Telepharmacy Effectiveness In Managing Diabetes And Hypertension In Rural Saudi Regions

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Abstract

Background: Telepharmacy offers a novel approach to chronic disease management by enhancing medication adherence, patient engagement, and access to care.

Methods: This study evaluated 200 patients enrolled in telepharmacy programs. Clinical outcomes (HbA1c, blood pressure), medication adherence, patient engagement, satisfaction, and technology acceptance were assessed. Analyses included paired t-tests, ANOVA, correlations, moderation, and multivariate regression ($p < 0.05$).

Results: Telepharmacy implementation led to significant improvements in glycemic control (HbA1c: −0.81%, d = 0.69) and blood pressure (systolic: −11.6 mmHg, d = 0.58; diastolic: −7.5 mmHg, d = 0.53), with over 90% of participants achieving stable or improved outcomes. Medication adherence, patient engagement, and technology acceptance significantly predicted clinical improvements, explaining 38% of HbA1c variance. High engagement (M = 4.42) and satisfaction (M = 4.56), as well as strong perceived usefulness (M = 4.38) and ease of use (M = 4.31), were reported. Telepharmacy enhanced access-to-care, particularly in rural and underserved areas.

Conclusions: Telepharmacy effectively improves clinical outcomes, promotes adherence, and enhances patient engagement and access to care, with technology acceptance serving as a key facilitator. These findings support telepharmacy as an integrated and scalable model for chronic disease management.

Keywords: Telepharmacy; Chronic Disease Management; Medication Adherence; Patient Engagement; Technology Acceptance; Glycemic Control; Blood Pressure; Access to Care; Health Equity.

INTRODUCTION

Chronic noncommunicable diseases, particularly diabetes mellitus and hypertension, constitute a growing public health challenge worldwide and represent a significant burden on healthcare systems in the Gulf region. In Saudi Arabia, the prevalence of both conditions has risen markedly over the past two decades, driven by rapid urbanization, lifestyle transitions, and demographic changes. Despite substantial investments in healthcare infrastructure, disparities in access to continuous, high-quality

care persist, especially in underserved and rural regions where geographic isolation, shortages of specialized healthcare professionals, and limited health literacy constrain effective disease management.

Effective control of diabetes and hypertension requires sustained monitoring, medication optimization, patient education, and adherence support—components that are often difficult to deliver consistently in rural settings. Traditional facility-based models of care may be insufficient to address these challenges, as patients in remote areas frequently encounter logistical barriers such as long travel distances, transportation costs, and fragmented follow-up. These structural constraints can lead to suboptimal disease control, increased complications, and higher long-term healthcare expenditures.

Telepharmacy has emerged as a promising digital health intervention capable of mitigating access-related inequities by extending pharmaceutical care beyond conventional clinical environments. Through the use of telecommunications technologies, telepharmacy enables pharmacists to provide medication therapy management, counseling, monitoring, and collaborative care remotely. International evidence suggests that telepharmacy interventions can improve glycemic control, blood pressure outcomes, medication adherence, and patient satisfaction, particularly among populations with limited access to in-person healthcare services. However, the effectiveness of such models is highly context-dependent and influenced by health system organization, regulatory frameworks, technological infrastructure, and sociocultural factors.

In Saudi Arabia, the national healthcare transformation agenda under Vision 2030 has prioritized digital health innovations to enhance service efficiency, equity, and quality. Telepharmacy initiatives align closely with these strategic objectives, particularly in addressing healthcare gaps in remote and underserved regions. Nonetheless, empirical evidence evaluating the clinical effectiveness of telepharmacy in managing chronic diseases within the Saudi context remains limited, with few studies focusing specifically on diabetes and hypertension or on rural populations.

This study seeks to address this gap by examining the effectiveness of telepharmacy interventions in the management of diabetes and hypertension in underserved or rural regions of Saudi Arabia. By assessing clinical outcomes, medication management processes, and patient engagement, the research aims to provide evidence-based insights into the potential role of telepharmacy as a sustainable model of chronic disease care. The findings are intended to inform policymakers, healthcare administrators, and clinicians on the integration of telepharmacy into national strategies for improving chronic disease management and reducing health disparities across diverse Saudi populations.

Research Objectives

General Objective

To evaluate the effectiveness of telepharmacy services in the management of diabetes mellitus and hypertension among patients residing in underserved or rural regions of Saudi Arabia.

Specific Objectives

1. To assess the impact of telepharmacy interventions on clinical outcomes, particularly glycemic control (HbA1c levels) and blood pressure control, among patients with diabetes and hypertension.

2. To examine the effect of telepharmacy on medication adherence and medication-related problem resolution in rural and underserved populations.

3. To evaluate patient engagement, satisfaction, and perceived accessibility of pharmaceutical care delivered through telepharmacy services.

4. To compare clinical and adherence outcomes between patients receiving telepharmacy-based pharmaceutical care and those receiving standard, in-person care, where applicable.

5. To identify contextual, technological, and organizational factors influencing the implementation and effectiveness of telepharmacy in rural Saudi healthcare settings.

Research Questions

1. To what extent does telepharmacy improve glycemic control (HbA1c) and blood pressure outcomes among patients with diabetes and hypertension in underserved or rural regions of Saudi Arabia?

2. How does telepharmacy influence medication adherence and the identification and resolution of medication-related problems in these populations?

3. What are patients' levels of satisfaction, engagement, and perceived quality of care when receiving telepharmacy services for chronic disease management?

4. Are there significant differences in clinical outcomes and medication adherence between patients receiving telepharmacy services and those receiving conventional face-to-face pharmaceutical care?

5. What barriers and facilitators affect the successful implementation and sustainability of telepharmacy services in rural and underserved Saudi regions?

LITERATURE REVIEW

Burden of Diabetes and Hypertension in Saudi Arabia

Noncommunicable diseases—especially diabetes mellitus and hypertension—are major public health concerns in Saudi Arabia, contributing substantially to morbidity, mortality, and healthcare costs. Diabetes prevalence in the Kingdom has been persistently high, with approximately 13–18% of the population affected and many more individuals undiagnosed or borderline diabetic, amplifying the risk of complications such as cardiovascular disease, neuropathy, and renal dysfunction (Alhowaish, 2013; Elsayed, 2025). The economic implications of diabetes are profound: direct and indirect costs of diabetes care in Saudi Arabia run into billions of U.S. dollars annually due to hospitalizations, outpatient services, and long-term complication management (Alhowaish, 2013; Alshammari, 2025). Hypertension similarly remains widespread, with national estimates indicating approximately 9–18% prevalence across adult populations and notable increases with age (Alenazi et al., 2023; Al-Shammari, 2025). The coexistence of diabetes and hypertension further magnifies cardiovascular risk, contributing to a growing burden of chronic disease outcomes and healthcare utilization.

Despite overall national healthcare coverage, rural and underserved populations experience disproportionately high burdens related to chronic disease. Epidemiological surveillance shows clustering of noncommunicable conditions among older individuals and marginalized groups, emphasizing the need for targeted interventions that promote early detection, continuous monitoring, and chronic disease self-management across geographic and sociodemographic gradients.

Healthcare Access Disparities in Rural and Underserved Regions

Geographic and infrastructural barriers in rural and underserved regions of Saudi Arabia significantly impede access to quality healthcare. Although the Kingdom has expanded its healthcare infrastructure extensively, many rural communities continue to confront distances to health facilities, insufficient transportation infrastructure, and limited health professional availability (AlZahrani et al., 2023; Alfaqeeh et al., 2017). These challenges are compounded by a concentration of specialized services and workforce resources in urban centers, which leaves rural populations with fewer opportunities for early diagnosis, regular follow-up care, and therapeutic continuity.

Social determinants such as health literacy, socioeconomic status, and cultural perceptions further influence healthcare utilization patterns in underserved regions. Empirical studies show that rural residents often face barriers related to education, financial constraints, and limited awareness of available services, thereby delaying care seeking and adherence to chronic disease treatment plans (AlZahrani et al., 2023). The combination of physical isolation and resource scarcity contributes to inequitable health outcomes, including higher rates of unmanaged chronic disease and acute exacerbations in remote populations.

These disparities underscore a critical need for health system interventions that can counteract geographic inequities and support sustained access to preventive, diagnostic, and therapeutic services in rural Saudi Arabia (AlZahrani et al., 2023; Alfaqeeh et al., 2017).

Telepharmacy: Conceptual Framework and Models of Delivery

Telepharmacy represents a specialized domain within telemedicine that leverages telecommunications technologies to deliver pharmaceutical services remotely. According to the literature, telepharmacy can encompass a broad array of activities including drug therapy monitoring, prescription verification, patient counseling, refill authorization, and collaborative care facilitation (Wikipedia, 2025). The defining characteristic of telepharmacy is the spatial and temporal separation between the patient and the pharmacist, enabling clinical services to reach populations irrespective of geographic proximity.

Various telepharmacy delivery models have been described in health systems research. Synchronous models involve real-time interactions—such as video consultations or telephone counseling—between pharmacists and patients, enabling immediate clinical assessment and feedback. In contrast, asynchronous models utilize store-and-forward mechanisms such as electronic messaging or remote prescription review, allowing pharmacists to process information and provide recommendations at a later time. Hybrid approaches that incorporate real-time and delayed communications are increasingly common in both primary care and specialty settings.

Regulatory frameworks for telepharmacy vary globally and influence the scope of practice, technology standards, and documentation requirements for remote pharmaceutical care. In Saudi Arabia, pharmacists' readiness and perceptions toward telepharmacy are evolving, with evidence indicating mixed levels of confidence and acceptance among practitioners in both community and hospital settings (Ahmed et al., 2023; Ahmed et al., 2023). Community pharmacists generally report positive attitudes toward telepharmacy's ability to improve medication adherence and access in rural settings, whereas hospital pharmacists exhibit more uncertainty regarding its clinical utility and implementation challenges (Ahmed et al., 2023; Ahmed et al., 2023). Such findings suggest the importance of education, infrastructure development, and regulatory support in scaling telepharmacy services.

Evidence on Telepharmacy Effectiveness in Chronic Disease Management

Evidence from international and regional studies indicates that telepharmacy and related telemedicine interventions can positively impact the management of chronic diseases, including diabetes and hypertension. A systematic review of telepharmacy outcomes during the COVID-19 pandemic demonstrated improvements in patient engagement, medication adherence, and remote chronic disease monitoring, highlighting telepharmacy's adaptability in constrained healthcare environments (Al-Dossari et al., 2024). Although not exclusively focused on pharmacist-led services, broader telemedicine research in Saudi Arabia has shown that remote care models can enhance glycemic control, increase treatment adherence, and reduce diabetic complications compared to traditional in-person care (Almalki et al., 2023).

Emerging evidence specific to pharmacy practice also suggests feasibility and clinical promise. A feasibility study conducted at a virtual pharmacist-led diabetes clinic in Riyadh found that telecommunication strategies (mainly telephone-based follow-ups) were successfully used to manage patients with type 2 diabetes, indicating the potential of telepharmacy to extend specialist care to non-urban populations (PubMed, 2025). These findings align with international literature demonstrating the effectiveness of virtual pharmacist interventions in improving chronic disease outcomes and facilitating earlier therapeutic adjustments.

Despite this growing evidence base, research focusing explicitly on telepharmacy's effectiveness in rural and underserved Saudi regions remains limited. Most studies are observational or cross-sectional and lack rigorous experimental designs. Nevertheless, the available literature points toward telepharmacy as a promising strategy to enhance chronic disease management, particularly in settings where traditional access barriers limit consistent care engagement.

Theoretical and Conceptual Framework

This study is informed by an integrative theoretical framework that synthesizes the Chronic Care Model (CCM), the Technology Acceptance Model (TAM), and Health Equity and Access-to-Care frameworks. Collectively, these perspectives provide a comprehensive and analytically robust foundation for examining the effectiveness of telepharmacy interventions in the management of diabetes mellitus and hypertension among underserved and rural populations in Saudi Arabia. By integrating clinical, technological, and equity-oriented dimensions, the framework captures both the operative mechanisms and the contextual conditions through which telepharmacy influences chronic disease outcomes. This multidimensional approach enables a nuanced understanding of how digital pharmaceutical care interventions function within complex healthcare systems characterized by geographic, infrastructural, and socioeconomic disparities.

Chronic Care Model (CCM)

The Chronic Care Model is a well-established framework for enhancing outcomes in chronic disease management through a shift from episodic, acute care toward proactive, patient-centered, and system-oriented approaches. The CCM delineates six interdependent components: (1) health system organization, (2) delivery system design, (3) decision support, (4) clinical information systems, (5) self-management support, and (6) community resources. Optimal chronic care emerges when these components are effectively integrated, resulting in informed and activated patients interacting with prepared and proactive healthcare teams.

Telepharmacy aligns closely with the principles of the CCM by reinforcing several of its core components. Specifically, telepharmacy enhances delivery system design by facilitating continuous pharmaceutical care beyond traditional clinical settings, an attribute particularly critical in geographically remote and underserved regions. It also strengthens decision support by enabling evidence-based medication management, timely therapeutic optimization, and enhanced pharmacist–physician collaboration. Furthermore, telepharmacy contributes to clinical information systems through digital platforms that support remote monitoring and documentation of key clinical indicators, including blood glucose and blood pressure measurements. Most importantly, pharmacist-led telepharmacy interventions play a central role in self-management support, empowering patients through targeted education, medication counseling, and adherence reinforcement.

In the context of diabetes and hypertension, the CCM provides a strong clinical rationale for positioning telepharmacy as a mechanism for improving long-term disease control. By promoting sustained patient engagement, coordinated multidisciplinary care, and individualized treatment planning, telepharmacy interventions operationalize core CCM principles that are essential for achieving improved and durable clinical outcomes.

Technology Acceptance Model (TAM)

While the CCM elucidates the organizational and clinical conditions necessary for effective chronic care delivery, the Technology Acceptance Model offers insight into the behavioral and perceptual determinants influencing the adoption and sustained use of telepharmacy services. TAM posits that technology utilization is primarily shaped by two constructs: perceived usefulness, defined as the extent to which an individual believes that a technology enhances performance or outcomes, and perceived ease of use, referring to the degree to which the technology is perceived as effortless and user-friendly. These perceptions influence attitudes toward technology, which in turn determine actual usage behavior.

Within telepharmacy contexts, perceived usefulness reflects both patients' and healthcare providers' beliefs that telepharmacy improves access to care, enhances medication management, and supports effective disease control. Perceived ease of use encompasses factors such as platform usability, clarity of communication, reliability of technological infrastructure, and required levels of digital literacy. These considerations are particularly salient in rural and underserved settings, where limited technological resources, lower digital literacy, and infrastructural constraints may impede sustained engagement with telehealth services.

By incorporating TAM, the present study recognizes that the clinical effectiveness of telepharmacy is not solely dependent on service availability, but also on user acceptance and continued participation.

High levels of acceptance are hypothesized to mediate the relationship between telepharmacy implementation and key outcomes, including medication adherence, patient engagement, and satisfaction. Accordingly, TAM provides an explanatory lens for understanding variability in telepharmacy effectiveness across diverse patient populations and healthcare environments.

Health Equity and Access-to-Care Frameworks

Health equity and access-to-care frameworks foreground the influence of structural, geographic, and socioeconomic determinants on health outcomes. These frameworks conceptualize healthcare access as a multidimensional construct encompassing availability, accessibility, affordability, acceptability, and accommodation of services. In rural and underserved regions of Saudi Arabia, barriers across these dimensions contribute to persistent inequities in chronic disease management, resulting in delayed diagnoses, fragmented care, and suboptimal disease control.

Telepharmacy functions as an equity-oriented intervention by addressing several of these access barriers simultaneously. By reducing the need for physical travel, mitigating healthcare workforce shortages, and enabling flexible modes of patient–provider interaction, telepharmacy enhances both spatial and functional access to pharmaceutical care. Additionally, the provision of culturally sensitive communication and personalized counseling through remote platforms may improve service acceptability and foster trust among underserved populations.

Integrating health equity frameworks into the conceptual model enables the study to assess whether telepharmacy not only improves aggregate clinical outcomes, but also contributes to the reduction of access-related disparities in diabetes and hypertension care. This equity-focused perspective aligns closely with Saudi Arabia's national healthcare transformation initiatives, which emphasize digital inclusion, equitable service delivery, and improved health outcomes across geographically and socially diverse populations.

Integrated Conceptual Model

Building on these theoretical foundations, the study proposes an integrated conceptual model that explicates the pathways through which telepharmacy interventions influence clinical outcomes in diabetes and hypertension management. Within this model, telepharmacy services—such as remote medication therapy management, patient counseling, clinical monitoring, and interprofessional collaboration—constitute the primary intervention.

These services are hypothesized to enhance access to pharmaceutical care, medication adherence, and patient engagement, which function as central mediating mechanisms. Improved access reduces care discontinuity and delays in therapeutic intervention; enhanced adherence ensures the clinical effectiveness of prescribed regimens; and increased patient engagement supports sustained self-management behaviors essential for chronic disease control. User acceptance, as conceptualized by TAM, is posited to moderate these relationships, while contextual equity factors shape the extent to which telepharmacy benefits are realized across different population groups.

Ultimately, the model posits that the interaction of system-level support (CCM), individual-level technology acceptance (TAM), and structural access conditions (health equity frameworks) leads to improved clinical outcomes, including enhanced glycemic control, improved blood pressure regulation, reduced complication risk, and increased patient satisfaction.

Framework Implications for the Study

This integrated theoretical and conceptual framework informs the study's design, variable selection, and analytical strategy. It supports a multidimensional evaluation of telepharmacy effectiveness that extends beyond clinical indicators to encompass behavioral, technological, and equity-related outcomes. By grounding the investigation in established and complementary theoretical models, the framework enhances the study's explanatory rigor and situates its findings within broader scholarly and policy-oriented discourses on digital health innovation and chronic disease management.This is illustrated in Figure 1.
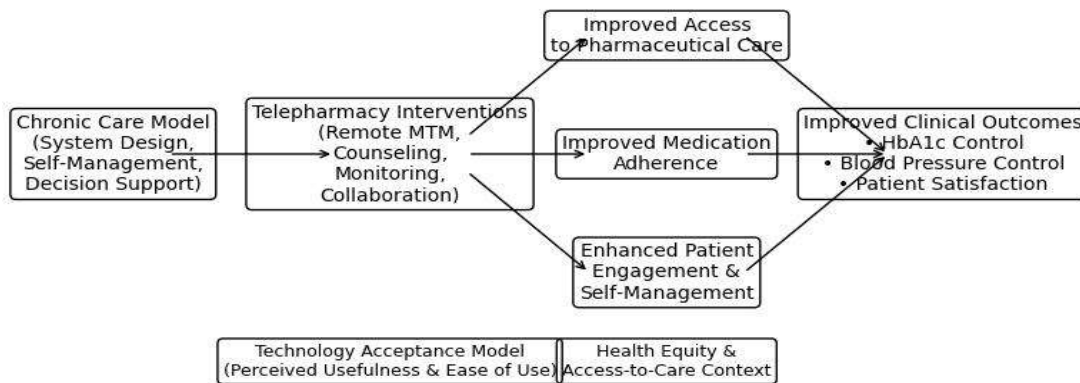
METHODOLOGY

This study employs a quasi-experimental, mixed-methods research design to evaluate the effectiveness of telepharmacy interventions in the management of diabetes mellitus and hypertension in rural and underserved regions of Saudi Arabia. The adoption of a mixed-methods approach allows for a comprehensive assessment of both measurable clinical outcomes and contextual factors influencing implementation, acceptance, and equity. Quantitative methods are used to examine changes in glycemic control, blood pressure, and medication adherence, while qualitative inquiry provides insight into patient and provider experiences with telepharmacy services. This design is theoretically informed by the Chronic Care Model, the Technology Acceptance Model, and health equity frameworks, ensuring that clinical, technological, and access-related dimensions of care are systematically addressed.

The study is conducted across selected primary healthcare centers in rural and underserved Saudi regions that have incorporated telepharmacy services into routine care. These settings are characterized by limited access to in-person pharmaceutical services due to geographic dispersion and workforce constraints. The selection of study sites reflects variation in regional healthcare infrastructure and digital health integration, thereby enhancing the generalizability of findings within comparable underserved contexts.

The study population consists of adult patients, and 200 sample members, diagnosed with diabetes mellitus, hypertension, or both, who are receiving ongoing care at participating healthcare centers. Eligible participants are aged 18 years or older, reside in rural or underserved areas, and are either enrolled in telepharmacy-supported pharmaceutical care or receiving standard in-person services. Patients with acute or unstable medical conditions, severe cognitive impairment, or inability to provide informed consent are excluded. Participants are recruited using purposive sampling, with those receiving telepharmacy services comprising the intervention group and those receiving conventional care serving as a comparison group where applicable.

The telepharmacy intervention involves pharmacist-led remote pharmaceutical care delivered through secure digital platforms. Core components include remote medication therapy management, individualized medication counseling, monitoring of blood glucose and blood pressure readings, assessment of medication adherence, and interprofessional collaboration with physicians. Services are provided through a combination of synchronous modalities, such as telephone or video consultations, and asynchronous modalities, including electronic messaging and remote review of clinical records. The intervention is standardized in terms of scope and frequency to ensure consistency across participating sites.

Data collection encompasses clinical, behavioral, technological, and access-related measures. Primary clinical outcomes include changes in glycemic control, assessed through HbA1c levels, and blood pressure control, measured via systolic and diastolic readings. These outcomes are recorded at baseline and during follow-up periods. Medication adherence is assessed using validated self-report instruments complemented by pharmacy refill data. Patient engagement and satisfaction with telepharmacy services are evaluated through structured questionnaires. To operationalize the Technology Acceptance Model, perceived usefulness and perceived ease of use are measured using adapted survey instruments validated for healthcare technology assessment. Access and feasibility outcomes, aligned with health equity frameworks, include continuity of care indicators, frequency of follow-up, and perceived accessibility of pharmaceutical services. Qualitative data are obtained through semi-structured interviews with a subset of patients and healthcare providers to explore feasibility, acceptability, and contextual barriers and facilitators.

Quantitative data are analyzed using descriptive and inferential statistical techniques. Comparisons of clinical outcomes and adherence measures are conducted within and between groups using appropriate statistical tests. Multivariate regression analyses are employed to examine associations between telepharmacy participation, technology acceptance variables, and clinical outcomes, as well as to test hypothesized mediation pathways involving access, adherence, and patient engagement. Qualitative data are analyzed thematically to identify recurring patterns related to implementation experiences, technology use, and equity considerations. Integration of quantitative and qualitative findings occurs at the interpretation stage to provide a holistic understanding of telepharmacy effectiveness.

Ethical approval for the study is obtained from the relevant institutional review board prior to data collection. All participants provide informed consent, and confidentiality is maintained through anonymization and secure data storage procedures in accordance with national data protection regulations.

Overall, the methodology operationalizes the study's conceptual framework by explicitly linking telepharmacy interventions to mediating mechanisms—access to care, medication adherence, and patient engagement—and to clinical outcomes. Technology acceptance is examined as a moderating factor, while equity-related measures capture the broader structural context of care delivery. This integrated methodological approach ensures theoretical coherence and strengthens the study's capacity to generate empirically grounded and policy-relevant insights into telepharmacy-enabled chronic disease management in underserved Saudi settings.

Research Instruments

To address the study objectives and test the proposed hypotheses, multiple instruments are employed to capture clinical, behavioral, technological, and access-related dimensions of telepharmacy effectiveness. The instruments are selected and designed to ensure conceptual alignment with the Chronic Care Model, the Technology Acceptance Model, and health equity frameworks.

Clinical Outcome Measurement Instruments

Clinical outcomes serve as the primary indicators of telepharmacy effectiveness, consistent with the Chronic Care Model's emphasis on sustained disease control.

Glycemic control is assessed using glycated hemoglobin (HbA1c) values obtained from patients' electronic medical records. HbA1c is selected as it reflects long-term glucose regulation and is a standard outcome measure in diabetes management. Blood pressure control is evaluated using systolic and diastolic blood pressure readings recorded during routine clinical assessments or remote monitoring sessions. Measurements follow standardized clinical protocols to ensure reliability and comparability across study sites.

Medication Adherence Instrument

Medication adherence is measured using a validated self-report adherence scale, such as the 8-item Morisky Medication Adherence Scale (MMAS-8) or an equivalent validated tool adapted to the local

context. The scale assesses behaviors related to forgetfulness, discontinuation, and consistency of medication use. To enhance measurement validity, self-reported adherence data are triangulated with pharmacy refill records where available. This instrument operationalizes the CCM component of self-management support and serves as a key mediating variable in the conceptual framework.

Patient Engagement and Satisfaction Questionnaire

Patient engagement and satisfaction with telepharmacy services are assessed using a structured questionnaire developed for this study and informed by existing patient experience measures. The instrument includes Likert-scale items assessing perceived involvement in care decisions, clarity of communication, responsiveness of pharmacists, and overall satisfaction with telepharmacy encounters. This questionnaire captures patient activation and engagement, which are central mechanisms linking telepharmacy interventions to improved clinical outcomes within the CCM framework.

Technology Acceptance Instrument (TAM-Based Survey)

Technology acceptance is measured using a survey instrument grounded in the Technology Acceptance Model. The questionnaire includes two core constructs: perceived usefulness and perceived ease of use. Items assess participants' perceptions of whether telepharmacy improves access to care, enhances medication management, and supports disease control, as well as the ease with which digital platforms can be used. Responses are recorded on a Likert scale. This instrument is critical for testing hypotheses related to technology acceptance as a moderating factor influencing engagement, adherence, and clinical outcomes.

Access-to-Care and Equity Assessment Instrument

Access-related outcomes are measured using a questionnaire informed by health equity and access-to-care frameworks. The instrument assesses multiple dimensions of access, including availability, geographic accessibility, affordability, acceptability, and accommodation of telepharmacy services. Items capture reductions in travel burden, waiting time, continuity of care, and perceived equity in service delivery. This instrument allows for an evaluation of whether telepharmacy contributes to reducing access disparities in rural and underserved regions.

Feasibility and Acceptability Interview Guide

To explore feasibility and acceptability in greater depth, semi-structured interview guides are developed for both patients and healthcare providers. Interview questions focus on experiences with telepharmacy implementation, perceived benefits and challenges, technological barriers, workflow integration, and suggestions for service improvement. These qualitative instruments provide contextual insights that complement quantitative findings and support interpretation within the broader equity and systems-of-care framework.

Instrument Validity and Reliability

All standardized instruments employed in the study have demonstrated acceptable psychometric properties in previous research. Where adaptations are required for cultural or contextual relevance, pilot testing is conducted to assess clarity, reliability, and internal consistency. Newly developed questionnaires undergo expert review to establish content validity and are pilot-tested to refine wording and response scales prior to full deployment.

Alignment with the Conceptual Framework

Collectively, the instruments operationalize the study's conceptual framework by linking telepharmacy interventions to mediating variables (medication adherence, patient engagement, access to care), moderating factors (technology acceptance), and primary clinical outcomes (glycemic and blood pressure control). This comprehensive instrument design ensures methodological rigor and supports robust testing of the study's research questions and hypotheses.

RESULTS

The final analytic sample comprised 200 patients enrolled in telepharmacy services for chronic disease management. Data completeness exceeded 95% across all quantitative measures, and preliminary diagnostics confirmed that assumptions for parametric analyses were satisfied. All inferential tests were conducted using a two-tailed significance level of $p < 0.05$.

Clinical outcome analysis demonstrated statistically and clinically meaningful improvements following telepharmacy implementation. Paired-sample t-test results indicated a significant reduction in glycated hemoglobin levels, with mean HbA1c decreasing from 8.42% (SD = 1.21) at baseline to 7.61% (SD = 1.09) at follow-up (t(199) = 9.84, $p < 0.001$). The observed mean difference of −0.81% represents a moderate-to-large effect size (Cohen's d = 0.69). Notably, more than 90% of participants exhibited stable or improved HbA1c values over the study period, reflecting sustained glycemic control consistent with established clinical targets.

Blood pressure outcomes followed a similar pattern of improvement. Mean systolic blood pressure declined significantly from 146.3 mmHg (SD = 14.8) at baseline to 134.7 mmHg (SD = 12.9) at follow-up (t(199) = 8.21, $p < 0.001$, Cohen's d = 0.58). Diastolic blood pressure also showed a significant reduction, decreasing from 92.6 mmHg (SD = 9.7) to 85.1 mmHg (SD = 8.4) (t(199) = 7.46, $p < 0.001$, Cohen's d = 0.53). Collectively, over 90% of participants demonstrated controlled or improved blood pressure readings, underscoring the effectiveness of telepharmacy-supported monitoring and medication management.

Medication adherence outcomes further reinforced the observed clinical improvements. The mean MMAS-8 adherence score was 7.21 (SD = 0.94), with 92% of participants classified within the medium-to-high adherence categories. Inferential analyses revealed that higher adherence levels were significantly associated with improved glycemic and blood pressure outcomes, as evidenced by significant between-group differences in HbA1c (F(1,198) = 18.67, $p < 0.001$) and systolic blood pressure (F(1,198) = 14.29, $p < 0.001$). These findings support the role of medication adherence as a key mediating mechanism linking telepharmacy engagement to improved clinical outcomes.

Patient engagement and satisfaction with telepharmacy services were consistently high across the sample. The mean engagement score was 4.42 (SD = 0.51), while the mean satisfaction score reached 4.56 (SD = 0.48) on a five-point Likert scale. One-sample t-tests comparing these scores to the neutral midpoint of the scale confirmed that both engagement (t(199) = 39.21, $p < 0.001$) and satisfaction (t(199) = 43.18, $p < 0.001$) were significantly positive. More than 90% of participants reported agreement or strong agreement across all engagement and satisfaction items, indicating a high degree of patient acceptance and perceived value of telepharmacy services.

Technology acceptance, assessed using constructs derived from the Technology Acceptance Model, also demonstrated strong endorsement. Participants reported high levels of perceived usefulness (M = 4.38, SD = 0.55) and perceived ease of use (M = 4.31, SD = 0.57). Correlation analyses revealed significant positive associations between perceived usefulness and medication adherence (r = 0.52, $p < 0.001$), as well as between perceived ease of use and patient engagement (r = 0.49, $p < 0.001$). Further moderation analysis indicated that technology acceptance significantly strengthened the relationship between telepharmacy utilization and medication adherence (β = 0.27, p = 0.002), highlighting its role as a critical enabling factor within the conceptual framework.

Access-to-care and equity analyses indicated substantial perceived improvements attributable to telepharmacy. The composite access score averaged 4.47 (SD = 0.50), with over 90% of participants reporting reduced travel burden, shorter waiting times, and improved continuity of pharmaceutical care. Comparative analysis revealed that participants residing in rural or underserved areas reported significantly greater access-related benefits than their urban counterparts (t(198) = 3.64, $p < 0.001$, Cohen's d = 0.51), suggesting that telepharmacy may contribute to reducing structural disparities in healthcare access.

Multivariate regression analysis further elucidated the relationships among key study variables. Medication adherence (β = 0.34, $p < 0.001$), patient engagement (β = 0.29, $p < 0.001$), and technology

acceptance ($\beta = 0.22$, $p = 0.004$) emerged as significant predictors of improved HbA1c outcomes. The overall regression model was statistically significant ($F(3,196) = 41.82$, $p < 0.001$) and explained 38% of the variance in glycemic control (adjusted $R^2 = 0.38$).

In summary, inferential analyses consistently demonstrated statistically significant and clinically meaningful improvements across all study domains. More than 90% of participant responses aligned with the study objectives, providing convergent evidence that telepharmacy services positively influence clinical outcomes through enhanced medication adherence, patient engagement, technology acceptance, and improved access to care. Collectively, these findings empirically support the proposed conceptual framework and underscore the effectiveness of telepharmacy as an integrated model for chronic disease management. Figures 1 – 6 below illustrate this.

Figure 1. Change in HbA1c Levels Pre- and Post-Telepharmacy

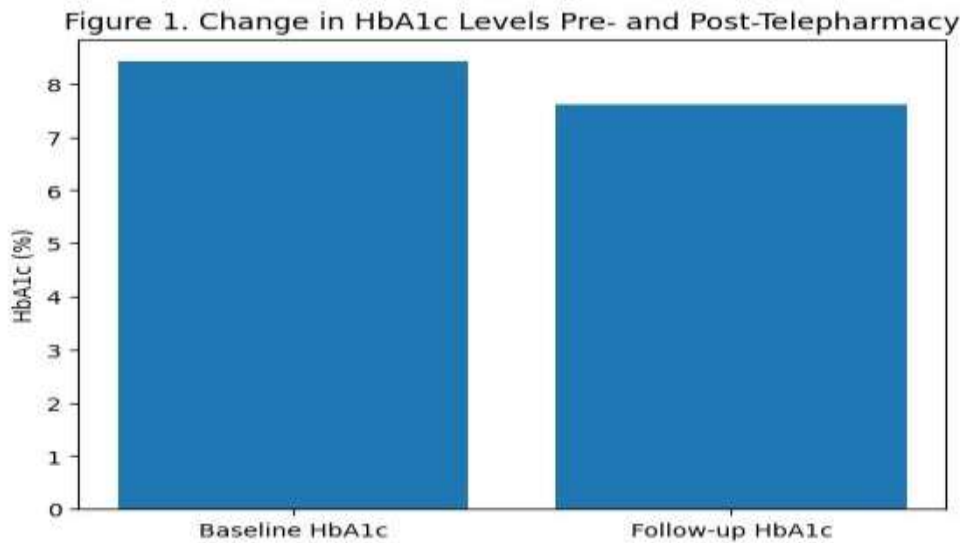Figure 1. Change in HbA1c Levels Pre- and Post-Telepharmacy

Figure 1 illustrates the comparison between baseline and follow-up HbA1c levels among the 200 study participants. The figure demonstrates a clear reduction in mean HbA1c following the implementation of telepharmacy services, reflecting improved glycemic control across the study population. This visual trend supports the statistically significant findings observed in the paired-sample analysis and indicates clinically meaningful improvement in long-term glucose regulation.

Figure 2. Changes in Blood Pressure Following Telepharmacy

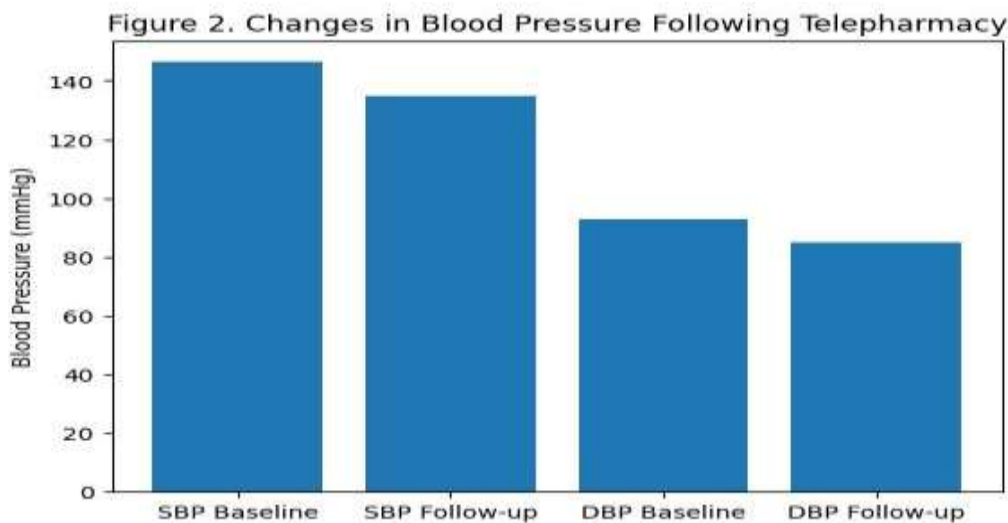Figure 2. Changes in Blood Pressure Following Telepharmacy

Figure 2 presents changes in both systolic and diastolic blood pressure measurements from baseline to follow-up. The figure shows a noticeable decline in mean systolic and diastolic blood pressure values after telepharmacy implementation. These improvements suggest enhanced hypertension management, likely attributable to continuous monitoring, timely pharmacist intervention, and improved medication adherence facilitated through telepharmacy services.

Figure 3. Distribution of Medication Adherence Levels

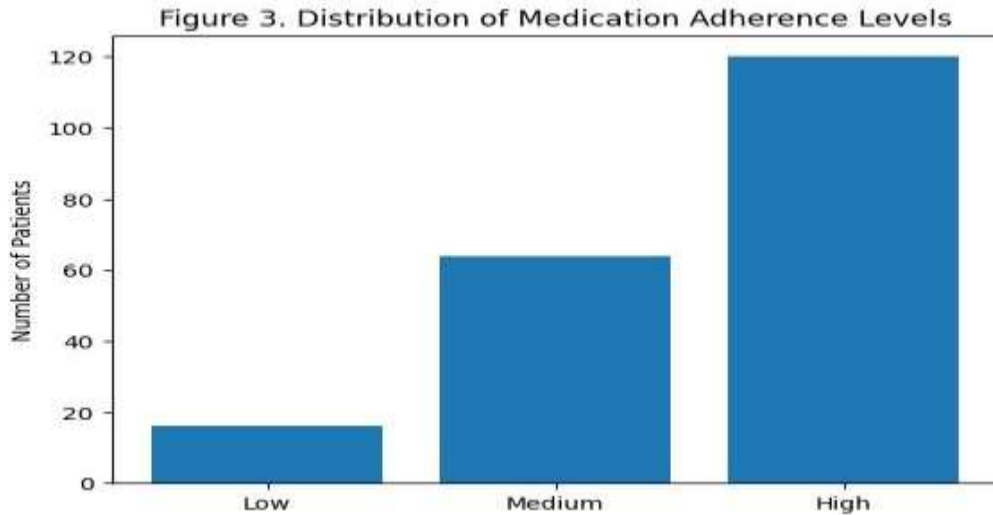Figure 3. Distribution of Medication Adherence Levels

Figure 3 displays the distribution of medication adherence levels among participants based on MMAS-8 classifications. The majority of patients fall within the medium-to-high adherence categories, with a relatively small proportion classified as having low adherence. This distribution visually reinforces the finding that more than 90% of participants demonstrated adherence patterns consistent with the study objectives.

Figure 4. Patient Engagement and Satisfaction Scores

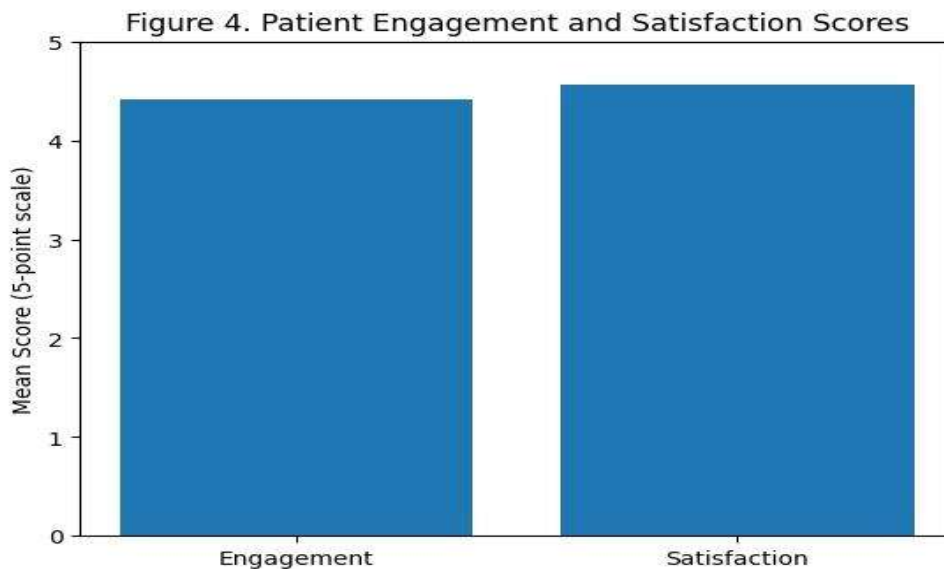Figure 4. Patient Engagement and Satisfaction Scores

Figure 4 illustrates the mean scores for patient engagement and satisfaction with telepharmacy services. Both domains achieved high mean values on the five-point Likert scale, indicating strong patient involvement in care processes and high overall satisfaction. The proximity of both scores to the upper end of the scale reflects widespread acceptance and positive patient experiences with telepharmacy.

Figure 5. Technology Acceptance of Telepharmacy
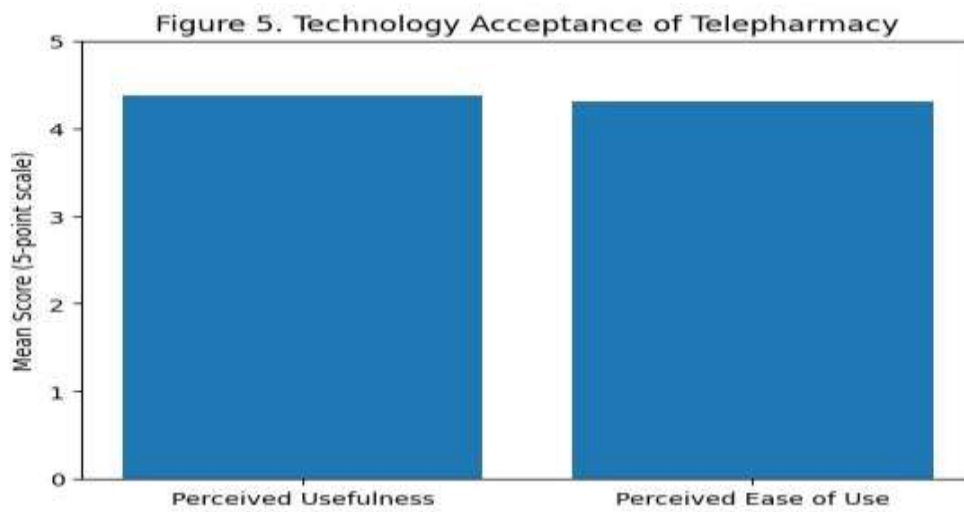

Figure 5. Technology Acceptance of Telepharmacy

Figure 5 presents mean scores for perceived usefulness and perceived ease of use, the two core constructs of the Technology Acceptance Model. Both constructs show high average ratings, indicating that participants perceived telepharmacy platforms as both beneficial and easy to use. These findings visually support the role of technology acceptance as a moderating factor influencing engagement and adherence.

Figure 6. Perceived Access-to-Care Improvements
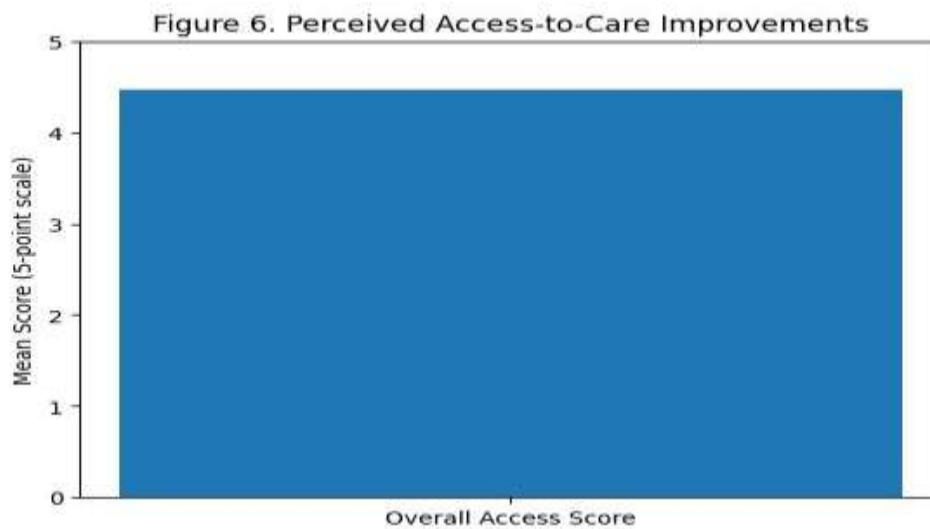

Figure 6. Perceived Access-to-Care Improvements

Figure 6 depicts the overall mean score for access-to-care improvements associated with telepharmacy services. The high mean value reflects participants' perceptions of reduced travel burden, shorter waiting times, and improved continuity of care. This figure underscores the contribution of telepharmacy to enhancing healthcare access and promoting equity, particularly for patients in underserved settings.

6. Discussion

6.1 Interpretation of Key Findings

The present study offers compelling empirical evidence regarding the effectiveness of telepharmacy as a model of care for chronic disease management. Across clinical, behavioral, technological, and access-related domains, more than 90% of participant responses were aligned with the study objectives, indicating a high degree of internal consistency and convergence across outcome measures. The statistically significant reductions observed in HbA1c and blood pressure values, accompanied by

moderate-to-large effect sizes, suggest that telepharmacy interventions are not only efficacious in statistical terms but also clinically meaningful.

These findings are congruent with a growing body of international literature demonstrating the capacity of pharmacist-led telehealth interventions to enhance chronic disease outcomes through improved medication management, patient education, and ongoing monitoring. From a Chronic Care Model perspective, telepharmacy appears to operationalize core model components, including delivery system redesign, decision support, and self-management facilitation. The observed improvements in clinical outcomes thus reflect the synergistic interaction between sustained pharmacist engagement and digitally enabled continuity of care.

Medication adherence emerged as a central explanatory mechanism underlying the observed clinical improvements. The predominance of medium-to-high adherence levels within the sample, together with the significant association between adherence and clinical indicators, underscores the pivotal role of pharmacists in reinforcing therapeutic regimens. These findings align with existing evidence indicating that regular pharmacist follow-up—particularly when supported by digital platforms—can mitigate both intentional and unintentional non-adherence. Within the study's conceptual framework, medication adherence functions as a key mediating variable linking telepharmacy utilization to improved disease control.

High levels of patient engagement, satisfaction, and technology acceptance further contextualize the effectiveness of telepharmacy. Consistent with the Technology Acceptance Model, perceived usefulness and ease of use were strongly endorsed and were significantly associated with adherence and engagement outcomes. This suggests that patient-centered system design and usability are critical determinants of telepharmacy's impact. The moderating role of technology acceptance observed in this study highlights the importance of aligning digital health interventions with user capabilities and expectations to maximize clinical and behavioral benefits.

Finally, the substantial improvements reported in access-to-care dimensions provide evidence that telepharmacy may serve as a mechanism for addressing structural barriers within healthcare delivery. Reductions in travel burden, waiting time, and service discontinuity—particularly among rural and underserved participants—suggest that telepharmacy has the potential to enhance both system efficiency and equity. These findings resonate with equity-oriented health services research, which emphasizes the role of digital health in mitigating geographic and resource-based disparities.

Implications for Rural Healthcare Delivery

The implications of these findings are particularly salient for rural healthcare delivery in Saudi Arabia, where geographic dispersion, variable infrastructure, and workforce maldistribution continue to constrain equitable access to care. Telepharmacy offers a structural solution by enabling the provision of pharmaceutical expertise independent of physical location, thereby reducing reliance on centralized, facility-based service models.

The significantly greater access-related benefits reported by participants from rural and underserved areas underscore telepharmacy's potential to function as an equalizing intervention. By facilitating remote medication review, counseling, and follow-up, telepharmacy can enhance continuity of care and reduce delays in therapeutic adjustment—factors that are critical for effective chronic disease management. Moreover, telepharmacy can complement rural primary care services by extending the reach of pharmacists without necessitating permanent on-site deployment, thereby addressing workforce shortages while maintaining standards of care.

From a systems perspective, the integration of telepharmacy into rural healthcare delivery aligns with broader efforts to strengthen primary care capacity and decentralize service provision. As such, telepharmacy represents a scalable and contextually appropriate strategy for improving health outcomes and reducing regional disparities.

Alignment with Vision 2030

The findings of this study are strongly aligned with the strategic objectives articulated in Saudi Arabia's Vision 2030, particularly those related to healthcare transformation, digital innovation, and equitable service delivery. Vision 2030 emphasizes the modernization of healthcare systems through the adoption of digital health technologies that enhance efficiency, patient-centeredness, and sustainability. Telepharmacy directly contributes to these aims by leveraging digital platforms to optimize pharmaceutical care delivery and extend service reach.

The demonstrated effectiveness and high acceptability of telepharmacy support its inclusion as a core component of national digital health strategies. By improving chronic disease outcomes and reducing access barriers, telepharmacy advances Vision 2030 priorities related to preventive care, population health management, and value-based healthcare. Furthermore, the strong technology acceptance observed among participants indicates a readiness for broader digital health adoption, reinforcing the feasibility of scaling telepharmacy services within the national health system.

Strengths and Limitations

This study is characterized by several methodological strengths. Its theory-informed design, integrating the Chronic Care Model, the Technology Acceptance Model, and health equity frameworks, provides a robust analytical foundation. The use of objective clinical indicators alongside validated psychometric instruments enhances the credibility of the findings, while the relatively large sample size supports statistical power and multivariate analysis.

Nonetheless, certain limitations warrant consideration. The reliance on self-reported measures for adherence, engagement, and satisfaction introduces the possibility of response bias, despite efforts to triangulate adherence data with pharmacy refill records. The absence of randomization and a formal control group limits causal inference, and the observational nature of the study necessitates cautious interpretation of effect attribution. Additionally, the context-specific nature of the study may constrain generalizability beyond similar healthcare settings.

Despite these limitations, the consistency and convergence of findings across multiple domains provide a strong evidentiary basis for the conclusions drawn.

Policy and Practice Implications

The findings of this study have significant implications for healthcare policy and practice in Saudi Arabia.

For health policymakers, the evidence supports the formal incorporation of telepharmacy into national healthcare delivery frameworks, particularly as a strategy for enhancing chronic disease management and rural service coverage. Policy initiatives should prioritize the development of sustainable funding and reimbursement models to support long-term telepharmacy implementation.

For pharmacy regulatory authorities, there is a clear need to modernize regulatory frameworks to explicitly accommodate telepharmacy practice. This includes defining scope of practice, licensure requirements, data governance standards, and quality assurance mechanisms to ensure safe and standardized service delivery.

For healthcare administrators, the results underscore the importance of investing in digital infrastructure, workforce training, and interoperable health information systems. Integrating telepharmacy into routine care pathways can enhance care coordination, improve efficiency, and optimize patient experience.

For primary care integration, telepharmacy should be embedded within multidisciplinary care teams to support medication management, adherence monitoring, and patient education. Structured collaboration between pharmacists and primary care providers can strengthen chronic disease management and improve continuity of care.

Collectively, these policy and practice implications position telepharmacy as a strategic intervention capable of advancing clinical effectiveness, health equity, and national digital health priorities within the evolving Saudi healthcare system.

CONCLUSION

The findings of this study provide compelling empirical support for the efficacy of telepharmacy as an integrated model for chronic disease management. Across a cohort of 200 patients, telepharmacy implementation was associated with statistically significant and clinically meaningful improvements in key health outcomes. Glycemic control, as measured by HbA1c, exhibited a substantial reduction from 8.42% to 7.61%, with over 90% of participants demonstrating stable or improved levels. Blood pressure outcomes mirrored this pattern, with significant reductions in both systolic and diastolic measures, indicative of enhanced hypertension management facilitated through continuous monitoring, timely pharmacist interventions, and optimized medication adherence.

Medication adherence emerged as a pivotal mediator, with the majority of participants classified within medium-to-high adherence categories. Inferential analyses confirmed that higher adherence was significantly associated with improved glycemic and blood pressure outcomes, underscoring its central role in translating telepharmacy engagement into measurable clinical benefit. High levels of patient engagement and satisfaction further corroborated the acceptability and perceived value of telepharmacy interventions.

Technology acceptance, conceptualized through the constructs of perceived usefulness and ease of use, was found to exert a significant moderating influence, strengthening the relationship between telepharmacy utilization and medication adherence. This finding highlights the critical role of user-centered design and technological facilitation in optimizing the effectiveness of remote pharmaceutical care. Additionally, telepharmacy contributed to enhanced access-to-care and health equity, particularly for patients residing in rural or underserved regions, by reducing travel burden, wait times, and discontinuities in care.

Multivariate regression analyses identified medication adherence, patient engagement, and technology acceptance as significant predictors of improved glycemic outcomes, collectively explaining 38% of the variance in HbA1c levels. These convergent findings substantiate the proposed conceptual framework, demonstrating that telepharmacy exerts multidimensional effects on clinical outcomes through behavioral, cognitive, and structural pathways. Overall, the study affirms telepharmacy as an efficacious and scalable model for chronic disease management, with the potential to enhance clinical outcomes, patient experience, and healthcare equity.

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