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ARTIFICIAL INTELLIGENCE APPLICATION IN COLONOSCOPY SCREENING: A LITERATURE REVIEW

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ABSTRACT

Background: Colorectal cancer (CRC) is the third most commonly diagnosed cancer globally and remains a leading cause of cancer-related deaths. Despite the effectiveness of colonoscopy in reducing CRC incidence and mortality through adenoma removal, some polyps are frequently missed. Artificial intelligence (AI) has recently appeared as a promising tool to enhance detection rates during colonoscopy.
Aim of the study: This study aims to compare AI-assisted colonoscopy with standard colonoscopy in terms of adenoma detection rate and polyp detection rate. The goal is to evaluate whether one approach is superior to the other.
Material and methods: A systematic literature search of the PubMed database was performed for studies published between 2015 and 2025. Search terms included "artificial intelligence", "machine learning", "colonoscopy", and "mass screening". Only English-language studies directly comparing adenoma and polyp detection rates between AI and standard colonoscopy procedures were included. A total of 18 studies involving 12,000 patients met the inclusion criteria.
Results: The AI group consistently demonstrated higher adenoma detection rates compared to the standard colonoscopy group, with 36.06% vs. 28.85%, respectively. Similarly, AI showcased greater polyp detection rates, detecting polyps in 41.05% of patients compared to 34.17% in the standard colonoscopy group. Advanced AI techniques reported the highest detection rates. AI showed enhanced performance in identifying diminutive lesions and polyps located in challenging regions. Importantly, AI did not significantly prolong withdrawal times.
Conclusions: AI integration into colonoscopy improves adenoma and polyp detection rates across diverse patient populations and clinical settings. Even among experienced endoscopists, AI provides added diagnostic value. The findings highlight AI's potential to enhance CRC screening, though further studies are needed to standardize AI tools, validate their efficacy in real-world settings, and assess long-term clinical outcomes.

KEYWORDS

Mass Screening, Colonoscopy, Colorectal Neoplasms, Artificial Intelligence, Machine Learning

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Introduction

Colorectal cancer (CRC) remains a major public health concern due to its high incidence and mortality rates. Based on the study conducted by Sung et al. (2020), CRC is the third most commonly diagnosed cancer in both men and women and is among the leading causes of cancer-related deaths worldwide [1,2]. The International Agency for Research on Cancer (IARC) estimates that in 2022, there were over 1.9 million new cases and almost 904,000 deaths attributed to CRC. [3]. Projections indicate that these numbers will rise substantially in the coming decades, fueled by demographic shifts such as aging populations, increasing urbanization, and the widespread adoption of Westernized dietary and lifestyle habits [4,3]. As healthcare systems face growing demands, the need to enhance screening strategies, improve detection rates, and reduce mortality becomes even more urgent.

Epidemiology and Risk Factors

The global distribution of CRC highlights significant geographic and socioeconomic disparities [5]. The highest incidence rates are observed in countries with a high Human Development Index (HDI), particularly in North America, Western Europe, Australia, and parts of East Asia [1]. These regions often share common lifestyle factors, including diets rich in red and processed meats, high caloric intake, low physical activity, and increased prevalence of obesity [6]. However, emerging economies are also experiencing a rising CRC burden, reflecting rapid nutritional transitions, urbanization, and limited access to healthcare infrastructure [1,7,8].

Risk factors can be broadly divided into modifiable and non-modifiable [8]. Modifiable factors include dietary habits such as high consumption of processed meat, refined carbohydrates, and sugary beverages, as well as alcohol consumption and tobacco use. Obesity and physical inactivity further contribute to increased risk by promoting metabolic disturbances, chronic inflammation, and insulin resistance. Inflammatory bowel diseases, such as ulcerative colitis and Crohn's disease, significantly elevate lifetime risk due to prolonged mucosal inflammation [6,9]. Non-modifiable factors include advancing age, family history of CRC [10], and hereditary syndromes such as Lynch syndrome and familial adenomatous polyposis.

Although sporadic CRC is the most common type, 5-10% cases are caused by inherited genetic mutations. The most common of these are Lynch syndrome and familial adenomatous polyposis (FAP) [2,11]. These genetic mutations increase the risk of CRC occurrence to up to 80% in Lynch syndrome [11], and up to 100% by the age of 60 in FAP [10].

The interplay of these risk determinants highlights the multifactorial nature of CRC and underscores the importance of both primary prevention (lifestyle modification) and secondary prevention (screening and surveillance) [12].

In addition to biological risk factors, social determinants of health exert substantial influence on CRC incidence and outcomes. Limited access to preventive services, geographic barriers, socioeconomic disadvantage, and cultural perceptions of cancer screening all affect participation in screening programs. These inequities contribute to disparities in CRC outcomes, with underserved populations often presenting at later stages and experiencing higher mortality rates [13,14].

Screening and Prevention

Effective screening in CRC has been consistently shown to reduce both incidence and mortality [15]. Unlike many other malignancies, where screening primarily enables earlier diagnosis, CRC screening can directly prevent disease development by enabling the detection and removal of premalignant adenomas [16]. Several screening modalities are currently employed, each with varying levels of sensitivity, specificity, invasiveness, and cost-effectiveness.

The fecal occult blood test (FOBT) and the fecal immunochemical test (FIT) are widely used as non-invasive screening methods [16-18]. They are inexpensive and easy to administer, making them suitable for population-level programs. However, they are limited by relatively low sensitivity for advanced adenomas and the need for repeated testing over time [19]. Flexible sigmoidoscopy allows direct visualization of the distal colon and has demonstrated substantial mortality reductions in randomized controlled trials. Yet, its inability to evaluate the proximal colon remains a drawback [20]. Colonoscopy is widely regarded as the gold standard for CRC screening, offering full visualization of the colon and the ability to remove adenomas during the procedure. Numerous studies have confirmed its efficacy in reducing both incidence and mortality [21-23]. Current guidelines from organizations such as the U.S. Preventive Services Task Force and the American Cancer Society recommend initiation of CRC screening at age 45 for average-risk individuals, with colonoscopy every 10 years being a primary option [18].

Despite the proven effectiveness of screening, real-world uptake remains suboptimal [23,24]. The primary obstacles include limited public awareness, procedural discomfort, logistical challenges, and inadequate access to healthcare [25]. Screening participation remains unequally distributed because minority groups, along with rural residents and lower-income individuals, show reduced screening rates [23]. Public health programs that address these obstacles through educational outreach, combined with resource equalization and culturally appropriate solutions, must be developed to enhance screening compliance and reduce outcome disparities.

Timely detection not only improves survival but also enhances quality of life. Patients diagnosed at an early stage often require less aggressive treatment, while advanced stages may necessitate chemotherapy, immunotherapy, or, in selected cases, radiotherapy, leading to higher toxicity and recurrence rates. Effective screening strategies that enable diagnosis before symptom onset, therefore, remain essential to reducing CRC-related morbidity and mortality [2].

Limitations of Conventional Colonoscopy

Colonoscopy is one of the most effective screening tools, but it also has its own limitations. During the procedure, polyps can be missed, especially when they are flat, small (below 5mm), or located in areas that are difficult to visualize. Adenoma miss rates (AMR) have been reported to be around 32%, depending on polyp characteristics and operator experience [26,27]. These missed lesions can progress to interval cancers, undermining the protective effect of colonoscopy.

Adenoma detection rate (ADR) is one of the main indicators of the quality of colonoscopy [2]. ADR is the proportion of screening colonoscopies in which at least one adenoma is detected. Studies have shown that higher ADRs are associated with reduced risk of postcolonoscopy CRC [28,29]. Training, experience, and procedural duration are factors that may influence endoscopist expertise. Human factors such as fatigue, cognitive overload, and time pressure further compromise detection accuracy [30].

Technological improvements, such as high-definition imaging, narrow-band imaging, and chromoendoscopy, have been developed to enhance mucosal visualization [31]. While these innovations improve detection to some degree, they do not fully eliminate variability or the risk of human error. There is a constant need for additional solutions that can support endoscopists in achieving consistently high detection rates across diverse clinical settings.

Artificial Intelligence in CRC Screening

Artificial intelligence (AI) models, particularly those based on computer vision and deep learning, have been developed to assist endoscopists by providing real-time detection and characterization of polyps, thus improving diagnostic accuracy and reducing AMR [32,33]. By standardizing detection quality across practitioners, AI offers the potential to reduce operator variability and enhance patient outcomes at a population level [33].

Together with real-time detection, AI-based solutions for CRC screening extend to other domains. Automated risk stratification platforms can integrate patient data, including genetic information, lifestyle factors, and prior medical history, to provide personalized screening and decision support [34,35]. AI algorithms are also being developed for pathology, such as automated histological grading of colorectal polyps with concordance rates comparable to those of expert pathologists [36].

AI-assisted colonoscopy has demonstrated greater cost-effectiveness than standard procedures by improving cancer detection while reducing overall healthcare expenses. By lowering the risk of missed lesions, AI decreases the likelihood of interval cancers and the need for repeat procedures, ultimately reducing treatment costs associated with advanced disease. Studies across different healthcare systems also suggest that incorporating AI into endoscopic screening shifts certain strategies into the cost-effective range, making it a favorable option for large-scale colorectal cancer prevention programs [37-39].

Aim of the study

This study aims to comprehensively analyze recent research comparing AI and standard colonoscopy (SC) in adult patients. Specifically, the study seeks to determine which method demonstrates superior outcomes in the detection and diagnosis of adenomas and polyps during colonoscopy procedures. The research aims to inform clinical practice and potentially enhance diagnostic accuracy in CRC prevention by evaluating the effectiveness of AI-assisted techniques versus conventional approaches.

Material and methods

A systematic literature search was conducted using the PubMed database, covering publications between 2015 and 2025. The objective was to identify studies comparing ADR and polyp detection rate (PDR) in SC versus colonoscopy assisted by AI. For this search, MeSH terms and keywords such as "artificial intelligence", "machine learning", "colonoscopy", and "mass screening" were used. Only articles published in English and providing relevant comparative data were included. Studies lacking original data or not addressing ADR/PDR outcomes were excluded. In total, 18 eligible studies met the inclusion criteria. The search process used for the literature review is summarized in Figure 1.

Limitations

This study has several limitations. The literature search was restricted to the PubMed database, potentially leading to selection bias and limiting the comprehensiveness of the review. Furthermore, the inclusion of only English-language publications may have introduced bias by excluding findings published in other languages. Some of the included studies did not disclose the type of AI-detected algorithm utilized, limiting the ability to assess the comparative performance or specific AI systems or modalities.

Results

We analyzed 18 studies involving approximately 12,000 patients undergoing colonoscopy. Four studies did not report PDR, and one did not report ADR. The SC group included 6,041 patients, while the AI-assisted group comprised 6,885 patients.

Across the studies, the AI-assisted colonoscopy group demonstrated higher ADR compared to the SC group, with 2,483 cases (36.06%) versus 1,743 cases (28.85%), respectively. Similarly, the AI group had greater outcomes in terms of PDR, detecting polyps in 2,826 patients (41.05%) compared to 2,064 patients (34.17%) in the SC group. These findings indicate a consistent improvement in both primary outcomes when AI support was employed. The increased detection rates were not limited to a single trial or geographic region but were observed across multiple healthcare systems, suggesting a generalizable advantage of AI assistance in routine clinical practice.

Various AI-enhanced techniques were utilized, reflecting the rapid evolution of technological approaches in this field. These included real-time computer-aided detection (CADe), AI-assisted platforms combined with mechanical devices such as Endocuff (E-AI), linked-color imagining with AI (LCA), systems incorporating computer-aided quality improvement (CAQ), and hybrid models combining CADe and CAQ (COMBO). In contrast, the SC group relied on established traditional colonoscopy methods, such as standard white-light colonoscopy, high-definition (HD) colonoscopy, HD white-light endoscopy (HD-WLE), and linked-color imaging (LCI).

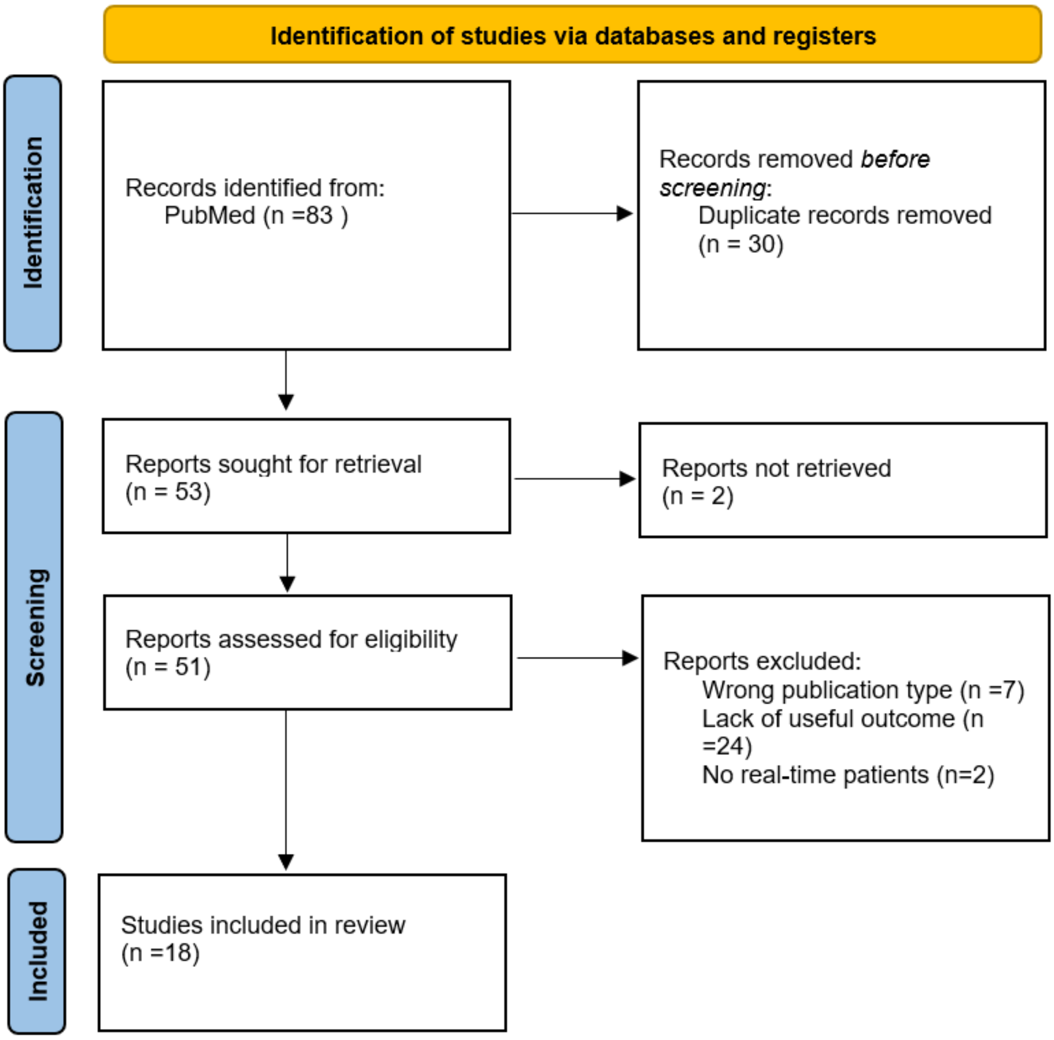

Fig. 1. *PRISMA 2020 Flow Diagram (for more information, visit www.prisma-statement.org) demonstrating the identification, screening, and selection of the included studies in this systematic review.*

Among the 14 studies eligible for ADR analysis, all but one reported favorable outcomes for AI-assisted colonoscopy compared to the SC (Table 1). In total, 10,558 patients from over 29 institutions across eight countries - the Republic of Korea, the United States, China, Sweden, Japan, Germany, the United Kingdom, and Italy - were included in this subset. The favorable outcomes of AI assistance were showcased in a wide geographic area, in diverse populations and healthcare environments. Subgroup analyses within individual trials highlighted that the benefit of AI was most pronounced for small and flat polyps, which are traditionally more challenging to detect and often missed during SC.

The consistency of results across multiple AI modalities further supports the conclusion that AI assistance provides meaningful clinical value. Studies utilizing more advanced systems, such as COMBO and E-AI, achieved the highest ADRs, pointing to the potential for continued improvement as algorithms become more sophisticated and better integrated into clinical workflows. These findings highlight not only the effectiveness of AI in enhancing detection but also its adaptability to different procedural techniques and technological platforms.

Table 1. ADR comparison between AI and SC groups.

Study	Year	Total patients	SC Group Patients	AI Group Patients	ADR SC	ADR AI
Park et al.[40]	2024	805	368	437	103 (28%)	153 (35%)
Thiruvengadam et al.[41]	2024	1100	550	550	189 (34.4%)	234 (42.5%)
Lui et al.[42]	2024	682	214	AI - 238 E-AI - 230	99 (46.3%)	E-AI- 135 (58.7%) AI-128 (53.8%)
Schöler et al.[32]	2024	240	118	122	53 (43%)	48 (41%)
Miyaguchi et al.[43]	2024	800	400	400	174 (43.5%)	235 (58.8%)
Hüneburg et al.[44]	2023	96	46	50	12 (26.1%)	18 (36.0%)
Ahmad et al.[45]	2023	614	306	308	199 (65%)	220 (71.4%)
Shaukat et al.[46]	2022	1359	677	682	297 (43.9%)	326 (47.8%)
Repici et al.[47]	2022	660	330	330	147 (44.5%)	176 (53.3%)
Glissen Brown et al.[27]	2022	223	110	113	58 (52.73%)	63 (55.75%)
Yao et al.[48]	2022	1210	271	CADe 268 CAQ 269 COMBO 268	40 (14.76)	CADe 57 (21.27) CAQ 66 (24.54) COMBO 82 (30.60)
Repici et al.[49]	2020	685	344	341	139 (40.4%)	187 (54.8%)
Liu et al.[50]	2020	1026	518	508	124 (23.89%)	203 (39.1%)
Wang et al.[51]	2019	1058	536	522	109 (20.34%)	152 (29.1%)
TOTAL		10558	4788	5636	1743 (36,40%)	2355 (49,19%)

A total of 12 studies were eligible for PDR analysis; all but one demonstrated superior outcomes with AI-assisted colonoscopy compared to standard methods (Table 2). These studies collectively analyzed data from 8,755 patients across 31 institutions in six countries - the Republic of Korea, China, Sweden, Germany, the United Kingdom, and the United States. It represented a diverse range of healthcare systems and patient populations, suggesting that the benefits of AI integration are not limited to a specific geographic area or endoscopic practice environment. Even in high-performing SC groups, where baseline PDRs exceeded 60%, AI still provided measurable diagnostic gains. This showcases the capacity of AI systems to add value not only in settings with lower detection rates but also when procedures are performed by skilled endoscopists with already high standards of care.

Table 2. PDR comparison between AI and SC groups.

Study Title	Year	Total patients	SC Group Patients	AI Group Patients	PDR SC	PDR AI
Park et al.[40]	2024	805	368	437	191 (52%)	271(62%)
Lui et al.[42]	2024	682	214	AI - 238 E-AI - 230	131 (61.2%)	E-AI- 177 (77%) AI-176 (74%)
Schöler et al.[32]	2024	240	118	122	67 (57%)	79 (65%)
Hüneburg et al.[44]	2023	96	46	50	34 (73.9%)	42 (84.0%)
Ahmad et al.[45]	2023	614	306	308	244 (79.7%)	264 (85.7%)
Shaukat et al.[46]	2022	1359	677	682	414 (61.2%)	439 (64.4%)
Glissen Brown et al.[27]	2022	223	110	113	84 (76.36%)	85 (75.22%)
Yao et al.[48]	2022	1210	271	CADe 268 CAQ 269 COMBO 268	113 (41.70)	CADe 149 (55.60) CAQ 144 (53.53) COMBO 172 (64.18)
Xu et al.[52]	2021	1292	1175	1177	425 (36.2%)	457 (38.8%)
Luo et al.[53]	2021	150	78	72	51 (34%)	58 (38.7%)
Liu et al.[50]	2020	1026	518	508	144 (27.81%)	222 (43.65%)
Wang et al. [51]	2019	1058	536	522	166 (29.1%)	235 (45.02%)
TOTAL		8755	4417	5264	2064 (46,73%)	2970 (56,42%)

The highest PDRs and ADRs were observed in studies utilizing advanced AI systems, suggesting a potential benefit of multimodal AI integration. For example, studies utilizing hybrid platforms that combined real-time computer-aided detection (CADe) with computer-aided quality improvement (CAQ) consistently demonstrated superior outcomes. These findings suggest a synergistic effect when detection algorithms are paired with systems designed to monitor and optimize procedural quality. Additionally, AI demonstrated greater efficacy in detecting smaller lesions (≤5 mm) and polyps located in anatomically challenging regions such as the sigmoid colon [40]. This has clinical significance because diminutive and flat lesions, while often missed during SC, are increasingly recognized as contributors to interval cancers.

Another important consideration is whether AI prolongs the duration of colonoscopy procedures. Several included studies specifically evaluated withdrawal time and reported that AI usage did not significantly extend procedure duration, indicating that improvements in detection can be achieved without compromising efficiency or patient throughput [48]. Moreover, AI demonstrated effectiveness not only in average-risk populations undergoing mass screening but also in subgroups with elevated risk profiles, such as patients with Lynch syndrome [44].

Repici et al. observed that AI improved ADR among less experienced endoscopists, suggesting that AI may serve as a valuable training adjunct and help reduce variability in performance between operators.

Although this finding may be partly explained by the natural improvement in performance that comes with experience, it still suggests that AI can act as a useful tool to balance differences between endoscopists [47]. Importantly, later studies by Shaukat et al. and Brown et al. showed that AI also improved ADR among experienced endoscopists [27,47].

When comparing ADR and PDR improvements, it is important to recognize that these metrics reflect complementary aspects of colonoscopy quality. ADR is strongly correlated with reduced risk of interval cancers and is considered the gold standard for measuring colonoscopy performance, whereas PDR provides a broader measure of lesion detection that is easier to report in clinical practice. The consistent improvement in both parameters with AI assistance, therefore, reinforces its clinical relevance: by raising ADR, AI directly improves cancer prevention, and by enhancing PDR, it ensures a more comprehensive and reproducible standard of care.

Conclusions

The analysis reveals the increasing role of AI in enhancing diagnostic performance during colonoscopies, particularly in detecting adenomas and polyps. By consistently improving both ADR and PDR, AI has demonstrated the capacity to elevate the overall quality of CRC screening. The integration of AI into routine endoscopic practice represents a significant advancement, with improvements observed across multiple studies, diverse clinical settings, and varied patient populations. AI has shown greater results in detecting small and flat lesions, which are among the most frequently missed lesions during SC and are closely associated with the development of interval cancers [40]. The data suggest that AI optimizes ADR and PDR, especially when used in conjunction with advanced tools such as Endocuff or multimodal systems like COMBO.

While SC remains an effective tool, the added value of AI is evident even among experienced endoscopists and in high-performing clinical environments. Studies suggest that AI enhances lesion detection, reduces operator variability, thereby raising the baseline quality of colonoscopy across practitioners [33]. This showcases the possible role of AI as both a clinical aid and a training adjunct, ensuring more consistent outcomes in real-world practice. AI has also demonstrated improved detection of diminutive lesions and polyps in anatomically challenging regions, such as the sigmoid colon [40].

This review highlights the current evidence on AI-assisted endoscopy and emphasizes the importance of interdisciplinary collaboration among gastroenterologists, engineers, and computer scientists. Further research is needed to standardize AI technologies, validate their performance across diverse populations, and assess their impact on long-term clinical outcomes. Addressing the gap between technological development and clinical implementation remains a key step in evaluating the role of AI in colorectal cancer screening and patient management.

Economic analyses further support the implementation of AI-assisted colonoscopy by showing that the technology can be cost-effective at both individual and population levels. By preventing missed lesions, AI reduces the incidence of interval cancers, lowers the need for repeat procedures, and decreases treatment costs associated with advanced disease. These advantages not only improve patient outcomes but also alleviate financial burdens on healthcare systems, making AI integration a practical and sustainable advancement [37-39].

AI-assisted colonoscopy has the potential to transform CRC prevention strategies globally. Its adaptability across different endoscopic platforms, patient risk groups, and healthcare systems underscores its versatility. However, challenges remain. Further research is needed to standardize AI technologies, ensure their reproducibility across diverse populations, and establish long-term evidence linking improved detection to reductions in cancer incidence and mortality. Issues of data privacy, regulatory approval, integration into clinical guidelines, and equitable access will also need to be addressed to ensure that AI benefits are widely and fairly distributed.

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