

# The Role of Artificial Intelligence in Primary Care: A Systematic literature review

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In recent years, Artificial Intelligence (AI) has opened new opportunities in primary care, from diagnosis and treatment planning to patient management. However, concerns about fairness, equity, and ethics in healthcare arise. This study follows PRISMA guidelines to systematically review AI applications addressing these challenges. It provides insights to guide future research and inform practices in primary care. The findings highlight significant theoretical and practical advancements in AI integration but also raise ethical concerns, particularly around data privacy and algorithmic bias. AI should complement, not replace, human healthcare professionals, requiring careful implementation to balance its benefits with potential risks.

**Keywords:** Artificial Intelligence, Primary care, Literature review, Applications, Equity, Ethical concerns.

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## 1. Introduction

Implementing Artificial Intelligence (AI) has brought about a paradigm shift in numerous industries, with healthcare particularly affected (Younis *et al.*, 2024). AI has effectively revolutionized disease diagnosis, treatment, and management by implementing sophisticated algorithms and intelligent technology. This has resulted in concrete advantages for practitioners and patients alike. In recent research, the transformative potential of AI in healthcare, along with the associated challenges, has garnered significant attention. (Vidal-Alaball *et al.*, 2023; Manne and Kantheti, 2021; Secinaro *et al.*, 2021; Sunarti *et al.*, 2021; Davenport and Kalakota, 2019; Castonguay *et al.*, 2024).

As a result, the implementation of AI in the healthcare sector is being recognised as a potent instrument for influencing medical treatment and decision-making, particularly in primary care (Gurevich *et al.*, 2023; Kueper *et al.*, 2020), which serves as the fundamental infrastructure of healthcare systems (Starfield, 1998; Wang *et al.*, 2021). Its applications include patient management, administrative duties, and diagnosis and treatment planning (Allen *et al.*, 2024, Giest and

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Klievink, 2022; Liaw and Kakadiaris, 2020). However, AI also gives rise to substantial apprehensions concerning ethical considerations, fairness, and equity in the provision of healthcare (Safdar *et al.*, 2020; Topol, 2019).

The literature concerning the potential benefits and obstacles of AI in primary care is expanding (Lin *et al.*, 2019; Blease *et al.*, 2019; Terry *et al.*, 2022). However, it is still fragmented, necessitating a methodical approach to comprehensively comprehend the present state of the art and prospective developments (Roppelt *et al.*, 2023). In pursuit of this objective, a novel systematic literature review is required due to several critical characteristics distinguishing it from previous compilations.

First, the swift progression of AI technologies requires an up-to-date examination that incorporates the most recent developments and their ramifications for primary care. This review is crucial due to the rapid evolution of AI tools and algorithms, which may alter how medical care is provided (Gurevich *et al.*, 2023; Kueper *et al.*, 2020).

Furthermore, with the increasing prevalence of AI systems in healthcare environments, it may become imperative to delve more extensively into complex ethical, equity, and fairness issues that were not adequately addressed in earlier literature reviews. Safdar *et al.* (2020) and Topol (2019), among others, have identified knowledge gaps regarding the impact of AI on these critical domains; additional research may be able to fill these gaps. Given the significance of these concerns, a fresh examination may unveil how current AI applications are confronting these obstacles, proposing

remedies or drawing attention to domains that necessitate further investigation. Furthermore, the environment in which AI is being implemented in healthcare has undergone a radical transformation due to global issues such as the prevalence of chronic diseases, the ageing of the population, and the aftermath of the COVID-19 pandemic (Boscolo and Lico, 2020; Roppelt *et al.*, 2023). A novel systematic review could analyse how AI technologies are being modified to tackle these particular obstacles and evaluate their efficacy in real-world scenarios.

Existing literature reviews scrutinize the benefits and drawbacks of artificial intelligence in primary care. However, a systematic review is necessary to assist scholars, professionals, and decision-makers by furnishing a comprehensive framework that clarifies the findings, guides future research endeavours, and impacts practices and policies (Lin *et al.*, 2019; Blease *et al.*, 2019). This effort would not solely offer a present-day overview of the utilization of AI in primary care but also influence the course of subsequent advancements and investigations by taking into account critical elements – such as ethics and fairness – which, to the best of our knowledge, have not been exhaustively scrutinized in previous research. Given the aforementioned considerations, this investigation aims to address the gap in the prior literature review by posing the subsequent research questions:

- RQ1: What are the current applications of AI in primary care?
- RQ2: What are the main opportunities?
- RQ3: What challenges and ethical considerations are associated with

integrating AI into primary care settings?

- RQ4: Is there a “dark side,” and how can it be managed regarding future scholarly and managerial efforts?

## 2. Background

The term AI refers to the generation of novel knowledge, tools, and concepts through the emulation of human intelligence by machines programmed to mimic human thinking and actions (De Reave *et al.*, 2021; D’Elia *et al.*, 2022; Hamet and Tremblay, 2017; Rahman *et al.*, 2024; Zahlan *et al.*, 2023). AI comprises a range of technologies, including machine learning, deep learning, neural networks, and reinforcement learning, each with its unique relevance (Lin *et al.*, 2019; Manne and Kantheti, 2021). However, their specific applications and supportive functions vary significantly (Davenport and Kalakota, 2019).

Over the past six decades, AI has been utilised across diverse fields for various purposes (Whal *et al.*, 2018), yet its adoption in healthcare has been constrained (Bohr and Memarzadeh, 2020). This limitation primarily stems from the lack of access to high-quality, precise, and reliable electronic data (e-data), which is essential for AI algorithm development (Yang *et al.*, 2019). In recent years, there has been considerable optimism surrounding the potential of AI to significantly enhance various aspects of healthcare, especially in primary care, spanning from diagnosis and treatment planning to patient management and administrative tasks (Allen *et al.*, 2024, Giest and Klievink, 2022; Liaw and Kakadiaris, 2020; Davenport and Kalakota, 2019). It is widely believed that AI

tools will serve to augment and streamline human efforts rather than replace the roles of physicians and other healthcare professionals outright (Manne and Kantheti, 2021; Romero-Brufau *et al.*, 2020, Upshaw *et al.*, 2023). AI stands poised to assist healthcare personnel across various responsibilities, including administrative tasks, clinical documentation, patient engagement, and specialised functions such as image analysis, medical device automation, and continuous patient monitoring (Bohr and Memarzadeh, 2020). This transformative prospect depends on the validity and reliability of data collected and donated from electronic health records (EHRs) (De Raeve, 2021).

According to Lin *et al.* (2019: p. 1626), «Primary care is where the power, opportunity, and future of AI are most likely to be realised in the broadest and most ambitious scale.»

There is no simple commonly agreed definition of primary care in the literature. The term is often used interchangeably with primary health care (Awofeso, 2004; Muldoon *et al.*, 2006; Amisi and Downing, 2017). However, “primary care” concerns more a level of service and can be used to refer to “family doctor-type” services (Starfield, 1998), while “primary health care” refers more to an approach to health policy and service provision (Muldoon *et al.*, 2006). In fact, according to the World Health Organization (WHO, 1978: 1-2): «Primary health care is essential health care based on practical, scientifically sound and socially acceptable methods and technology made universally accessible to individuals and families in the community through their full participation and at a cost that the community

and the country can afford to maintain at every stage of their development... It is the first level of contact of individuals, the family and community with the national health system, bringing health care as close as possible to where people live and work, and constitutes the first element of a continuing health care process.»

Primary care boasts distinct characteristics, such as being the initial point of contact for care, maintaining long-term relationships with a dedicated patient population, and coordinating care seamlessly across the healthcare continuum (Kasteleyn *et al.*, 2021; Terry *et al.*, 2022). Historically, it has played a pivotal role in acknowledging and addressing the social determinants of health, which significantly influence unequal health outcomes among vulnerable populations (Khanassov *et al.*, 2016). The significance of primary care for a nation's health makes it essential to share primary care research findings internationally. This exchange will be much more effective with commonly shared definitions of primary care research. To this end, some authors (Amisi and Downing, 2017) suggest including the patient's health-seeking behaviour, screening and other prevention activities, and experience of the disease in the classification of primary care research.

Embracing a broad range of diseases and diverse patient care responsibilities, primary care is well-suited for integrating AI tools into clinical practice. By leveraging AI for routine duties, primary care practitioners can dedicate more attention to intricate diagnostic and therapeutic challenges, fostering deeper patient-physician connections (Wang *et al.*, 2021).

AI tools in primary healthcare encom-

pass a diverse range of applications, including diagnostic decision support, treatment decision support, risk prediction, workforce assessment, and extracting information from narrative electronic medical record (EMR) data (Nickson *et al.*, 2023; Sohl *et al.*, 2022; Rahimi *et al.*, 2022; Lin *et al.*, 2019). In the broader healthcare landscape, AI's utilization continues to expand, incorporating conversational agents like chatbots, radiology products and forecasting healthcare-associated infections (Andrew, 2024).

AI-driven algorithms for disease diagnosis have surpassed physicians in detecting various conditions, such as many types of cancer (Ayling *et al.*, 2019; Brennan and Kirby, 2022; Brigiden *et al.*, 2023; Miller *et al.*, 2023); dementia (Ford *et al.*, 2023), mental health issues (Levkovich and Elyoseph, 2023), cardiac arrhythmias (Hill *et al.*, 2022) and a wide variety of acute and chronic diseases such as diabetes and hypertension (De Raeve *et al.*, 2021). Particularly in regions with limited access to specialty care, equipping primary care doctors with these tools can substantially benefit patients (Lin *et al.*, 2019).

In addition, the present healthcare system is overwhelmed by a significant volume of paperwork and administrative duties, detracting precious time from healthcare professionals. Physicians are estimated to dedicate nearly half of their time to managing electronic hospital records and administrative tasks, with only 27% devoted to direct patient-care interactions (Sinsky *et al.*, 2016). This substantial administrative burden significantly contributes to clinician burnout and dissuades doctors from pursuing or remaining in family medicine. Thus,

reducing this load not only directly relieves stress and enhances the well-being of primary care clinicians but also holds the potential to attract more practitioners to this area. Leveraging Language Model Machines (LLMs) can assist primary care clinicians in reclaiming time from non-clinical duties by automating routine medical tasks, such as data entry and medical information retrieval. This automation can produce comprehensive summaries encompassing diverse patient data, medical histories, potential diagnoses, and available treatment options (Andrew, 2024).

AI technologies will have a fundamental role in facilitating the achievement of the quintuple aim for primary healthcare improvement (Cresswell, Rigby *et al.*, 2023): better care, better health, lower costs, and health equity while preserving clinician wellbeing (Nundy *et al.*, 2022), but many factors need to be considered regarding its implementation (Terry *et al.*, 2022;). AI applications in data utilisation entail considerable risks, particularly concerning ethical considerations such as patient safety and privacy. Inaccurate algorithms or insecure data storage methods could jeopardise these aspects. Moreover, algorithms that surpass doctors' abilities in certain tasks, such as diagnostics, can lead to improved patient outcomes (Kasteleny *et al.*, 2021).

### 3. Methods

To address the mentioned research questions, this study conducts a systematic analysis using the PRISMA 2020 checklist (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) outlined by Page *et al.* (2021).

This process was carried out in three stages: planning the review, conducting the review, and reporting and dissemination (Tranfield *et al.*, 2003). Such a systematic approach enabled the identification of relevant studies within the research domain, allowing for a thorough analysis and evaluation of the data, ultimately leading to synthesized conclusions addressing the study's objectives (Tranfield *et al.*, 2003).

To ensure a rigorous and comprehensive literature search, a systematic review protocol was followed, aimed at answering a specific set of research questions. This review framework supports identifying and mapping key concepts based on qualitative and quantitative evidence. The data were charted and synthesized through a thematic analysis related to various aspects of AI applications in primary care, emphasizing ethical considerations, equity, and practical implementation issues.

The thematic analysis systematically identified and provided insights into common themes derived from the data set (Braun & Clarke, 2012). This study adhered to the approach proposed by Braun & Clarke (2012), synthesizing the data set to identify different codes dispersed across the data. These codes highlighted features relevant to the study's research questions. The data set was divided into specific codes and the selected studies were reclassified based on these codes. We then aggregate the codes onto two classification layers: (1) research focus (primary-care subspecialty and/or functional objective) and (2) macro-thematic categories derived through iterative coding (Table 1) – Opportunities (i.e. Improved Diagnostics & Screenings; Emerging/

Promising Applications), Challenges (i.e. Equity/Ethical & Legal/Preconditions for Adoption; Adoption Barriers & Acceptance), and Synthesis & Research Trajectories (State of the Field & Data Quality; Future Directions & Protocols).

### 3.1. Literature Selection and Eligibility Criteria

We used the Web of Science, Scopus, and PubMed databases to identify research trends and future potentialities of AI in primary care (Massaro *et al.*, 2016; Petticrew and Roberts, 2006; Tranfield *et al.*, 2003). The deliberate choice of these databases guarantees the thoroughness and caliber of the material evaluated. The extensive coverage of peer-reviewed journals and the potent citation tracking tools found in Web of Science make it an excellent choice for locating important research and following the development of AI applications in primary care. Scopus's extensive collection of articles broadens the review's scope and improves the study's worldwide perspective. Its sophisticated search skills are essential for analysing intricate subjects like the subtleties of technology and the uses of AI in healthcare. Understanding the real-world applications of AI in primary care settings requires direct access to clinical research and reviews, which PubMed's focus on health sciences provides. Through clinical trials and case studies that highlight practical applications of AI technologies, this database also offers priceless insights. A balanced approach that integrates theoretical understanding and real-world implementations to give a thorough picture of AI's involvement in primary care is made possible by com-

binning Web of Science, Scopus, and PubMed.

Our review comprehensively examines scholarly contributions from the past five years. The process is structured into three distinct phases: firstly, data collection, where relevant academic works are gathered; secondly, data refinement, involving the careful selection and filtration of pertinent studies; and thirdly, data analysis, where we cluster scholarly contributions to identify prominent themes and trends. This analytical approach categorizes the existing literature and helps formulate a targeted research agenda for future studies.

Adhering to the guidelines recommended by Busenitz *et al.* (2003), our search was confined to articles published in scholarly journals. We excluded book chapters, conference proceedings, and unpublished works to maintain high publication quality, leveraging the rigorous and transparent peer review process.

As for data collection, we accessed the Web of Science (WoS) database, applying a precise search string: (“artificial intelligence” AND “primary care”) AND (application\* OR adoption\* OR use\* OR utilisation) AND (ethic\* OR equity OR inequity\* OR impact OR risk\*). We restricted our search to articles published in English from January 2019 to March 2024. This search yielded 163 articles. The choice of a relatively short time span, from January 2019 to March 2024, is primarily due to the rapid advancements and evolving nature of AI technologies, particularly in the context of primary care.

Therefore, focusing on the most recent five years ensures that the review captures the latest research,

developments, and current state-of-the-art applications of AI in primary care. Moreover, recent literature is more likely to address contemporary issues, including the latest ethical considerations, equity challenges, and practical implementation problems, which are critical to the current discourse. Older studies might not reflect the latest technological advancements or the current regulatory and ethical standards, potentially leading to outdated or less relevant findings.

The selected keywords were deliberately chosen to balance specificity and comprehensiveness. By using focused keywords, the search aimed to target the most relevant articles without overwhelming the review with excessive unrelated studies. The core terms “artificial intelligence” and “primary care” ensure that the search is directly relevant to the intersection of AI technologies and their applications within primary care settings. Keywords related to application, such as “application,” “adoption,” “use,” and “utilisation,” capture various aspects of how AI is being integrated and utilized in primary care, covering both practical applications and adoption processes. Additionally, keywords addressing ethics, including “ethics,” “equity,” “inequity,” “impact,” and “risk,” are crucial for examining the broader implications of AI adoption, focusing on ethical considerations, equity issues, and potential risks associated with AI in healthcare. Including these keywords ensures the review addresses critical concerns beyond mere technical implementation.

By narrowing down the keyword set, the search remains manageable and focused on high-quality, pertinent studies that provide meaningful insights into AI applications in primary care.

This approach enhances the efficiency and effectiveness of the systematic review, ensuring that the selected articles are directly aligned with the study’s objectives and research questions.

Next, we utilised the same search string in the Scopus database under identical criteria, retrieving 132 articles. In the last step of data collection, a search in the PubMed database with the same parameters was conducted, and 144 articles were retrieved. In total, the searches across all three databases initially produced 439 articles.

Data refinement started with removing 233 duplicates. We thoroughly reviewed the remaining 206 abstracts to assess their alignment with our research objectives. During this second phase, we eliminated 33 articles based on several exclusion criteria: articles were excluded if they did not directly address the practical application, adoption, use, or utilisation of AI in primary care or failed to adequately address associated issues such as ethics, equity, inequity, impact, or risks, despite matching our keyword criteria.

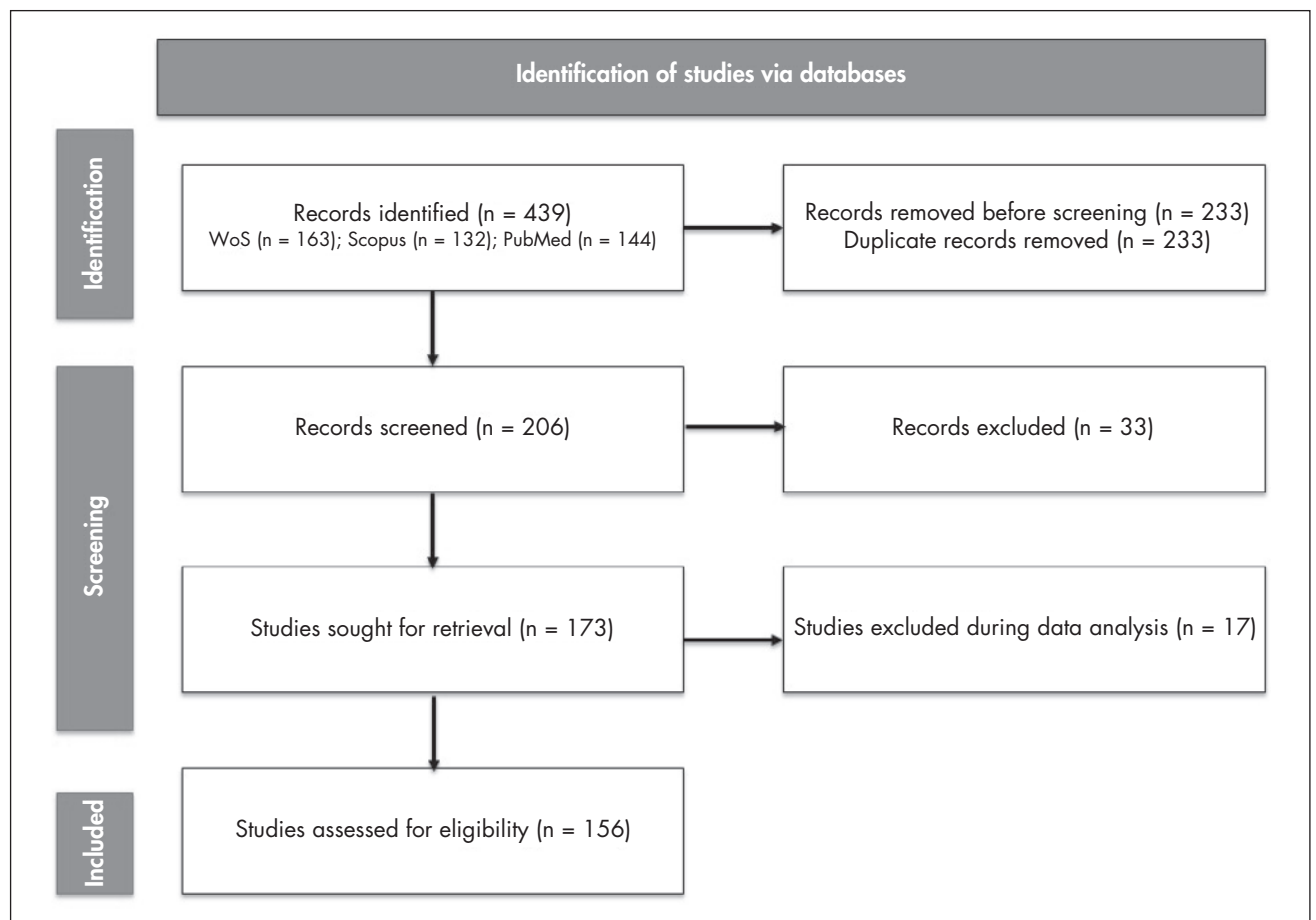
This meticulous filtering process was crucial to ensuring that every article included in our study was relevant and provided significant insights into the practical and theoretical advancements of AI in primary care settings. The final selection comprised 173 articles, each contributing valuable perspectives to our understanding of AI’s role and potential in primary care. This robust selection of articles equips our study with a solid foundation for influencing future research and policy-making in integrating AI within primary care environments.

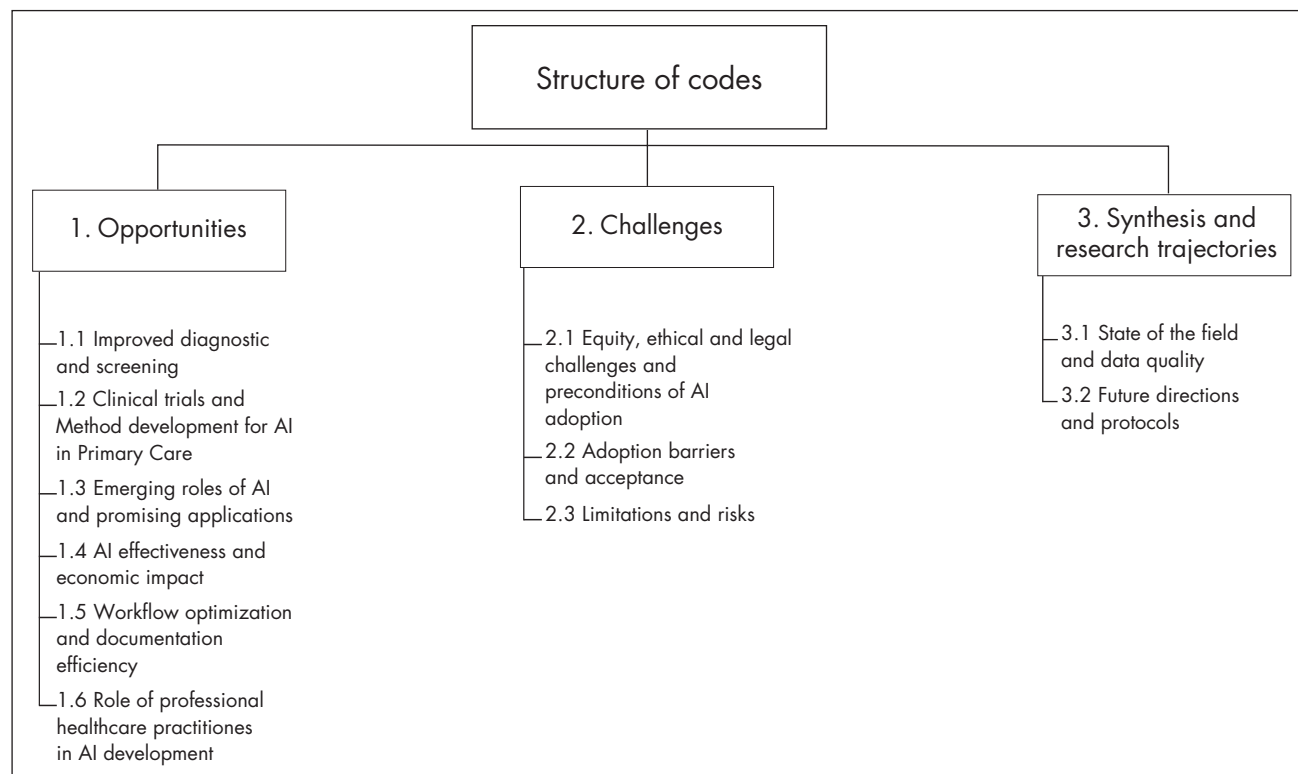
Data analysis was performed through the NVivo 12 software in order to create a categorisation framework for the

set of 173 articles. The software enabled us to identify emergent themes within the examined articles and assess their coherence with the research questions. Next, we sorted the articles alphabetically and divided them into two groups of 86 and 87 articles each. Each author was then distributed to a specific group, ensuring that each group was read by two coders. The articles were then independently read and coded. After the initial round of independent coding, we compared and reconciled the emergent coding categories to establish a single, cohesive coding strategy. Following this coding stage, a total of 17 articles were removed from the review

process as they discussed AI purely theoretically without demonstrating real-world applications in primary care, those that overly focused on the technological dimensions without considering clinical implications, and those solely dedicated to medical perspectives without acknowledging broader interdisciplinary impacts. The identified codes allowed us to categorize the articles and answer our research questions, providing insights into applications, opportunities, challenges, equity, and ethics. After this process, the number of articles included in the final analysis was 156. Figure 1 summarizes the PRISMA 2020 flow diagram.

**Fig. 1**  
The PRISMA 2020 flow diagram





The coding process led to the development of 11 thematic categories, designed to ensure comprehensive coverage while avoiding excessive fragmentation. Guided by the research questions, the categories were grouped under three main areas: opportunities, challenges, and synthesis, and research trajectories, as Figure 2 depicts.

#### 4. Results

A descriptive analysis of 156 articles revealed a sharp increase in publications between 2021 and 2023, highlighting a growing academic interest in AI applications in primary care, as evidenced in Figure 3.

The most frequently recurring journals included *JMIR Research Protocols*, *Journal of Medical Internet Research*, and *Annals of Family Medicine*, indicat-

ing a strong presence of open-access and interdisciplinary outlets (see Table 1).

A limited group of authors appeared more than once, suggesting a dispersed authorship scenario. Thematic keywords pointed to AI applications in mental health, chronic disease management (e.g., diabetes, retinopathy), and COVID-19 response.

Concerning the analysis of the articles' content, as previously stated, NVivo was employed to classify and code the articles, thereby enabling their analysis and categorisation.

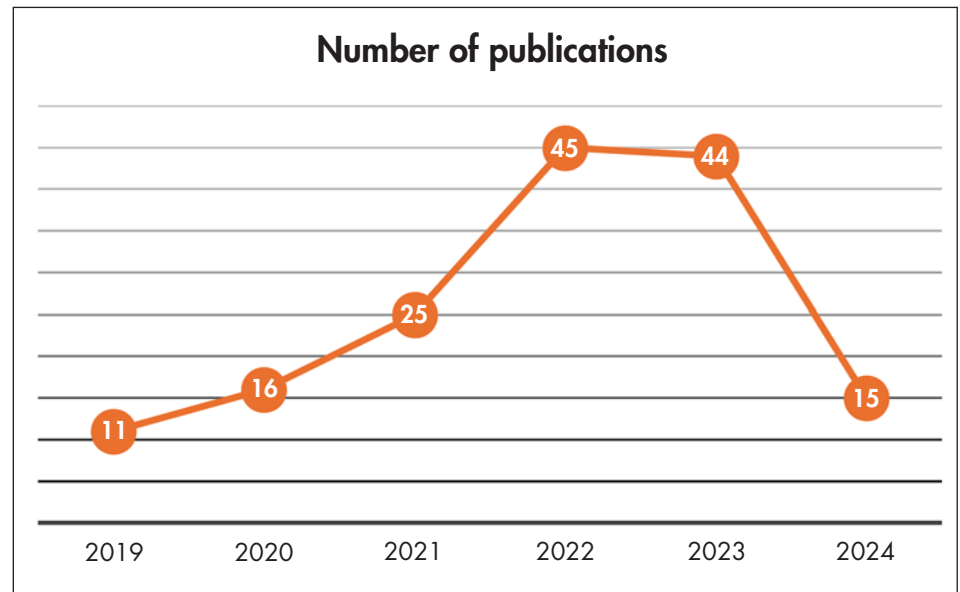
Initially, the categorisation process was conducted with the aim of examining the different primary healthcare subspecialties and their relevant contexts, as evidenced by the analysed research studies.

**Fig. 2**  
Coding structure

**Table 1** – Number of publications per journal

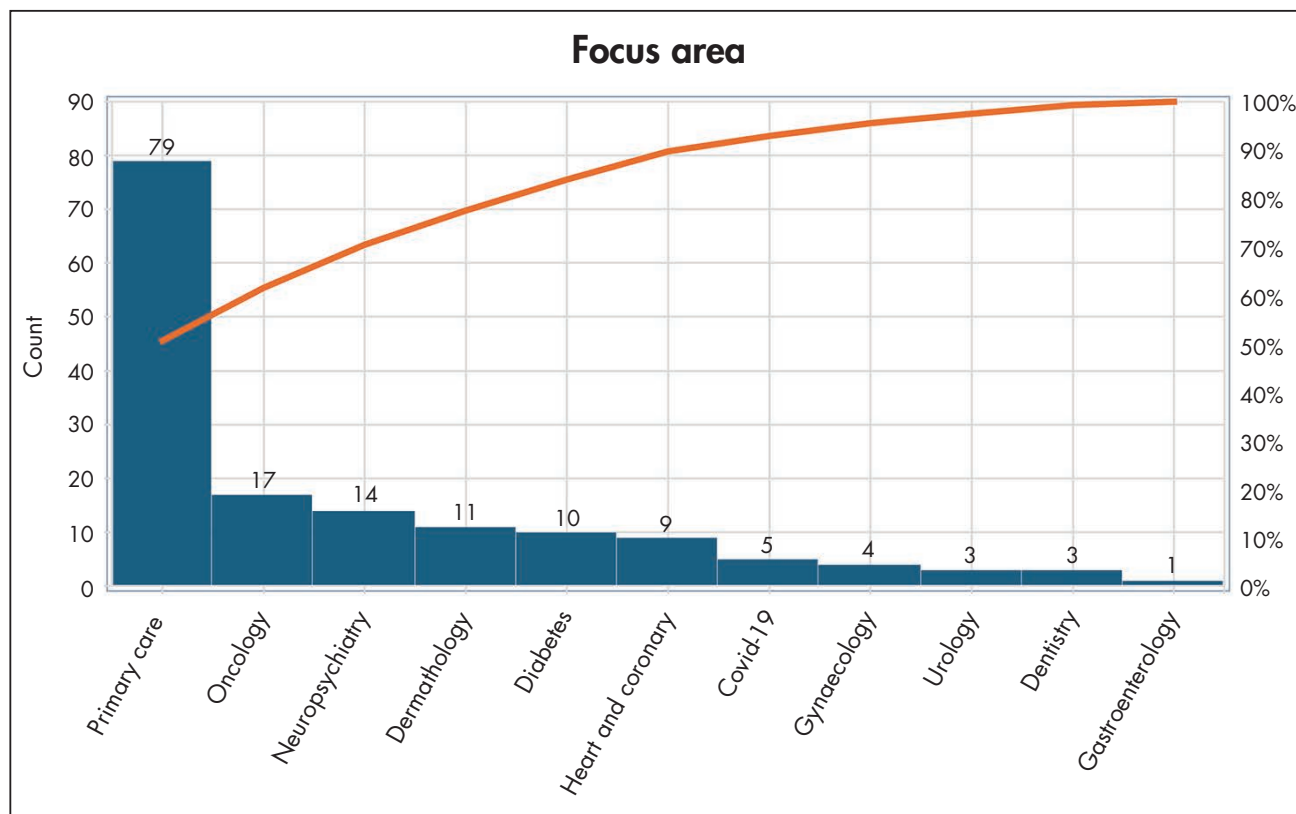
Journal	N. of publications
<i>JMIR Research Protocols</i>	6
<i>Journal of Medical Internet Research</i>	5
<i>Annals of Family Medicine</i>	5
<i>JMIR Medical Informatics</i>	4
<i>International Journal of Medical Informatics</i>	4
<i>International Journal of Environmental Research and Public Health</i>	4
<i>Scientific Reports</i>	3
<i>BMC Medical Informatics and Decision Making</i>	3
<i>Journal of the American Board of Family Medicine</i>	3
<i>PLoS ONE</i>	3
Two publications	20
Only one publication	96
Total	156

**Fig. 3**  
Number of publications per year



The results of the analysis for the final set of 156 articles, shown in Figure 4, indicate that most of the articles are concerned with investigating the general potential of AI in primary care without a specific emphasis on any particular subspecialty. Among the

many subspecialties, Oncology stands out as a cross-category encompassing articles from other subspecialties, comprising 17 articles. Coming in third place is Neuropsychiatry, which focuses on utilising AI to detect early indicators of various types of demen-



tia and to reduce the risk of suicide episodes, with 14 articles dedicated to this topic. Additionally, 11 studies concentrate specifically on dermatology, with a particular emphasis on the early detection of skin cancer (9 out of 11). At the same time, 10 articles focus on the application of AI in mitigating the consequences of diabetes. Moving to the classification of the studies introduced based on the previously-defined coding structure (Figure 2) Table 2 shows that the most prominent theme emerging from the review concerns the opportunities offered by AI-based technologies, particularly in the realm of diagnostic and screening improvements. A large number of studies fall under this category, underscoring the pivotal role of

AI in enhancing diagnostic precision and streamlining screening procedures. These technologies have demonstrated the ability to support faster, more accurate identification of conditions across a range of clinical areas (5; 7; 12; 21; 33; 35-37; 39; 41; 48; 55; 57; 66-69; 75-76; 80; 82; 84; 93; 96-97; 99; 101; 103-105; 107; 109; 113; 119; 124-126; 134; 137-138; 140; 143; 154-156). An exemplary exert can be the following:

*“An autonomous AI system can accurately detect vtDR and mtmDR without physician oversight or need for dilation in most individuals, facilitating diabetic eye examinations at non-specialist facilities and enabling accelerated referral of vtDR” (Ipp et al., 2021, p. 1).*

**Fig. 4**  
Pareto chart of research focus areas by healthcare specialties

Within this category, two subthemes stand out. One relates to oncology, where AI has significantly improved screening capabilities, enabling more rapid, precise outcomes while reducing the need for invasive procedures (7; 68; 93; 105; 113; 125; 137). The other focuses on neuropsychiatry, with studies highlighting AI's effectiveness in the early detection of conditions such as cognitive impairment, depression, suicidal ideation, and autism spectrum disorders (36; 84; 96; 99; 104; 107; 138; 143). The remaining articles cover diverse specialties, reflecting the broad applicability of AI in enhancing diagnostic workflows across primary care.

Beyond diagnostic applications, AI presents further opportunities through its emerging roles and promising applications. Several studies explore the transformative potential of AI in reshaping primary care. As underlined by Lin (2022: 180),

*"[...] primary care is the most uniquely suited specialty to lead the health care AI revolution."*

The benefits of using these tools are manifold and include enhanced risk prediction capabilities, streamlined administrative tasks, improved service quality, and support to healthcare providers in their clinical activities (4; 10; 11; 13; 17; 24; 30; 43; 46; 52; 56; 71; 100; 126; 131; 132; 135; 139). While these studies are predominantly exploratory in tone, they provide valuable insights into how AI could reconfigure care delivery and redefine the role of healthcare providers.

Another key opportunity involves the effectiveness and economic impact of AI. Fifteen articles address this theme,

focusing either on cost-efficiency or clinical improvements (30; 38; 40; 44; 53; 58; 59; 60; 64; 74; 81; 97; 108; 152; 153). Among these, seven studies report that AI-based interventions are more cost-effective than traditional methods, citing reduced screening costs and decreased clinician workload (13; 30; 58; 59; 64; 108; 152). Hu *et al.* (2024) exemplify this evidence base, noting that

*"implementing an AI-based DR screening system in primary care settings was a highly cost-saving strategy" (p. 12).*

In contrast, two studies (97; 153) stress the need for rigorous economic evaluation before AI tools can be widely adopted. Complementing the economic analyses, seven additional studies (38; 40; 44; 53; 60; 74; 81) focus on AI effectiveness in clinical settings, highlighting improvements in workflow efficiency, triage, communication, and risk stratification. While some of these tools may indirectly support diagnostic processes, they are not primarily focused on enhancing diagnostic accuracy or screening performance, which is the emphasis of a separate subcategory. These studies offer limited or qualitative cost data but contribute to the broader understanding of AI's clinical utility. Collectively, the 16 articles in this category stress that while AI can improve clinical processes and outcomes, demonstrating tangible economic value remains a crucial prerequisite for large-scale implementation.

A related area of opportunity concerns the diverse and prospective applications of AI in the primary-care field, frequently highlighting conceptual, strategic, or early-stage innova-

tions. The selected studies, classified in the category Emerging roles of AI and promising applications (4; 10; 11; 13; 17; 24; 30; 43; 46; 52; 56, 71; 100; 132; 135; 139), highlight the transformative potential of AI to reshape various aspects of healthcare delivery. Common themes include enhanced clinical decision support, real-time analytics for preventive care, and AI's integration into digital platforms for remote monitoring and triage. Rather than focusing on validated outcomes, these works tend to speculate on the future impact of AI, outlining strategic opportunities and the possible evolution of the physician's role. Importantly, these contributions serve more as visionary propositions than empirical validations. The tone within this subcategory is predominantly exploratory, frequently emphasizing potential rather than quantifiable outcomes. Consequently, it serves to complement the more empirically grounded "AI Effectiveness & Economic Impact" subcategory by offering a strategic perspective.

Additional opportunities are categorized under the designation of Clinical Trials and Method Development for Artificial Intelligence in Primary Care. This category includes studies that either present pilot trials (2; 6; 22; 42; 45; 65; 90; 123; 127; 133) or feasibility assessments of AI tools or focus on the development and validation of novel AI-based methodologies (1; 9; 18; 26; 27; 112; 148; 151). These articles contribute to building evidence on the clinical applicability, reliability, and integration of AI technologies in real-world primary care settings. Together, they advance the operational readiness and scientific rigor of AI innovations in healthcare.

Two additional opportunity-driven themes have also been identified. The first focuses on workflow optimization and documentation efficiency, where studies investigate the potential of AI technologies to streamline administrative tasks, enhance clinical documentation, and alleviate the workload of healthcare providers. These studies underscore the potential of AI to enhance operational efficiency in primary care, highlighting the time-saving benefits and support for clinicians' routine workflows (52; 63; 94; 131). The second, though supported by only two studies, emphasizes the role of professional healthcare practitioners in AI development (88; 122). These contributions underline the importance of engaging clinicians in the design and implementation of AI tools to ensure trust, usability, and relevance to clinical needs.

While the opportunities are numerous, literature also highlights substantial challenges associated with the integration of AI in primary care. The most discussed among these involves equity, ethical, and legal considerations, as well as the prerequisites for responsible AI adoption (15; 23; 25; 28; 30; 31; 32; 34; 47; 62; 72; 77; 83; 85; 86; 89; 91; 92; 94; 95; 114; 116; 120; 130; 144; 150). Among the articles coded at this node, many addressed disparities issues (15; 23; 25; 28; 31; 47; 62; 92; 114; 150). The aforementioned articles underline the significance of providing AI algorithms with extensive datasets to avert the occurrence of subset underrepresentation (15). Harnessing advanced analytics and AI in clinical practice offers unprecedented scope for earlier diagnosis, tailored treatment, and streamlined workflows. Realising

these benefits, however, requires that equity considerations shape every step, from data curation to algorithm deployment.

*“Without such efforts, tools can reflect data, algorithmic and analytic biases, widening inequities by race, ethnicity, gender and other socio-demographic factors.” (Clark et al., 2021, p. 1).*

Furthermore, the articles in this category stress the risk that these tools might only be utilised by a minority of the more educated and affluent population segment (31). Additionally, some studies highlight the capacity of digital health to diminish the disparity in the quality of care between less prosperous regions and more affluent ones (23; 25; 28; 114); To achieve this objective, Clark *et al.* (2021) (25) underscore the importance of primary care providers collaboration in the development of AI technologies, whilst Wu *et al.* (2023) (151) findings support the necessity to establish ethical guidelines for digital detection surveillance to avoid the risk of social inequity and disparate care outcomes. The contrary viewpoint, as highlighted by Ford *et al.* (2023) (47), draws attention to the potential hazards associated with the utilisation of digital devices and automated systems. Specifically, they emphasise that the current evidence base regarding the advantages of detecting dementia through automated methods is feeble, and there are no disease-modifying treatments currently available. Therefore, it is crucial that users fully comprehend the limited benefits they can attain from these technologies before deciding to utilise them. Holm (2023) (62) explores the issue of deferring

referral decisions in primary care to recommendations from machine learning models. The author posits that the legitimacy and validity of an algorithmic decision-making process can be thoroughly justified by examining the instrumental values of accuracy and fairness. In a similar manner, Lu *et al.* (2022) (92) examine the challenges of fairness and reliability in AI models used in healthcare. They note that although various guidelines emphasise the importance of conducting audits on these models, practical guidance on how to do so is limited. Therefore, the authors conduct their own audit to provide guidance to others on implementing routine fairness and reliability audits of AI models before deployment in clinical settings. Another significant strand of articles pertains to ethical concerns (47; 72; 77). It is feared that if an algorithm proves to be defective or data are not adequately protected, ethical considerations, including patient safety and confidentiality, could be jeopardised. (72). Similarly, Kretzschmar *et al.* (2019) (77) emphasise the importance of AI-based applications respecting users' privacy and minimising the collection of personal data. Consistently, Liaw *et al.* (2020) (87) contend that users ought to be clearly informed about the benefits and risks associated with these applications, in particular with regard to safety and privacy. Transparency plays a pivotal role not only in patient care but also in the context of clinicians. The need for transparency about the underlying frameworks of AI-driven decision support systems is considered essential to build confidence among healthcare professionals (62; 92; 95). A final crucial prerequisite for effectively

integrating AI-based technologies into primary healthcare is the engagement of all pertinent stakeholders in their design to foster trust among both healthcare practitioners and patients (130).

The literature further identifies barriers related to adoption and acceptance. These studies (3; 14; 19; 20; 87; 102; 111; 141; 147) explore the factors influencing whether AI tools are embraced or resisted in primary care. It encompasses studies that emphasize physicians' concerns regarding AI technologies (3; 19;

141), the necessity for training healthcare professionals in AI technologies (87; 147), and the key determinants influencing the acceptance of AI applications (14; 20; 63; 102; 111).

The final group of challenges involves the limitations and risks of AI applications. These include insufficient clinical evidence supporting the benefits of AI (50; 70; 73), practical implementation issues such as usability and resistance from end users (29; 61), and concerns about over-reliance on algorithms at the expense of human judgment (121; 131; 147). Technical

**Table 2** – Article counts per identified classification code

Macrocategory	Subcategory	Articles	Total articles
Opportunities	Improved diagnostic and screenings	5;7; 12; 21; 33; 35; 36; 37;39; 41; 48;55; 57; 66; 67; 68; 69; 75;76; 80; 82; 84; 93; 96; 99; 101; 103; 104; 105; 107; 109; 113; 119; 124; 125; 134; 137; 138; 140; 143; 155; 156	42
	Clinical Trials & Method Development for AI in Primary Care	1; 2; 6; 9; 18; 22; 26; 27;42; 45; 65; 90;112; 123; 127; 133; 148;151	18
	Emerging roles of AI and promising applications	4; 10; 11; 13; 17; 24; 43; 46;56;71; 100; 126; 132; 135; 139	15
	AI effectiveness & economic impact	; 30; 38; 40; 44; 53;58; 59; 60; 64;74; 81; 97; 108; 152; 153;	15
	Workflow optimization & documentation efficiency	52;63;94;131	4
	Role of professional healthcare practitioners in AI development	88;122	2
Challenges	Equity, ethical and legal challenges, and preconditions for AI adoption	15; 23; 25; 28; 31; 32; 34; 47; 62; 72; 77; 83; 85; 86; 89; 91; 92; 95; 114; 116; 120; 130; 144; 150	24
	Adoption barriers & acceptance	3;14; 19;20; 87;102;111;141;147;	9
	Limitations and risks	29;50;54;61;70;73;98;121;136	9
Synthesis and research trajectories	State of the art & data quality	16; 106; 110; 115; 117; 118; 128;142;145;146	10
	Future directions & protocols	8; 49; 51; 78; 79; 129;149;154	8
Total			156

\* Details of each article can be found in Table A1 in the Appendix

limitations, such as poor generalizability, algorithmic flaws, and low accuracy, are also discussed (54; 98; 136), prompting calls for more critical evaluation and cautious deployment of AI in clinical practice.

The final thematic area, termed “Synthesis and Research Trajectories,” captures the literature that reflects on the current state of AI in primary care and outlines future directions. One subset of this category is forward-looking, offering research agendas, methodological frameworks, or policy recommendations aimed at guiding the continued integration of AI into healthcare (8; 49; 51; 78; 79; 88; 122; 129; 149; 154). The other subset provides comprehensive reviews of AI applications in healthcare or specific clinical fields, summarizing current achievements, persistent challenges, and unresolved questions (16; 34; 106; 110; 115; 117; 118; 128; 142; 145; 146). These contributions are instrumental in shaping a coherent research agenda and in identifying both gaps and opportunities for future innovation.

## 5. Discussion

Our findings have highlighted that AI’s applications in primary care (RQ1) are expansive, particularly in enhancing diagnostic accuracy and patient management across various subspecialties. Notably, the emphasis on oncology and neuropsychiatry reveals AI’s capability in early disease detection, such as identifying early indicators of cancer and mental health disorders, which are critical for timely intervention (Jaiswal, Katz, Nesca, & Milios, 2023). These applications highlight the transformative potential of AI to support and significantly advance diagnostic processes within primary care.

AI’s opportunities (RQ2) in primary care are profound, and this study underscores its impact on improving screening accuracy and predictive analytics, indicating that AI is instrumental in refining diagnostic precision and enhancing the specificity of patient assessments. This technological advancement is pivotal in enabling more personalised care plans. It could substantially improve patient outcomes by ensuring timely and precisely tailored interventions to individual health profiles.

Additionally, AI technologies can support primary care clinicians by automating routine medical tasks like data entry and medical information retrieval, thus allowing them to focus more on patient care. Through this automation, comprehensive summaries can be generated, consolidating various patient data, medical histories, potential diagnoses, and available treatment options.

The integration of AI within primary care is fraught with ethical complexities and challenges (RQ3). Issues such as data privacy, the potential for algorithmic bias, and ensuring the inclusivity of AI technologies are central concerns (Ford, Milne, & Curlewis, 2023). Addressing these ethical challenges ensures that AI tools are employed responsibly and equitably, fostering trust among patients and practitioners. The need for transparent AI systems and rigorous ethical guidelines cannot be overstated, as they are essential in maintaining the integrity of patient care and data security.

Finally, concerns about AI’s ‘dark side’ (RQ4), including the potential dehumanisation of care and over-reliance on technology, emerge prominently in

the literature. Effective management of these risks involves reinforcing AI's supportive role to healthcare providers, ensuring that AI augments rather than replaces human judgment in clinical decisions (Holm, 2023). AI applications in primary care must be designed and implemented to enhance the clinician-patient relationship rather than undermine it.

The dark side of AI in primary care lies not in overt technological failure but in its potential to institutionalize biases, obscure decision-making processes, and undermine patient trust. The analyzed literature consistently emphasizes that mitigating these risks demands interdisciplinary collaboration, transparent development, and ongoing regulatory oversight.

The results clarify substantial theoretical and practical advancements that emphasise the integration of AI in primary care.

Theoretical contributions primarily concern the expansion of current knowledge and the establishment of a strong foundation for subsequent academic pursuits. The results demonstrate the potential of AI to revolutionise the provision of healthcare, enhancing both operational effectiveness and patient results, while simultaneously giving rise to significant ethical and logistical dilemmas.

In theory, the incorporation of AI into primary care has resulted in an enhanced comprehension of its functionalities and constraints. Academic literature has extensively documented the accuracy and effectiveness of AI in diagnosing diseases. This is consistent with prior research that has underscored the potential of AI to improve the delivery of healthcare (Lin *et al.*, 2019; Younis *et al.*, 2024). The ability

of AI to amalgamate extensive datasets to generate precise diagnoses has formed a fundamental aspect of its theoretical impact, forcing and broadening the existing frameworks of medical diagnostics (Manne and Kantheti, 2021; Vidal-Alaball *et al.*, 2023).

Furthermore, this systematic literature review underscores the growing discussion surrounding the ethical ramifications of AI, reflecting the apprehensions expressed by Safdar *et al.* (2020) and Topol (2019) concerning the impartiality and correctness of AI implementations. This particular facet holds significant importance in comprehending the socio-technical aspects of healthcare technology and informing the formulation of policies that guarantee equitable access to the advantages of AI without further exacerbating pre-existing healthcare inequalities. Further examination of the ethical implications of AI in theoretical contexts highlights the continuous necessity to revise ethical principles in light of the advancements and increased integration of AI technologies into healthcare systems.

The practical implications of the findings indicate that AI can effectively optimise administrative procedures within primary care environments. This aligns with the findings of Giest and Klievink (2022) regarding the capacity of AI to alleviate routine responsibilities from healthcare practitioners. By refocusing human resources on more intricate and compassionate patient interactions, this operational improvement has the potential to enhance patient satisfaction and care outcomes. Moreover, the potential of AI to decrease healthcare expenditures via streamlined

resource allocation and prognostic diagnostics carries substantial ramifications for the economics of healthcare and paves the way for adopting more sustainable medical practices.

Practical implications also encompass the monitoring of patients and the management of chronic diseases, areas in which AI tools have demonstrated considerable potential. AI applications contribute to the prevention of the long-term consequences of chronic diseases by enhancing the precision and promptness of management. This proactive healthcare approach is consistent with the preventative care model postulated by Wang *et al.* (2021). In addition, Kueper *et al.* (2020) propose that the capacity of AI to augment patient engagement via interactive platforms and personalised care may fundamentally transform the way in which healthcare providers and patients interact.

However, the challenges emphasised in the review mitigate these practical benefits. Significant logistical and ethical concerns are raised by integrating AI into primary care, primarily concerning data privacy and the risk of algorithmic bias, which could compromise the effectiveness and confidence of AI systems. The review emphasises the criticality of establishing comprehensive AI governance frameworks that guarantee openness, responsibility, and inclusivity in the implementation of AI, which, in turn, underscores recent demands for enhanced AI audits and the implementation of benchmarks that protect patient rights while fostering innovation (Ford *et al.*, 2023).

Study findings have relevant policy implications, too, highlighting the areas in which healthcare policies

need to be designed and implemented. AI increasingly influences these policies, shaping how medical services are delivered and regulated. Healthcare policies are evolving to incorporate guidelines on the ethical use of AI, to enhance patient accessibility and equity, and they are being updated to address concerns about data protection.

## 6. Conclusion

The systematic literature review proposed in this study emphasised the critical integration of AI technologies in primary care across multiple domains, such as treatment planning, patient management, and diagnosis. Although using AI promises to increase accuracy and efficiency, the evaluation points out several difficulties. Notably, challenges such as data privacy concerns, the requirement for large, diverse training datasets, and the integration of AI outputs into clinical processes make applying AI technologies in routine clinical practice challenging. Contemporarily, as AI technologies become more prevalent in primary care settings, ethical considerations become increasingly critical. Potential biases in AI algorithms that may result in unequal healthcare outcomes are discussed in the review. Concerns about patient permission and openness to applying AI-powered diagnostic technologies have also been raised. It is critical to address these ethical concerns to preserve public confidence in healthcare systems and guarantee the equitable and responsible application of AI tools. Moreover, applying AI to primary care can drastically change how healthcare is provided. AI can improve patient care planning, minimise diagnostic

errors, and expedite administrative work. The research also clarifies that although AI can help healthcare providers, it cannot replace human professionals' sophisticated judgment. The conversation focuses on the necessity of a balanced strategy in which AI augments human decision-making rather than does it. The challenge ahead revolves around humans exercising wisdom and willingness to discern the optimal role of AI in twenty-first-century healthcare. It's crucial to ascertain when AI enhances and when it potentially detracts from the human aspect of healing, as highlighted by Lin (2009). Striking this balance between AI capabilities and the need for human judgment and expertise is paramount. Ethical considerations loom large, emphasising the importance of not allowing AI to entirely supplant human healthcare professionals, but rather to complement their skills. This requires thoughtful deliberation and responsible implementation to navigate potential risks and challenges effectively (Younis *et al.*, 2024).

The state of the art suggests a rich research agenda, especially concerning the need for longitudinal and impact studies to evaluate the long-term effects of AI on healthcare delivery and patient outcomes. Such studies could provide crucial data on the efficacy and safety of AI applications in real-world settings, with a special focus on understanding how AI can improve the quality of doctor-patient interactions. Other studies could develop ethical frameworks due to the evolution of AI technologies that call into action scholars and practitioners

to build and/or update ethical guidelines that address emerging privacy concerns, algorithmic biases, and transparency issues. In line with this, future studies could focus on embedding ethical, legal, and equity principles at every stage of AI system design and deployment to ensure responsible and inclusive innovation. In addition, to ensure the ethical deployment of AI in primary care, there must be ongoing collaboration among technologists, healthcare providers, ethicists, and patients. This approach will help align AI development with open healthcare needs and ethical standards.

The present study has a number of limitations that should be acknowledged. Initially, we relied on three main databases: Web of Science, Scopus, and PubMed. Although these databases are esteemed and inclusive, incorporating additional databases could have yielded supplementary valuable insights. Secondly, restricting our search to English-language articles may have led to a narrower spectrum of perspectives concerning AI innovation in healthcare. Thirdly, one potential methodological limitation of our study is that our search strategy, which included broad terms such as 'Artificial Intelligence' and 'Primary Care', may have favoured the inclusion of articles focusing on the general potential of AI rather than detailed reports on specific applications or interventions. Lastly, the exclusive inclusion of peer-reviewed journal articles might have overlooked pertinent information available in conference proceedings, professional reports, or book chapters.

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## Appendix



Table A1

1.	Adamou, M., <i>et al.</i> , Toward Automatic Risk Assessment to Support Suicide Prevention. <i>Crisis-the Journal of Crisis Intervention and Suicide Prevention</i> , 2019. <b>40</b> (4): pp. 249-256.
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