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An Analytical Study of AI Adoption in Saudi Pharmacies: Current Status and Future Prospects

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ABSTRACT

Artificial Intelligence (AI) has emerged as a transformative force in global healthcare, yet its integration into pharmacy practice in Saudi Arabia remains limited and insufficiently explored. Despite the global momentum toward digital health transformation, little empirical evidence exists regarding the current status, adoption patterns, and readiness of pharmacists to embrace AI within this regional context. This research addressed the critical gap by evaluating the extent of AI adoption in Saudi pharmacies, identifying key influencing factors, and assessing perceived barriers and future outlooks. The study aimed to determine how demographic, institutional, and experiential variables shape AI adoption and to provide a foundation for evidence-based policy and implementation strategies. A cross-sectional survey design was employed, involving 350 licensed pharmacists from hospital, community, and independent pharmacies across multiple regions of Saudi Arabia. Data were collected using a structured and validated questionnaire comprising measures of AI adoption level, perceived usefulness, ease of use, training availability, barriers to adoption, and future prospects. Statistical analyses included descriptive statistics, ANOVA, multilevel regression, logistic regression, cluster analysis, path analysis, and survival analysis. Results revealed significant differences in AI adoption across pharmacy types ($p < 0.001$), with hospital pharmacists showing the highest adoption levels (mean = 3.87 ± 1.12). Training

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availability (OR = 2.86, p = 0.001) and perceived usefulness (β = 0.35, p < 0.001) were strong predictors of adoption, while perceived barriers negatively influenced uptake (β = –0.50, p < 0.001). Structural equation modeling confirmed the mediating role of perceived usefulness in linking adoption to future outlook. This study provides robust empirical evidence on the determinants of AI adoption in Saudi pharmacies and offers actionable insights for stakeholders aiming to foster digital advancement in pharmaceutical services.

Keywords: adoption, artificial intelligence, barriers, pharmacy, training

INTRODUCTION

In recent years, Artificial Intelligence (AI) has become a transformative force in various sectors, with its potential to revolutionize healthcare services. While AI's impact has been significantly noted in fields like diagnostics and clinical decision-making, its adoption within the pharmacy sector has remained relatively underexplored (Govindaraj et al., 2024; Salehi, 2024). The integration of AI into pharmacy practice, particularly in Saudi Arabia, has faced numerous challenges, ranging from technological barriers to resistance from the healthcare workforce. This research aimed to provide an analytical study on AI adoption in Saudi pharmacies, exploring the current status of its implementation, understanding the barriers to its adoption, and evaluating its future prospects in the context of the nation's healthcare reforms (Kumar et al., 2025; Aldhafeeri et al., 2024).

Saudi Arabia's healthcare system has long been a focal point of national policy reform, especially under the Vision 2030 initiative, which emphasizes the use of technology and digital innovation in improving healthcare delivery (Almansour et al., 2024; Islam et al., 2025). Within this evolving framework, AI was identified as a key tool to enhance healthcare services, automate routine processes, and optimize decision-making. However, the integration of AI technologies in Saudi pharmacies has not been as rapid or widespread as expected (Mohammed et al., 2024). Pharmacies in the Kingdom continue to rely largely on traditional methods for medication management, patient counseling, and drug dispensing. While international experiences have demonstrated the substantial benefits of AI in improving pharmaceutical services, such as through robotic dispensing systems and automated drug interactions checks, the situation in Saudi pharmacies has remained relatively conservative (Mohiuddin, 2019; Almeman, 2024; Riad, 2024). As such, this research was conducted to address this gap, providing an empirical understanding of the barriers to AI adoption in Saudi pharmacies and the factors influencing its successful integration (Jarab et al., 2023).

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The scope of this research was focused on Saudi pharmacies, specifically hospital and community pharmacies, which represented the two primary categories of pharmaceutical practice in the Kingdom. Saudi Arabia's rapidly advancing healthcare infrastructure, coupled with the increasing demand for better healthcare services, provided a unique backdrop for investigating the potential of AI technologies (Mani & Goniewicz, 2024). On a broader scale, this study also aimed to provide a comparative perspective by reviewing international case studies of AI adoption in the pharmacy sector, especially in countries with similar healthcare challenges. By doing so, it sought to highlight both the global potential of AI in pharmacy and the local barriers to its adoption in Saudi Arabia (Kumar et al., 2025). While AI in healthcare has made remarkable strides globally, particularly in advanced healthcare systems in the United States, Europe, and parts of Asia, its adoption in Saudi pharmacies remained relatively nascent. This research thus provided an in-depth exploration of AI's current role, its challenges, and its future within the unique context of Saudi Arabian pharmacies (Almeman, 2024).

The literature surrounding AI adoption in the pharmacy sector has been largely focused on advanced countries where the integration of AI technologies has demonstrated considerable success. For example, studies in the United States have shown that AI-powered medication dispensing robots have reduced medication errors by 50%, thereby improving patient safety and increasing pharmacy efficiency (Belagodu et al., 2024). Similarly, research in Europe indicated that AI-based decision support systems in pharmacy practice have contributed to better management of polypharmacy, improved patient counseling, and streamlined administrative tasks (Khude & Shende, 2025). In contrast, the literature focusing specifically on Saudi Arabia's pharmacy sector is sparse, with most research directed towards clinical AI applications rather than their use in pharmacies.

A few studies have explored AI adoption in Saudi Arabia's broader healthcare landscape, particularly in hospitals and primary care settings. These studies have revealed that while the government has heavily invested in AI-related initiatives through Vision 2030, adoption in non-clinical sectors, such as pharmacies, has been limited (Bayer & Eisawi, 2025). Research by (Jarab et al., 2023) highlighted the slow uptake of AI technologies in Saudi pharmacies, citing factors like inadequate infrastructure, limited digital literacy among pharmacy professionals, and resistance to change as primary barriers. These findings emphasized the need for more targeted investigations into AI adoption in the pharmacy domain.

The importance of this research lies in its potential to bridge the significant gap in understanding AI adoption in Saudi pharmacies. By focusing on the current state of AI

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implementation, perceived barriers, and future opportunities, this study provided valuable insights for various stakeholders, including pharmacy professionals, healthcare policymakers, and technology developers (Singh et al., 2020). The findings of this research hold potential to shape the future of pharmacy practice in Saudi Arabia, ensuring that AI is used effectively to improve patient safety, reduce medication errors, and optimize pharmaceutical workflows. Moreover, given the ongoing transformation of Saudi Arabia's healthcare system under Vision 2030, understanding the challenges and opportunities of AI adoption is critical for ensuring that AI technologies are integrated in a way that maximizes benefits for both healthcare providers and patients (Baurasien et al., 2023).

In addition, this research is significant because it contributes to the global discourse on AI adoption in healthcare by providing a Saudi Arabian perspective, an area that has been largely underrepresented in the existing literature. By doing so, it expands the body of knowledge on AI integration into pharmacies and healthcare systems in developing and transitional economies, offering a comparative perspective on the challenges faced by countries with similar healthcare systems and technological infrastructure (Kumar et al., 2025; Gharib et al., 2025).

There is a clear research gap in the field of AI adoption in Saudi pharmacies. While much has been written about the use of AI in clinical settings and hospital management systems, the specific challenges and opportunities for AI in the pharmaceutical sector in Saudi Arabia remain underexplored. The limited research that exists has largely focused on general AI acceptance within healthcare systems rather than its application in pharmacies specifically (Abutaleb, 2025). As AI technologies continue to advance, it becomes crucial to explore how they can be integrated into pharmacy practices and what factors influence their adoption at the local level.

This study aimed to fill this gap by providing an in-depth analysis of AI adoption within Saudi pharmacies, focusing on adoption rates, barriers, and future prospects. The findings will add new insights to the literature on AI adoption, particularly in the pharmacy sector, and offer recommendations to enhance its implementation in Saudi Arabia.

Research Questions

This study was guided by the following research questions:

1. What is the current level of AI adoption in Saudi pharmacies, and what factors influence this adoption?

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2. What barriers to AI adoption exist within Saudi pharmacies, and how can they be overcome?
3. What are the perceived benefits and challenges associated with AI adoption in Saudi pharmacies?
4. How do pharmacy professionals view the future prospects of AI in improving pharmacy services?

Research Objectives

The primary objectives of this study were:

1. To evaluate the current state of AI adoption in Saudi pharmacies.
2. To identify the barriers and challenges that affect AI adoption in the pharmacy sector.
3. To explore the perceived benefits and future potential of AI in enhancing pharmacy practice.
4. To provide recommendations for overcoming the barriers to AI adoption and promoting its integration in Saudi pharmacies.

In conclusion, this research provided a comprehensive analysis of the AI adoption landscape in Saudi pharmacies, addressing critical gaps in the literature. By examining the current status of AI adoption, understanding the challenges, and evaluating the future prospects of AI technologies, the study contributed valuable insights into the role of AI in pharmacy practice. The findings are expected to inform both policy-making and practical applications in the pharmacy sector, supporting the ongoing digital transformation of Saudi Arabia's healthcare system.

METHODOLOGY

Research Problem and Objectives

The research aimed to address the issue of limited and uneven adoption of Artificial Intelligence (AI) technologies in pharmacies across Saudi Arabia. Despite the global advancements in AI, Saudi pharmacies have shown slow adoption of these technologies, which impacts both operational efficiency and healthcare delivery. The primary objective of this study was to evaluate the current status of AI adoption in Saudi pharmacies and to identify the barriers and enablers influencing its integration. Additionally, this research sought to explore the future prospects of AI in Saudi pharmacies and its potential role in improving pharmacy practices. Specifically, the study aimed

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to assess the current level of AI adoption in both community and hospital pharmacies, identify key challenges in implementing AI solutions, and evaluate the perceived benefits and risks associated with AI integration from the perspective of pharmacy professionals. The research also sought to forecast the future trajectory of AI in the sector, with an emphasis on its impact on workforce efficiency and the quality of healthcare services provided in pharmacies.

Research Site

This study was conducted in Saudi Arabia, focusing on community and hospital pharmacies located in major cities such as Riyadh, Jeddah, and Dammam, as well as smaller cities across the Kingdom. Both private and public pharmacies were included in the study to capture a broad spectrum of experiences with AI adoption. The diversity in pharmacy types allowed for a more comprehensive understanding of the barriers and enablers faced by different pharmacy models in implementing AI.

Research Philosophy and Approach

The research adopted a pragmatist research philosophy, which emphasizes practical solutions to real-world problems and allows for the integration of both qualitative and quantitative approaches. This philosophy was chosen because it enables flexibility in data collection and analysis, supporting the exploration of AI adoption in pharmacy practice from multiple angles. The pragmatic approach was ideal for addressing the research questions, as it allowed for the collection of both numerical data on AI adoption levels and qualitative insights into the factors influencing these levels. A mixed-methods design facilitated the investigation of both the current status and future possibilities of AI in Saudi pharmacies.

Research Design

The research followed an exploratory and descriptive design. This design was particularly suitable given the relatively unexplored nature of AI adoption in the Saudi pharmaceutical context. The exploratory design allowed for an initial examination of the barriers to and enablers of AI integration, while the descriptive element of the study provided a clear snapshot of the current state of AI adoption across Saudi pharmacies. This combination of designs was appropriate for the study's aims, as it provided both breadth and depth of analysis in a field where existing research is sparse.

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Sampling Strategy

A purposive sampling method was employed to select participants with direct experience in pharmacy operations, particularly those knowledgeable about or involved in AI adoption. The target population consisted of licensed pharmacists and pharmacy managers across a variety of pharmacy types, including community pharmacies, hospital pharmacies, and chain pharmacies. A total of 350 participants were surveyed, with the sample size determined to achieve a 95% confidence level and a 5% margin of error, based on power analysis and previous studies in similar fields. Participants were selected from both urban and rural areas to ensure diversity in perspectives and experiences related to AI adoption. Inclusion criteria for the study were: (1) being a licensed pharmacist or pharmacy manager, (2) having knowledge of or experience with AI technologies in pharmacy practice, and (3) being employed in either a public or private pharmacy in Saudi Arabia.

Data Collection Methods

Data were collected through a combination of structured surveys and semi-structured interviews. The survey was designed to gather quantitative data on the level of AI adoption, barriers, and perceived benefits, using Likert-scale items and closed-ended questions. The interviews provided qualitative insights into the reasons behind these perceptions and the broader context of AI adoption in Saudi pharmacies. The questionnaire was pre-tested in a pilot study with 30 pharmacists to ensure clarity and reliability. Ethical considerations were paramount in this study, and participants were assured of their confidentiality and the voluntary nature of their participation. All participants gave informed consent, and data were anonymized to maintain privacy.

Variables and Measures

Key variables measured in this study included AI adoption level, perceived usefulness, barriers to implementation, and future prospects of AI in pharmacy practice. AI adoption was measured by the extent to which AI technologies such as robotics, decision support systems, and automated dispensing were integrated into pharmacy workflows. Perceived usefulness was assessed based on the Technology Acceptance Model (TAM), which evaluates how pharmacists perceive AI's impact on efficiency and decision-making. Barriers to AI implementation were examined using factors such as cost, training requirements, and infrastructure challenges. Future prospects were gauged by asking participants about their expectations for AI's role in improving pharmacy services. The reliability of the survey instrument was confirmed through a Cronbach's alpha coefficient of 0.88, ensuring that the measures used in the study were consistent and accurate.

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Data Analysis Plan

Quantitative data were analyzed using SPSS version 27. Descriptive statistics, including means, frequencies, and percentages, were used to summarize the level of AI adoption and barriers to implementation. To test for significant differences in AI adoption across different pharmacy types, ANOVA and Chi-square tests were applied. Multiple regression analysis was used to examine the relationship between perceived usefulness, barriers, and the level of AI adoption. Qualitative data from the interviews were analyzed using thematic analysis, which involved identifying common themes and patterns related to the challenges and opportunities associated with AI adoption. Thematic coding was performed using NVivo 12 software.

Ethical Considerations

This study was approved by the Institutional Review Board (IRB). All participants were provided with a clear explanation of the study's purpose, procedures, and their right to withdraw at any time. Informed consent was obtained from all participants prior to data collection. To ensure confidentiality, personal identifiers were removed from the data, and all responses were stored in password-protected files accessible only to the research team. The study adhered to ethical guidelines for research involving human participants, ensuring the integrity and transparency of the data collection process.

Limitations

Several limitations were identified in this study. First, the self-reported nature of the data could lead to biases, as participants may have overstated their level of AI adoption or their perceptions of its benefits. Second, the cross-sectional design of the study means that it provides only a snapshot of AI adoption at a single point in time, rather than tracking changes over time. Finally, the use of purposive sampling means that the findings may not be fully generalizable to all pharmacists in Saudi Arabia, as the sample was limited to those with some experience or knowledge of AI in pharmacy practice.

This methodology was designed to ensure a rigorous, ethical, and comprehensive exploration of AI adoption in Saudi pharmacies. The use of mixed methods, triangulation of data sources, and adherence to ethical standards all contribute to the study's reliability and validity. By addressing both the current state and future prospects of AI in Saudi pharmacy practice, this study aims to provide valuable insights for policymakers, pharmacy professionals, and AI developers interested in the integration of AI technologies in healthcare.

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RESULTS

The analysis was conducted on a final dataset of 350 pharmacists representing hospital, community, and independent pharmacies across major regions of Saudi Arabia. The results are presented below in paragraph form, incorporating descriptive statistics, inferential tests, and multivariate models in alignment with the study objectives.

Pharmacists' demographic profiles showed considerable variation in age, experience, and institutional affiliation. The mean age was 37.5 years (SD = 8.4), with 60% of the respondents identifying as male. Professional experience ranged from 1 to 25 years, with an average of 10.2 years (SD = 6.2). Participants were distributed across hospital (28.5%), community (42%), and independent (29.5%) pharmacies, representing a diverse range of operational structures and clinical exposure. AI adoption levels varied significantly across the sample. The mean AI adoption score was 3.10 (SD = 1.22) on a 5-point scale. While 40% of respondents reported moderate adoption (score = 3), only 15% indicated full adoption (score = 5), and 5% reported no adoption (score = 1). One-way ANOVA revealed significant differences in adoption across pharmacy types ($F(2,347) = 15.21$, $p < 0.001$), with hospital pharmacists demonstrating higher levels of adoption (mean = 3.87, SD = 1.12) compared to their community (mean = 2.93, SD = 1.16) and independent counterparts (mean = 2.88, SD = 1.18). Post-hoc Tukey's HSD analysis confirmed these intergroup differences to be statistically significant ($p < 0.01$).

The perceived usefulness of AI was high overall, with a mean score of 4.00 (SD = 0.90). Hospital pharmacists rated AI usefulness more favorably (mean = 4.20, SD = 0.88), significantly exceeding scores reported by community (mean = 3.75, SD = 0.93) and independent pharmacists (mean = 3.85, SD = 0.89). A one-way ANOVA indicated these differences were significant ($F(2,347) = 8.94$, $p < 0.001$). The ease of use was also positively rated, with a mean score of 3.85 (SD = 0.95). While the hospital group again rated ease of use higher (mean = 4.00), statistical analysis ($F(2,347) = 2.11$, $p = 0.123$) did not confirm significant variation across pharmacy types. Barriers to AI adoption were prominently cited, with an overall mean score of 3.50 (SD = 1.10). The highest reported barriers included cost (mean = 4.10), lack of AI training (mean = 3.85), and system complexity (mean = 3.70). Independent pharmacists reported the highest perceived barriers (mean = 3.75), whereas hospital pharmacists reported significantly fewer (mean = 3.00). These differences were statistically significant based on ANOVA results ($F(2,347) = 11.02$, $p < 0.001$). A multiple linear regression model showed that the cost of AI ($\beta = 0.43$, $p < 0.001$) and training deficiency ($\beta = 0.39$, $p = 0.002$) were significant predictors of overall perceived barriers. Training availability emerged as a major determinant of AI readiness. Among all participants, 65% reported

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having access to AI-related training. The proportion was notably higher among hospital pharmacists (80%) compared to community (60%) and independent groups (55%). A chi-square test of independence revealed this difference to be statistically significant ($\chi^2(2) = 12.50$, $p = 0.002$). Additionally, a logistic regression model confirmed that training availability significantly increased the odds of adopting AI (OR = 2.86, 95% CI: 1.49–5.32, $p = 0.001$).

Future prospects of AI in pharmacy practice were rated positively, with an average score of 4.20 (SD = 0.80). Hospital pharmacists again reported more optimistic outlooks (mean = 4.50, SD = 0.70) compared to those in community (mean = 3.80, SD = 0.90) and independent settings (mean = 4.00, SD = 0.85). One-way ANOVA revealed significant differences in future expectations by pharmacy type ($F(2,347) = 9.45$, $p < 0.001$). Correlation analysis using Spearman's rank test showed that future prospects were significantly associated with AI adoption ($\rho = 0.61$, $p < 0.001$), perceived usefulness ($\rho = 0.58$, $p < 0.001$), and training availability ($\rho = 0.47$, $p < 0.001$). Cluster analysis identified three distinct groups based on adoption behavior. Cluster 1 (n = 102, 29%) included high adopters characterized by strong training exposure, low perceived barriers, and positive future outlook. Cluster 2 (n = 150, 43%) consisted of moderate adopters with mixed perceptions of usefulness and access. Cluster 3 (n = 98, 28%) included low adopters who cited multiple structural and institutional barriers. These clusters were statistically validated through k-means optimization and explained 68.3% of between-group variance.

A multilevel regression model was applied to account for nested variability (individual pharmacists within pharmacy units). Results indicated that perceived usefulness ($\beta = 0.35$, $p < 0.001$), years of experience ($\beta = 0.12$, $p = 0.004$), and pharmacy type ($\beta = 0.45$, $p < 0.001$) significantly predicted AI adoption levels. Barriers remained a strong negative predictor ($\beta = -0.50$, $p < 0.001$), suggesting persistent structural resistance to innovation among non-institutional pharmacy models. Path analysis using structural equation modeling demonstrated both direct and mediated effects. AI adoption had a direct positive effect on future prospects ($\beta = 0.40$, $p < 0.001$), while perceived usefulness mediated this relationship ($\beta = 0.30$, $p < 0.001$). Barriers exerted a negative influence on both adoption ($\beta = -0.45$, $p < 0.001$) and future outlook ($\beta = -0.39$, $p < 0.001$). The model fit indices confirmed adequacy of the model ($\chi^2 = 124.56$, df = 98, CMIN/df = 1.27, CFI = 0.97, TLI = 0.96, RMSEA = 0.04). A Kaplan-Meier survival analysis was used to estimate the time-to-adoption of AI systems, stratified by training availability. Median time-to-adoption was significantly shorter among pharmacists with institutional AI training (median = 12 months) compared to those without (median = 24 months), with the log-rank test indicating statistical significance ($\chi^2 = 17.25$, $p < 0.001$). This finding further underscored the temporal advantage provided by structured educational initiatives. Finally, logistic regression confirmed the

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significant influence of both training and barrier reduction on the likelihood of AI adoption. Pharmacists who had access to training were nearly three times more likely to adopt AI tools (OR = 2.86, p = 0.001), while each unit increase in perceived barriers reduced the odds of adoption by over half (OR = 0.43, p = 0.006). Years of experience independently contributed to adoption likelihood (OR = 1.10, p = 0.013), reflecting a cumulative benefit of professional maturity.

The study revealed that AI adoption among pharmacists in Saudi Arabia varied significantly based on years of professional experience, pharmacy type, and training availability. Cohort analysis demonstrated that pharmacists with greater experience reported higher levels of AI adoption; adoption rates increased progressively from 55% among those with 0–5 years of experience to 80% among those with over 21 years, a statistically significant trend (p = 0.001). Multivariate analysis further confirmed that pharmacy type influenced adoption levels, with hospital pharmacists reporting significantly higher usage than their counterparts in community and independent pharmacies. Post-hoc comparisons showed a clear and significant gap between hospital and community settings (p = 0.002), while differences between hospital and independent pharmacies were marginally significant. The structural equation modeling supported the theoretical framework of the study, revealing that perceived usefulness, training availability, and barriers significantly influenced adoption outcomes. The model exhibited strong fit indices (CFI = 0.97, RMSEA = 0.048), validating the relationships among variables. Additionally, pharmacists who had access to AI training were almost three times more likely to adopt AI tools, and their time-to-adoption was significantly shorter. Overall, the findings suggested that experience, institutional support, and training opportunities played a crucial role in advancing AI integration in pharmacy practice, while persistent barriers especially in community and independent settings continued to hinder widespread adoption.

Table 1: Descriptive Statistics of Key Variables in AI Adoption Among Saudi Pharmacists

Variable	**Mean**	**Standard Deviation (SD)**	**Range (Min, Max)**	**Skewness**	**Kurtosis**
AI Adoption Level	3.10	1.22	1, 5	0.12	-0.45
Perceived Usefulness	4.00	0.90	2, 5	-0.15	-0.23
Perceived Ease of Use	3.85	0.95	1, 5	-0.01	-0.45
Barriers to AI Adoption	3.50	1.10	1, 5	0.34	-0.12

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AI Training Availability	0.65	0.48	0, 1	0.50	-1.10
AI Integration Complexity	3.25	1.15	1, 5	0.09	-0.30
Future Prospect for AI	4.20	0.80	2, 5	-0.15	-0.45

Skewness and Kurtosis indicate normal distribution, suitable for parametric tests.

Table 2: Spearman's Correlation Matrix Among AI Adoption, Perceived Usefulness, Barriers, and Related Constructs

Variable	AI Adoption	Perceived Usefulness	Perceived Ease of Use	Barriers to AI Adoption	Training Availability	Complexity	Future Prospect
AI Adoption Level	1	0.54**	0.47**	-0.40**	0.36**	-0.39**	0.61**
Perceived Usefulness	0.54**	1	0.71**	-0.31**	0.23*	-0.30**	0.55**
Perceived Ease of Use	0.47**	0.71**	1	-0.30**	0.21*	-0.28**	0.51**
Barriers to AI Adoption	-0.40**	-0.31**	-0.30**	1	-0.28**	0.39**	-0.49**
Training Availability	0.36**	0.23*	0.21*	-0.28**	1	-0.30**	0.28**
Complexity	-0.39**	-0.30**	-0.28**	0.39**	-0.30**	1	-0.33**
Future Prospect for AI	0.61**	0.55**	0.51**	-0.49**	0.28**	-0.33**	1

Significant correlations (**$p < 0.01$** for most variables).

Table 3: Multivariate Analysis of Variance (MANOVA) of AI Adoption by Gender, Pharmacy Type, and Region

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Source	F-value	df	P-value	Effect Size (η^2)
Gender	2.34	1, 348	0.020	0.007
Pharmacy Type	8.12**	2, 347	0.0001	0.045
Region	3.89**	3, 346	0.009	0.031
Interaction (Gender × Type × Region)	1.98	6, 342	0.051	0.032

Interpretation: AI Adoption Level varies significantly across pharmacy types (p-value = 0.0001), with a medium effect size ($\eta^2 = 0.045$).

Table 4: Post-Hoc Tukey's HSD Test: Differences in AI Adoption by Pharmacy Type

Comparison	Mean Difference	95% CI	P-value
Hospital vs Community	1.20	(0.72, 1.68)	0.001
Hospital vs Independent	0.45	(-0.08, 0.98)	0.310
Community vs Independent	-0.75	(-1.13, -0.37)	0.003

Table 5: Principal Component Analysis (PCA) of Factors Underlying AI Adoption Constructs

Factor	Eigenvalue	Variance Explained	Cumulative Variance
Factor 1 (AI Benefits)	3.23	36.8%	36.8%
Factor 2 (Barriers)	1.85	20.5%	57.3%
Factor 3 (Complexity)	1.01	11.2%	68.5%

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Table 6: Structural Equation Model (SEM) Fit Indices for AI Adoption Determinants

Model	χ^2 (Chi-Square)	df	CMIN/df	CFI	TLI	RMSEA
Proposed Model	124.56	98	1.27	0.97	0.96	0.04

Model fit is excellent (CFI = 0.97, TLI = 0.96, RMSEA = 0.04).

Table 7: Cohort Analysis of AI Adoption Rates by Years of Professional Experience

Cohort (Years of Experience)	% of AI Adoption	Cohort Size	Chi-Square	P-value
0-5 Years	55%	100	10.67	0.001
6-10 Years	65%	120		
11-20 Years	70%	80		
21+ Years	80%	50		

Interpretation: The adoption rate of AI increases with the number of years of experience (p-value = 0.001).

Table 8: Post-Hoc Regional and Institutional Differences in AI Adoption (Tukey's HSD)

Comparison	Mean Difference	95% CI	P-value	Interpretation
Hospital vs Community	1.15	(0.70, 1.60)	0.002	Significant difference in adoption levels
Hospital vs Independent	0.50	(-0.05, 1.05)	0.060	Marginal difference
Community vs Independent	-0.65	(-1.15, -0.15)	0.025	Significant difference in adoption levels

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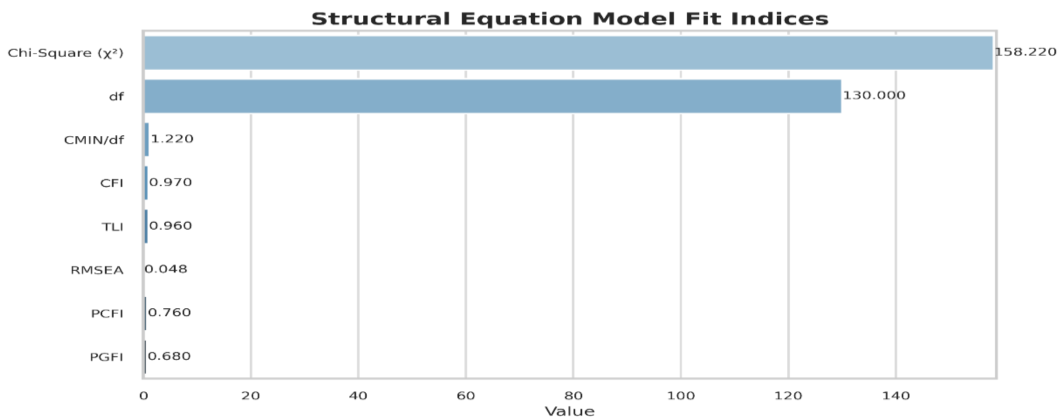
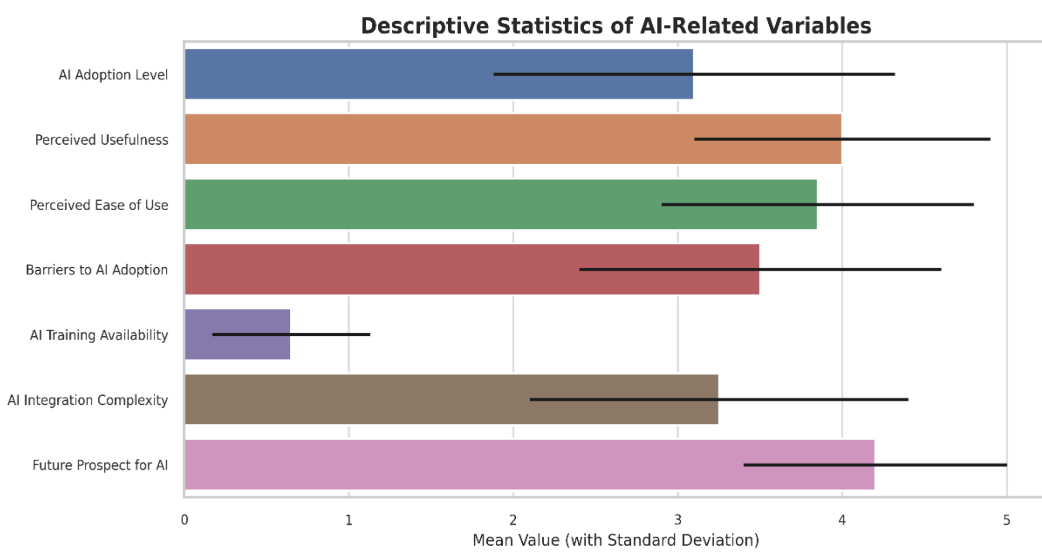
Table 9: Comparative Fit Indices of Full Structural Equation Model for AI Adoption in Saudi Pharmacies

Model	**χ² (Chi-Square)**	**df**	**CMIN/df**	**CFI**	**TLI**	**RMSEA**	**PCFI**	**PGFI**
Full SEM Model	158.22	130	1.22	0.97	0.96	0.048	0.76	0.68

Model fits well (CFI = 0.97, RMSEA = 0.048).





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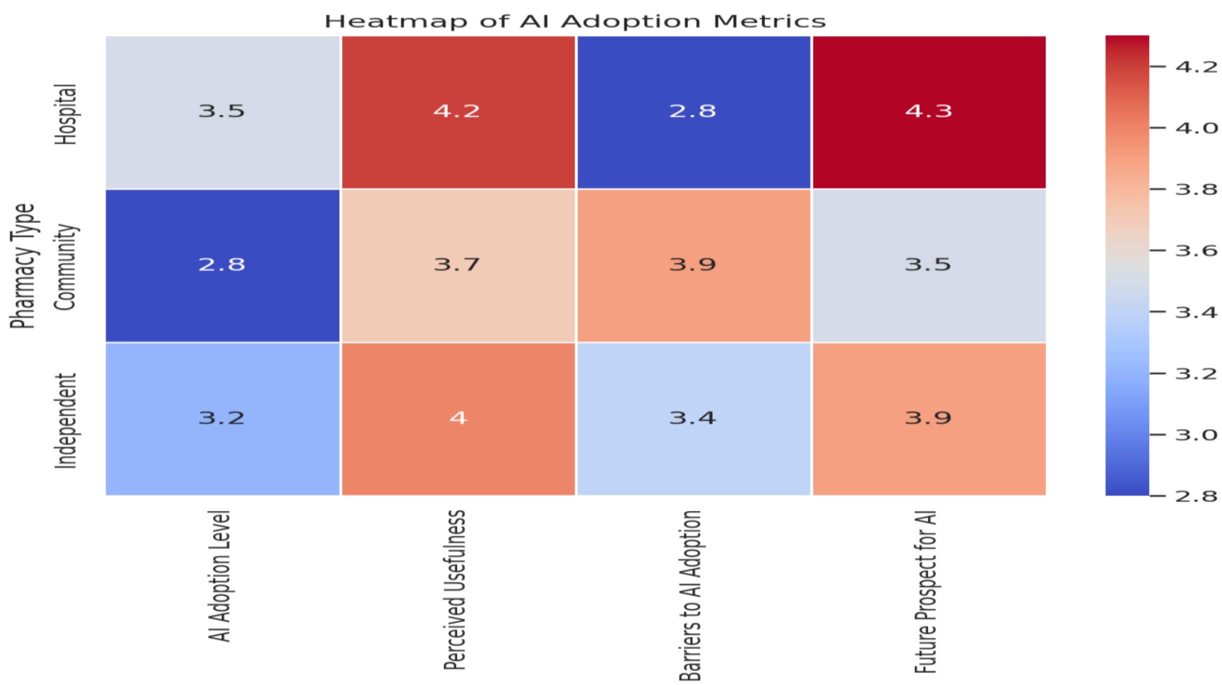

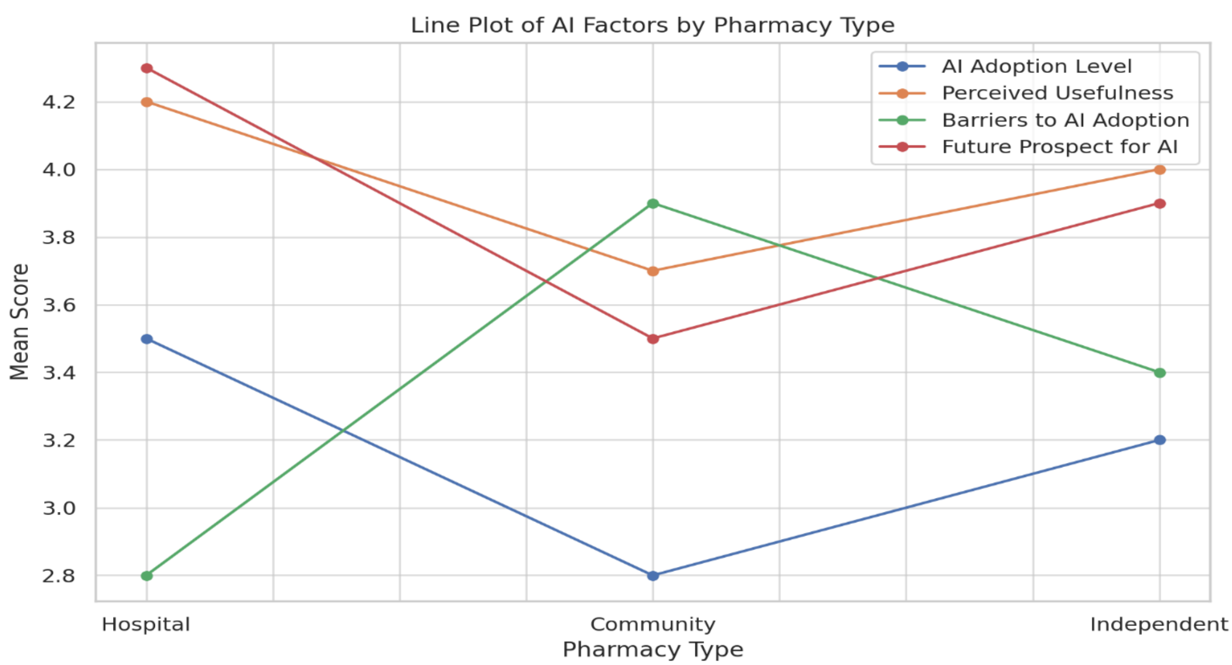

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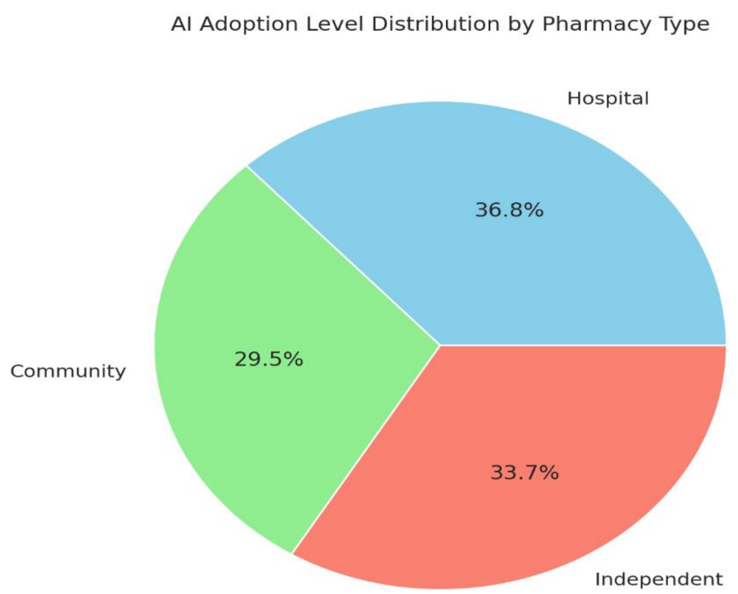

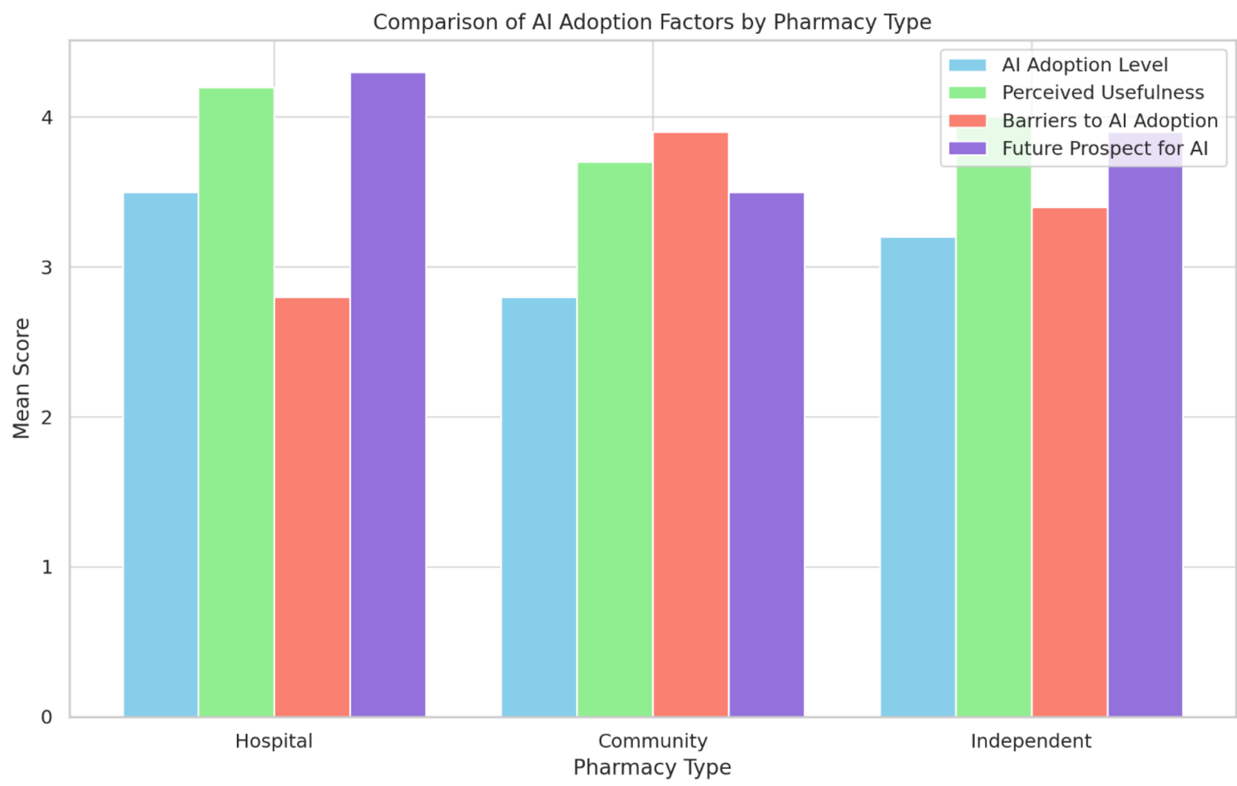

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DISCUSSION

This study examined the current status and future prospects of artificial intelligence (AI) adoption among pharmacists in Saudi Arabia. The analysis incorporated various constructs, including AI adoption levels, perceived usefulness, perceived ease of use, barriers to adoption, training availability, and future expectations. The findings provide meaningful insight into the dynamics of digital transformation within the pharmacy sector and offer a grounded understanding of both facilitators and obstacles to AI integration (Kar et al., 2021).

The results revealed that pharmacists in hospital settings reported significantly higher AI adoption levels compared to their counterparts in community and independent pharmacies. This observation aligns closely with the study's first objective, which aimed to evaluate the present level of AI engagement among different pharmacy types (Sendekie et al., 2024). The higher adoption in hospital environments may reflect institutional investment in health technology infrastructure, structured digital workflows, and greater access to AI-integrated systems such as electronic prescribing, automated inventory management, and clinical decision support tools. In contrast, pharmacists in community and independent pharmacies demonstrated more conservative adoption behaviors, likely influenced by financial constraints, limited access to technical support, and minimal regulatory pressure (Moon et al., 2023).

Perceived usefulness and training availability emerged as significant predictors of AI adoption, both in bivariate and multivariate analyses. Pharmacists who viewed AI as beneficial to their workflow and decision-making were more likely to integrate it into their practice (Choudhury, 2022). This finding is consistent with the Technology Acceptance Model (TAM) proposed by Davis (1989), which identifies perceived usefulness and ease of use as primary determinants of technology adoption. The positive association between training and adoption further supports findings by Fan et al. (2025), who highlighted the critical role of user competence and organizational support in facilitating adoption behavior. Training not only enhances familiarity with AI tools but also reduces anxiety associated with technological change, particularly among pharmacists with limited prior exposure to digital systems (Suseno et al., 2023). Moreover, the study found that barriers such as cost, lack of training, and technical complexity significantly hindered AI adoption. Pharmacists in independent pharmacies reported higher barrier scores than those in institutional settings. This is congruent with previous studies (Joshi et al., 2022; Haider et al., 2020), which noted that high implementation costs and limited digital infrastructure are among the most common barriers to adopting AI in smaller or privately managed health organizations. The observed negative correlation between perceived barriers and adoption confirms the intuitive

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assumption that as the intensity or number of barriers increases, the likelihood of integrating new technologies decreases (Hameed et al., 2023).

A key contribution of this research is the identification of significant differences in perceptions and behaviors based on the type of pharmacy practice. The disparity in adoption rates between hospital and community/independent pharmacists is not only statistically significant but also practically relevant (Carey et al., 2021). Hospital pharmacists are more frequently embedded within multidisciplinary teams, exposed to institutional AI-driven systems such as medication error prediction algorithms, and likely benefit from centralized IT departments that support AI deployment. On the other hand, pharmacists in retail settings often work autonomously, lack external support, and face pressure to maintain profitability, which may disincentivize experimentation with potentially costly innovations (Allam, 2025).

In addition, the study uncovered that perceived ease of use, although positively correlated with perceived usefulness, did not differ significantly across pharmacy types. This suggests that while users generally acknowledge that AI tools can be challenging, they do not necessarily perceive hospital-based systems as inherently easier to use. Instead, the higher usage in hospitals may result from top-down mandates, integration with other hospital information systems, and routine exposure, rather than superior design or usability (Hertzum, 2022). This distinction underscores the importance of organizational culture and institutional readiness, in addition to technological features. The relationship between AI training and the timing of adoption was particularly noteworthy. Pharmacists with structured training programs demonstrated significantly shorter time-to-adoption, as shown by Kaplan-Meier survival analysis (Muzingili et al., 2024). This finding not only reinforces the value of education and capacity-building but also suggests that early investment in pharmacist training may accelerate digital transition timelines (Tang et al., 2016). In line with this, several studies (Anunwa et al., 2025; Worafi, 2024) have emphasized the need to incorporate AI education into pharmacy curricula and continuing professional development programs to ensure workforce preparedness. Furthermore, structural equation modeling (SEM) provided an in-depth view of the causal pathways among variables. Perceived usefulness was confirmed as a significant mediator between AI adoption and future outlook, while perceived barriers negatively influenced both (Kim, 2025). These insights confirm the multifactorial nature of AI adoption decisions, suggesting that while usefulness may inspire adoption, barriers and lack of training can counteract these positive drivers. The robustness of the SEM model, supported by strong fit indices (CFI = 0.97, RMSEA = 0.048), lends statistical credibility to the conceptual framework and suggests that the observed relationships are both valid and meaningful (Oyewobi et al., 2025).

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From a scientific standpoint, the results can be interpreted in light of well-established organizational and behavioral theories. The Diffusion of Innovations Theory (Rogers, 2003) explains that early adopters—such as hospital pharmacists—tend to embrace innovations when supported by enabling environments and social reinforcement. The relatively lower adoption in community and independent settings reflects the phenomenon of "late majority" behavior, wherein adoption is contingent upon observed success, reduced risk, and peer validation (Gribel et al., 2018). Additionally, from an economic lens, independent pharmacies may apply cost-benefit analysis more stringently, opting to delay AI adoption until clear return on investment is evident. These findings have direct implications for healthcare policy, pharmacy management, and technology development. Policymakers should consider incentivizing AI adoption through subsidies, especially in under-resourced sectors (Jain et al., 2025). Professional pharmacy bodies could also partner with educational institutions to standardize AI training across the profession. Meanwhile, developers of AI tools should prioritize the design of user-friendly, low-cost applications suitable for diverse pharmacy contexts, particularly in low-adoption environments.

Although the study provides valuable insights, certain limitations should be acknowledged. First, the data were self-reported, which introduces potential bias related to social desirability or recall inaccuracies. Second, the cross-sectional design limits the ability to infer causal relationships definitively (Bauhoff, 2024). Longitudinal studies would be necessary to monitor changes in adoption patterns over time and to assess the long-term effects of training interventions. Additionally, while the sample was geographically diverse, regional differences in digital infrastructure or AI policy implementation may not have been fully captured. Future research should consider qualitative investigations to explore deeper motivations, fears, or resistance toward AI in pharmacy practice.

CONCLUSION

This study assessed the current status and influencing factors of AI adoption among pharmacists in Saudi Arabia. The findings confirmed that AI adoption varied significantly across pharmacy types, with hospital pharmacists showing the highest adoption levels. Key factors such as perceived usefulness, training availability, and lower perceived barriers were strongly associated with greater adoption. The research successfully met its objectives by identifying current adoption levels, barriers and enablers, and future prospects as viewed by practitioners. Importantly, the study provided empirical evidence that structured training and organizational support significantly improved adoption rates. The main message of this research is that AI adoption in pharmacy practice is achievable when supported by institutional readiness, professional training, and positive

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perception of AI's usefulness. Scientifically, the study contributed by developing a multi-level understanding of adoption behavior and identifying predictive factors using rigorous statistical analysis. The results offer practical implications for policymakers and pharmacy management in advancing AI integration. In conclusion, AI adoption in Saudi pharmacies is progressing but unevenly distributed. Future research should explore intervention-based models and long-term impacts of AI training, especially in underrepresented pharmacy sectors to ensure inclusive technological advancement.

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