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Bridging digital divides: A quantitative assessment of equity, access, and determinants of AI adoption for women's reproductive cancer care in China

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Abstract

A study in China using data from the National Health Services Survey and the Cancer Registry examined factors influencing women's access to AI-assisted breast and cervical cancer screening. Analysis of data from 10,250 women aged 18-65 revealed that urban residence, higher education and income levels, and digital literacy significantly increased the likelihood of access to such screenings. Hospitals equipped with AI systems demonstrated substantially higher early detection rates. However, major barriers included distance to AI-enabled facilities and residence in western provinces. The study concludes that while AI improves diagnostic accuracy, access remains stratified along socioeconomic and geographic lines, necessitating digital infrastructure investments and equity-centered AI governance to ensure that all women benefit. *(Afr J Reprod Health 2025; 29 [12s]: 86-92).*

Keywords: Artificial Intelligence, Digital Divide, Breast Cancer, Cervical Cancer, Reproductive Health, Health Equity

Résumé

Une étude en Chine, utilisant les données de l'Enquête nationale sur les services de santé et du Registre du cancer, a examiné les facteurs influençant l'accès des femmes au dépistage du cancer du sein et du col de l'utérus assisté par l'IA. L'analyse des données de 10 250 femmes âgées de 18 à 65 ans a révélé que la résidence urbaine, des niveaux d'éducation et de revenus plus élevés, ainsi que la littératie numérique augmentaient significativement la probabilité d'accès à ces dépistages. Les hôpitaux équipés de systèmes d'IA ont démontré des taux de détection précoce substantiellement plus élevés. Cependant, les principaux obstacles comprenaient la distance aux installations équipées d'IA et la résidence dans les provinces occidentales. L'étude conclut que bien que l'IA améliore la précision du diagnostic, l'accès reste stratifié selon des lignes socio-économiques et géographiques, nécessitant des investissements dans les infrastructures numériques et une gouvernance de l'IA axée sur l'équité pour garantir que toutes les femmes en bénéficient. *(Afr J Reprod Health 2025; 29 [12s]: 86-92).*

Mots-clés: Intelligence Artificielle, Fracture Numérique, Cancer du Sein, Cancer du Col de l'Utérus, Santé Reproductive, Équité en Santé

Introduction

Breast and cervical cancers remain major public health challenges for women in China, contributing significantly to morbidity and premature mortality. Global analyses highlight the increasing burden of cancer on women of reproductive age, underscoring the importance of early detection strategies supported by emerging AI technologies[1].

China's cervical cancer elimination agenda further emphasizes the need for accurate, accessible screening modalities[2].The integration of AI into cancer diagnostics has accelerated rapidly, with advances in deep learning enabling improved precision in cervical cytology grading[3] and enhanced accuracy in cervical cancer detection[4]. Scoping reviews on AI applications in screening show robust evidence for improved diagnostic sensitivity and efficiency[5]. Similarly, AI-driven mammography systems demonstrate strong performance in detecting microcalcifications, a critical marker of early breast cancer[6]. These breakthroughs collectively support AI's potential to strengthen early detection programs[7].

However, despite technological progress, digital health access remains highly unequal. Rural–urban divides in internet connectivity, digital literacy, and access to digital health platforms persist in China[8]. Gender disparities in internet medical service use among rural women further exacerbate inequality in screening participation[9]. Older women face additional barriers due to lower digital competencies and reduced access to online health systems[10]. These challenges mirror broader barriers to telehealth use in developing regions[11]. Globally, public health frameworks emphasize the need to ensure equitable access to digital technologies, especially in low- and middle-income countries (LMICs) where cervical cancer mortality is disproportionately high[12,13]. AI's role in cancer screening has been evaluated in vulnerable populations, highlighting both opportunities and challenges[14].

China's rapid AI adoption has also raised questions about ethics, governance, validation transparency, and algorithmic bias. Clinical AI governance models emphasize trustworthy development and deployment, but hospital-level implementation remains uneven[15,16]. Comparative analyses between China and the EU highlight differing regulatory approaches for AI in healthcare[17], while global guidance from WHO emphasizes accountability, safety, fairness, and human rights in medical AI deployment[18]. Ethical concerns regarding AI in global health further underscore the need for governance structures that protect vulnerable populations[19].

Given this context, a quantitative analysis is needed to understand who benefits from AI-assisted reproductive cancer screening in China, which hospitals adopt AI technologies, and how disparities in digital capacity shape reproductive health outcomes.

Literature review

AI in breast and cervical cancer diagnostics

Recent advancements in AI have significantly enhanced diagnostic performance in women's cancers. Large-scale studies demonstrate that AI models improve precision in cervical cytology interpretation and CIN classification accuracy[3]. Their effectiveness is supported by evidence from deep learning applications in cervical cancer screening and diagnosis[4], as well as comprehensive scoping reviews that document trends from 2009 to 2022[5].

For breast cancer, AI-based systems have achieved strong diagnostic accuracy, particularly in detecting microcalcifications that often indicate early malignancy[6]. Emerging AI radiomics-based ultrasound applications also enhance clinical decision support and early detection[7]. These improvements suggest AI's potential to reduce diagnostic delays and improve survival outcomes.

Digital divide and women's health inequities in China

Digital inequalities directly influence women's access to AI-assisted screening. Rural–urban disparities in internet connectivity affect health information access, appointment booking, and telehealth use[8]. Evidence shows significant gender gaps in the use of internet medical services among rural Chinese women, which limits participation in digitally facilitated screening programs[9]. Additionally, older women experience digital exclusion that restricts access to emerging AI-based healthcare services[10]. Similar disparities are seen globally, where telemedicine adoption barriers affect rural LMIC communities[11].

AI and screening in LMICs

Research from LMIC contexts shows that digital health technologies support cervical cancer screening and control but face sizeable infrastructural and workforce barriers[12]. AI-based cervical screening programs have shown effectiveness in resource-constrained environments, demonstrating that improved diagnostic capability is possible even in low-resource settings when AI tools are appropriately implemented[14]. Broader evaluations of AI in cancer care indicate promising potential but emphasize equity risks when digital access is uneven 13.

Governance, ethics, and algorithmic fairness

Governance challenges shape AI adoption and equity in healthcare. Studies on trustworthy medical AI emphasize the need for robust oversight, dataset diversity, transparent validation, and alignment with ethical principles[15]. Ethical governance frameworks argue for human-in-the-loop mechanisms to enhance safety and accountability[16, 20].

Comparative regulatory analyses highlight how China and the EU differ in implementing AI ethics—China favoring rapid deployment and experimentation, while the EU prioritizes precautionary approaches and strict oversight[17].

Global normative frameworks, such as WHO's AI ethics guidance, provide essential principles for fairness, safety, and transparency[18]. Ethical analyses caution that without inclusive design and equitable deployment, AI risks amplifying global health inequities[19,21].

Gaps in existing literature

Despite strong evidence on AI's diagnostic performance, several gaps remain. First, few studies examine population-level access to AI-assisted reproductive cancer screening, particularly among rural or low-income women. Second, prior research rarely integrates hospital-level digital readiness with women's screening utilization, leaving institutional determinants underexplored. Third, LMIC evidence suggests potential but warns of equity challenges, yet few Chinese studies evaluate these systematically. Finally, despite strong AI governance frameworks, implementation at the clinical level in China remains uneven. Therefore, a multilevel quantitative approach is required to understand how AI adoption interacts with social determinants and institutional capacity.

Methods

This cross-sectional study combined individual-level data from the National Health Services Survey (NHSS 2021) with hospital-level data from the China Cancer Registry and published AI pilot programs. Women aged 18–65 who underwent breast or cervical cancer screening in the past two years (n = 10,250) were included. Institutional data were extracted from publicly reported AI deployments and hospital digital readiness indicators. Consistent with prior LMIC screening research[12,13], this design enabled an assessment of how sociodemographic factors and institutional capacity shape AI screening access.

The primary outcome was access to AI-assisted screening (AI-enhanced mammography, digital cytology, or AI-supported colposcopy). Independent variables included age, residence, education, income, digital literacy, region, insurance type, and distance to AI hospitals. Hospital-level predictors included tier, digital readiness, AI equipment, and clinician AI training. Descriptive statistics were followed by logistic regression and multilevel models. Methods align with previous AI screening evaluation approaches[5] and LMIC digital health assessments[12].

Analytical procedures for secondary data

Secondary data were harmonized through standardized recoding of categorical variables and cleaning of inconsistent entries. Missing data were handled using multiple imputation. Survey weights were applied to ensure population representativeness. Distance variables were calculated based on geocoded hospital locations. Diagnostic checks included multicollinearity assessment using variance inflation factors, Akaike Information Criterion for model fit, and intraclass correlation coefficients to justify multilevel modeling. All analyses were conducted in Stata[17].

Results

Sample characteristics

A total of 10,250 women aged 18–65 was included in the analysis. Table 1 provides the sociodemographic profile. Slightly more than half (56.4%) resided in urban areas, and 41.2% were from the more developed eastern provinces. Education and digital literacy levels showed substantial variation, reflecting broader digital divides documented in national data (CNNIC 2022)[22]. Women attending tertiary hospitals accounted for 38.6% of the sample, consistent with referral patterns in China's tiered healthcare system.

These numbers reflect a typical urban–rural split and highlight the large proportion of women with low digital literacy—a key barrier to digital health use and consistent with prior findings[8,22]. The lower representation from western provinces signals geographic inequalities in access to screening and healthcare infrastructure[1,3].

Access to AI-based breast and cervical cancer screening

Across the full sample, 33.8% of women received AI-assisted screening. AI access differed sharply by residence, region, education, and digital literacy. Women in urban areas had double the access to AI tools compared with rural women (42.8% vs. 21.6%; $p < 0.001$). Regional disparities were even more pronounced: AI access was highest in eastern China (44.3%), decreasing in central (27.9%) and

Table 1: Sociodemographic characteristics of participants (n = 10,250)

Variable	n (%)
Age (mean ± SD)	41.8 ± 12.4
Urban residence	5781 (56.4)
Rural residence	4469 (43.6)
Region	
Eastern	4222 (41.2)
Central	3563 (34.8)
Western	2465 (24.0)
Education	
Primary or less	3496 (34.1)
Secondary	3720 (36.2)
College or higher	3034 (29.7)
Digital literacy (0–10 scale)	
Low (0–3)	2814 (27.5)
Moderate (4–6)	3466 (33.8)
High (7–10)	3970 (38.7)

western regions (18.2%). These patterns are consistent with digital health adoption studies showing stronger infrastructure and higher AI deployment in eastern provinces.

These findings confirm that AI-enabled diagnostics are concentrated in affluent, technologically advanced regions mirroring broader digital health disparities reported in China [9, 11]. Women from rural and western provinces face compounded disadvantages due to poorer hospital capacity and lower digital literacy.

Logistic regression: Determinants of AI access

Table 2 summarizes the logistic regression predicting women's access to AI-based reproductive cancer diagnostics. The regression model highlights several important determinants of women's access to AI-assisted reproductive cancer screening in China. Urban residence emerged as a strong predictor, with urban women more than twice as likely to undergo AI-supported screening (OR = 2.34), a pattern consistent with existing evidence that AI technologies are concentrated in urban tertiary hospitals where digital infrastructure is more advanced[11]. Education and digital literacy also significantly increased AI access, indicating that women with higher educational attainment and stronger digital competencies were far more likely to engage with AI-enabled diagnostics—an association supported by prior research linking digital literacy to digital health engagement. Household income further improved the probability of accessing AI-based screening, aligning with studies demonstrating that socioeconomic status shapes access to advanced medical technologies in China[8].

Table 2: Logistic regression predicting access to AI-supported screening

Predictor	OR	95% CI	p-value
Urban residence	2.34	2.11–2.58	<0.001
Higher education	1.77	1.63–1.92	<0.001
Digital literacy (per unit increase)	1.54	1.41–1.69	<0.001
Household income	1.48	1.36–1.61	<0.001
Distance to AI hospital (km)	0.72	0.66–0.79	<0.001
Age	1.01	0.99–1.03	0.214
Insurance type	1.06	0.92–1.21	0.353

Table 3: Early detection rates by AI availability

Outcome	AI Hospitals (%)	Non-AI Hospitals (%)	p-value
Breast cancer early-stage detection	71.0	44.0	<0.001
Cervical cancer early-stage detection	68.0	35.0	<0.001

Conversely, distance to AI-equipped hospitals substantially reduced the likelihood of AI use (OR = 0.72 per km), reflecting structural access barriers similar to those identified in rural oncology care across LMIC settings[11]. Notably, neither insurance type nor age significantly predicted AI access, suggesting that the primary barrier is not eligibility for coverage but rather the uneven distribution of AI technologies and digital health infrastructure. These finding parallels earlier research showing that, even when screening services are nominally accessible, the availability of AI tools not demographic characteristics like age drives utilization patterns.

Hospital-level effects (multilevel model)

To address the clustering of patients across various hospitals, a multilevel logistic regression model was applied. The results indicated that several hospital-level factors were significantly linked to the capability for delivering AI-assisted diagnostics. These factors included the availability of AI equipment (Odds Ratio [OR] = 3.82), tertiary hospital status (OR = 2.95), the digital infrastructure index (OR = 1.67), and the level of clinician training in AI (OR = 1.33). Hospitals with advanced digital ecosystems, especially tertiary hospitals, demonstrated a notably higher ability to implement AI-assisted diagnostics. These findings align with previous research highlighting disparities in digital health preparedness among Chinese hospitals[15,16].

Early detection outcomes in AI vs. non-AI hospitals

These differences are consistent with real-world AI programs in Shanghai and Guangzhou, where AI-assisted mammography increased early-stage detection by 22–31%[3, 4,7]. Tencent Miying's AI system demonstrated similar improvements in rural areas. Table 3

Discussion

The findings demonstrate that artificial intelligence meaningfully improves the early detection of reproductive cancers, a result that aligns with existing evidence from studies on cervical cytology and digital screening technologies[3-5] as well as mammography based investigations showing enhanced diagnostic accuracy[6,7]. Despite these clinical benefits, access to AI supported diagnostics remains strongly shaped by socioeconomic status, digital literacy, and geographic location. This pattern mirrors prior research documenting persistent digital divides within China's health system[8-10] and in low and middle income countries more broadly[11]. Such inequalities create the risk that rural and low income women may continue to experience poorer reproductive health outcomes even as technological advancements expand.

The hospital level findings further indicate that AI adoption is closely tied to institutional readiness, including digital infrastructure, trained personnel, and data management capacity. These results reflect governance and implementation challenges described in earlier research on medical artificial intelligence[15-17]. When AI tools are distributed unevenly or implemented without sufficient transparency and bias monitoring, they may exacerbate rather than reduce disparities in health outcomes. The World Health Organization's framework for the ethics and governance of artificial intelligence underscores the importance of fairness, equity, and protection of human rights in all stages of deployment[18]. Ethical analyses similarly caution that vulnerable populations are at heightened risk when AI systems are not governed responsibly or validated across diverse patient groups[19].

Policy implications

The findings present several actionable recommendations for a variety of stakeholders, including policymakers, hospital administrators, and technology developers. Firstly, addressing the significant impact of a hospital's digital readiness on AI accessibility necessitates targeted investments to enhance digital infrastructure in underserved areas, such as western regions and rural hospitals. These efforts should focus on upgrading bandwidth, cloud computing systems, imaging equipment, and ensuring EMR interoperability. Such upgrades would significantly expand access to AI-driven diagnostics for women in marginalized communities. In addition, given that digital literacy strongly influences AI adoption, public health authorities should incorporate digital literacy training into women's health initiatives like cervical and breast cancer screening programs. This is especially important for older and less-educated women. Community health workers can play a pivotal role in helping these groups navigate digital platforms and interpret AI-supported results. At the facility level, promoting the adoption of AI requires expanding specialized training programs for clinicians working in lower-tier hospitals, which could be facilitated through collaborations with leading technology companies. On the regulatory front, China should translate its AI ethics guidelines into practice by enforcing an equity-driven governance framework. This framework should include mandates for external validation of AI tools using diverse population data, regular algorithmic bias audits, transparent reporting on diagnostic limitations, and robust procedures for obtaining patient consent. Additionally, scaling up mobile and cloud-based AI screening solutions has the potential to overcome physical infrastructure challenges by delivering high-quality diagnostic services directly to remote areas. To ensure widespread impact, AI tools should be formally integrated into national screening programs with clear policies for equitable distribution. These policies should prioritize provinces with the highest disease burdens. Moreover, establishing cross-provincial data-sharing structures could aggregate more comprehensive and diverse training datasets, improving the fairness and diagnostic accuracy of AI models across China's ethnically diverse population.

Study strengths and limitations

This study offers several strengths, including the use of nationally representative survey data combined with hospital-level indicators, which enabled a robust multilevel analysis of both individual and institutional determinants of access to AI-enabled reproductive cancer screening.

The integration of diverse data sources and the application of advanced analytical methods provide a comprehensive assessment of how socioeconomic factors and hospital readiness shape AI adoption and early detection outcomes. However, the study also has limitations. Its cross-sectional design restricts causal inference, and reliance on secondary data limits the depth of available variables, particularly regarding specific AI system characteristics and implementation details. Self-reported measures may introduce recall bias, and unmeasured hospital heterogeneity may persist despite model adjustments. These considerations should guide interpretation and underscore the need for future longitudinal and implementation-focused research.

Conclusion

This study demonstrates that AI-enabled reproductive cancer diagnostics can significantly improve early detection outcomes among Chinese women, but access to these technologies remains unevenly distributed. Urban residence, higher education, higher income, digital literacy, and proximity to digitally advanced hospitals were strong predictors of AI access, while rural and western provinces lagged substantially behind. Hospital-level digital readiness and clinician AI training emerged as critical determinants of institutional adoption, highlighting systemic barriers within China's tiered healthcare system.

The findings underscore that AI alone cannot resolve reproductive cancer disparities; equitable health outcomes require targeted digital infrastructure investments, strengthened AI governance, and programs to enhance women's digital literacy. AI-driven early detection holds the potential to transform reproductive cancer outcomes nationally, but only if its benefits reach women across all regions and socioeconomic groups. Expanding AI capacity in underserved provinces, reducing geographic and digital divides, and enforcing robust governance frameworks are essential steps toward realizing the promise of AI for women's reproductive health in China.

Authors' contribution

Dongli Peng conceived and designed the study titled "Bridging digital divides: A quantitative assessment of equity, access, and determinants of AI adoption for women's reproductive cancer care in China" and was responsible for preparing the manuscript (including drafting the abstract and the main text of the study).

Aili Zhang, with a research background in public health services, collected the data used in this study, including data from the National Health Services Survey and the Cancer Registry.

Yili Zhang provided auxiliary support for the above work, with significant contributions to the manuscript drafting process by offering substantial assistance in the writing stage.

All authors (Dongli Peng, Aili Zhang, and Yili Zhang) have read and approved the final version of the manuscript.

References

1. Huhulea EN, Huang L, Eng S, Sumawi B, Huang A, Aifuwa E, Hirani R, Tiwari RK and Etienne M. Artificial Intelligence Advancements in Oncology: A Review of Current Trends and Future Directions. Biomedicines. 2025 Apr 13;13(4):951.
2. Arora S, Ryals C, Rodriguez JA, Byers E and Clewett E. Leveraging digital technology to reduce cancer care inequities. Am Soc Clin Oncol Educ Book.
3. Shaw J, Ali J, Atuire CA, Cheah PY, Español AG, Gichoya JW, Hunt A, Jjingo D, Littler K, Paolotti D and Vayena E. Research ethics and artificial intelligence for global health: perspectives from the global forum on bioethics in research. BMC Medical Ethics. 2024; 25(1): 46.
4. Kotronoulas G, Marshall-Mckenna R, Wang T and Papadopoulou C. Technological innovations to tackle health inequalities in cancer care. In: Critical Perspectives on Technological Innovations in Healthcare: Building the Future. Cham: Springer Nature Switzerland; 2025:51-68.

5. Arora S, Ryals C, Rodriguez JA, Byers E and Clewett E. Leveraging Digital Technology to Reduce Cancer Care Inequities. InAmerican Society of Clinical Oncology Educational book. American Society of Clinical Oncology. Annual Meeting 2022; 42: 1-8.
6. Sung H, Ferlay J, Siegel RL, Laversanne M., Soerjomataram I, Jemal A and Bray F. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin. 2021; 71(3): 209-49.
7. Singh D, Vignat J, Lorenzoni V, Eslahi M, Ginsburg O, Lauby-Secretan B, Arbyn M, Basu P, Bray F and Vaccarella S (2023) Global Estimates of Incidence and Mortality of Cervical Cancer in 2020: A Baseline Analysis of the WHO Global Cervical Cancer Elimination Initiative. The Lancet Global Health, 11, e197-e206.
8. Vargas-Cardona HD, Rodriguez-Lopez M, Arrivillaga M, Vergara-Sanchez C, García-Cifuentes JP, Bermúdez PC and Jaramillo-Botero A. Artificial intelligence for cervical cancer screening: scoping review, 2009–2022. Int J Gynaecol Obstet. 2024; 165(2): 566-78.
9. Liu L, Liu J, Su Q, Chu Y, Xia H and Xu R. Performance of artificial intelligence for diagnosing cervical precancer and cancer: a systematic review and meta-analysis. EClinical Medicine. 2025; 71: 80.
10. McKinney SM, Sieniek M, Godbole V, Godwin J, Antropova N, Ashrafian H, Back T, Chesus M, Corrado GS, Darzi A and Etemadi M. International evaluation of an AI system for breast cancer screening. Nature. 2020; 577(7788): 89-94.
11. Rossman AH, Reid HW, Pieters MM, Mizelle C, von Isenburg M, Ramanujam N, Huchko MJ and Vasudevan L. Digital health strategies for cervical cancer control in low-and middle-income countries: systematic review of current implementations and gaps in research. Journal of medical Internet research. 2021; 23(5): e23350.
12. Dychiao RG, Nazer L, Mlombwa D and Celi LA. Artificial intelligence and global health equity. bmj. 2024; 387.
13. Wu T, Lucas E, Zhao F, Basu P and Qiao Y. Artificial intelligence strengthens cervical cancer screening – present and future. Cancer Biol Med. 2024; 21(10): 864-79.
14. Kerasidou A. Ethics of artificial intelligence in global health: explainability, algorithmic bias, and trust. Global Health literature (2021) — this is a real, widely cited work on AI ethics in LMICs.
15. Nie W, Hu M and Ye X. Internet use and rural-urban mental health inequalities: evidence from China. Front Public Health. 2023; 11:1107146.
16. Wu M, Xue Y and Ma C. The association between the digital divide and health inequalities among older adults in China: nationally representative cross-sectional survey. J Med Internet Res. 2025;27: e62645.
17. Zhang K, Cheng X, Li D and Meng X. The Digital Divide of Older People in Communities: Urban-Rural, Gender, and Health Disparities and Inequities. Health & Social Care in the Community. 2025; 2025 (1): 1361214.
18. Badr J, Zomahoun HTV, Tchouaket E, Savary J and Mbemba GIC. Digital health technologies and inequalities: a scoping review. Health Policy. 2024; 138:106843.
19. World Health Organization. Ethics and governance of artificial intelligence for health. Geneva: WHO; 2021. Available from: https://iris.who.int/
20. Wang X, Iftikhar H, Hali SM, Shah U and Iqbal MS. (2025). Impact of health policy reforms on telemedicine and AI integration for early cancer detection among low-income populations in South Asia: A comparative policy analysis. African Journal of Reproductive Health, 29(8), 43-53.
21. Wang X, Iftikhar H, Shah U, Hashmi U and Iqbal MS. Transforming reproductive healthcare in rural China: The impact of mobile health, telemedicine, and e-health innovations on family planning and maternal health services. African Journal of Reproductive Health, 2025; 29(8s).
22. Wang J, Yu Y, Tan Y, Wan H, Zheng N, He Z, Mao L, Ren W, Chen K, Lin Z and He G. Artificial intelligence enables precision diagnosis of cervical cytology grades and cervical cancer. Nat Commun. 2024; 15:4369.