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Artificial intelligence in community pharmacy practice: Pharmacists' perceptions, willingness to utilize, and barriers to implementation

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ABSTRACT

Background: Artificial intelligence (AI) has a significant potential to impact pharmacy practices worldwide. This study investigates pharmacists' perceptions of AI's role in pharmacy practices, their willingness to adopt it, and perceived barriers to its implementation at community pharmacies in Ethiopia.

Methods: A cross-sectional study was conducted among community pharmacists in Ethiopia. Data were collected using a self-administered questionnaire. Independent samples *t*-test, one-way ANOVA, and post-hoc analyses were used to compare pharmacists' perception and willingness scores. A linear regression analysis examined the association of independent variables with pharmacists' perception of AI and willingness to utilize AI. A *p*-value <0.05 was considered statistically significant.

Results: Of 241 pharmacists approached, 225 (93.3 %) completed the survey. Overall, about two-thirds (67.1 % and 66.2 %) of community pharmacists had a high level of perception and willingness to use AI applications in pharmacy, respectively. Pharmacists with bachelor's degrees and above (β = 2.76: 95 % CI: 0.09, 5.01 vs. β = 1.79: 95 % CI: 0.05, 4.21), those who utilized scientific drug information sources (β = 2.45, 95 %: 0.17, 4.45 vs. β = 1.76, 95 % CI: 0.91, 3.89), pharmacists who had a previous exposure of AI (β = 1.02, 95 %: 0.03, 3.24 vs. β =1.13, 95 % CI: 0.07, 2.93), and those who with higher perceived AI knowledge (β =1.09, 95 % CI: 0.02, 2.46 vs. β = 1.14, 95 %CI: 0.17, 3.11) had significantly higher perception of AI and willingness to utilize it, respectively compared to their counterparts. Lack of internet availability (89.3 %), lack of AI-related software/hardware (88.2 %), and limited training (80.9 %) were the most frequently reported barriers by pharmacists to AI adoption. Over 90 % of pharmacists agreed on the importance of internet availability (93.3 %), policies/frameworks (91.6 %), and research/learning from others (89.3 %) for successful AI integration.

Conclusion: Despite positive perceptions and willingness from pharmacists, AI implementation in community pharmacies could be hindered by resource limitations, training gaps, skill constraints, and infrastructure issues. To facilitate adoption, enhancing knowledge and skills, and developing policies/frameworks are crucial.

1. Introduction

The healthcare delivery system has continued to advance and needs technology-assisted interventions. The emergence of artificial intelligence (AI) and its connection with the healthcare system has given rise to innovative solutions that promise to transform the delivery of care.[1–3]

Abbreviations: AI, artificial inelegance; CDROs, community drug retail outlets.

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Community pharmacy, as a vital component of the healthcare ecosystem, is poised to benefit significantly from the integration of AI technologies.

Applications of AI in pharmacy practice can be defined as the application of computer systems to perform tasks that typically require human intelligence, such as data analysis and interpretation, decision support, automation of tasks, and personalized patient care.[4,5] Different key characteristics of AI, such as machine learning, natural language processing, and robotics, can be used to perform various tasks.[5] Generative AI chatbots, for example, Pharmabot provide information about generic medicines for children, while Pharmabroad is a chatbot tool to identify a pharmaceutical product.[6] Buoy Health is also among the interactive chatbots that offer personalized advice about medication usage, diet changes, lifestyle modifications, and treatment plans.[7] By leveraging AI's capabilities, pharmacists can enhance efficiency and accuracy, improve patient safety, and optimize medication management.[8,9]

Artificial intelligence's potential in community pharmacy is multifaceted. One of its most promising applications lies in the realm of medication management.[10–12] AI-powered systems can assist pharmacists in tasks such as medication reconciliation, drug interaction checking, medication adherence monitoring, detecting potential medication errors, such as incorrect dosing or adverse drug reactions, and alert pharmacists to take appropriate action.[4,5,13,14] This can help to maintain patient safety by preventing medication-related harm and ensuring the safe and effective use of medications.[15] AI algorithms can analyze vast amounts of patient data to identify patterns and trends that may inform medication decisions and improve treatment outcomes.[5,16,17] A robotic medication dispensing system automates the process of preparing medicines for dispensing in community pharmacy settings, working alongside pharmacists.[12]

Another area where AI can significantly impact is inventory management.[16] AI-enabled systems can predict medication demand, optimize stock levels, and prevent shortages or overstocking.[5] This can lead to cost savings and ensure essential medications are always available to patients. Additionally, AI can help streamline the ordering process by automating tasks such as generating purchase orders and tracking shipments.[18] Omnicell's Automated Pharmacy Solutions is an example of AI-driven inventory management systems that monitor drug usage patterns, automates ordering, and helps pharmacies manage their stock more efficiently.[19]

While AI's role in pharmacy practices has been investigated and has been evolving in well-developed settings,[4,8–10,16,18,20,21] its extent of utilization and pharmacist readiness in resource-limited settings such as Ethiopia remain unexplored. No published evidence addressed pharmacist perceptions and their readiness to apply AI application in community pharmacy practices. To gain a deeper understanding of the potential role of AI in community pharmacy and the challenges associated with its implementation, this study aimed to investigate pharmacists' perceptions of AI's role in service provision, willingness to use it, perceived barriers to implementation, and recommendations for future AI adoption to effectively apply AI technologies in the community pharmacy settings in Ethiopia.

2. Methods

2.1. Study design and settings

A community-based cross-sectional survey was conducted among the pharmacists working in community drug retail outlets (CDROs) from 15 November 2023 to 20 January 2024. The pharmacists were recruited from Gondar and Bahir Dar, two cities in Northwest Ethiopia, which had lots of CDROs. These cities were chosen randomly from other cities in the region. CDROs in both cities are considered to have comparable community pharmacy practices and pharmacists' experiences.

2.2. Study sample and eligibility criteria

Initially, using a simple proportion formula, a sample size of 143 pharmacists was calculated for the study: n = p (1-p) * (Z)2/d2; assuming a 5 % margin error or degree of accuracy (d = 0.05), reliability coefficient for 95 % confidence level (Z = 1.96), and $p = 0.5$ (50 %) response distribution. Considering the limited number of pharmacists in 195 active CDROs as of 15 November 2023, all working pharmacists were approached. More than one pharmacist from the same CDRO was allowed to participate. All licensed pharmacists in the identified CDROs, with at least three months of experience in the pharmacy setting, were eligible to participate. Those unavailable during the study and refusing to participate were excluded. Finally, 241 pharmacists were approached.

2.3. Operational definitions

2.3.1. Artificial intelligence

In this study, artificial intelligence indicates the application of computer systems to perform tasks that typically require human intelligence, such as data analysis and interpretation, decision support, automation of tasks, and personalized patient care using different AI models including machine learning, natural language processing, and robotics, and more. This definition of AI was made clear for pharmacists during recruitment before data collection.

2.3.2. Community drug retail outlets (CDROs)

Community drug retail outlets are a broad category that encompasses both pharmacies and drug stores, where pharmacists are actively involved in providing healthcare services in the community settings.[22]

2.3.3. Pharmacy

A pharmacy is a drug retail outlet with legal authorization to dispense and sell all types of prescription and over-the-counter medications, as well as medical equipment. Pharmacists, who possess a degree in pharmacy or higher, are responsible for licensing and overseeing the operations of pharmacies. Diploma-holder pharmacy technicians assist pharmacists in dispensing medications but are not permitted to license pharmacies, as per the regulations of the Ethiopian Food and Drug Authority (EFDA).

2.3.4. Drug store

A drug store is a drug retail outlet that typically offers a more limited range of medications than a pharmacy. Unlike pharmacies, drug stores may not have access to all types of prescription drugs, including controlled substances like psychotropics and narcotics. Licensed diploma-holder pharmacy levels may own drug stores, but their scope of practice is generally more limited than that of a licensed pharmacist.

2.3.5. Drug information sources

In this study, drug information is categorized as scientific and non-scientific. Scientific drug information sources, such as peer-reviewed articles, guidelines from reputable organizations, verified medical websites, and expert consensus reports, adhere to rigorous scientific methods and standards, providing reliable and accurate information about drugs. Non-scientific drug information sources, including social media posts, personal opinions, online forums, commercial websites, and unverified blogs, may not follow these standards and may provide information that is inaccurate, biased, or misleading.

2.4. Data collection instruments and procedures

The data was collected using a self-administered structured questionnaire. The data collection instrument was prepared after reviewing previously published related literature.[4,21,23] It was then translated into the local language Amharic and back to English to check its consistency and clarity. After contextual amendment based on the local settings, a self-administered questionnaire was provided to pharmacists. The five sections of the data collection instrument focused on: (1) pharmacists' socio-demographic characteristics; (2) assessments of pharmacists' perception of the roles of AI in pharmacy practices; (3) assessments of pharmacists' willingness to utilize AI in their practice; (4) pharmacists' perceived barriers to applying AI technology; and (5) pharmacists' recommendations for effective implementation of AI technologies in the community pharmacy setting.

Pharmacists' perception of the roles of AI in pharmacy practices was assessed using a 15- was assessed using a 15-item on a five-level Likert scale. Items covered pharmacists' perceptions related to AI applications and the need for training, service quality, patient outcomes improvement and satisfaction, and task efficiency impacts on AI utilization. Each item ranges from 1 to 5 (strongly disagree = 1 to strongly agree = 5). The possible total sum score ranged from (minimum =15) and (maximum = 75). A higher total score indicated a higher pharmacists' perception of the roles of AI in pharmacy practices. Perception levels were categorized as low or negative (below the mean) and high or positive (equal to or above the mean) based on previous literature.[21]

Pharmacists' willingness to apply AI in their practice was assessed using a 16-item question with response options ranging from strongly disagree =1 to strongly agree =5 on a 5-point Likert scale. Items covered AI applications for social, medical, and medication-related issues. The possible sum of scores ranges between 16 (minimum) and 80 (maximum), with a higher score indicating a higher level of willingness to apply AI technology. Willingness levels were categorized as low (below the mean) and high (equal to or above the mean) based on previous literature.[21]

Pharmacists' perceived barriers to AI implementation were assessed using 14-item question covering skills, training, resources, and infrastructure. Responses were on a three-level scale (agree, not sure, disagree). Pharmacists also provided recommendations on the importance of resources, training, and infrastructure for effective AI adoption, using eight items utilizing a three-level scale (agree, not sure, disagree).

Reliability tests for perception, willingness, barriers, and recommendations demonstrated good internal consistency with Cronbach's alpha values of 0.86, 0.92, 0.89, and 0.81, respectively.

A factor analysis of the scales was conducted, revealing three factors across all scales. For the pharmacists' perception of AI assessment questions, the factors comprised five, seven, and three items, collectively explaining 70.2 % to 78.6 % of the total variance, with factor loadings ranging from 0.701 to 0.834. Pharmacists' willingness to utilize AI assessment items was validated, showing a total variance explained of 74.1 % to 80.5 %, with factor loadings ranging from 0.652 to 0.862 across three factors composed of six, seven, and three items. Additionally, the perceived barriers and future recommendations for AI application were examined, resulting from 70.2 % to 81.4 % of the total variance explained, with factor loadings ranging from 0.671 to 0.814 across all factors.

2.5. Data quality control methods

The questionnaire underwent expert review for content and face validity. It was also pretested among 10 pharmacists working in the CDROs. Minor modifications were made for clarity and readability. Data were collected by four trained clinical pharmacy students under the principal investigator's supervision after they received a half-day training on data collection procedures and ethical aspects. Initially, pharmacists were informed of the study objectives and consented to participate. Data cleanliness, completeness, and clarity were checked daily during the data collection.

2.6. Data analysis

Data were collected, cleaned, and entered into EPI-info 8, then transferred to SPSS 26 for analysis. Shapiro-Willick test ($p > 0.05$), histogram, and Q-Q plots were used to assess the normality of continuous variables. Results were presented as mean(±SD) for continuous variables and frequency (%) for categorical variables. An Exploratory Factor analysis (EFA) of the instrument was performed using the principal components method of extraction and varimax rotation.

Independent *t*-tests (for variables with two categories) and one-way ANOVAs with further Post-hoc analysis (for variables with more than two categories) were used to compare mean scores of pharmacists' perceptions and willingness. Post-hoc analysis was applied to compare scores of paired groups for those subgroups found to have a statistically significant difference with one-way ANOVA analysis.

Two independent linear regression analysis were applied to examine the association between pharmacists' perception and willingness scores and other independent variables. Variables with a *p*-value of ≤0.2 in the bivariable analysis were analyzed further in multivariable linear regression analysis to identify factors having statistically significant associations. The regression results showed that the model was explained by an adjusted R square of 80.6 % and 76.2 % for pharmacists' perception of AI and pharmacists' willingness to utilize AI applications, respectively. A variance inflated factor (VIF of <5 was observed for all variables in both analyses. Unstandardized coefficients were expressed in standard deviations and represented the effect size of the average change in the pharmacists' perceptions of AI and willingness to utilize AI for each unit increase in the predictor variable. A *p*-value <0.05 was considered statistically significant.

3. Results

3.1. Sociodemographic characteristics of pharmacists

Of 241 contacts, 225 completed the survey resulting in a 93.3 % response rate. Over half of the pharmacists (120, 53.3 %) were male with an average age of 31.4 ± 6.5 years. Most pharmacists (127, 56.4 %) had a higher degree level. More than half (121, 53.8 %) had 1–5 years of work experience. None of the CDROs had internet access during the study period and most pharmacists (139, 61.8 %) used nonscientific resources as their drug information sources. Over half (118, 52.4 %) have not heard of or been experienced with AI technology, and most (141, 62.7 %) rated their AI knowledge as minimal (Table 1).

3.2. Pharmacists' perceptions of AI's role in pharmacy practice

The mean score for pharmacists' perception was 59.1 ± 9.2 (range: 51.7–66.8). Over two-thirds (151, 67.1 %) had a high or positive perception of AI's roles in community pharmacy practices. Most agreed or strongly agreed with statements about AI's impact on their practice. Three-fourths (170, 75.6 %) expressed interested in staying up to date on AI applications, and a similar proportion believed AI would assist in clinical investigation tasks more efficiently than humans (Table 2).

3.3. Pharmacists' willingness to utilize AI

Most pharmacists were willing to apply AI for medical data collection (165, 73.3 %), social data collection (156, 69.3 %), inventory management (162, 72.0 %), medication dispensing (140, 62.2 %), patient counseling (147, 65.3 %), care plan designing (141, 62.7 %), connecting healthcare systems (156, 69.3 %), and providing care from a distance (150, 66.7 %). The average willingness score was 65.3 ± 10.2 (range: 61.2–71.3). Overall, about two-thirds of pharmacists (149, 66.2 %) were willing to apply AI technologies in the community pharmacy setting (Table 3).

Table 1
Pharmacists' characteristics in CDORs in Gondar and Bahir Dar cities ($N = 225$).

Characteristic		Frequency (%)	Mean (±SD)
Sex	Male	120 (53.3)	
	Female	105 (46.7)	
Age (years)		–	31.4 (±6.5)
Educational level	Diploma level	98 (43.6)	
	Degree and above	127 (56.4)	
Service duration as a pharmacist (years)	<1	42 (18.6)	4.7 (±1.7)
	1–5	121 (53.8)	
	>5	62 (27.6)	
Role in pharmacy	Employee	181 (80.4)	
	Owner	44 (19.6)	
Income level per month (ETB)	<2500	42 (18.7)	5235 (±187.6)
	2500–5999	119 (52.9)	
	≥6000	64 (28.4)	
Type of CDROs	Drug store	108 (48.0)	
	Pharmacy	117 (52)	
Number of clients served per day	<50	147 (65.3)	27.2 (±11.8)
	>50	78 (34.7)	
Number of prescriptions received per day	<50	141(62.7)	30.5 (10.3)
	>50	84 (37.3)	
Average minutes spent with a client	<5	171 (76.0)	2.6 (±1.1)
	>5	54 (24.0)	
Working hours per day:	≤8	120(42.1)	8. 6(±2.3)
	>8	165 (57.9)	
Number of working pharmacists		–	1.6 (±0.7)
Internet access in the CDRO	Yes	0	
	No	225 (100)	
Drug information sources	Nonscientific	139 (61.8)	
	Scientific	86 (38.2)	
Have you heard/been experienced with AI and related issues before this survey?	Yes	107 (47.6)	
	No	118 (52.4)	
How do you rate your knowledge of AI technology applications?	Minimal	141 (62.7)	
	Moderate	73 (32.5)	
	High	11 (5.8)	

ETB; Ethiopian birr, CDROs; community drug retail outlets.

3.4. Comparison of pharmacists' perception of AI's role and willingness to utilize AI

Independent sample *t*-tests revealed that pharmacists with higher education (degree and above) had significantly higher perception scores (Mn = 66.9, $t = 1.71$; $p = 0.01$) and willingness scores (Mn = 66.9, $t = 1.71$; $p = 0.01$) compared with their counterparts. Similarly, pharmacists who were using scientific sources of drug information had significantly higher perception scores (Mn = 64.2, $t = 1.35$; $p = 0.023$) and willingness scores (Mn = 70.6, $t = 1.97$; $p = 0.015$) compared with their counterparts. Moreover, pharmacists with previous AI experience before this study had significantly higher perception scores (Mn = 65.1, $t = 1.26$, $p = 0.001$) and willingness scores (Mn = 72.1, $t = 1.09$; $p = 0.01$) compared with their counterparts. One-way ANOVA also revealed that pharmacists' perception of AI and willingness to utilize it scores were significantly higher among pharmacists who rated their levels of knowledge high about AI technology (Table 4). Further Post hoc comparison of paired groups analysis showed that there was a statistically significant perception scores difference between pharmacists who had a higher [Mn = 63.5] and minimal [Mn = 55.6] perceived knowledge of AI application [$p = 0.021$). Similarly, pharmacists who had a higher perceived knowledge had a higher willingness score [Mn = 71.7] compared with those who had minimal perceived knowledge [Mn = 60.2]; ($p = 0.03$) to the application of AI technology.

3.5. Association between pharmacists' perception of AI's role and willingness to utilize AI and other variables

After running a simple linear regression analysis for pharmacists' perception of AI and willingness to utilize it, variables with *p*-value ≤0.2 were further analyzed in the multivariable analysis. Pharmacists' educational level, previous experience with AI, drug information sources, and pharmacists perceived knowledge had a statistically significant association with both pharmacists' perception of AI and their willingness to utilize it.

Pharmacists with bachelor's degrees and above (β = 2.76: 95 % CI: 0.09, 5.01) and (β = 1.79: 95 % CI: 0.05, 4.21) had a higher perception of AI and willingness to utilize AI compared with pharmacy technicians, respectively. Pharmacists who utilized scientific drug information sources had a higher perception of AI (β = 2.45, 95 %: 0.173, 4.45) and higher willingness to utilize AI (β = 1.76, 95 % CI: 0.91, 3.89) compared with those who utilized nonscientific drug information sources. Similarly, pharmacists who had a previous exposure of AI (β = 1.02, 95 %: 0.03, 3.24 vs. β =1.13, 95 % CI: 0.07, 2.93) and those who rate their AI knowledge high (β =1.09, 95 % CI: 0.02, 2.46 vs. β = 1.14, 95 %CI: 0.17, 3.1) had higher perception of AI and willingness to utilize it, respectively (Table 5).

3.6. Perceived barriers to AI implementation in community pharmacy settings

Over 80 % of pharmacists agreed that lack of resources including internet (201, 89.3 %), lack of AI-related software and hardware (185, 88.2 %), and lack of training (182, 80.9 %) as potential barriers to the application of AI technologies in community pharmacy practices. More than two-thirds of pharmacists also agreed that the high running cost of AI (170, 75.6 %), fear of litigation (165, 73.3 %), regulatory and social constraints (152, 67.6 %), and lack of AI information (150, 66.7 %) were among the potential barriers to applying AI in community pharmacy settings (Table 6).

3.7. Pharmacists' response on future direction recommendations to apply AI

Over 90 % of pharmacists agreed on the importance of resources such as the availability of the internet (210, 93.3 %), policies and frameworks (206, 91.6 %), and research and learning from other experiences (201, 89.3 %). More than 80 % also agreed on the need for infrastructure such as software and hardware, training and education, pharmacists' readiness and skills, and sufficient personnel to effectively implement AI in community pharmacy settings (Table 7).

4. Discussion

Advanced technologies such as AI are increasingly impacting pharmacy practice worldwide.[4,5,10,24,25] However, the pharmacy workforce's readiness for these technologies is crucial, especially in resource-limited settings like Ethiopia. This study reveals that two-thirds of community pharmacists had a positive perception of and willingness to adopt AI in their practice settings. However, pharmacists' perceptions and willingness varied based on factors such as the education status of pharmacists, pharmacists' drug information sources, AI exposure, and perceived AI knowledge. The study identified a lack of resources, software/hardware, and training as major barriers to AI adoption. As recommendations for future AI implementation, over 90 % of pharmacists agreed on the importance of internet access, policies/frameworks, and research/learning from well-established settings to effectively integrate AI technologies in community pharmacy practice settings in Ethiopia.

This study found that over two-thirds of community pharmacists had a positive perception of AI's impact on community pharmacy practice, aligning with previous research.[21] Consistent with earlier evidence, pharmacists were enthusiastic about staying up-to-date on AI applications and believed AI could enhance their careers, improve services, and streamline tasks such as clinical investigations, multitasking, customer satisfaction, daily organization, and patient care planning.[24] These

Table 2
Perception of community pharmacists related to AI technology applications in community pharmacy practices ($N = 225$).

Perception item	Level of pharmacist response (*n*, %)					Average perception score (Mean ± SD)
	Strongly disagree	disagree	Neutral	agree	Strongly agree	
I like to be up to date in AI applications in the pharmacy setting	10 (4.4)	20 (8.9)	25 (11.1)	101 (44.9)	69 (30.7)	66.8(±9.1)
I like to receive training in AI because it's important to improve my career as a community pharmacist	14 (6.2)	21 (9.3)	35 (15.6)	90 (40.0)	65 (28.9)	64.5(±8.9)
I believe that AI would improve the services provided in the community pharmacy	15 (6.7)	24 (10.7)	45 (20.0)	90 (40.0)	51 (22.7)	61.9(±9.2)
I feel that AI would improve community pharmacy customer satisfaction	17 (7.6)	27 (12.0)	41 (18.2)	78 (34.7)	62 (27.6)	58.6(±9.2)
I fear that AI could replace my job as a pharmacist	27 (12.0)	23 (10.2)	56 (24.9)	69 (30.7)	50 (22.2)	51.7(±9.4)
I believe that AI applications will be widely used in pharmacy practice	21 (9.3)	14 (6.2)	40 (17.8)	84 (37.3)	60 (26.7)	62.0(±9.2)
I believe that AI can help reduce medication errors	24 (10.7)	15 (6.7)	41 (18.2)	80 (35.6)	45 (20.0)	52.7(±9.3)
I feel that AI would enhance tailored pharmaceutical care plan	13 (5.8)	30 (13.3)	51 (22.7)	82 (36.4)	49 (21.8)	53.9(±9.4)
I feel that AI would assist in performing clinical investigation tasks more efficiently than humans	25 (11.1)	10 (4.4)	20 (8.9)	71 (31.6)	99 (44.0)	66.5(±8.9)
I feel that AI can enhance pharmacist's role in patient follow-up and monitoring	18 (8.0)	26 (11.6)	40 (17.8)	79 (35.1)	61 (27.1)	57.4(±9.4)
I believe that AI is very useful for organizing our daily work	14 (6.2)	21 (9.3)	58 (25.8)	86 (38.2)	46 (20.4)	54.7(±9.3)
I believe that AI always makes the best choice since it never gets tired (mentally or physically)	12 (5.3)	19 (8.4)	27 (12.0)	99 (44.0)	68 (30.2)	65.9(±9.1)
I believe that AI can multitask more effectively than humans and analyze data more quickly	11 (4.9)	30 (13.3)	50 (22.2)	83 (36.9)	51 (22.7)	56.1(±9.4)
I feel that AI can improve patient outcomes	16 (7.1)	23 (10.2)	62 (27.6)	81 (36.0)	43 (19.1)	53.2(±9.4)
I feel that AI can reduce the cost of care	19 (8.4)	25 (11.1)	39 (17.3)	80 (35.6)	62 (27.6)	60.2(±9.3)
Overall perception average score						**59.1(±9.2)**
Pharmacists' level of perception (%) Low						73 (32.9)
High						151 (67.1)

Table 3
Willingness of community pharmacists to apply AI technologies in community pharmacy practices ($N = 225$).

Willingness assessing items	Level of pharmacist response (*n*, %)					Average willingness score (Mean ± SD)
	Strongly disagree	disagree	Neutral	agree	Strongly agree	
Medical data collection	12 (5.3)	20 (8.9)	28 (12.4)	97 (43.1)	68 (30.2)	71.3(±10.3)
Social data collection	15 (6.7)	20 (8.9)	34 (15.1)	92 (40.9)	64 (28.4)	67.6(±10.1)
Inventory management	19 (8.4)	21 (9.3)	25 (11.1)	107 (47.6)	55 (24.4)	68.3(±10.3)
Medication dispensing	26 (11.5)	24 (10.7)	36 (16.0)	76 (33.8)	64 (28.4)	61.4(10.2)
Patient counseling	20 (8.9)	23 (10.2)	45 (20.0)	82 (36.4)	65 (28.9)	64.7(±10.1)
Detecting hidden and undiagnosed diseases	14 (6.2)	22 (9.8)	43 (19.1)	94 (41.8)	52 (23.1)	64.9(±10.3)
Identifying drug-related problem	16 (7.1)	20 (8.9)	33 (14.7)	92 (40.9)	65 (28.9)	67.5(±10.1)
Resolved drug-related problem	23 (10.2)	12 (5.3	31 (13.8)	91 (40.4)	68 (30.2)	66.4(±102)
Designing care plan	13 (5.8)	23 (10.7)	48 (21.3)	83 (36.9)	58 (25.8)	62.1(±103)
Implementing care plan	17 (7.6)	26 (11.5)	49 (21.8)	73 (32.4)	60 (26.7)	61.2(±10.2)
Evaluating different treatment options	22 (9.8)	17 (7.6)	40 (17.8)	84 (37.3)	62 (27.6)	64.8(±10.3)
Follow up and monitoring patients	15 (6.7)	23 (10.2)	50 (22.2)	85 (37.8)	52 (23.1)	61.3(±102)
Improving patient adherence	13 (5.8)	20 (8.9)	44 (19.6)	87 (38.7)	61 (27.1)	65.3(±10.0)
Specifying treatment outcome	18 (8.0)	23 (10.2)	41 (18.2)	80 (35.6)	63 (28.0)	65.1(±10.2)
Connecting healthcare systems	14 (9.3)	17 (6.2)	39 (17.8)	91 (40.4)	65 (28.9)	68.0(±10.3)
Proving primary care from a distance	12 (5.3)	21 (9.3)	40 (17.8)	89 (39.6)	61 (27.1)	64.8(±10.2)
Overall willingness mean score						**65.3 (±10.2)**
Pharmacists' level of willingness (%) Low						76 (33.8)
High						149 (66.2)

aspects highlight the potential of AI to positively transform the role of community pharmacists, improving both their work experience and the quality of care they provide to patients.

Pharmacists showed a high level of willingness to adopt AI applications in community pharmacy services. This finding is consistent with studies conducted worldwide.[21] Two-thirds and ore of community pharmacists were open to utilizing AI technologies for various activities, including medical and social data collection, inventory management, medication dispensing, patient counseling, care plan design, and monitoring treatment outcomes. The application of AI in these areas of pharmacy practice has also been demonstrated in previous studies.[5,16,26] Despite minimal previous experience with AI, most pharmacists expressed a willingness to adopt AI tools in their practice after learning about their potential applications in this study. The study's brief on AI applications may have convinced pharmacists of their potential benefits for practice. Pharmacists also believe that AI can be used to integrate healthcare systems and provide primary care remotely. This underscores the potential of AI to revolutionize community pharmacy services by

Table 4
A t-test and one-way ANOVA comparison of perception and willingness scores among different subgroups of pharmacists.

Variables		Perception scores			Willingness scores		
		Mean (±SD)	*t/F*	*P*-value	Mean (±SD)	*t/F*	*P*-value
Sex	Male	60.0 (±9.1)	0.16*	0.43	63.1 (±10.0)	−0.84*	0.56
	Female	58.2 (±9.3)			67.6 (±10.4)		
Educational level	Degree and above	66.9 (±9.0)	1.71*	**0.01**	71.0 (±10.1)	2.15*	**0.035**
	Diploma	55.3 (±9.4)			59.6 (±10.3)		
Employment status	Employee	61.3 (±9.2)	0.41*	0.71	67.0 (±10.2)	1.097*	0.43
	Owner	56.9 (±9.2)			63.6 (±10.2)		
Type of CDROs	Pharmacy	61.1 (±9.4)	1.02*	0.34	66.6 (±10.1)	0.57*	0.62
	Drug store	57.1 (±9.0			64.0 (±10.3)		
Number of clients serving per day	<50	61.0 (±9.1)	1.45*	0.76	67.2 (±10.3)	2.97*	0.23
	>50	57.2 (±9.3)			63.4 (±10.1)		
Number of prescriptions received per day	<50	62.1 (±9.3)	1.01*	0.42	66.9 (±10.2)	0.27*	0.74
	>50	56.1 (±9.1)			63.7 (±10.2)		
Average minutes spent with a client	<5	61.8 (±9.0)	1.21*	0.21	69.0 (±10.4)	1.31*	0.61
	>5	56.4 (±9.4)			61.6 (±10.0)		
Working hours per day	≤8	62.0 (±9.2)	0.91*	0.41	67.0 (±10.1)	0.86*	0.37
	>8	56.2 (±9.2)			63.6 (±10.3)		
Drug information sources	Scientific	64.2 (±9.1)	1.35*	**0.023**	70.6 (±10.4)	1.97*	**0.015**
	Nonscientific	54.0 (±9.3)			60.0 (±10.0)		
Have you heard/been experienced with AI and related issues before this survey?	Yes	65.1 (±9.3)	1.26*	**0.001**	72.1 (±10.2)	1.09*	**0.01**
	No	53.1 (±9.1)			58.5 (±10.2)		
Service duration as a pharmacist (years)	<1	57.7 (±9.3)	0.34**	0.53	67.2 (±10.1)	0.87**	0.31
	1–5	61.4 (±9.0)			66.0 (±10.2)		
	>5	58.2 (±9.1)			62.7 (±10.3)		
Income level/month (ETB)	<2500	58.3 (±9.4)	−0.69**	0.56	63.1 (±10.3)	−0.56**	0.27
	2500–5999	61.0 (±9.0)			65.0 (±10.3)		
	≥6000	58.0 (±9.2)			67.8 (±10.0)		
How do you rate your knowledge of AI technology applications?	Minimal	55.6 (±9.3)	−1.71**	**<0.001**	60.2 (±10.2)	−3.41**	**0.001**
	Moderate	58.2 (±9.1)			64.0 (±10.2)		
	High	63.5 (±9.2)			71.7 (±10.2)		

* Denotes independent sample t-test; ** indicates One-way ANOVA; bold letter at p-value indicates $p < 0.05$; t stands t-test for equality of means and F stands one-way ANOVA test of a sum of squares, ETB, Ethiopian birr, CDRO, community drug retail outlets.

enhancing efficiency, improving patient outcomes, and expanding the scope of pharmacists' roles. By integrating AI, pharmacists can more effectively manage time-consuming tasks, focus on personalized patient care, and contribute to broader healthcare innovations, ultimately improving access to healthcare and supporting the evolving needs of communities.[27]

While the overall perception and willingness of pharmacists toward AI were positive, significant differences existed among subgroups. Pharmacists with higher education (bachelor's degree and above) demonstrated higher perception and willingness than those with lower educational level pharmacy technicians, consistent with previous research demonstrating that AI utilization correlated with educational status.[28] This could be because pharmacists with higher educational backgrounds may have better exposure and understanding of these technologies. More importantly, in the current study, there were a significant number of pharmacy technicians in the community pharmacies. This highlights the need to enhance educational levels and provide continuous training to effectively implement AI in practice settings.

Table 5
Linear regression analysis of associations between scores of pharmacists' perception of AI and willingness to utilize and other variables.

Characteristics		Pharmacists' perceptions of AI		Pharmacists' willingness to utilize AI	
		Multivariable		Multivariable	
		β-coefficient (95 % CI)	p-value	β-coefficient (95 % CI)	p-value
Sex	Male	1	0.351	1	0.165
	Female	−0.094 (−0.561, 3.023)		−0.034 (−0.361, 2.781)	
Age (years)		0.125 (−0.095, 0.481)	0.352	0.091 (−0.025, 1.031)	0.267
Educational level	Pharmacy technician	1	0.02	1	0.015
	Bachelor's degree and above	2.763 (0.092, 5.013)*		1.791 (0.045, 4.210)*	
Service duration as a pharmacist (years)	<1	1	0.124	1	0.119
	1–5	0.049(−0.376, 0.680)		0.013 (−0.271, 0.541)	
	>5	0.129(−0.311, 0.468)		0.087 (−0.214, 0.347)	
Income level per month (ETB)	<2500	1	0.221	1	0.181
	2500–5999	0.078 (−0.236, 2.810)		0.128 (−0.023, 1.789)	
	≥6000	0.124 (−0.091, 1.767)		0.210 (−0.010, 0.321)	
Number of prescriptions received per day	<50	1	0.131	1	0.371
	>50	−0.041 (−0.238, 0.181)		−0.019 (−0.372, 0.561)	
Average minutes spent with a client	<5	1	0.102	1	0.234
	>5	0.215 (−0.086, 0.431)		0.178 (−0.061, 0.371)	
Working hours per day	≤8	1	0.305	1	0.240
	>8	0.123 (−0.087, 1.612)		0.072 (−0.023, 0.921)	
Number of working pharmacists		0.091(−0.145, 0.562)	0.126		0.061
Drug information sources	Nonscientific	1	0.003	1	<0.001
	Scientific	2.451 (0.173, 4.451)*		1.761(0.912, 3.893)*	
Have you heard/been experienced with AI and related issues before this survey?	No	1	0.007	1	0.01
	Yes	1.024 (0.029, 3.241)*		1.125 (0.072, 2.932)*	
How do you rate your knowledge of AI technology applications?	Minimal	1	0.031	1	0.013
	Moderate	0.062 (−0.091, 1.682)		0.021 (−0.023, 1.452)	
	High	1.092 (0.023, 2.456)*		1.136 (0.173, 3.109)*	

ETB, Ethiopian birr, CI, confidence interval; CDRO, community drug retail outlets; * indicated p-value <0.05, Adjusted $R^2 = 80.6$ %; $F = 7.01$, $p < 0.001$ for perception and R2 = 76.2 %; $F = 6.46$, $p < 0.001$ for willingness; VIF < 5 for all variables in both analysis; β-coefficient denotes unstandardized effect size.

Table 6
Perceived barriers to implementing AI technologies in community pharmacy practices ($N = 225$).

Items	Responses (frequency, %)		
	Disagree	Not sure	Agree
Lack of resources including internet access	14 (6.2)	10 (4.4)	201 (89.3)
Lack of AI-related software and hardware	17 (7.6)	23 (10.2)	185 (88.2)
Lack of training	20 (8.9)	23 (10.2)	182 (80.9)
High running cost of AI	33 (14.7)	22 (9.8)	170 (75.6)
Fear of litigation	31 (58.2)	29 (12.9)	165 (73.3)
Regulatory and social constraints may limit AI's potential to help medical practitioners	28 (12.4)	45 (20.0)	152 (67.6)
Lack of AI information	34 (15.1)	41 (18.2)	150 (66.7)
Lack of time	48 (21.3)	43 (19.1)	134 (59.6)
Lack of AI flexibility	25 (11.1)	67 (29.8)	133 (59.1)
Difficulty in vital decisions such as end-of-life care	50 (22.2)	46 (20.4)	129 (57.9)
Difficulty in translating medical terminology into AI language	34 (15.1)	61 (27.1)	130 (57.8)
Difficulty in applying AI	41 (18.2)	62 (27.6)	122 (54.2)
The low ability to sympathize	36 (16.0)	71 (31.6)	118 (52.4)
AI requires human supervision	45 (20.0)	84 (37.3)	96 (42.7)

Table 7
Pharmacists' recommendations for future effective implementation of AI technologies in community pharmacies ($N = 225$).

Items	Responses (frequency, %)		
	Disagree	Not sure	Agree
Resources such as full Internet access	5 (2.2)	10 (4.4)	210 (93.3)
Policies and frameworks	14 (6.2)	5 (2.2)	206 (91.6)
Research and learning from well-established settings	13 (5.8)	11 (4.9)	201 (89.3)
Infrastructure such as software and hardware	11 (4.9)	22 (9.7)	192 (85.5)
Training and education	12 (5.3)	23 (10.2)	190 (84.4)
Pharmacists' readiness and skills	17 (7.6)	20 (8.9)	188 (83.6)
Sufficient pharmacist personnel	8 (3.6)	30 (13.3)	187 (83.1)
Public awareness and readiness to utilize	25 (11.1)	20 (8.8)	180 (80.0)

Educational training and curriculum should be designed to incorporate fundamental skills and ethical considerations for AI implementation.

Drug information resource utilization was significantly associated with pharmacists' perceptions and willingness on AI applications. As found in previous studies, pharmacists using scientific drug information resources demonstrated higher perception and willingness toward AI adoption. This may be attributed to their exposure to literature and scientific evidence on AI's impact in practice settings. These findings suggest the importance of scientific resources over non-scientific ones for familiarization with practice advancements. Additionally, pharmacists with previous AI experience and higher perceived AI knowledge exhibited significantly higher perception and willingness, aligning with previous research.[21,24,29] These findings highlight the need for pharmacists to have basic information and knowledge to effectively implement AI in their practice settings.

This study highlights the barriers perceived by pharmacists in implementing AI technologies in community pharmacy settings. Key barriers identified include lack of resources (internet, software/hardware, training), high running costs, fear of litigation, regulatory/social constraints, and lack of AI information, consistent with previous studies.[21,30] These findings emphasize the challenges of AI implementation in resource-limited settings such as Ethiopia. Notably, none of the pharmacy settings had functional internet during the study period, likely due to the state of emergency in the Amhara regional state, Ethiopia. Ensuring internet availability, along with resources and workforce readiness, is crucial for effective AI implementation in such settings.

This study also reveals that most of the pharmacists agreed on the importance of the availability of resources such as internet, software and hardware, training, and education. Pharmacists also emphasized the need for policies and frameworks to regulate and control ethical utilization and applications which is supported by previous findings that suggest the need for ensuring safety and providing justification before implementing.[31] Applying AI technologies based on specific frameworks and policies may help to maintain ethical utilization.[8,30] Pharmacists also agreed on the need to learn from well-established settings and research. Pharmacists' readiness and skills, sufficient pharmacist personnel, and public awareness and readiness were recommended by pharmacists to effectively implement AI applications in community pharmacy practices in resource-limited settings. Successful AI integration into community pharmacy practice requires careful consideration of several factors. Key challenges include technological advancements for reliable, accurate, and user-friendly systems,[5,8,12] adequate pharmacist training and equipment,[8,20] and addressing privacy and security concerns.[8,32,33]

4.1. Implication of the study

4.1.1. Pharmacists and community pharmacy settings

The study indicates a high level of perception and willingness among pharmacists to adopt AI in their practice, suggesting potential readiness for successful implementation. However, the study reveals disparities in perception and willingness based on educational status, highlighting the need for targeted training and education programs to address knowledge gaps and ensure equitable adoption. Addressing resource constraints, such as internet access and infrastructure, is crucial for AI integration. This includes exploring cost-effective solutions and leveraging existing resources. Pharmacists also need to develop the necessary skills and knowledge to effectively utilize AI tools. This may involve training programs, workshops, and mentorship opportunities. Sharing experiences and lessons from well-established settings can accelerate AI adoption in resource-limited countries like Ethiopia.

4.1.2. Policy implication

The study emphasizes the need for clear policies and frameworks to guide AI implementation in community pharmacy settings. These policies should address data privacy, ethical considerations, and regulatory requirements. Governments and policymakers should invest in AI initiatives by allocating resources for training, infrastructure development, and research. Collaboration among policymakers, healthcare providers, and technology experts is crucial to ensure that AI policies align with the needs and priorities of the healthcare sector.

4.1.3. Further research

The study recommends additional nationwide studies to assess the pharmacy workforce's readiness for AI implementation. This will provide valuable insights into the specific challenges and opportunities in different sub-nationals. Researchers can also evaluate AI's impact on pharmacy practice, patient outcomes, and healthcare costs to inform future policy decisions and identify areas for improvement. Addressing ethical concerns, such as data privacy, bias, and accountability, is crucial. Developing guidelines and best practices for ethical AI research and implementation is essential.

4.2. Study's strengths and limitations

This study is the first to explore pharmacists' perspectives on AI technologies in community pharmacy settings in a resource-limited country such as Ethiopia. It provides valuable insights for assessing nationwide readiness for AI implementation. However, it has limitations. The study was conducted in major cities only, limiting its generalizability to all pharmacists, particularly those in rural areas. Additionally, the self-reported nature of the questionnaires may have influenced responses, potentially leading to under- or overestimations.

5. Conclusion

This study found that two-thirds of community pharmacists in Ethiopia had a positive perception of and willingness to adopt AI in their practice. However, these attitudes varied based on education, drug information sources, AI exposure, and perceived AI knowledge. The study emphasizes the need for resources, policies, training, infrastructure, and learning from established settings to integrate AI into Ethiopian community pharmacies effectively. Further nationwide studies are recommended to assess the pharmacy workforce's readiness for AI implementation.

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Research ethics approval and consent to participate

The study was ethically approved by the research and ethics committee of the School of Pharmacy at the University of Gondar with a reference number of SOP/248/2023. Participants were informed and given written consent forms after the objectives of the study were briefed. Participants involved in the study were able to provide informed consent and had a full understanding of the study's purposes. Consent was obtained from the study participants. Anonymity was maintained and all methods of data collection were carried out according to relevant legislation.

CRediT authorship contribution statement

Ashenafi Kibret Sendekie: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Liknaw Workie Limenh:** Writing – review & editing, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation. **Biruk Beletew Abate:** Writing – review & editing, Visualization, Validation, Software, Resources, Methodology, Investigation, Formal analysis, Data curation. **Gashaw Sisay Chanie:** Writing – review & editing, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation. **Abebe Tarekegn Kassaw:** Writing – review & editing, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation. **Fasil Bayafers Tamene:** Writing – review & editing, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation. **Kalab Yigermal Gete:** Writing – review & editing, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation. **Ephrem Mebratu**

Dagnew: Writing – review & editing, Visualization, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Availability of data and materials

All necessary materials are within the manuscript. The datasets generated and analyzed during the current study are available from the corresponding author upon resealable request.

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