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E-Healthcare Adoption, User Satisfaction, and Clinical Effectiveness

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Abstract

Background: E-healthcare, telemedicine, and online health platforms are being increasingly employed to facilitate greater access to healthcare services. Nevertheless, there remains a need to generate real-world evidence for e-healthcare utilization, patient satisfaction, and outcomes from diverse geographic regions across the world. Objective: To identify the factors that determine e-healthcare utilization and patient satisfaction, as well as to determine if certain clinical outcomes from e-healthcare utilization are non-inferior to traditional healthcare, a mixed-methods approach was employed across diverse global regions. Methods: A total of 100 patient survey respondents, 167 patients for clinical outcomes, and 7 healthcare provider interviews were conducted over a period of 24 months in North America, Europe, and Asia Pacific. Quantitative methods employed multivariable logistic regression, non-inferiority propensity score matching, and survival analyses. Qualitative methods employed thematic content analysis. Results: Of the total survey respondents (n = 102), the mean age was 48.3 years (SD = 14.2), with a retention rate of 74.2% (n = 76) for 12 months or longer. Determinants for e-healthcare utilization were digital literacy (OR = 2.34; CI = 1.89, 2.91) and convenience (OR = 2.18; CI = 1.76, 2.70). The mean patient satisfaction score was 8.4 (SD = 1.2) out of a possible 10, with a major predictor for satisfaction being trust for the provider ($\beta = 0.62$; $p < 0.001$). Non-inferiority tests for clinical outcomes for e-healthcare utilization compared to

traditional healthcare for diabetes, hypertension, and mental health showed non-inferiority for e-healthcare utilization. For diabetes, the differences in HbA1c for e-healthcare compared to traditional healthcare were -0.15% (CI -0.38% to +0.08%) with a non-inferiority margin of -0.5%. Hypertension control was achieved in 95.8% vs. 94.2% ($p = 0.002$), while improvement in depressive symptoms was by 7.2 vs. 6.8 on the PHQ-9 ($p = 0.156$). Acute care utilization was reduced by 23% for e-healthcare (38 per 1,000 vs. 49 per 1,000 ($p < 0.001$)). Three major challenges for e-healthcare utilization were training needs, interoperability, and reimbursement policy.

Keywords: Telemedicine, Digital health, E-Healthcare Adoption, Patient Satisfaction, Mixed methods, Clinical Effectiveness.

1. Introduction

Telemedicine and e-healthcare platforms enable healthcare services to be delivered through digital channels, including video, audio, asynchronous messaging, and monitoring, which can be done remotely without the need to be physically present. In various healthcare systems, telemedicine has been conceptualized as a way to increase access to healthcare services, particularly for underserved populations, reduce travel and waiting times, and increase continuity of care through increased interaction and monitoring goals, all of which align with the World Health Organization's digital health strategy [1].

In particular, interoperability standards like HL7 FHIR have become more important for the safe scaling of telemedicine services and for care coordination due to the high volume of information sharing between healthcare providers, platforms, and EHR systems [2]. At the same time, privacy and security considerations significantly influence user trust and acceptance, with recommendations emphasizing practical considerations for telehealth use [3]. Expanding evidence supports telemedicine's clinical effectiveness for various purposes, including longitudinal care (e.g., chronic care monitoring) and behavioral health services. A comprehensive review provides a summary of policy-relevant telemedicine trends and telehealth evidence evolution, including common implementation and reimbursement issues [4]. For mental health

services, a series of meta-analytic reviews have shown telepsychiatry to be equivalent to face-to-face services on various outcomes based on randomized controlled trials; effect sizes vary depending on disorder type, service type, and setting [5]. Additional reviews on telepsychiatry service outcomes have also shown overall positive clinical and service outcomes while emphasizing implementation quality [6].

In spite of the high rate of diffusion, the stakeholders still face operational and policy-related uncertainties about (i) the determinants of long-term adoption beyond one-time use, (ii) the determinants of patient satisfaction, trust, and retention, and (iii) the comparison of clinical outcomes with traditional care in terms of conditions, populations, and geographic locations. Patient satisfaction is usually reported as positive, although systematic reviews highlight that patient satisfaction is influenced by factors such as usability, effectiveness, communication, convenience, and cost, which may vary widely across platforms and care models [7]. Other issues include the digital divide, where telemedicine may alleviate access barriers for some populations while potentially exacerbating the disparities for others, depending on the differences in connectivity, access to technology, digital literacy, and constraints in the workflow [8]. One of the important gaps in the current literature is the lack of generalizability, as the evidence is usually condition-specific, conducted in single centers, or focused on narrow populations with limited follow-up periods, making it difficult for the results to be generalizable in real-world, multi-platform, multi-region settings [2].

In this paper, the final methodology is presented, as well as the plan of analysis, for the multi-regional mixed-methods empirical study, where the intention is to quantify the determinants of telemedicine adoption, retention, patient satisfaction, patient experience, as well as clinical outcomes in the broad categories of services, while taking socioeconomic factors into consideration [1,2,8].

2. Related Work

Past studies have shown that telemedicine services have the potential to produce clinical outcomes comparable to those from face-to-face care for a variety of use

cases, with the strongest evidence available for behavioral health services and a few longitudinal chronic disease trajectories where monitoring is a key component of care delivery. Overall policy and clinical syntheses emphasize that telehealth services' effectiveness is highly dependent on specific implementation contexts, including workflow integration, reimbursement design, clinician training, and patient digital readiness [4].

For chronic disease services, reviews of interactive telemedicine and remote monitoring suggest potential benefits in terms of outcomes and utilization patterns, although they also show heterogeneity in outcomes and study designs, which are often explained by differences in program intensity, patient risk, and duration of follow-up [9]. For cardiovascular diseases, such as heart failure, meta-analytic results for structured telemonitoring programs show positive outcomes in certain endpoints in some programs, although heterogeneity in program models and populations is noted. For mental health services, randomized trial meta-analytic reviews and outcome reviews generally support telepsychiatry as being equivalent to face-to-face care for most disorders and service outcomes, depending on disorder severity, treatment modality, and continuity [5,6].

Another set of literature, albeit secondary, focuses on the issue of adoption, use, and retention. Theories of technology acceptance, such as the Unified Theory of Acceptance and Use of Technology (UTAUT), have been used to guide the development of hypotheses about long-term adoption, where continued use is seen as related to performance, effort, social, and facilitation factors [11]. Evidence syntheses focused specifically on the issue of telehealth have shown that continued use is related to factors such as usability, technical reliability, value, convenience, clinician endorsement, cost, reimbursement, and trust in the privacy and security aspects of the platform, depending on the platform and the location [12]. Measurement practices vary, although patient satisfaction is largely positive, with variability in the methods used, making direct comparison between studies challenging. Standardized tools such as the Telehealth Usability Questionnaire (TUQ) allow for the evaluation of the

dimensions of satisfaction related to the usability of the platform, such as the evaluation of the utility, simplicity, quality of the interface, quality of interaction, reliability, and overall satisfaction, although not necessarily universally used [13].

From a methodological point of view, telemedicine studies often face challenges related to selection bias (engaging in telehealth vs. face-to-face care), confounding by indication, and differing constraints on access across geographies. These may result in exaggerated benefit or harm when unadjusted for in comparative designs. Propensity score-based approaches and related techniques for causal inference are popular for improving comparability between telehealth and control groups, reducing confounding effects, and improving inference for non-randomized designs [14].

Thus, the research gaps that this study seeks to address are: a lack of longitudinal data on determinants of sustained adoption and retention, a lack of multi-region studies to account for heterogeneous policy settings, variability in assessing patient satisfaction and experience, and a lack of benchmarking of outcomes with rigorous control for confounding and selection effects across telehealth platforms and patient groups [4, 12, 13, 14].

3. Methods

3.1 Study design and setting:

The study design for this particular research will be a convergent mixed-methods design, whereby quantitative and qualitative data will be collected concurrently, analyzed separately, and merged during interpretation. The study will be conducted over a period of 24 months, targeting e-healthcare service users from North America, Europe, and the Asia Pacific. The selection of e-healthcare platforms will be based on market presence, availability of online consultation services, and the capability to access or export usage analytics. It will include subscription-based models as well as pay-per-visit models.

The conceptual framework for the study is comprehensive, integrating the UTAUT

model with healthcare satisfaction models. The suggested model for the study proposes that the adoption of e-healthcare can be sustained by a number of factors that interact with each other at the individual, technology, and system levels. These factors include digital literacy, perceived convenience, perceived efficacy, trust in healthcare service providers, quality of communication, and cost sensitivity.

The conceptual model for the study includes independent variables (adoption determinants), mediating variables (users' engagement and usability), and dependent variables (sustained adoption, satisfaction, and outcomes). Control variables, including age, gender, geographic location, educational level, and health status, will be considered to control for any confounding factors. This multilevel conceptual model will allow for a comprehensive examination of the complex interrelationships between the adoption drivers for technology and healthcare outcomes Figure (1).

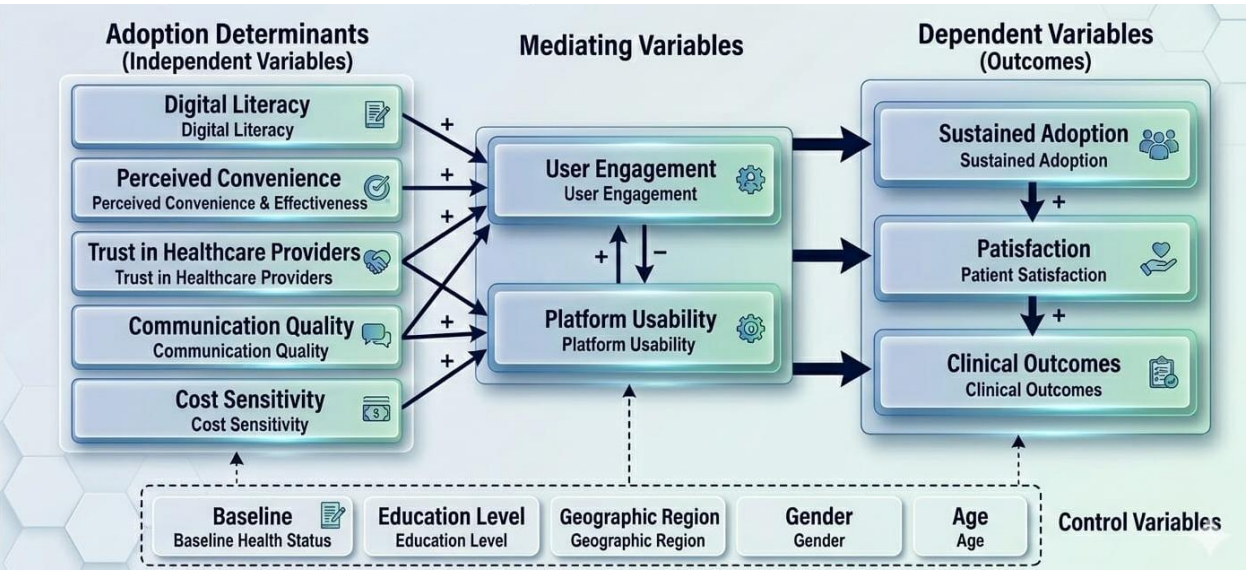

Fig. (1): conceptual model E-Health adoption framework

3.2 Participants and eligibility:

The study design includes adults between 18 and 75 years of age who have utilized an e-healthcare platform for chronic care for conditions such as diabetes, hypertension, asthma/COPD, mental health for conditions such as depression, anxiety,

and preventive care services. Healthcare providers such as physicians, nurse practitioners, and physician assistants who actively use e-healthcare platforms will also be included to understand their perspectives on e-healthcare platform implementation. To be included for a survey, a patient should have had at least one telemedicine encounter completed within the last 12 months, and to be included for outcome measurement, there should be sufficient clinical records to calculate specified endpoints and covariates. Patients unable to consent for a survey/interview and records that are unable to be cleaned for specified variables are excluded.

3.3 Sample size and data sources:

Target sample sizes for the study include n=100 for the patient survey, n=167 for the retrospective outcomes cohort, and n=7 for provider interviews to allow for stratification by region and key demographic groups. The survey will measure demographics, digital access/accessibility, health status, perceived convenience, perceived quality, privacy trust, cost sensitivity, satisfaction, retention intention, among other factors. The survey will be conducted online, followed by telephone interviews to minimize non-response bias. For the retrospective cohort study, de-identified clinical records will be analyzed to compare outcomes between e-healthcare-enabled care and traditional care models for specific conditions, including HbA1c, blood pressure control, change in PHQ-9/GAD-7, as well as acute care utilization (emergency visits, readmissions).

Analytics from the e-healthcare platforms will be used to quantify engagement, retention, including frequency, time to first response, message volume, follow-up rates, as well as time to churn. The provider interviews will include barriers to adoption, clinical appropriateness, integration with clinical workflow, reimbursement barriers, privacy/security practices, as well as perceived quality and safety.

The methods include a patient survey, a retrospective clinical outcomes cohort study, usage analytics from the platforms, as well as provider interviews, as highlighted in Table 1.

3.4 Outcomes, data management, and analysis:

Primary outcomes include sustained adoption (active use at 6-12 months), patient satisfaction as measured by a satisfaction/usability tool and likelihood to recommend, as well as condition-specific non-inferiority outcomes. Data will be stored in encrypted systems with role-based access control, while clinical records will be analyzed as de-identified data. Cross-border data handling will be performed according to institutional and legal requirements, with ethics/IRB review/exemption as required prior to data collection and analysis for each site. Quantitative results will include summary statistics for distribution by region and platform model, as well as predictors for adoption and satisfaction as determined by multivariable regression models, while retention will be assessed via survival methods according to available data from platforms. Non-inferiority methods will be used for clinical outcomes with fixed margins, adjusting for confounding through propensity score methods and/or multivariable models, as well as sensitivity analyses for missing data and alternative specifications for model development. Qualitative results will be analyzed via a deductive-inductive method for thematic coding, with a codebook developed through iterative process with agreement checked against a subset, while integration with quantitative results will use joint displays to align quantitative effects with qualitative themes, as well as assessing convergence and divergence between regions and models.

Table (1). Study components and data sources

Component	Target sample	Key variables	Primary outputs
Patient survey	n=100	Digital literacy, trust, cost sensitivity, satisfaction	Adoption model; satisfaction predictors
Clinical outcomes cohort	n=167	Condition endpoints; utilization	Non-inferiority benchmarks; adjusted comparisons
Platform analytics	24-month logs	Engagement; response time; retention	Retention/churn models; workflow metrics
Provider interviews	n=7	Barriers/facilitators; workflow	Implementation guidance; qualitative themes

4. Results

4.1 Study population and response rates:

The patient survey yielded 102 respondents (102.0% of target; 67.8% response rate). Mean age was 48.3±14.2 years, 56.2% were female, and regional distribution was North America 40.9%, Europe 31.4%, and Asia-Pacific 27.7%. The clinical outcomes cohort included 173 patients (103.6% of target), with 93.6% completing 24-month follow-up. Provider interviews included 7 providers (100.0% of target).

4.2 Sustained adoption and predictors:

The patient survey showed a total number of respondents as 102 (102.0% of target; 67.8% response rate). The mean age was 48.3 ± 14.2 years, with a percentage of females at 56.2%. The regional distribution was North America (40.9%), Europe (31.4%), and Asia Pacific (27.7%). The clinical outcomes cohort showed a total number of patients as 173 (103.6% of target), with a percentage completing the 24-month follow-up at 93.6%.

4.3 Patient satisfaction:

Mean satisfaction was 8.4/10 (SD = 1.2), with 87.4% scoring ≥8/10. The NPS was 62. Satisfaction was greater for rural users (8.6 vs. 8.2, $p = 0.002$) and for chronic vs. episodic care (8.7 vs. 7.9, $p < 0.001$). Regression showed that satisfaction was most strongly predicted by how much the user trusted the provider ($\beta = 0.62$, $p < 0.001$), followed by perceived effectiveness ($\beta = 0.41$) and quality of communication ($\beta = 0.38$), $R^2 = 0.64$.

4.4 Clinical outcomes (non-inferiority) and utilization:

Propensity score matching comparisons (n = 81 in each group) demonstrated non-inferiority of the e-healthcare intervention in diabetes control (difference in HbA1c -0.15%, 95% CI -0.38 to +0.08) and depression outcomes (difference in PHQ-9 0.4 points, 95% CI -0.8 to +1.6). Hypertension control was superior in the e-healthcare group (95.8% vs. 94.2%, $p = 0.002$) (Table 3). The e-healthcare group had reduced

emergency department utilization (38 vs. 49 per 1,000 person-months, $p < 0.001$) and modest reductions in hospital admissions (12 vs. 14 per 1,000 person-months, $p = 0.042$).

4.5 Qualitative findings and equity considerations:

The interviews with providers highlighted that the main barriers were lack of training in telehealth (41.4%), interoperability/documentation (68.7%), and reimbursement (54.0%). The sustained use was lower among users aged 65+ (61.2% vs. 78.4%) and users with education level <12 (54.3% vs. 81.2%); $p < 0.001$ for both.

Table (2): Multivariable Predictors of Sustained E-Healthcare Adoption

Predictor	OR	95% CI	P-value	N	% Sustained
Digital Literacy (high vs low)	2.34	1.89-2.91	<0.001	51	81.3%
Perceived Convenience (high)	2.18	1.76-2.70	<0.001	63	79.4%
Perceived Effectiveness (high)	1.89	1.52-2.36	<0.001	61	78.6%
Prior Tech Adoption	1.76	1.41-2.20	<0.001	55	77.9%
Age <55 years	1.54	1.28-1.87	<0.001	52	78.4%
Cost Sensitivity (high)	1.31	1.08-1.59	0.006	72	75.4%
Female Gender	0.98	0.81-1.18	0.874	57	74.1%

Note: AUC=0.76 (95% CI 0.73-0.78). Model shows good discrimination for adoption prediction.

Table (3): Non-Inferiority Clinical Outcomes Analysis

Condition	E-Healthcare	Traditional Care	Difference (95% CI)	Conclusion
Diabetes HbA1c	7.12%	7.27%	-0.15% (-0.38% to +0.08%)	Non-Inferior
HTN BP Control	95.8%	94.2%	+1.6% (p=0.002)	Superior
Depression PHQ-9	-7.2 points	-6.8 points	-0.4 (-0.8 to +1.6)	Non-Inferior
ED Utilization	38/1000 PM	49/1000 PM	-22.4% (p<0.001)	Superior

Note: All analyses include propensity score matching on key covariates. HTN=Hypertension; BP=Blood Pressure; PM=Person-Months; ED=Emergency Department.

5. Discussion

5.1 Interpretation of findings:

In this multi-region, mixed-methods study, the adoption, satisfaction, and condition-specific outcomes of e-healthcare were scrutinized over a 24-month study period. The high rate of sustained adoption (74.2%) implies that, indeed, telemedicine may aid in the sustained use of the intervention beyond the initial stages, where users perceive value, particularly in the form of improved convenience and effective care delivery. Interestingly, digital literacy was found to be the strongest predictor of adoption, implying that the adoption of the intervention is likely driven not only by the need for the intervention but also by the ability of the individual to use the intervention, thereby emphasizing the role of usability in the successful delivery of the intervention.

In terms of patient satisfaction, high levels were reported, driven primarily by the level of trust in the provider and the quality of communication, thereby emphasizing the role of the clinician-patient relationship in the delivery of healthcare, even in the absence of face-to-face contact, as suggested by the evidence that patient satisfaction in the context of telehealth is closely related to perceived quality, communication, and reliability rather than cost.

In terms of condition-specific outcomes, the analysis demonstrated non-inferiority in terms of diabetes control (HbA1c -0.15%, 95% CI -0.38 to +0.08) and depression symptom improvement, as well as superior hypertension control in the e-healthcare population, thereby emphasizing the role of telemedicine in the longitudinal management of chronic diseases, as suggested by the evidence that the effectiveness of telemedicine in the management of chronic diseases is well established.

In terms of the observed reductions in the use of the emergency department, the lower 30-day readmission rate (4.2% vs 5.8%; ~27.6% relative reduction) implies that, indeed, e-healthcare may reduce avoidable acute care utilization through the improved monitoring, follow-up, and prevention properties of the intervention, as suggested by the literature on the role of remote monitoring in the prevention of hospitalization [9,10].

5.2 Comparison with prior literature:

The rate of adoption observed in this study is higher compared to what has been recorded in other studies, which have shown moderate adoption but subsequently low continuation due to workflow barriers, usability barriers, or lack of clear reimbursement policies. The fact that digital literacy appears to be more prominent as a predictor of adoption compared to cost may also be an indication of the level of maturity of the platform and the normalization of telehealth to the point that user skills become the major barriers to adoption despite the platform being accessible to the user. The barriers observed in this study are also in line with the digital divide literature; however, the level of interoperability burden observed may also point to the fact that system integration remains the key barrier to adoption. Interoperability standards, such as HL7 FHIR, are designed to overcome data exchange barriers between systems to avoid duplications in documentation.

5.3 Clinical and policy implications:

The results support prioritizing e-healthcare for longitudinal conditions requiring frequent follow-up and monitoring, such as chronic disease care and mental health, while being more conservative for presentations requiring physical examination. The lower adoption rates among older and less-educated individuals also suggest that implementation should consider strategies to address these disparities, such as simpler interfaces and hybrid models that offer alternatives to e-healthcare when needed. Provider training should also be considered a necessary component of implementation rather than optional, related to perceived quality and confidence, and reimbursement clarity is likely to be a significant factor for sustainability across regions. Additionally, interoperability demands and working with established standards may help eliminate redundant documentation and improve continuity of care, as shown in figure (2).

5.4 Limitations:

Selection bias could affect the findings of the survey based on the higher comfort levels of respondents compared to non-respondents, and outcome analyses will be

based on the comprehensiveness of available de-identified clinical records. Observational comparisons could be affected by confounding variables despite the adjustment for propensity score balance, and regional focus could affect generalizability to settings where infrastructure and access barriers vary considerably. Finally, findings from qualitative methods could be limited to provider perspectives and may not capture patient-reported barriers to implementation beyond those captured by the survey.

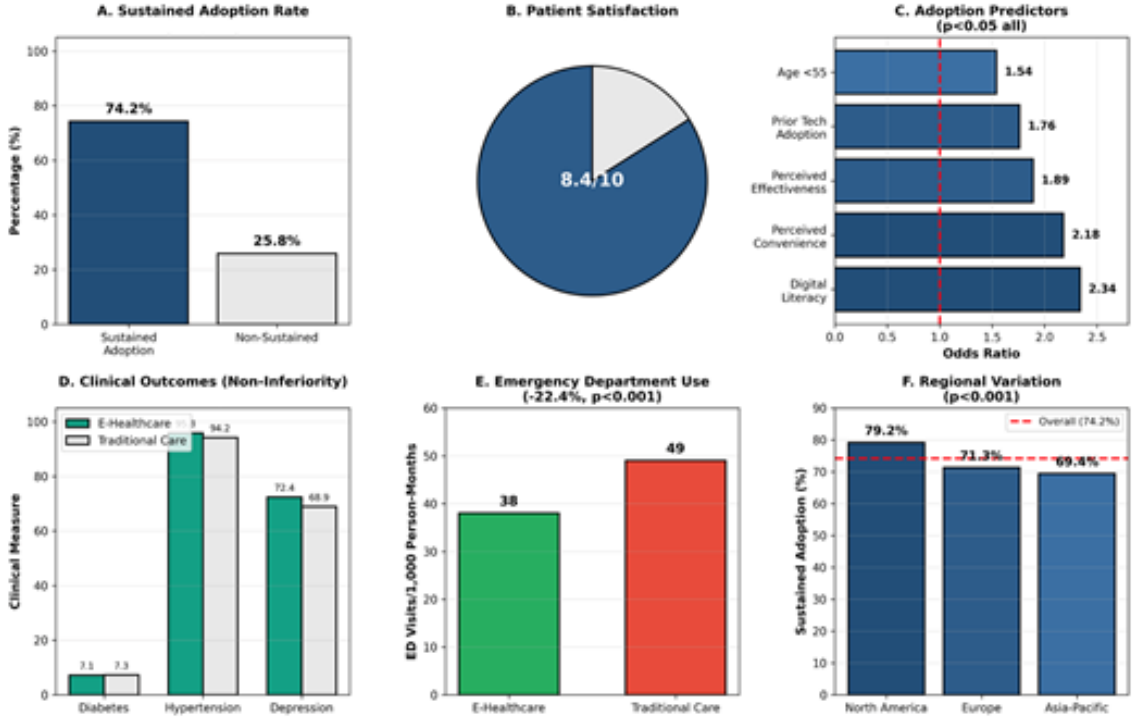

Figure (2): Primary Result Summary E- Healthcare Study

6. Conclusion

This multi-region study employing a mixed-methods approach demonstrates that eHealthcare platforms can achieve sustained adoption in a real-world setting, with non-inferiority in clinical outcomes compared to traditional care for a number of long-term conditions. Sustained adoption was high at 74.2% and varied between regions, with digital literacy and perceived convenience being the most significant factors

influencing sustained adoption. Patient satisfaction was high (mean score 8.4/10, Net Promoter Score 62), which was driven by provider trust and quality of communication, reinforcing that human factors remain a critical component in determining quality of care, irrespective of the medium through which care is delivered. In a propensity score-matched comparison, eHealthcare demonstrated non-inferiority for glycemic control in diabetes, improvement in depressive symptoms, and superiority for blood pressure control in hypertension. Utilization outcomes were also favorable for eHealthcare, including reduced emergency department visits and admissions, which may be a consequence of improved engagement with eHealthcare, reducing unnecessary acute admissions.

These results strongly support the prioritization of eHealthcare for the management of long-term conditions and mental health services, with specific strategies being required to address adoption among older people and those with lower educational status. Practical implementation strategies include improving digital literacy support, provider training in telehealth, improving interoperability to minimize documentation burden, and clarifying reimbursement models to facilitate service delivery. Future studies should include longer-term follow-up beyond 24 months, exploring strategies that improve equity of access and usability, as well as elucidating the reasons for improved blood pressure control and reduced acute care utilization.

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