially retrieved articles were imported into the Endnote X9 software, and repeated literature was removed. Two investigators (CXW and XYC) screened all the records independently and read the titles and abstracts to exclude literature that did not match the inclusion criteria. They then read the full texts to identify studies that could be adopted into the analysis. In the event of conflicts, a third researcher (DXB) was invited to join the discussion and resolve the conflict.

Assessment of methodological quality

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The methodological validity of the retrieved qualitative research papers was assessed by two reviewers using the JBI Qualitative Critical Appraisal Checklist, which contains ten criteria to ensure the appropriateness of the methodological approach, the method application and the representation of the voice of participants in studies. Each criterion had three levels, i.e., “yes”, “no” and “unclear”, and papers with less than six “yes” were excluded to ensure quality. All disagreements between two reviewers were resolved through discussion, or with a third reviewer.

Data extraction and synthesis

General characteristics of included studies will be extracted to gain a better understanding of the literature, these information including author(s), regions, research objects, research methods, phenomena of interest and main research results. The texts labeled as results / findings, discussion / interpretation and conclusions by the original qualitative studies’ authors will be extracted verbatim and entered into Nvivo 2021 software.The JBI meta-aggregation aproach[29,30] was used to extract and synthesize the data. The philosophical foundation of the meta-aggregation approach is pragmatism and Husserian transcendental phenomenology. The consistency of this approach with the philosophy pragmatism is reflected in its aim to produce comprehensive statements in the form of ‘lines of action’ to inform decision-making at the clinical or policy level.[31] As a result, it avoids reinterpretation of original research results and moves beyond the generation of theories. All findings or themes will be presented in the way they were in the original studies, without reinterpretation. Two reviewers(CXW and DXB) re-read each included study to ensure maximum familiarity with the data.Then, a three-step process was undertaken to synthesis qualitative findings.First, all the concluding findings from every included paper were extracted. Second, the findings were catergorized based on similarity in meaning, with at least two findings per category.Third, these categories were subjected to a meta-synthesis to form a comprehensive set of synthesized findings. As a finding was extracted, two reviewers independently assessed the degree of the congruity between the findings and the supporting data, and a credibility level would provided for each finding: unequivocal, credible, unsupported. “Unequivocal” refers to the congruence of the finding and the supporting data was beyond a reasonable doubt, “credible” means a clear association between them was lacking, and “unsupported” refers to the data did not support the findings. Only unequivocal and credible findings were included, unsupported findings were presented separately (There is no unsupported findings in this study).

Patient and public involvement statement

No patients or members of the public were involved in this research.

Results

A total of 12 papers were included in this study, including 5 grounded theory studies, 6 descriptive qualitative studies, and 1 phenomenological study. **Figure 1** shows the literature screening process and results.

Study characteristics and quality of studies

The characteristics of the included literatures are shown in **Table 1**. All studies showed congruity between the research methodology and research questions, the representation and analysis of data, the data collection methods and the interpretation of results. Participants and their voices were adequately represented, and the conclusions were based on the data. Almost all studies(n=11) didn’t included statements regarding the cultural or theoretical perspectives of the researchers except the research conducted by McCradden. Furthermore, 10 studies did not addressed the influence of the researcher on the research nor the influence of the research on the researcher. Almost all studies(n=11) presented the evidence of ethical approval by the respective body. 6 studies showed unclear congruity between the stated philosophical perspective and the research methodology. Results of the quality assessment are presented in **Table 2**.

Table 1 Study characteristics

Study	Country	Methodology	Participants(n)	AI’s application setting	Phenomenon of interest	Main results
Haan, Marieke2019[32]	Netherlands	Grounded theory	Patients scheduled for a CT scan of the chest and abdomen on an outpatient basis (20)	In radiology outpatient	Patients’ view on what They need to know about the use of AI in radiology.	Six themes：①Proof of technology about efficacy and reliability of AI；②Procedural knowledge about understanding how AI will be implemented in the current radiological practice；③The capability of AI to produce reliable results；④Efficiency related to the scanning process；⑤Personal interaction between patients and doctors；⑥The responsibility of humans when computers make mistakes.

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Thenral M 2020[33]	India	Grounded theory	Patients of psychiatrists who had used web-based/ phone-based telemedicine services for consulting patients(14)	In psychological consultation of clinical practice	The perceive challenges of building, developing and using AI-enabled telepsychiatr for clinical practice from the perspectives of patients.	Four themes：①Ethical, legal, accountability, and regulatory problems of AI；②Financial issues；③Tefchnology problems of AI；④Clinical-practice problems of AI
Chao Bian 2021[34]	Canada	Descriptive qualitative study	Adults be aged at least 65 years and older (15)	Assessing frailty in home settings	Older adults' perceptions and preferences of technologies that can potentially assess frailty at home.	Four themes：①General attitude towards using the technologies；②Conditions for accepting certain technologies；③Existing living habits or patterns Related to using the technologies；④Constructive suggestions related to the technologies.
Zhan Zhang 2021[35]	USA	Descriptive qualitative study	Patients who have recent experience with using patient portals to review their diagnostic results (13)	Interpreting imaging data and radiology reports	Patients' perceptions and acceptance of using AI technology to interpret their radiology reports.	There themes：①General perceptions of using AI tools to interpret diagnostic results；②Concerns；③Increasing acceptability and trustworthy of AI-based systems in communicating radiology report findings.
T.E. Sangers 2021[36]	Netherlands	Grounded theory	General Public(27)	In skin cancer screening	The perceived barriers and facilitators towards mHealth apps for skin cancer screening among the Dutch general population.	Two themes：①Barriers to using mHealth skin cancer screening apps ②Facilitators of mHealth use.
Melissa D 2020[37]	Canada	Descriptive qualitative study	General public who had signed up to participate in research studies(41)	In health data research	The perspectives of the general public regarding the use of health data in AI research.	Five themes：①Mixed, mostly negative views about artificial intelligence (AI) in general；②Hopes and perceived benefits of health artificial intelligence (AI) research scenarios；③Fears and perceived drawbacks of health AI research scenarios；④Conditions under which health AI research scenarios are more acceptable；⑤Educational effect of realistic health AI research scenarios.
Melissa D 2020[38]	Canada	Descriptive qualitative study	Patients with meningioma and their caregivers (18)	In health care research	Current perspectives of patients on ethical issues surrounding AI in health care.	Four themes：①Protection of health data；②Skepticism regarding accountability mechanisms；③Computer-based predictions；④Trust and confidentiality
Vandemeulebr2 019[39]	Belgium	Grounded theory	Adults be aged at least 70 years and older (59)	In aged care	Community-dwelling older adults perceive as ethical issues of socially assistive robots(SARs) in aged care.	There themes：①SARs as components of a techno-social evolution；② SARs' embeddedness in aged-care dynamics,；③ SARs as embodiments of ethical considerations
Caroline A. 2020[40]	USA	Grounded theory	Patients with skin cancer (48)	In skin cancer screening	How patients perceive the use of AI for skin cancer screening.	Five themes：①AI's benefits；② AI's risks；③AI's strengths；④AI's weaknesses；⑤AI's implementation
Jordan P. 2021[41]	USA	Descriptive qualitative study	Patients（87）	In healthcare	How patients view the use of AI in their healthcare.	Five themes：①Participants were excited about healthcare AI but wanted assurances about safety；② Patients expect their clinicians to ensure AI safety；③ Preservation of patient choice and autonomy；④ Concerns about healthcare costs and insurance coverage；⑤Ensuring data integrity；⑥Risks of technology-dependent systems.
Ding Ping 2016[42]	China	Phenomenology	Patients undergoing Da Vinci robotic surgery（12）	In surgery	Perioperative psychological experience of patients undergoing DaVinci robotic surgery	Four themes：①Patients have a gradual psychological acceptance process for robotic surgery；②Most patients need knowledge about robotic surgery and postoperative rehabilitation guidance；③Most patients are confident about robotic surgery；④Most patients are worried about the cost of robotic surgery.
Anne Müller 2021[43]	Germany	Descriptive qualitative study	Patients visiting the department of oral diagnostics（5）	In dental diagnostics	How all these different factors may act as barriers or enablers to implement AI in care	Three themes：①Enablers for patients；②Conflicting Themes for patients；③Barriers for patients

Table 2 Quality assessment of included studies

Citation	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Score
Haan et al. (2019)	Y	Y	N	Y	Y	Y	Y	Y	N	Y	8

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Meta-aggregation

A total of 39 findings rated as "unequivocal" or "credible" were extracted from 12 studies included in the synthesis. The 39 findings were aggregated into 12 categories, which were subsequently synthesized into 3 synthesized findings. **Figure 2** shows the summary of study findings, categories, and synthesized findings on the perceptions of the public on the application of AI in healthcare.

Synthesized finding 1: Advantages of medical AI from the public's perspective.

The first theme integrated from the included studies was that, to the public eye, medical AI has its advantages. For instance, AI has the advantage of a huge data-storage capacity, remarkable efficiency, and it can help monitor and promote health in real time.

Category 1: AI has the advantage of a huge data storage capacity.

The public described the role of AI's huge data storage advantage in meeting their medical needs. According to most individuals, the AI system can be used to seek more personalized and actionable information. Through the medical AI system, more medical information that is easy to understand can be obtained, and comparison of medical information or data can be realized to provide more evidence-based suggestions. Additionally, the public could get a second opinion besides their care providers. The large amount of medical data possessed by AI also becomes an important aid to making accurate diagnoses. In the eyes of the public, healthcare AI is more intelligent, and can use more information to make a proper diagnosis. Two exemplar quotes follow:

"I mean, it's (AI) not a human. It's got more data, so probably. … [I]t probably has more intelligence; it just has more information to work with to try to come up with a proper diagnosis. … I don't think you will cure a lot of diseases without that advanced intellect."[41]

"Exactly, with such a report you could go to another dentist and get a second opinion. This would be fantastic, right."[43]

Category 2: AI is remarkably efficient.

High efficiency is considered one of the outstanding advantages of AI technology applied to the healthcare. According to most members of the public, healthcare AI can improve the efficiency of medical tasks, such as imaging scans, thereby reducing the waiting time. In addition, AI can process massive amounts of data to detect possible abnormalities in time to speed up diagnosis and treatment, hence preventing deterioration caused by disease. Two exemplar quotes follow:

"When you can reach out and have a sample size of a group of ten million people and to be able to extract data from that … a team of researchers can't do that. You need AI."[34]

"If the app says, 'You probably have melanoma—go see your doctor,' they might actually get in there sooner…so it could be lifesaving."[40]

Category 3: AI helps monitor and promote health in real time.

In the eyes of the public, medical AI can continuously track and collect health data to help in understanding the health status of users, find potential health problems in time, and provide corresponding suggestions. The data collected by medical AI can also provide a basis for physicians to make medical decisions. Moreover, healthcare AI was perceived as a useful tool to help individuals prepare for clinical visits. Specifically, it can provide reliable information that individuals can research on and construct relevant questions prior to the consultation. Therefore, by doing so, people can be more prepared for consultations with their care providers. Two exemplar quotes follow:

"I would use it (healthcare AI) because I think the more information you can give to your doctor, the better off he/she's going to be when it comes to treating something that you might have, whether it's a frailty or whatever, and if things like this can help improve the quality of people's lives as we age, then I think it's a good thing."[34]

"Maybe give a user questions that they can ask the doctor, because that's the other thing I noticed, is that a lot of people don't get the results they want, or the medical outcomes,because they don't know what questions to ask the doctor. ……But if AI could be like, 'Hey, here is your results, do you feel this? Or do you have problems breathing? Or so on and so forth, and if you do, please bring this up with your doctor.' My stepmother works in the ER and she's an RN [Registered Nurse]. And she's like, 'Half the time when people come in, if they were just able to ask the right questions, they would be in and out, they'd start treatment immediately.'"[35]

Synthesized finding 2*:* Ethical and legal concerns about medical AI from the public's perspective

Almost every study mentioned the public's concerns about the ethical and legal issues surrounding medical AI. First, people expressed concerns about the reliability of medical AI, as most of them had no knowledge on how the AI system works. Second, the public expressed concerns about data ethics in medical AI. Third, the responsibilities and rights of different parties during the application of medical AI are still not clear. In addition, some individuals believed that the use of medical AI will affect communication between people. Some members of the public were also worried that too much reliance on AI

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technology will affect the performance of medical staff. Finally, the public raised concerns over the cost of medical AI.

Category 4: Concerns about the reliability of AI.

The public had doubts about the accuracy and reliability of health data recorded by AI. AI algorithms have black box properties, for the public, the process by which medical AI makes decisions through calculations is opaque and difficult to understand. This lack of transparency puts the credibility of medical AI into question. In addition, the public was worried that AI could exacerbate biases that could arise from an inherently biased learning dataset or by developers inadvertently incorporating their biases into AI algorithms. Moreover, some people reported finding errors in their health records, and didn't know if medical staff could detect and fix errors in the AI platforms in use. Two exemplar quotes follow:

"I would need proof that it works and what you're actually getting is meaningful information. Like it's not just some crap. If it's going to make recommendations to me, I want them to be proven that they're actually legit."[35]

"So I've had a lot of different things in my medical chart that are inaccurate, very inaccurate, so if they're training an artificial intelligence that this is facts, it's like, well no."[36]

Category 5: Concerns about data security and privacy protection.

Data security and privacy is a major concern for the public in terms of data ethics. With this regard, the public's main concern is over whether medical AI systems can be kept confidential and whether they can protect sensitive health information from potential hacking or data leakage. Another concern is that health data provided for a medical AI could be sold or used for other purposes that most people disagreed with. Some members of the public also expressed concerns about medical apps sharing personal data for disease diagnosis. Moreover, some devices with monitoring functions also made most people feel that their privacy is violated. Two exemplar quotes follow:

"There is always a possibility of hackers taking over telemedicine platforms and causing data theft. Apart from that, when there are security lapses, the possibility of stealing vital bank information from the mobile (that is used for accessing the mental health service) is also possible….."[33]

"Are they going to take my information, are they going to sell it? So, it kind of makes you scared when other companies are buying it."[37]

Category 6: Concerns about the responsibilities and rights associated with the application of medical AI

The public was unsure whether the data collected by AI belonged to the patient alone, and the level of access that could be granted to developers or service providers. At the same time, people had concerns over who could be held responsible for errors made by medical AI. In addition, some members of the public were worried that low-quality AI products may come up when there is insufficient supervision, hence harming the interests of users. Two exemplar quotes follow:

"Several legal issues are yet to be clarified…for instance, if there is a misdiagnosis or missed diagnosis…who will the patient sue…. Doctor? Developer? Platform owners?"[33]

"I have some background in electronics….. The way things are made, 'cause I've actually worked in the industry of making medical equipment, it's all about using the cheapest method to get the end result. Well, electronics fail. They just do."[40]

Category 7: Concerns about communication being affected by AI.

From the public perspective, their medical needs can only be met if someone understands what they are expressing. They argue that the AI machines' depersonalized procedures, in which patients become numbers, they may be treated in an indiscriminate manner. Similarly, AI cannot understand patients' emotions during communication, and thus the responses provided by AI are considered depersonalized and dehumanizing. In addition, patients believe AI has a negative impact on interpersonal communication because people do not relate to each other under the atmosphere of AI, therefore communication with medical AI may be inefficient, both to the patients and doctors who prefer face-to-face communication. Two exemplar quotes follow:

"Emotionally, a robot would not appeal to me. It can be nice and say nice things, but I would have emotional difficulties with it."[39]

"I don't find it very appropriate. First of all, it's going to take jobs away from health professionals. If the app has to tell them, suggest things or whatever, there's no communication there, like face-to face."[37]

Category 8: Concerns about the over-reliance of healthcare workers on medical AI.

Although the public acknowledges that medical AI can help medical staff become more efficient, they raised concerns that doctors may get used to utilizing AI technology to process all information, which will affect their basic abilities, such as reading. This will imply that without access to these AI tools, high-quality care may not be able to provided. In addition, people believe that over-reliance on AI programs or algorithms will reduce the insight of medical staff, which may mean they lose some soft skills or even can't work without it. All of these concerns are indicative of the public's thinking about the role of AI in medical practice, preferring that AI should only be used as an auxiliary tool.Two exemplar quotes follow:

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"If they were to get hacked or a system goes down … like what's the contingency plan, but what is the contingency plan? If you have all these doctors who are so used to having this artificial intelligence read all these, and they don't have the skill of reading it, then what happens?"[41]

"So that's a concern, that you lose some of those soft skills and that relies on intuition when you rely solely on AI, on computers and programs and algorithms."[37]

Category 9: Concerns about economic impact.

The public expressed their concerns about the potential financial burden of medical AI, with many fearing it may increase healthcare costs which will be passed on to patients. In their opinion, AI is expensive to develop and deploy. Second, they worry about the impact of AI recommendations on the types of treatments covered by insurance, for example, AI may recommend a treatment which most patients cannot afford. In addition, artificial intelligence equipment needs equipment, network and other hardware guarantees, low-income groups may not afford, and this may exacerbate inequalities in health care. Two exemplar quotes follow:

"Robotic surgery is new,I don't know the reimbursement policy or how much insurance will cover it.If the cost is too much for me personally, then I can't afford it."[42]

"All these devices, technology, AI, etc., require high-speed internet ... patients who have basic livelihood issues cannot afford a device or internet."[33]

Synthesized finding 3: Public suggestions on the application of medical AI.

The public's has views on the application scenarios for medical AI, conditions that can facilitate the application of AI. They suggested that medical AI should first meet the individual needs and respect the autonomy of the public. In addition, medical AI should be transparent and credible, as well as properly regulated. Finally, AI should only be used as an auxiliary tool in medical practice, not as a decision maker.

Category 10: Meet the individual needs and respect their autonomy.

The public indicated that medical AI should fully consider users' specific needs; they considered providing personalized information is a key feature of AI. Also, medical AI should be usable by all ages, whether they're tech-savvy or not, and older people may need easier modes of AI interaction. Some argued that medical AI will be more acceptable if it can provide more functionality while performing its core functions. In addition, they indicated that medical AI should only provide a risk indication but not a diagnosis, and when medical AI makes a recommendation, it should be up to the users to decide whether or not to follow the recommendation, rather than forcing them to follow it. For example, when an app makes a recommendation to see a doctor, the recommendation should not be binding, nor should it take away the user's freedom to see a doctor. Two exemplar quotes follow:

"User-friendliness is an important precondition if you want to entice people to use it (mobile health (mHealth) apps)."[36]

"I would like her [the SAR "Alice"] (robot) in my environment . . . For when something has been spilled and she cleans it up and other things ... But I decide when she meddles with me."[39]

Category 11: Improve the transparency and credibility of medical AI.

The public will be more receptive to medical AI technology and its related research if there is transparency about how data are used in health AI. Moreover, some people expressed the need to understand how AI systems generate medical information so that they can decide whether to trust advice provided by AI. Another approach for increasing the credibility of medical AI is to disclose its information sources. In addition, the public also stressed that medical AI should be under proper supervision and management, and endorsement by healthcare providers and government regulators may also increase public acceptance of AI. Two exemplar quotes follow:

"My level of trust would depend on the source naturally. If it's from Joe down the street, obviously I wouldn't too crazy about it. But if it's from a trusted source, like a well-respected medical organization or something like that, like John Hopkins or Mayo Clinic, that would probably help build a little bit of trust."[35]

"If you would also give it approval because of a ministry or because of a legal regulation or something like that, this guarantee should be legal. The responsibility lies with the government with regard to its quality."[36]

Category 12: Use AI as an auxiliary tool in medical practice, not as a decision maker.

The public held the view that the human element should not be removed from the healthcare process, thus, medical AI should only be a complementary service, not a replacement for professional health forces, and the final decision should be made by real people, the users of AI (doctor, nurse, patient, etc.). The public also mentioned that the information provided by AI should be for reference only, not for determination of patient treatment. Finally, they hope medical AI could be equipped with assistive functions in order to find more detailed information apart from what they know what to know mainly. Two exemplar quotes follow:

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"As long as it's a tool, like the doctor uses the tool and the doctor makes the call. As long as the doctor is making the call, and it's not a computer telling the doctor what to do."[37]

"They report that they would like to receive results not only of findings based on the questions of the referring physician (i.e., the primary aims of the scans) but also of incidental or unrequested findings that can be extracted from the scan."[34]

Discussion

This meta-synthesis concluded the public's attitudes and perceptions towards medical AI. 12 qualitative studies were included in the present research, resulting in 39 findings, that were summarized into 12 categories and further generalized into 3 synthesized findings. The analysis revealed that while the public acknowledges the convenience and benefits of medical AI, it also has many concerns about its implementation, such as personal privacy, data security, and regulation. At the same time, members of the public gave their opinions on how to increase the credibility and acceptability of AI. These findings provide useful insights that can be used as a reference for not only research and development but also for the promotion and application of medical AI.

Understanding how medical AI works will help improve its acceptability

AI is already widely used in healthcare, and the studies included in this analysis involved the use of AI in such aspects as disease screening, diagnosis, risk warning, adjuvant therapy and intelligent health care. In addition, AI is increasingly being applied in the research and development of new drugs,[44] as well as in the prevention and treatment of COVID-19.[45] With the accumulation of massive medical data and the improvement of hardware computing capacity, medical AI has built a data-driven deep learning system.[46] This way, it can meet the public's medical and health needs more efficiently and with high quality in many aspects of healthcare. The results from the present study also show that the public fully recognizes the advantages of medical AI. However, two types AI technologies used in health care, machine learning (ML) and deep learning (DL) have black-box attributes, in the sense that they cannot explain how predictions are made based on the two technologies.[47,48] As a result, users are unable to understand the prediction process and verify the results given by ML or DL models, leading to low public acceptance of medical AI.[49] In the several original studies included in this paper, the public expressed doubts about the effectiveness and accuracy of medical AI.[36,40,41] Therefore, overcoming the black-box problem and helping the public to understand how models work and perform predictions, is an important aspect for the evolution of medical AI. This challenge could be solved through explainable artificial intelligence (XAI), defined as a set of features that explain how the AI model constructs its predictions.[50] For example, in a study involving categorizing tuberculosis diagnoses through deep learning chest radiographs, researchers used heat maps to show areas of increased activation of deep learning networks that could be inferred to be important for diagnosis.[51] Therefore, by adding the XAI technology to ML and DL models, the use of AI in healthcare will become more reliable and acceptable.[52-54] In addition, before application, it is necessary to educate the public on the principles of the medical AI system, including how it works.

A safe and healthy AI application environment is crucial

Literature review and the results from this study indicate that the public has concerns over medical AI, including those pertaining to security, privacy protection, responsibility attribution, and reimbursement of medical expenses, all of which are related to improper policy and regulatory systems.[55] Regarding medical security, AI systems can cause medical security accidents due to malicious attacks by hackers,[56] system loopholes,[57] algorithm differences[58] and other factors that may threaten the safety of patient lives. With regard to privacy protection, the development of medical AI requires the collection of a wide-range health data,[59] resulting in varying degrees of security risks to the public in terms of physical, information and the right to decision-making privacy. According to a previous study, 59.72% of the public was concerned about the privacy disclosure during the application of medical AI.[60] Personal privacy information may be obtained, spread and used by unauthorized individuals, through network breaches, resulting in the violation of personal privacy. Some information derived from artificial intelligence learning and analysis has also become one of the most important ways of privacy violation.[61] At the same time, the emergence of AI has created a fuzzy zone between academic research and clinical application, making the public wary of the exchange of their private information between commercial and non-commercial platforms. Notably, in a study of four thousand American adults, only 11% were willing to share health data with tech companies, versus 72% with physicians.[62] In terms of rights and responsibilities, public health data is an important basis for AI, but the ownership of data management has always been controversial. Conflicts of interest between data source subjects and data processors continue to exist, and ways to guarantee informed consent from the public in the process of using medical data need to be established.When AI poses a threat to public medical security or causes an accident, the definition of the subject of responsibility is still unclear. There is currently no consensus over whether responsibility in the event of accidents should be taken by medical staff, AI producers or AI itself. Regarding expenses, the operation of medical AI often requires the support of expensive equipment, network and other hardware or software facilities. This coupled with the currently unclear

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insurance reimbursement system for medical AI expenses, may increase the financial burden on the public from the use of medical AI.

In summary, the establishment and improvement of medical AI policy and regulation systems is key to enhancing its promotion and application.Most importantly, in order to maximize the protection of public health and safety, a quality evaluation system for medical AI should be formulated, and its acceptance criteria and regulatory system should be improved to enhance its service and protective performance.Secondly, the management of private information such as medical data should be strengthened to ensure the privacy and security of public information during the whole process of development, application, and destruction of medical AI.Thirdly, to avoid adverse events and improve the public's trust in medical AI, the responsibility supervision system and rights protection mechanism should be established and improved, and the rights and responsibilities of medical AI should be clarified.Finally, regulations should be formulated to reasonably control the costs associated with medical AI and improve the insurance reimbursement system to address people's economic concerns.

The public expects "people-oriented" medical AI

In this analysis, ethical issues such as social problems, excessive reliance on AI, and the role of AI have also attracted wide attention from the public. While medical AI has broadened the channels of communication between the public and healthcare workers, it also faces problems such as conflicting medical advice. Information asymmetry not only leads to public distrust in medical staff, but also makes the public anxious and worried about their own health conditions. In addition, the AI products in current use are basically programmed mechanical devices, which may lead to the absence of humanized therapies.[63,64] The use of medical AI may also deprive the public of autonomy and weaken emotional support among people. This problem is particularly evident in the application of AI in caring for the elderly[39] and in psychotherapy.[65] Moreover, members of the public believe that both they and medical staff are over-dependent on AI, and there is a risk that their skills and knowledge may be deprived by AI.

Such concerns suggest that the role of medical AI in healthcare is still not clearly defined. Furthermore, the public hold the idea that AI should only serve as an auxiliary tool. Therefore, the concept of "people-oriented" and the corresponding ethical principles should be implemented throughout the application of medical AI. Additionally, research, development and application of medical AI should be patient-centered and follow the medical ethical principles of “putting patients' interests first, respecting patients and being fair”. As medical AI is becoming increasingly popular, various fields have made attempts to strengthen its ethical governance. For example, in the fields of nuclear medicine and molecular imaging,16 ethical principles have been proposed to guide the development and implementation of AI.[66] Such include “ common good and benefit”, “first do no harm”, and “patient safety and quality of care”. In summary, ethical considerations should be taken into account during the development of medical AI, to ensure maximum benefit to the well-being of humans.

Limitations and future directions

Although this meta-synthesis adopted a rigorous design and complied with the meta-aggregation approach of JBI, several limitations were observed. Firstly, only studies published in English and Chinese were included, which may cause language bias. Besides, the participants of each study had different experience in application of medical AI . Specifically, of the 12 included studies, 6[32-34,37,38,43] did not specify whether interviewees had an experience with the application of medical AI, 2[39,41] reported that respondents had no experience with using medical AI, 2[35,42] reported that respondents had used the medical AI technology, and the other 2[36,40] had both experienced and inexperienced respondents. Since participants’ perception of medical AI may be affected by their experiences with it, future research should consider experiences as a variable, and compare differences in perceptions of various respondents and possible reasons, to arrive at richer and stronger conclusions.

Clinical implications for health managers and policymakers

According to this meta-integration, one of the main concerns for the public was the right to informed consent. Therefore, medical institutions should establish management systems for the use of AI, to guarantee the right of informed consent to the public, especially for institutions with their own data infrastructure. Secondly, health institutions should fully understand the performance of their medical AI platforms, clarify their role in the process of diagnosis and treatment, avoid over-reliance of medical staff on medical AI and ensure the safety of treatment.

Conclusions

Through meta synthesize, present study reveals the double-edged sword trend of the development of medical AI from public perspective, that is medical AI has greatly promoted the development of modern medical and health care, but also brought many social ethical issues and challenges. This study also puts forward suggestions to promote the application of medical AI from the perspective of the public. As one of the important audience of medical AI, the public's perception of the advantages of medical AI is an important driving force to promote its development. Meanwhile, the public's concerns about the application of medical AI should be deeply concerned, and it should be used as a reference perspective for the development, operation and management of

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medical AI to promote its continuous improvement and development.We should strengthen the management of AI from both legal governance and ethical constraints, minimize or eliminate its disadvantages and maximize its advantages, and maintain the social values of security, fairness and justice.

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Authors' contributions

CXW conceived the study idea,participated in study design and method development, screened titles, abstracts and full text articles,carried out the data extraction and quality appraisal of included articles, coded the extracted findings and performed the data synthesis. CXW wrote the manuscript.DXB independently screened the titles, abstracts and full texts of the retrieved articles to ensure that they met the inclusion criteria, and contributed to the writing of the manuscript. XYC applied for regulatory approval, independently extracted data from the included articles , evaluated their qualities and coded the extracted results, contributed to the final synthesis of the data.JG was involved in designing the study, developing the methods, contributed to the synthesis of the extracted findings.XLJ was involved in study design and research method development, contributed to the writing of the subsequent revision of the manuscript.All authors read and approved the final manuscript.

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Figure legends

Figure 1: Literature screening process and results using preferred reporting items for systematic reviews and meta-analyses (PRISMA) flow chart

Figure 2: Meta-synthesis findings of the general public's perceptions on the application of artificial intelligence in healthcare

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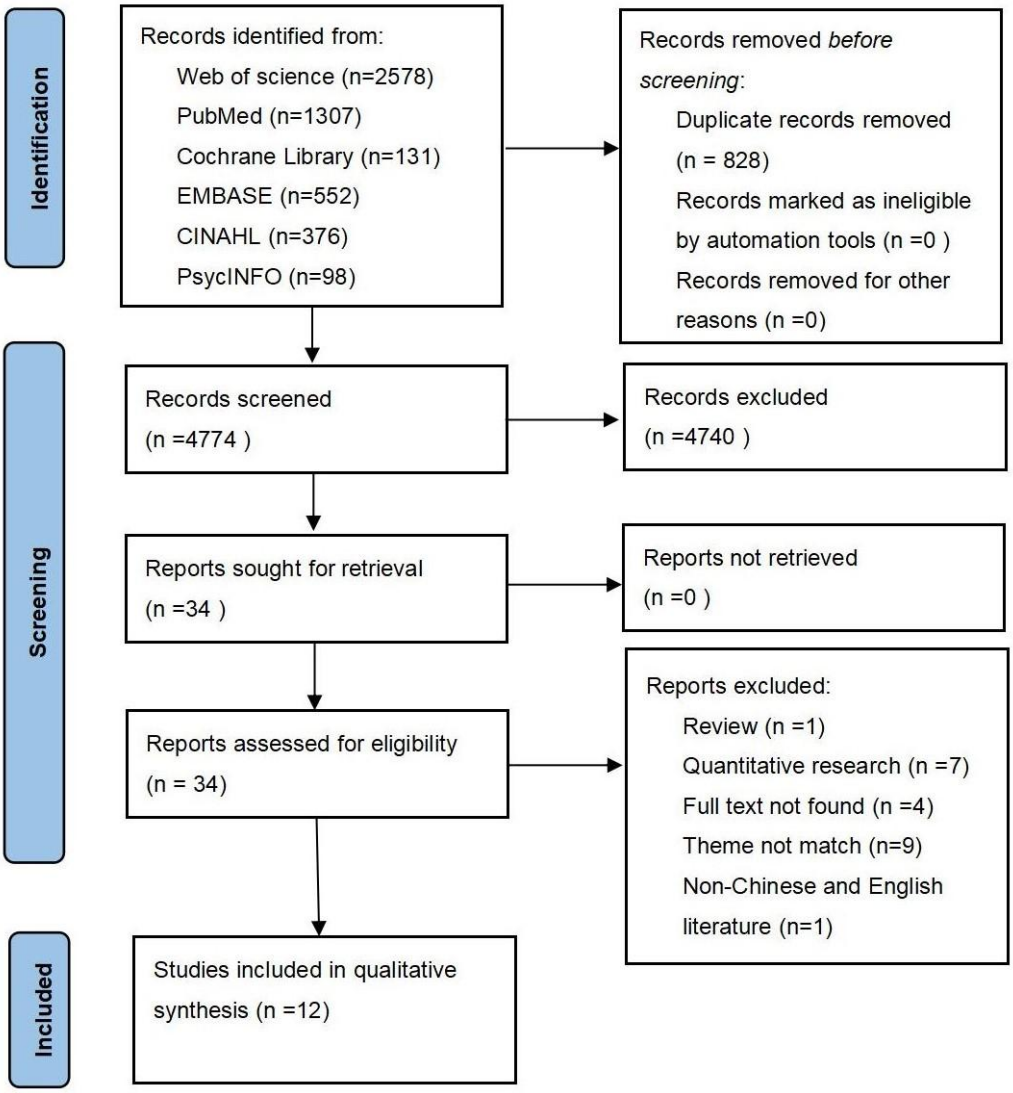

Figure 1: Literature screening process and results using preferred reporting items for systematic reviews and meta-analyses (PRISMA) flow chart
1531 x 1465mm (1152 x 1204 DPI)

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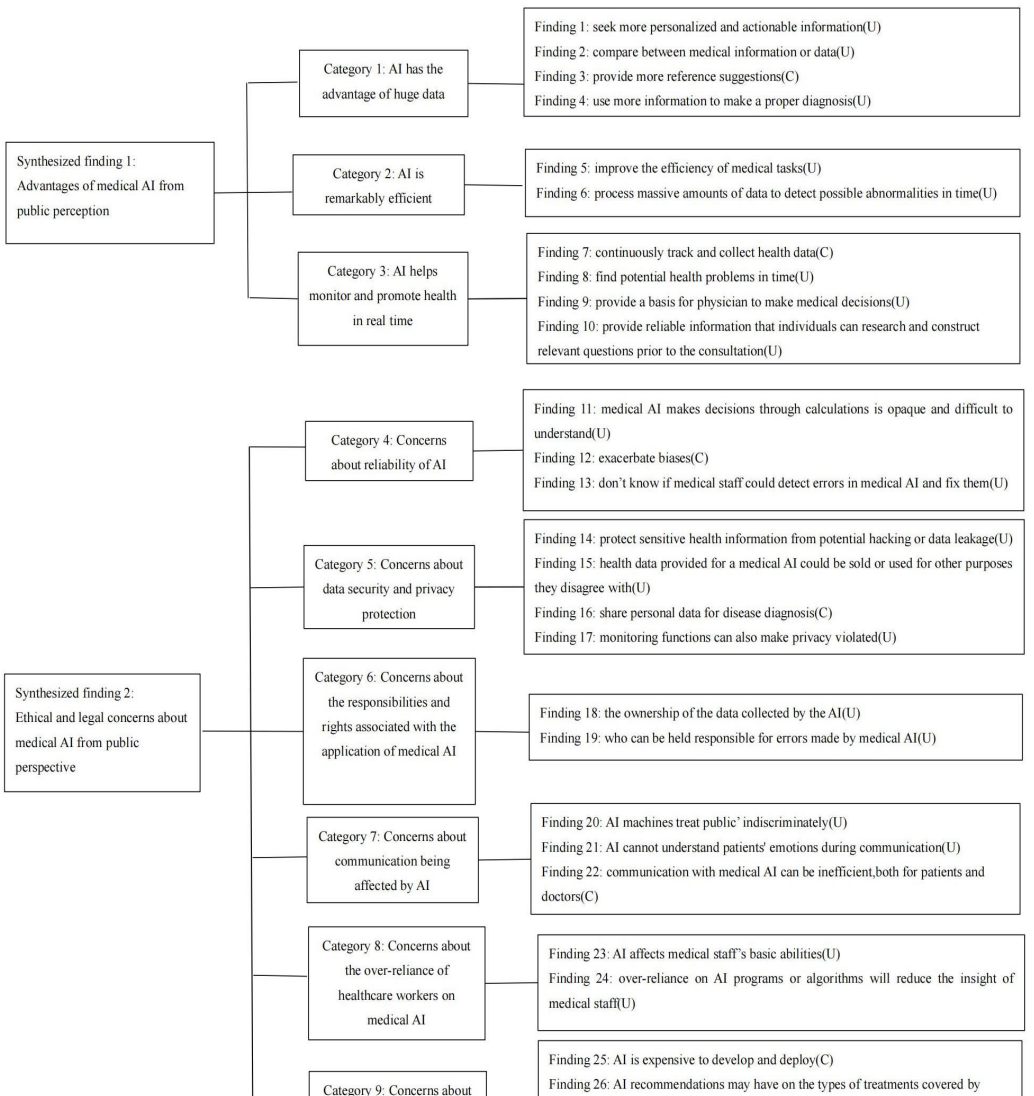

Figure 2: Meta-synthesis findings of the general public's perceptions on the application of artificial intelligence in healthcare
2141 x 1636mm (2339 x 2845 DPI)

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Supplemental File 1

Search strategies used for finding qualitative research articles about public's attitudes towards the application of artificial intelligence in healthcare field. Number of retrieved articles is given in the right-hand column.

CNKI (Totally=393)

S1	人工智能 + 医疗大数据 + 机器人 + 医疗数据共享 + AI + "Artificial intelligence" + "medical big data" + "healthcare data" + "data sharing"[SU]
S2	质性研究 + 质性访谈 + 观点 + 看法 + "qualitative study" + "qualitative research" + "qualitative inquiry" + interview + perception + attitude + view[SU]
S3	医疗 + 护理 + medicine + nurse + nursing + medical [SU]
S4	S1 AND S2 AND S3

VIP (Totally=21)

S1	人工智能 + 医疗大数据 + 机器人 + 医疗数据共享 + AI + "Artificial intelligence" + "medical big data" + "healthcare data" + "data sharing"[题目或关键词]
S2	质性研究 + 质性访谈 + 观点 + 看法 + "qualitative study" + "qualitative research" + "qualitative inquiry" + interview + perception + attitude + view[题目或关键词]
S3	医疗 + 护理 + medicine + nurse + nursing + medical[题目或关键词]
S4	S1 AND S2 AND S3

WanFang (Totally=146)

S1	人工智能 OR 医疗大数据 OR 机器人 OR 医疗数据共享 OR AI OR Artificial intelligence OR medical big data OR healthcare data OR data sharing[题目或关键词]
S2	质性研究 OR 质性访谈 OR 观点 OR 看法 OR qualitative study

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	OR qualitative research OR qualitative inquiry OR interview OR perception OR attitude OR view[题目或关键词]
S3	医疗 OR 护理 OR medicine OR nurse OR nursing OR medical[主题]
S4	S1 AND S2 AND S3

Web of science(Totally=2578)

S1	AI OR “Artificial intelligence” OR “medical big data” OR “healthcare data” OR “data sharing”[主题]
S2	"qualitative study" OR "qualitative research" OR "qualitative inquiry" OR interview OR perception OR attitude OR view[主题]
S3	medicine OR nurse OR nursing OR medical[主题]
S4	S1 AND S2 AND S3

PubMed(Totally=1307)

S1	Artificial intelligence[Mesh, ti, ab] OR "AI"[Title/Abstract] OR "Artificial intelligence"[Title/Abstract] OR "medical big data"[Title/Abstract] OR "healthcare data"[Title/Abstract] OR "data sharing"[Title/Abstract]
S2	"qualitative study"[Title/Abstract] OR "qualitative research"[Title/Abstract] OR "qualitative inquiry"[Title/Abstract] OR "interview"[Title/Abstract] OR "perception"[Title/Abstract] OR "attitude"[Title/Abstract] OR "view"[Title/Abstract] OR "qualitative research"[MeSH Terms]
S3	"medicine"[Title/Abstract] OR "nurse"[Title/Abstract] OR "nursing"[Title/Abstract] OR "medical"[Title/Abstract] OR "medicine"[MeSH Terms] OR "nurses"[MeSH Terms]
S4	S1 AND S2 AND S3

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Cochrane Library(Totally=131)

S1	AI OR “Artificial intelligence” OR “medical big data” OR “healthcare data” OR “data sharing”[Title Abstract Keyword]
S2	’qualitative study’ OR ‘qualitative research’ OR ‘qualitative inquiry’ OR interview OR perception OR attitude OR view[Title Abstract Keyword]
S3	medicine OR nurse OR nursing OR medical[Title Abstract Keyword]
S4	S1 AND S2 AND S3

EMBASE(Totally=552)

S1	'artificial intelligence' OR 'healthcare data' OR 'medical big data' OR 'data sharing' OR AI[ti, ab]
S2	’qualitative study’ OR ‘qualitative research’ OR ‘qualitative inquiry’ OR interview OR perception OR attitude OR view[ti, ab]
S3	medicine OR nurse OR nursing OR medical[ti, ab]
S4	S1 AND S2 AND S3

CINAHL(Totally=376)

S1	'artificial intelligence' OR 'healthcare data' OR 'medical big data' OR 'data sharing' OR AI[ti, ab,su]
S2	’qualitative study’ OR ‘qualitative research’ OR ‘qualitative inquiry’ OR interview OR perception OR attitude OR view[ti, ab,su]
S3	medicine OR nurse OR nursing OR medical[ti, ab,su]
S4	S1 AND S2 AND S3

PsycINFO (Totally=98)

S1	'artificial intelligence' OR 'healthcare data' OR 'medical big data' OR 'data sharing' OR AI[ti, ab,mh]
S2	’qualitative study’ OR ‘qualitative research’ OR ‘qualitative inquiry’ OR

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	interview OR perception OR attitude OR view[ti, ab,mh]
S3	medicine OR nurse OR nursing OR medical[ti, ab,mh]
S4	S1 AND S2 AND S3
Totally	98

TOTAL FOUND: 5602

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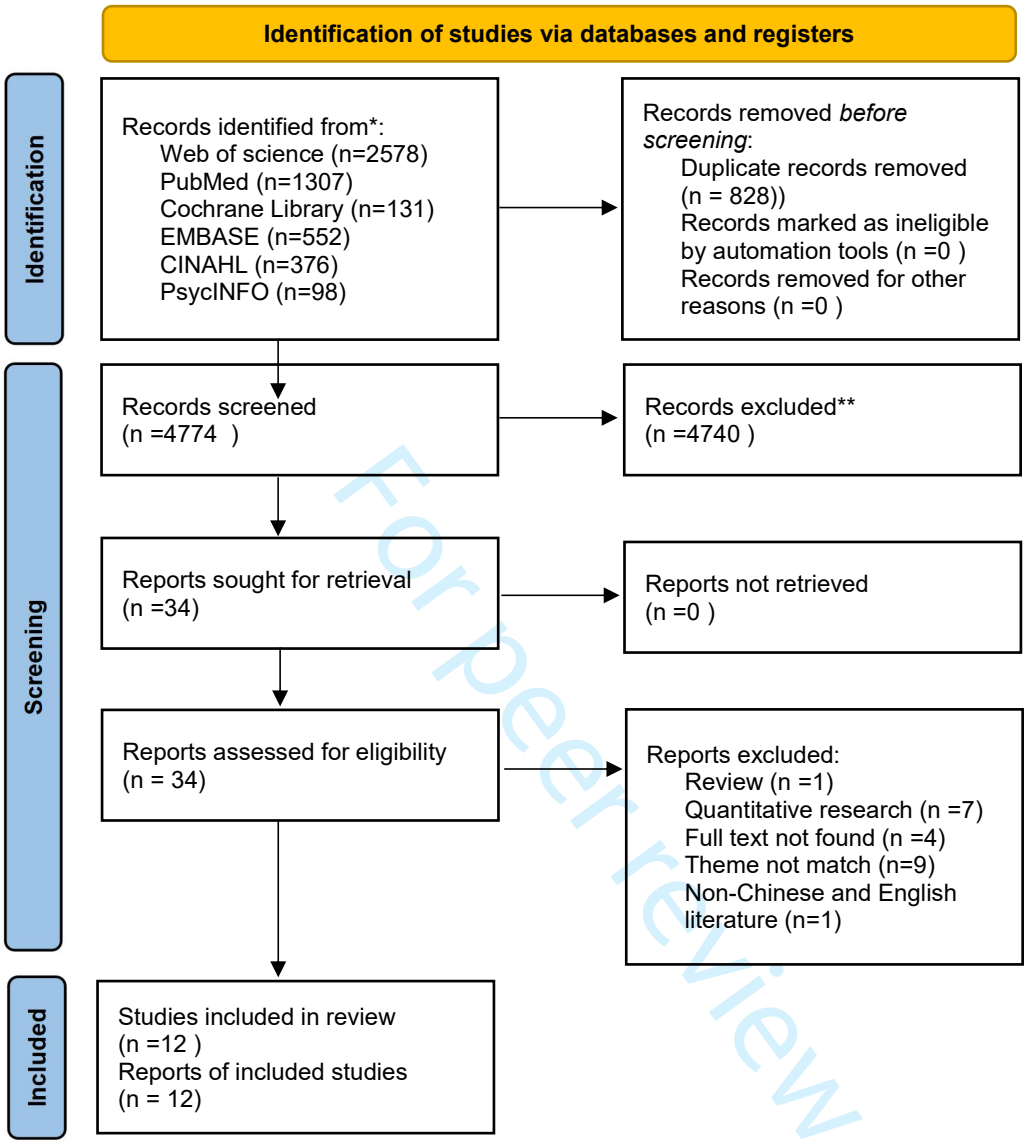
PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only



*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers).

**If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

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PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	2
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	2
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	3
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	3
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	3
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	3
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	3
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	4
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	5-6
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	5-6
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	4
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	Not Applicable
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	4
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	4
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Not applicable
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	Not applicable
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	Not applicable
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	Not applicable
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	Not applicable
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	4

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PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	4
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	4
Study characteristics	17	Cite each included study and present its characteristics.	5-6
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	6
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Not applicable
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	5
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	Not applicable
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	Not applicable
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	Not applicable
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	Not applicable
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	6
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	11-12
	23b	Discuss any limitations of the evidence included in the review.	12
	23c	Discuss any limitations of the review processes used.	12
	23d	Discuss implications of the results for practice, policy, and future research.	12
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	2
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	2
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	Not applicable
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	16
Competing interests	26	Declare any competing interests of review authors.	16
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	17

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

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BMJ Open

Public perceptions on the application of artificial intelligence in healthcare: A qualitative Meta-synthesis

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Manuscript ID	bmjopen-2022-066322.R2
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Complete List of Authors:	Wu, Chenxi; Sichuan University West China Hospital School of Nursing; Chengdu University of Traditional Chinese Medicine Xu, Huiqiong; Sichuan University West China Hospital School of Nursing Bai, Dingxi; Chengdu University of Traditional Chinese Medicine Chen, Xinyu; Chengdu University of Traditional Chinese Medicine Jiang, Xiaolian; Sichuan University West China Hospital School of Nursing Gao, Jing; Chengdu University of Traditional Chinese Medicine
Primary Subject Heading:	Qualitative research
Secondary Subject Heading:	Ethics, Health services research, Public health
Keywords:	MEDICAL ETHICS, Information technology < BIOTECHNOLOGY & BIOINFORMATICS, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

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Public perceptions on the application of artificial intelligence in healthcare: A qualitative Meta-synthesis

Title page

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Public perceptions on the application of artificial intelligence in healthcare: A qualitative Meta-synthesis

ABSTRACT

Objectives Medical artificial intelligence (AI) has been used widely applied in clinical field due to its convenience and innovation. However, several policy and regulatory issues such as credibility, sharing of responsibility and ethics have raised concerns in the use of AI. It is therefore necessary to understand the general public's views on medical AI. Herein, a meta synthesis was conducted to analyze and summarize the public's understanding of the application of AI in the healthcare field, to provide recommendations for future use and management of AI in medical practice.

Design This was a meta-synthesis of qualitative studies.

Method A search was performed on the following databases to identify studies published in English and Chinese: MEDLINE, CINAHL, Web of science, Cochrane library, Embase, PsycINFO, CNKI, Wanfang and VIP. The search was conducted from database inception to 25th December 2021. The meta-aggregation approach of JBI was used to summarize findings from qualitative studies, focusing on the public's perception of the application of AI in healthcare.

Results Of the 5128 studies screened, 12 met the inclusion criteria, hence were incorporated into analysis. Three synthesized findings were used as the basis of our conclusions, including advantages of medical AI from the public's perspective, ethical and legal concerns about medical AI from the public's perspective, and public suggestions on the application of AI in medical field.

Conclusion Results showed that the public acknowledges the unique advantages and convenience of medical AI. Meanwhile, several concerns about the application of medical AI were observed, most of which involve ethical and legal issues. The standard application and reasonable supervision of medical AI is key to ensuring its effective utilization. Based on the public's perspective, this analysis provides insights and suggestions for health managers on how to implement and apply medical AI smoothly, while ensuring safety in healthcare practice.

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Strengths and limitations of this study

- This meta-synthesis of qualitative studies was conducted in accordance with the Joanna Briggs Institute (JBI) methodology for meta-aggregation, and aimed to identify the public's perception on the application of AI in healthcare.
- The JBI Qualitative Critical Appraisal Checklist was used to evaluate the quality of the included studies.
- Synthesis of the included studies relied on the availability of direct quotes to the views or perceptions held by the public about the application of AI to healthcare.
- A limitation of this study is that only publications in English and Chinese were included in this meta-synthesis, which may potential cause language bias.
- The participants in each study showed varied experience with medical AI, future studies should consider this as a variable to explore the perceptions towards medical AI among different participants.

Introduction

Artificial intelligence (AI) is currently one of the most controversial topics,[1] especially since there is no consensus in its definition. Professor John McCarthy, one of the founders of AI, defines it as "the science and engineering of making intelligent machines".[2] In other monographs, AI was referred to as the development of computer algorithms to accomplish tasks traditionally associated with human intelligence, such as the ability to learn and solve problems.[3] In recent years, AI has been increasingly applied in the field of medical and health care. For example, in radiology, with the help of big data and deep learning technologies, AI imaging applications not only improve the accuracy of diagnosis, but also facilitate timely diagnosis.[4] Another widely used AI system is the medical robots,[5] and the advantages of the Da Vinci's robotic surgery system in reducing intraoperative bleeding and shortening the operation time have been document.[6-7] In addition, during the COVID-19 outbreak, the use of such aids as UV-disinfectants and social robots was found to be effective in managing disease, treating patients, and ensuring the safety of healthcare workers.[8] Artificial intelligence can also be used in public health management, for instance, use of mobile health apps in the rehabilitation of patients with chronic diseases[9] such as diabetes,[10] and stroke.[11] Moreover, some studies investigated the application of AI in diet,[12] sports[13] and emotional management.[14] In fact, some scholars believe that AI is likely to reshape and re-orient

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clinical medical practice in the next few years.[15] Moreover, it is estimated that by 2026, the global expenditure on healthcare AI technologies will reach up to 45 billion US dollars.[16] Although the application of AI in healthcare has greatly improved disease diagnosis and management, compared with the application of AI in other industry, such as engineering of smart devices, its use in health care is still at its infancy, and its promotion and application still faces many uncertainties and challenges. According to Choudhury,[17] these challenges may manifest evidently at the macro, technical and individual levels. At the macro level, a recent survey of 265 clinicians actively practicing in the United States revealed there are many regulatory and policy difficulties in the application of AI. The survey revealed that lack of AI accountability is a significant barrier to its adoption in health care.[10] At the technical level, since the performance of healthcare AI systems depends heavily on the data they are trained on, AI integrations that do not address data quality issues could exacerbate biases in healthcare due to the biased data storage inventories that are in existence.[12] For example, an algorithm that is mostly trained on Caucasian patients is not expected to have the same accuracy when applied to minorities.[18] In addition, many developers for health care AI apps are not the end users. As such, developers primarily focus on AI's analytic capabilities, accuracy, speed, and data handling, with little attention to the human perspective,[19] which limits the clinical utility of the designed apps. In fact, most AI tools that have shown good performance during development are impractical in clinical practice,[20] and according to a survey published on the BBC in 2020, 80% of health care AI apps fail to meet the National Health Service (NHS) standards.[21] Challenges at the individual level included issues around the awareness and trust of individuals on AI.[16,22] In his research, Choudhury[10] derived a framework that focuses on the interaction between AI and clinicians. This framework can explain how interactions between clinicians and AI vary according to human factors such as expectations, workload, trust, cognitive variables related to absorptive capacity and bounded rationality, and concerns about patient safety. Moreover, as additional potential users of healthcare AI, the public's attitudes, requirements, and expectations towards the tool need to be explored. Here, the term "public" refers to both patients and healthy individuals, because research on health care AI relies on large data sets, which should contain information from both patients who may benefit from the study, as well as people who with no health conditions and/or cannot benefit directly.[23] Therefore, a comprehensive understanding of the public's perspective can provide a more representative picture for future development of healthcare AI.[24]

To date, research on AI involves qualitative studies exploring the public's awareness and views towards healthcare AI.[25-27] However, results from a single qualitative study may not represent the public's perception in a holistic manner. Accordingly, this study integrated several qualitative studies on the public's perceptions and views on healthcare AI to provide guidance for the development of effective AI.

METHODS

A meta-aggregation approach developed by the Joanna Briggs Institution (JBI) was used in this systematic review and qualitative meta-synthesis. The study was conducted between September 2021 and January 2022, according to the PRISMA recommendations.[28]

Search strategy

The following three-step method was adopted in this review: Firstly, an initial limited search was conducted on the Medline and CINAHL, after which a text word analysis of the title, abstract, and index terms used to describe the articles was performed. A second extensive search was performed in the included databases (MEDLINE, CINAHL, Web of science, Cochrane library, Embase, PsycINFO, CNKI, Wanfang and VIP) using all the identified keywords and index terms. Lastly, the reference lists of all the identified reports and articles were searched to identify additional studies. Only studies published in English and Chinese were enrolled in this review, with no restriction for publication date. The search strings and titles extracted from each database are shown in the online **Supplemental File 1**.

Inclusion and exclusion criteria

► The following were the inclusion criteria for the study:

(a) Population: Members of the public, regardless of age, gender, health status, or history of medical AI use etc.

(b) Phenomenon of interest: The public's perceptions about the use of AI in healthcare.

(c) Setting: Hospitals, homes, or nursing homes, where healthcare AI was applied.

(d) Design: Qualitative or a mixed-methods study design.

(e) Language: English or Chinese.

► The Exclusion criteria included:

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(a) Design: Studies that did not use a qualitative approach.

(b) Study types: Conference papers, editorials, letters or general-comment articles.

(c) Language: Studies published in neither English nor Chinese.

(d) Studies for which we couldn't get either the full text or the data collection and analysis methods were not reported.

Study section

The initially retrieved articles were imported into the Endnote X9 software, and repeated literature were removed. Two investigators (CXW and XYC) screened all the records independently and read the titles and abstracts to exclude literature that did not met the inclusion criteria. The full texts were read to identify studies that could be included in the analysis. In the event of discrepant results, a third researcher (DXB) was invited to join the discussion and reach a consensus.

Assessment of methodological quality

The methodological validity of the retrieved qualitative research papers was assessed by two reviewers using the JBI Qualitative Critical Appraisal Checklist, which contains ten items to ensure the appropriateness of the methodological approach, the method application and the representation of the voice of participants in studies. Each criterion had three levels, i.e., "yes", "no" and "unclear", and papers with less than six "yes" were excluded to ensure quality. Any disagreements between two reviewers were resolved through discussion, or a third reviewer was involved to reach a consensus.

Data extraction and synthesis

General characteristics of included studies were extracted to gain a better understanding of the literature which included author (s) name, regions, research objects, research methods, phenomena of interest and main research results. The texts labeled as results / findings, discussion / interpretation and conclusions by the original qualitative studies' authors were extracted verbatim and entered into Nvivo 2021 software. The JBI meta-aggregation aproach[29,30] was used to extract and synthesize the data. The philosophical foundation of the meta-aggregation approach is pragmatism and Husserlian transcendental phenomenology. The consistency of this approach with the philosophy pragmatism is reflected in its aim to produce comprehensive statements in the form of 'lines of action' to inform decision-making at the clinical or policy level.[31] As a result, it avoids reinterpretation of original research results and moves beyond the generation of theories. All findings or themes were presented in the manner as they were in the original studies, without reinterpretation. Two reviewers (CXW and DXB) re-read each included study to ensure maximum familiarity with the data. Subsequently, a three-step process was adopted to synthesis qualitative findings. All the concluding findings from each included paper were extracted. The findings were then categorized based on similarity in meaning, with at least two findings per category. The categories were subjected to a meta-synthesis to form a comprehensive set of synthesized findings. For each finding, two reviewers independently assessed the degree of congruity between the findings and the supporting data, and a credibility score was provided for each finding as follows: unequivocal, credible, unsupported. "Unequivocal" indicates the congruence of the finding and the supporting data was beyond a reasonable doubt, "credible" means a clear association between them was lacking, and "unsupported" implies that the data did not support the findings. Only unequivocal and credible findings were included, unsupported findings were presented separately (There is no unsupported findings in this study).

Patient and public involvement statement

No patients or members of the public were involved in this research.

Results

A total of 12 papers were included in this study, including 5 grounded theory studies, 6 descriptive qualitative studies, and 1 phenomenological study. **Figure 1** shows the literature screening process and results.

Study characteristics and quality of studies

The characteristics of the included literatures are shown in **Table 1**. All studies showed congruity between the research methodology and research questions, representation and analysis of data, data collection methods and results interpretation. Participants and their voices were adequately represented, and the conclusions were based on the data. Almost all studies (n=11) did not include statements regarding the cultural or theoretical perspectives of the researchers except the research conducted by McCradden. Furthermore, 10 studies did not address the influence of the researcher on the research nor the influence of the

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research on the researcher. Almost all studies (n=11) presented evidence of ethical approval by the respective body. Six studies showed unclear congruity between the stated philosophical perspective and the research methodology. Results of the quality assessment are presented in **Table 2**.

Table 1 Study characteristics

Study	Country	Methodology	Participants(n)	AI's application setting	Phenomenon of interest	Main results
Haan, Marieke2019[32]	Netherlands	Grounded theory	Patients scheduled for a CT scan of the chest and abdomen on an outpatient basis (20)	In radiology outpatient	Patients' view on what They need to know about the use of AI in radiology.	Six themes：①Proof of technology about efficacy and reliability of AI；②Procedural knowledge about understanding how AI will be implemented in the current radiological practice；③The capability of AI to produce reliable results；④Efficiency related to the scanning process；⑤Personal interaction between patients and doctors；⑥The responsibility of humans when computers make mistakes.
Thenral M 2020[33]	India	Grounded theory	Patients of psychiatrists who had used web-based/ phone-based telemedicine services for consulting patients(14)	In psychological consultation of clinical practice	The perceive challenges of building, developing and using AI-enabled telepsychiatr for clinical practice from the perspectives of patients.	Four themes：①Ethical, legal, accountability, and regulatory problems of AI；②Financial issues；③Tefchnology problems of AI；④Clinical-practice problems of AI
Chao Bian 2021[34]	Canada	Descriptive qualitative study	Adults be aged at least 65 years and older (15)	Assessing frailty in home settings	Older adults' perceptions and preferences of technologies that can potentially assess frailty at home.	Four themes：①General attitude towards using the technologies；②Conditions for accepting certain technologies；③Existing living habits or patterns Related to using the technologies；④Constructive suggestions related to the technologies.
Zhan Zhang 2021[35]	USA	Descriptive qualitative study	Patients who have recent experience with using patient portals to review their diagnostic results (13)	Interpreting imaging data and radiology reports	Patients' perceptions and acceptance of using AI technology to interpret their radiology reports.	There themes：①General perceptions of using AI tools to interpret diagnostic results；②Concerns；③Increasing acceptability and trustworthy of AI-based systems in communicating radiology report findings.
T.E. Sangers 2021[36]	Netherlands	Grounded theory	General Public(27)	In skin cancer screening	The perceived barriers and facilitators towards mHealth apps for skin cancer screening among the Dutch general population.	Two themes：①Barriers to using mHealth skin cancer screening apps ②Facilitators of mHealth use.
Melissa D 2020[37]	Canada	Descriptive qualitative study	General public who had signed up to participate in research studies(41)	In health data research	The perspectives of the general public regarding the use of health data in AI research.	Five themes：①Mixed, mostly negative views about artificial intelligence (AI) in general；②Hopes and perceived benefits of health artificial intelligence (AI) research scenarios；③Fears and perceived drawbacks of health AI research scenarios；④Conditions under which health AI research scenarios are more acceptable；⑤Educational effect of realistic health AI research scenarios.
Melissa D 2020[38]	Canada	Descriptive qualitative study	Patients with meningioma and their caregivers (18)	In health care research	Current perspectives of patients on ethical issues surrounding AI in health care.	Four themes：①Protection of health data；②Skepticism regarding accountability mechanisms；③Computer-based predictions；④Trust and confidentiality
Vandemeulebr2 019[39]	Belgium	Grounded theory	Adults be aged at least 70 years and older (59)	In aged care	Community-dwelling older adults perceive as ethical issues of socially assistive robots(SARs) in aged care.	There themes：①SARs as components of a techno-societal evolution；② SARs' embeddedness in aged-care dynamics,；③ SARs as embodiments of ethical considerations
Caroline A. 2020[40]	USA	Grounded theory	Patients with skin cancer (48)	In skin cancer screening	How patients perceive the use of AI for skin cancer screening.	Five themes：①AI's benefits；② AI's risks；③AI's strengths；④AI's weaknesses；⑤AI's implementation

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Jordan P. 2021[41]	USA	Descriptive qualitative study	Patients（87）	In healthcare	How patients view the use of AI in their healthcare.	Five themes：①Participants were excited about healthcare AI but wanted assurances about safety；② Patients expect their clinicians to ensure AI safety；③ Preservation of patient choice and autonomy；④ Concerns about healthcare costs and insurance coverage；⑤Ensuring data integrity；⑥Risks of technology-dependent systems.
Ding Ping 2016[42]	China	Phenomenology	Patients undergoing Da Vinci robotic surgery（12）	In surgery	Perioperative psychological experience of patients undergoing DaVinci robotic surgery	Four themes：①Patients have a gradual psychological acceptance process for robotic surgery；②Most patients need knowledge about robotic surgery and postoperative rehabilitation guidance；③Most patients are confident about robotic surgery；④Most patients are worried about the cost of robotic surgery.
Anne Müller 2021[43]	Germany	Descriptive qualitative study	Patients visiting the department of oral diagnostics（5）	In dental diagnostics	How all these different factors may act as barriers or enablers to implement AI in care	Three themes：①Enablers for patients；②Conflicting Themes for patients；③Barriers for patients

Table 2 Quality assessment of included studies

Citation	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Score
Haan et al. (2019)	Y	Y	N	Y	Y	Y	Y	Y	N	Y	8
Thenral & Annamalai (2020)	Y	Y	N	Y	Y	Y	Y	Y	N	Y	8
Bian et al. (2021)	Y	Y	N	Y	Y	U	Y	Y	Y	Y	8
Zhang et al. (2021)	Y	Y	N	Y	Y	U	Y	Y	Y	Y	8
Sangers et al. (2021)	Y	Y	N	Y	Y	Y	Y	Y	N	Y	8
McCradden et al. (2020)	Y	Y	N	Y	Y	U	Y	Y	Y	N	8
McCradden, Sarker & Paprica (2020)	Y	Y	Y	Y	Y	U	Y	Y	N	Y	8
Topol (2019)	Y	Y	N	Y	Y	Y	Y	Y	N	Y	8
Nelson et al.(2020)	Y	Y	N	Y	Y	Y	Y	Y	N	Y	8
Richardson et al. (2021)	Y	Y	N	Y	Y	U	Y	Y	N	Y	7
Ding et al. (2016)	Y	Y	N	Y	Y	Y	Y	Y	N	Y	8
Müller et al. (2021)	Y	Y	N	Y	Y	U	Y	Y	N	Y	7

Q1:Is there congruity between the research methodology and the research questions or objectives?

Q2:Is there congruity between the research methodology and the representation and analysis of data ?

Q3:Is there a statement locating the researcher culturally or theoretically?

Q4:Are participants and their voices adequately represented?

Q5:Do the conclusions drawn from the research report flow from the analysis or interpretation of the data?

Q6:Is there congruity between the stated philosophical perspective and the research methodology?

Q7:Is there congruity between the research methodology and the data collection methods?

Q8:Is there congruity between the research methodology and the interpretation of results?

Q9:Is the influence of the researcher on the research, and vice- versa, addressed?

Q10:Is the research ethical according to current criteria or, for recent studies, and is there evidence of ethical approval by an appropriate body?

Appraisal result: “Y”: Yes; “N”: No; “U”: Unclear.

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Meta-aggregation

A total of 39 findings rated as “unequivocal” or “credible” were extracted from 12 studies included in the synthesis. The 39 findings were aggregated into 12

categories, which were subsequently classified into 3 synthesized findings. **Figure 2** shows the summary of study findings, categories, and synthesized findings on public perceptions on the application of AI in healthcare.

Synthesized finding 1: Advantages of medical AI from the public's perspective.

The first theme integrated from the included studies was that, to the public eye, medical AI has several advantages. For instance, AI has large data-storage capacity, remarkable efficiency, and it can help monitor and promote health in real time.

Category 1: AI has the large data storage capacity advantage.

The public described the role of AI's huge data storage advantage in meeting their medical needs. According to most individuals, the AI system can be used to seek more personalized and actionable information. Through the medical AI system, more medical information that is easy to understand can be obtained, and comparison of medical information or data can be realized to provide more evidence-based suggestions. Additionally, the public could get a second opinion besides their care providers. The large amount of medical data possessed by AI also becomes an important aid to making accurate diagnoses. In the eyes of the public, healthcare AI is more intelligent, and can use more information to make a proper diagnosis. Two exemplar quotes follow:

"I mean, it's (AI) not a human. It's got more data, so probably. … [I]t probably has more intelligence; it just has more information to work with to try to come up with a proper diagnosis. … I don't think you will cure a lot of diseases without that advanced intellect."[41]

"Exactly, with such a report you could go to another dentist and get a second opinion. This would be fantastic, right."[43]

Category 2: AI is remarkably efficient.

High efficiency is considered one of the outstanding advantages of AI technology applied to the healthcare. According to most members of the public, healthcare AI can improve the efficiency of medical tasks, such as imaging scans, thereby reducing the waiting time. In addition, AI can process massive amounts of data to detect possible abnormalities in time to speed up diagnosis and treatment, hence preventing deterioration caused by disease. Two exemplar quotes follow:

"When you can reach out and have a sample size of a group of ten million people and to be able to extract data from that … a team of researchers can't do that. You need AI."[34]

"If the app says, 'You probably have melanoma—go see your doctor,' they might actually get in there sooner…so it could be lifesaving."[40]

Category 3: AI helps monitor and promote health in real time.

In the eyes of the public, medical AI can continuously track and collect health data to help in understanding the health status of users, find potential health problems in time, and provide corresponding suggestions. The data collected by medical AI can also provide basis for physicians to make medical decisions. Moreover, healthcare AI was perceived as a useful tool to help individuals prepare for clinical visits. Specifically, it can provide reliable information that individuals can research on and construct relevant questions prior to the consultation. Therefore, by doing so, people can be more prepared for consultations with their care providers. Two exemplar quotes follow:

"I would use it (healthcare AI) because I think the more information you can give to your doctor, the better off he/she's going to be when it comes to treating something that you might have, whether it's a frailty or whatever, and if things like this can help improve the quality of people's lives as we age, then I think it's a good thing."[34]

"Maybe give a user questions that they can ask the doctor, because that's the other thing I noticed, is that a lot of people don't get the results they want, or the medical outcomes,because they don't know what questions to ask the doctor. ……But if AI could be like, 'Hey, here is your results, do you feel this? Or do you have problems breathing? Or so on and so forth, and if you do, please bring this up with your doctor.' My stepmother works in the ER and she's an RN [Registered Nurse]. And she's like, 'Half the time when people come in, if they were just able to ask the right questions, they would be in and out, they'd start treatment immediately.'"[35]

Synthesized finding 2*:* Ethical and legal concerns about medical AI from the public's perspective

Most studies mentioned the public's concerns about ethical and legal issues surrounding the application of medical AI. First, people expressed concerns about the reliability of medical AI, as most of them had no knowledge on how the AI system works. Second, the public expressed concerns about data ethics

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in medical AI. Third, the responsibilities and rights of different parties during the application of medical AI are currently not clear. In addition, some people believed that the use of medical AI will affect communication between people. Some members of the public were also worried that too much reliance on AI technology will affect the performance of medical staff. Finally, the public raised concerns over the cost of medical AI.

Category 4: Concerns about the reliability of AI.

The public had doubts about the accuracy and reliability of health data recorded by AI. AI algorithms have black box properties, for the public, the process by which medical AI makes decisions through calculations is opaque and difficult to understand. This lack of transparency puts the credibility of medical AI into question. In addition, the public was worried that AI could exacerbate biases that could arise from an inherently biased learning dataset or by developers inadvertently incorporating their biases into AI algorithms. Moreover, some people reported finding errors in their health records, and did not know if medical staff could detect and fix errors in the AI platforms in use. Two exemplar quotes follow:

"I would need proof that it works and what you're actually getting is meaningful information. Like it's not just some crap. If it's going to make recommendations to me, I want them to be proven that they're actually legit."[35]

"So I've had a lot of different things in my medical chart that are inaccurate, very inaccurate, so if they're training an artificial intelligence that this is facts, it's like, well no."[36]

Category 5: Concerns about data security and privacy protection.

Data security and privacy is a major concern for the public in terms of data ethics. Therefore, the public's main concern is whether medical AI systems contain confidentiality features and whether they can protect sensitive health information from potential hacking or data leakage. Another concern is that health data provided for a medical AI could be sold or used for other purposes that most people disagreed with. In addition, some members of the public expressed concerns about medical apps sharing personal data for disease diagnosis. Moreover, some devices with monitoring functions also made most people feel that their privacy is violated. Two exemplar quotes follow:

"There is always a possibility of hackers taking over telemedicine platforms and causing data theft. Apart from that, when there are security lapses, the possibility of stealing vital bank information from the mobile (that is used for accessing the mental health service) is also possible….."[33]

"Are they going to take my information, are they going to sell it? So, it kind of makes you scared when other companies are buying it."[37]

Category 6: Concerns about the responsibilities and rights associated with the application of medical AI

The public was unsure whether the data collected by AI belonged to the patient alone, and the level of access that could be granted to developers or service providers. At the same time, people had concerns over who could be held responsible for errors made by medical AI. In addition, some members of the public were worried that low-quality AI products may come up when there is insufficient supervision, hence harm the interests of users. Two exemplar quotes follow:

"Several legal issues are yet to be clarified …for instance, if there is a misdiagnosis or missed diagnosis, who will the patient sue…. Doctor? Developer? Platform owners?"[33]

"I have some background in electronics….. The way things are made, 'cause I've actually worked in the industry of making medical equipment, it's all about using the cheapest method to get the end result. Well, electronics fail. They just do."[40]

Category 7: Concerns about communication being affected by AI.

From the public perspective, their medical needs can only be met if someone understands what they are expressing. They argue that the AI machines' depersonalized procedures, in which patients become numbers, they may be treated in an indiscriminate manner. Similarly, AI cannot understand patients' emotions during communication, and thus the responses provided by AI are considered depersonalized and dehumanizing. In addition, patients believe AI has a negative impact on interpersonal communication because people do not relate to each other under the atmosphere of AI, therefore communication with medical AI may be inefficient, both to the patients and doctors who prefer face-to-face communication. Two exemplar quotes follow:

"Emotionally, a robot would not appeal to me. It can be nice and say nice things, but I would have emotional difficulties with it."[39]

"I don't find it very appropriate. First of all, it's going to take jobs away from health professionals. If the app has to tell them, suggest things or

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whatever, there's no communication there, like face-to face."[37]

Category 8: Concerns about the over-reliance of healthcare workers on medical AI.

Although the public acknowledges that medical AI can help medical staff become more efficient, they raised concerns that doctors may get used to utilizing AI technology to process all information, which will affect their basic abilities, such as reading. This will imply that without access to these AI tools, high-quality care may not be able to provided. In addition, people believe that over-reliance on AI programs or algorithms will reduce the insight of medical staff, which may mean they lose some soft skills or even can't work without it. These concerns indicate the public's perception about the role of AI in medical practice, preferring that AI should only be used as an auxiliary tool. Two exemplar quotes follow:

"If they were to get hacked or a system goes down … like what's the contingency plan, but what is the contingency plan? If you have all these doctors who are so used to having this artificial intelligence read all these, and they don't have the skill of reading it, then what happens?"[41]

"So that's a concern, that you lose some of those soft skills and that relies on intuition when you rely solely on AI, on computers and programs and algorithms."[37]

Category 9: Concerns about economic impact.

The public expressed their concerns about the potential financial burden of medical AI, with many fearing it may increase healthcare costs which will be passed on to patients. In their opinion, AI is expensive to develop and deploy. Second, they worry about the impact of AI recommendations on the types of treatments covered by insurance, for example, AI may recommend a treatment which most patients cannot afford. In addition, AI equipment needs equipment, network and other hardware guarantees, low-income groups may not afford, and this may exacerbate inequalities in health care. Two exemplar quotes follow:

"Robotic surgery is new, I don't know the reimbursement policy or how much insurance will cover it.If the cost is too much for me personally, then I can't afford it."[42]

"All these devices, technology, AI, etc., require high-speed internet ... patients who have basic livelihood issues cannot afford a device or internet."[33]

Synthesized finding 3: Public suggestions on the application of medical AI.

The public's has views on the application scenarios for medical AI, conditions that can facilitate the application of AI. They suggested that medical AI should first meet the individual needs and respect the autonomy of the public. In addition, medical AI should be transparent and credible, as well as properly regulated. Finally, AI should only be used as an auxiliary tool in medical practice, not as a decision maker.

Category 10: Meet the individual needs and respect their autonomy.

The public indicated that medical AI should fully consider users' specific needs; they considered providing personalized information is a key feature of AI. Also, medical AI should be usable by all ages, whether they are tech-savvy or not, and older people may need easier modes of AI interaction. Some argued that medical AI will be more acceptable if it can provide more functionality while performing its core functions. In addition, they indicated that medical AI should only provide risk levels but not a definite diagnosis, and when medical AI makes a recommendation, it should be up to the users to decide whether or not to follow the recommendation, rather than forcing them to follow it. For example, when an app makes a recommendation to see a doctor, the recommendation should not be binding, nor should it take away the user's freedom to see a doctor. Two exemplar quotes follow:

"User-friendliness is an important precondition if you want to entice people to use it (mobile health (mHealth) apps)."[36]

"I would like her [the SAR "Alice"] (robot) in my environment . . . For when something has been spilled and she cleans it up and other things ... But I decide when she meddles with me."[39]

Category 11: Improve the transparency and credibility of medical AI.

The public will be more receptive to medical AI technology and its related research if there is transparency about how data are used in health AI. Moreover, some people expressed the need to understand how AI systems generate medical information so that they can decide whether to trust advice provided by AI. Another approach for increasing the credibility of medical AI is to disclose its information sources. In addition, the people also stressed the need to have proper supervision and management of medical AI, and endorsement by healthcare providers and government regulators may also increase public acceptance

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of AI. Two exemplar quotes follow:

"My level of trust would depend on the source naturally. If it's from Joe down the street, obviously I wouldn't be too crazy about it. But if it's from a trusted source, like a well-respected medical organization or something like that, like John Hopkins or Mayo Clinic, that would probably help build a little bit of trust."[35]

"If you would also give it approval because of a ministry or because of a legal regulation or something like that, this guarantee should be legal. The responsibility lies with the government with regard to its quality."[36]

Category 12: Use AI as an auxiliary tool in medical practice, not as a decision maker.

The public held the view that the human element should not be removed from the healthcare process, thus, medical AI should only be a complementary service, not a replacement for professional health forces, and the final decision should be made by real people, the users of AI (doctor, nurse, patient, etc.). The public also mentioned that the information provided by AI should be for reference only, not for determination of patient treatment. Finally, they hope medical AI could be equipped with assistive functions in order to find more detailed information apart from what they what to know mainly. Two exemplar quotes follow:

"As long as it's a tool, like the doctor uses the tool and the doctor makes the call. As long as the doctor is making the call, and it's not a computer telling the doctor what to do."[37]

"They report that they would like to receive results not only of findings based on the questions of the referring physician (i.e., the primary aims of the scans) but also of incidental or unrequested findings that can be extracted from the scan."[34]

Discussion

This meta-synthesis concluded the public's attitudes and perceptions towards medical AI. 12 qualitative studies were included in the present research, resulting in 39 findings, that were summarized into 12 categories and further generalized into 3 synthesized findings. The analysis revealed that while the public acknowledges the convenience and benefits of medical AI, there are many concerns about its implementation, such as personal privacy, data security, and regulation. In addition, members of the public gave their opinions on how to increase the credibility and acceptability of AI. These findings provide important insights that can be used as a reference for future research, development, and application of medical AI.

Understanding how medical AI works will help improve its acceptability

AI is already widely used in healthcare, and the studies included in this analysis involved the use of AI in such aspects as disease screening, diagnosis, risk warning, adjuvant therapy and intelligent health care. In addition, AI is increasingly being applied in the research and development of new drugs,[44] as well as in the prevention and treatment of COVID-19.[45] With the accumulation of massive medical data and the improvement of hardware computing capacity, medical AI has built a data-driven deep learning system.[46] In this way, it can meet the public's medical and health needs more efficiently and with high quality in many aspects of healthcare. The present results show that the public fully recognizes the advantages of medical AI. However, two types AI technologies used in health care, machine learning (ML) and deep learning (DL) have black-box attributes, in the sense that they cannot explain how predictions are made based on the two technologies.[47,48] As a result, users are unable to understand the prediction process and verify the results given by ML or DL models, leading to low public acceptance of medical AI.[49] In the several original studies included in this paper, the public expressed doubts about the effectiveness and accuracy of medical AI.[36,40,41] Therefore, overcoming the black-box problem and helping the public to understand how models work and perform predictions, is an important aspect for the evolution of medical AI. This challenge could be solved through explainable artificial intelligence (XAI), defined as a set of features that explain how the AI model constructs its predictions.[50] For example, in a study involving categorizing tuberculosis diagnoses through deep learning chest radiographs, researchers used heat maps to show areas of increased activation of deep learning networks that could be inferred to be important for diagnosis.[51] Therefore, by adding the XAI technology to ML and DL models, the use of AI in healthcare will become more reliable and acceptable.[52-54] In addition, before application, the public should be educated on the principles of the medical AI system, including how it works.

A safe and healthy AI application environment is crucial

Literature review and the results from this study indicate that the public has concerns over medical AI, including those pertaining to security, privacy protection, responsibility attribution, and reimbursement of medical expenses, all of which are related to improper policy and regulatory systems.[55]

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Regarding medical security, AI systems can cause medical security accidents due to malicious attacks by hackers,[56] system loopholes,[57] algorithm differences[58] and other factors that may threaten the safety of patient lives. With regard to privacy protection, the development of medical AI requires collection of a wide-range health data,[59] resulting in varying degrees of security risks to the public in terms of physical, information and the right to decision-making privacy. According to a previous study, 59.72% of the public was concerned about the privacy disclosure during the application of medical AI.[60] Personal privacy information may be obtained, spread and used by unauthorized individuals, through network breaches, resulting in the violation of personal privacy. Some information derived from artificial intelligence learning and analysis has also become one of the most important ways of privacy violation.[61] At the same time, the emergence of AI has created a fuzzy zone between academic research and clinical application, making the public wary of the exchange of their private information between commercial and non-commercial platforms. Notably, in a study of four thousand American adults, only 11% were willing to share health data with tech companies, versus 72% with physicians.[62] In terms of rights and responsibilities, public health data is an important basis for AI, but the ownership of data management has always been controversial. Conflicts of interest between data source subjects and data processors continue to exist, and ways to guarantee informed consent from the public in the process of using medical data need to be established. When AI poses a threat to public medical security or causes an accident, the definition of the subject of responsibility is still unclear. There is currently no consensus whether responsibility in the event of accidents should be taken by medical staff, AI producers or AI itself. Regarding expenses, the operation of medical AI often requires the support of expensive equipment, network and other hardware or software facilities. This, coupled with the currently unclear insurance reimbursement system for medical AI expenses, may increase the financial burden on the public from the use of medical AI.

In summary, the establishment and improvement of medical AI policy and regulation systems is key to enhancing its promotion and application. Most importantly, to maximize the protection of public health and safety, a quality evaluation system for medical AI should be formulated, and its acceptance criteria and regulatory system should be improved to enhance its service and protective performance. Secondly, the management of private information such as medical data should be improved to ensure privacy and security of public information during the whole process of development, application, and destruction of medical AI. Thirdly, to avoid adverse events and improve the public's trust in medical AI, the responsibility supervision system and rights protection mechanism should be established and improved, and the rights and responsibilities of medical AI should be clarified. Finally, regulations should be formulated to reasonably control the costs associated with medical AI and improve the insurance reimbursement system to address people's economic concerns.

The public expects "people-oriented" medical AI

In this analysis, ethical issues such as social problems, excessive reliance on AI, and the role of AI have also attracted wide attention from the public. While medical AI has broadened the channels of communication between the public and healthcare workers, it also faces problems such as conflicting medical advice. Information asymmetry not only leads to public distrust in medical staff, but also makes the public anxious and worried about their own health conditions. In addition, the AI products in current use are basically programmed mechanical devices, which may lead to the absence of humanized therapies.[63,64] The use of medical AI may also deprive the public of autonomy and weaken emotional support among people. This problem is particularly evident in the application of AI in caring for the elderly[39] and in psychotherapy.[65] Moreover, members of the public believe that both they and medical staff are over-dependent on AI, and there is a risk that their skills and knowledge may be deprived by AI.

The aforementioned concerns suggest that the role of medical AI in healthcare is still not clearly defined. Furthermore, the public hold the idea that AI should only serve as an auxiliary tool. Therefore, the concept of "people-oriented" and the corresponding ethical principles should be implemented throughout the application of medical AI. Additionally, research, development and application of medical AI should be patient-centered and follow the medical ethical principles of “putting patients' interests first, respecting patients and being fair”. As medical AI is becoming increasingly popular, various fields have made attempts to strengthen its ethical governance. For example, in the fields of nuclear medicine and molecular imaging, 16 ethical principles have been proposed to guide the development and implementation of AI.[66] Such include “common good and benefit”, “first do no harm”, and “patient safety and quality of care”. In summary, ethical issues should be considered during the development of medical AI to ensure maximum benefit to the well-being of humans.

Limitations and future directions

Although this meta-synthesis adopted a rigorous design and complied with the meta-aggregation approach of JBI, several limitations were observed. Firstly, only studies published in English and Chinese were included, which may cause language bias. Besides, the participants of each study had different

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experience in application of medical AI. Specifically, of the 12 included studies, 6[32-34,37,38,43] did not specify whether interviewees had experience with the application of medical AI, 2[39,41] reported that respondents had no experience with using medical AI, 2[35,42] reported that respondents had used the medical AI technology, and the other 2[36,40] had both experienced and inexperienced respondents. Since participants' perception of medical AI may be affected by their experiences with it, future research should consider experiences as a variable, and compare differences in perceptions of various respondents and possible reasons, to arrive at richer and stronger conclusions.

Clinical implications for health managers and policymakers

According to this meta-integration, one of the main concerns for the public was the right to informed consent. Therefore, medical institutions should establish management systems to guide the use of AI, to guarantee the right of informed consent to the public, especially for institutions which have their own data infrastructure. Secondly, health institutions should fully understand the performance of their medical AI platforms, clarify their role in the process of diagnosis and treatment, avoid over-reliance by medical staff on medical AI and ensure the safety of treatment.

Conclusions

This meta-synthesis study reveals that from the public perspective, medical AI has greatly improved modern medical and health care, but also brought many social ethical issues and challenges. This study also puts forward suggestions to promote the application of medical AI from the perspective of the public. As one of the important component of the healthcare system, the public's perception of the advantages of medical AI is an important driving force to promote its development. Meanwhile, the public's concerns about the application of medical AI should be deeply concerned, and it should be used as a reference perspective for the development, operation and management of medical AI to promote its continuous application.We should strengthen the management of AI from both legal governance and ethical constraints, minimizing or eliminating its disadvantages and maximize its advantages while maintaining the social values of security, fairness and justice.

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Authors' contributions

CXW conceived the study idea, participated in study design and method development, screened titles, abstracts and full text articles,carried out the data extraction and quality appraisal of included articles, coded the extracted findings and performed the data synthesis. CXW wrote the manuscript.DXB independently screened the titles, abstracts and full texts of the retrieved articles to ensure that they met the inclusion criteria, and contributed to the writing of the manuscript. XYC applied for regulatory approval, independently extracted data from the included articles, evaluated their qualities and coded the extracted results, contributed to the final synthesis of the data. JG was involved in designing the study, developing the methods, contributing to the synthesis of the extracted findings, and monitoring article quality. XLJ was involved in study design, research method development and monitoring article quality. HQX contributed to the writing of the subsequent revision of the manuscript and enhanced the English quality of the article. All authors read and approved the final manuscript.

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Figure legends

Figure 1: Literature screening process and results using preferred reporting items for systematic reviews and meta-analyses (PRISMA) flow chart

Figure 2: Meta-synthesis findings of the general public's perceptions on the application of artificial intelligence in healthcare

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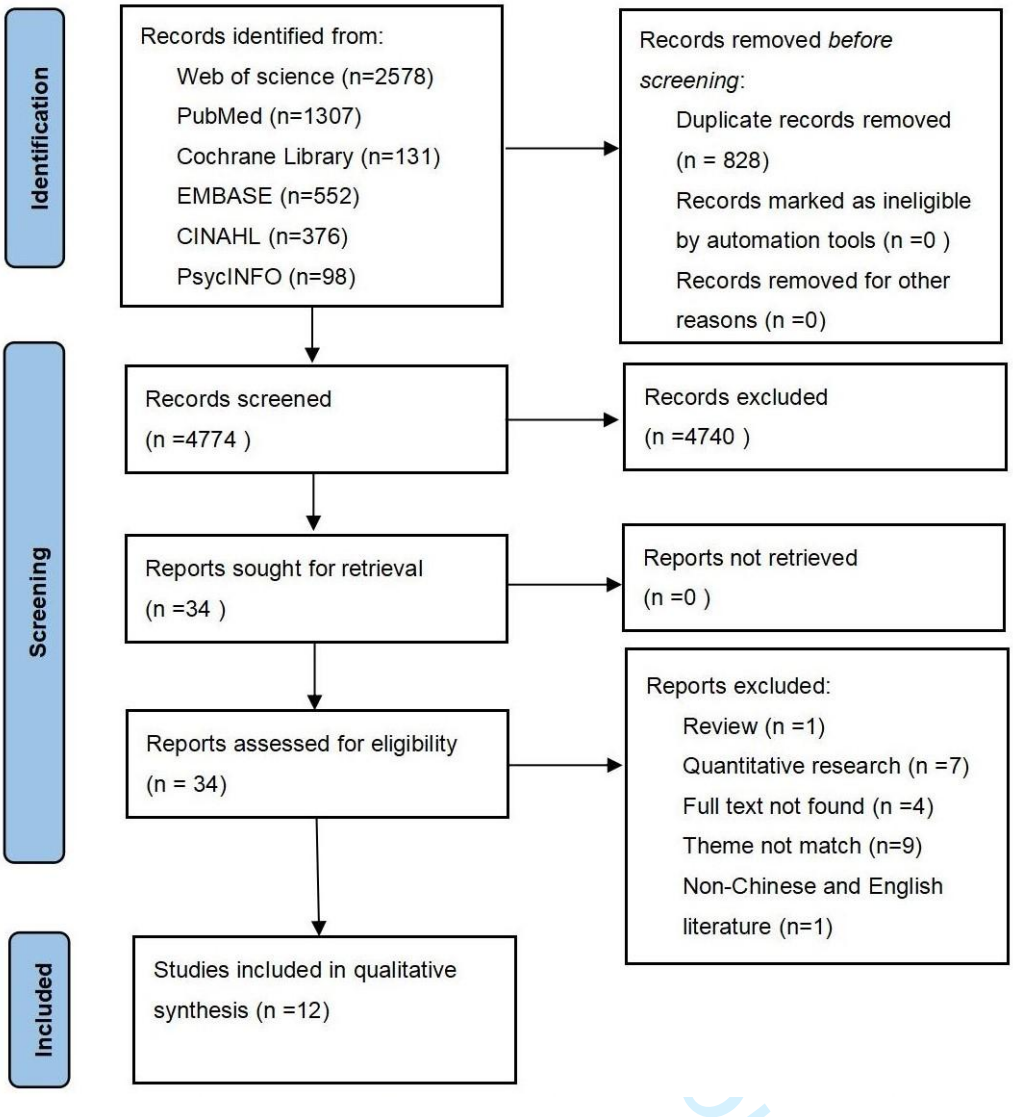

Figure 1: Literature screening process and results using preferred reporting items for systematic reviews and meta-analyses (PRISMA) flow chart
1531 x 1465mm (1152 x 1204 DPI)

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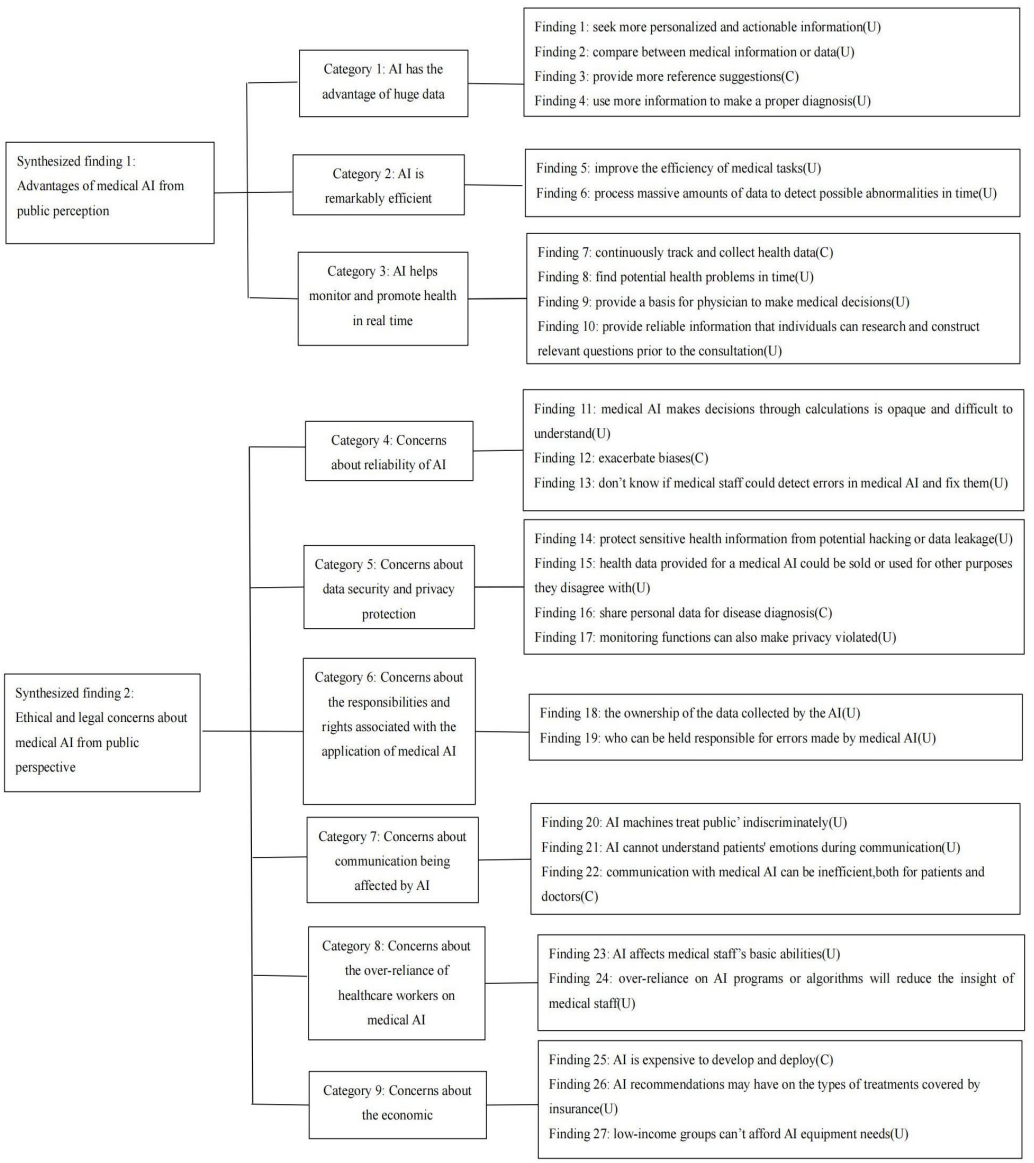

Figure 2: Meta-synthesis findings of the general public's perceptions on the application of artificial intelligence in healthcare
2141 x 1636mm (2339 x 2845 DPI)

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Supplemental File 1

Search strategies used for finding qualitative research articles about public's attitudes towards the application of artificial intelligence in healthcare field. Number of retrieved articles is given in the right-hand column.

CNKI (Totally=393)

S1	人工智能 + 医疗大数据 + 机器人 + 医疗数据共享 + AI + "Artificial intelligence" + "medical big data" + "healthcare data" + "data sharing"[SU]
S2	质性研究 + 质性访谈 + 观点 + 看法 + "qualitative study" + "qualitative research" + "qualitative inquiry" + interview + perception + attitude + view[SU]
S3	医疗 + 护理 + medicine + nurse + nursing + medical [SU]
S4	S1 AND S2 AND S3

VIP (Totally=21)

S1	人工智能 + 医疗大数据 + 机器人 + 医疗数据共享 + AI + "Artificial intelligence" + "medical big data" + "healthcare data" + "data sharing"[题目或关键词]
S2	质性研究 + 质性访谈 + 观点 + 看法 + "qualitative study" + "qualitative research" + "qualitative inquiry" + interview + perception + attitude + view[题目或关键词]
S3	医疗 + 护理 + medicine + nurse + nursing + medical[题目或关键词]
S4	S1 AND S2 AND S3

WanFang (Totally=146)

S1	人工智能 OR 医疗大数据 OR 机器人 OR 医疗数据共享 OR AI OR Artificial intelligence OR medical big data OR healthcare data OR data sharing[题目或关键词]
S2	质性研究 OR 质性访谈 OR 观点 OR 看法 OR qualitative study

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	OR qualitative research OR qualitative inquiry OR interview OR perception OR attitude OR view[题目或关键词]
S3	医疗 OR 护理 OR medicine OR nurse OR nursing OR medical[主题]
S4	S1 AND S2 AND S3

Web of science(Totally=2578)

S1	AI OR “Artificial intelligence” OR “medical big data” OR “healthcare data” OR “data sharing”[主题]
S2	"qualitative study" OR "qualitative research" OR "qualitative inquiry" OR interview OR perception OR attitude OR view[主题]
S3	medicine OR nurse OR nursing OR medical[主题]
S4	S1 AND S2 AND S3

PubMed(Totally=1307)

S1	Artificial intelligence[Mesh, ti, ab] OR "AI"[Title/Abstract] OR "Artificial intelligence"[Title/Abstract] OR "medical big data"[Title/Abstract] OR "healthcare data"[Title/Abstract] OR "data sharing"[Title/Abstract]
S2	"qualitative study"[Title/Abstract] OR "qualitative research"[Title/Abstract] OR "qualitative inquiry"[Title/Abstract] OR "interview"[Title/Abstract] OR "perception"[Title/Abstract] OR "attitude"[Title/Abstract] OR "view"[Title/Abstract] OR "qualitative research"[MeSH Terms]
S3	"medicine"[Title/Abstract] OR "nurse"[Title/Abstract] OR "nursing"[Title/Abstract] OR "medical"[Title/Abstract] OR "medicine"[MeSH Terms] OR "nurses"[MeSH Terms]
S4	S1 AND S2 AND S3

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Cochrane Library(Totally=131)

S1	AI OR “Artificial intelligence” OR “medical big data” OR “healthcare data” OR “data sharing”[Title Abstract Keyword]
S2	’qualitative study’ OR ‘qualitative research’ OR ‘qualitative inquiry’ OR interview OR perception OR attitude OR view[Title Abstract Keyword]
S3	medicine OR nurse OR nursing OR medical[Title Abstract Keyword]
S4	S1 AND S2 AND S3

EMBASE(Totally=552)

S1	'artificial intelligence' OR 'healthcare data' OR 'medical big data' OR 'data sharing' OR AI[ti, ab]
S2	’qualitative study’ OR ‘qualitative research’ OR ‘qualitative inquiry’ OR interview OR perception OR attitude OR view[ti, ab]
S3	medicine OR nurse OR nursing OR medical[ti, ab]
S4	S1 AND S2 AND S3

CINAHL(Totally=376)

S1	'artificial intelligence' OR 'healthcare data' OR 'medical big data' OR 'data sharing' OR AI[ti, ab,su]
S2	’qualitative study’ OR ‘qualitative research’ OR ‘qualitative inquiry’ OR interview OR perception OR attitude OR view[ti, ab,su]
S3	medicine OR nurse OR nursing OR medical[ti, ab,su]
S4	S1 AND S2 AND S3

PsycINFO (Totally=98)

S1	'artificial intelligence' OR 'healthcare data' OR 'medical big data' OR 'data sharing' OR AI[ti, ab,mh]
S2	’qualitative study’ OR ‘qualitative research’ OR ‘qualitative inquiry’ OR

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	interview OR perception OR attitude OR view[ti, ab,mh]
S3	medicine OR nurse OR nursing OR medical[ti, ab,mh]
S4	S1 AND S2 AND S3
Totally	98

TOTAL FOUND: 5602

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PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	2
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	2
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	3
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	3
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	3
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	3
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	3
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	4
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	5-6
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	5-6
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	4
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	Not Applicable
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	4
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	4
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Not applicable
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	Not applicable
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	Not applicable
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	Not applicable
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	Not applicable
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	4

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PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	4
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	4
Study characteristics	17	Cite each included study and present its characteristics.	5-6
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	6
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Not applicable
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	5
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	Not applicable
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	Not applicable
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	Not applicable
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	Not applicable
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	6
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	11-12
	23b	Discuss any limitations of the evidence included in the review.	12
	23c	Discuss any limitations of the review processes used.	12
	23d	Discuss implications of the results for practice, policy, and future research.	12
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	2
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	2
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	Not applicable
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	16
Competing interests	26	Declare any competing interests of review authors.	16
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	17

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

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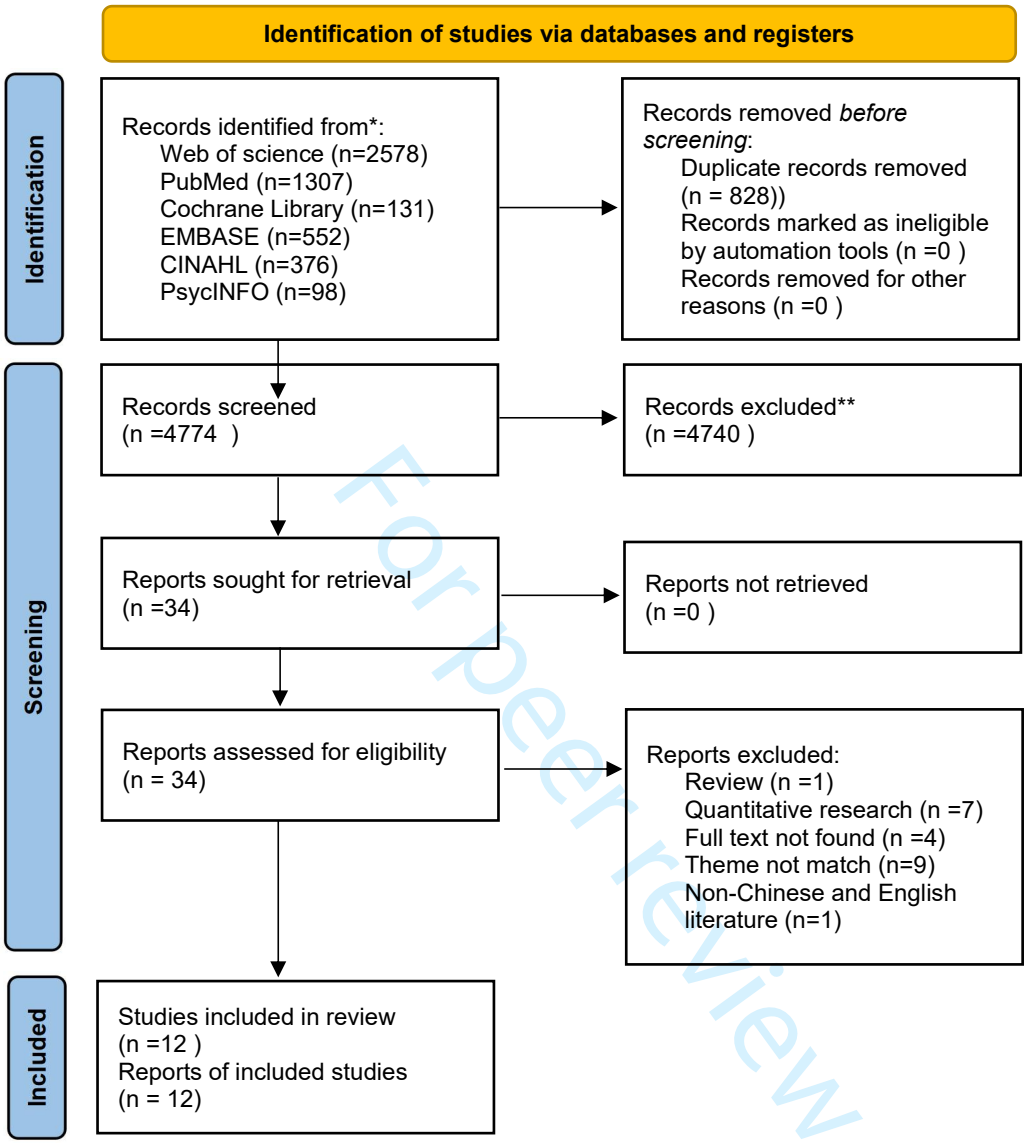
PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only



*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers).

**If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

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