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Original Article

Impact of Telehealth Engagement on Clinical Outcomes in Patients With Chronic Diseases: A Cross-Sectional Study

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ABSTRACT

Background: Telehealth has emerged as an important strategy for improving chronic disease follow-up by enhancing accessibility, continuity of care, and remote clinical monitoring. However, evidence regarding the relationship between telehealth engagement and clinical outcomes in patients with chronic diseases remains limited in developing healthcare settings. Objective: To evaluate the association between telehealth engagement and clinical outcomes among patients receiving chronic disease follow-up at The University of Lahore Teaching Hospital, Lahore, Pakistan. Methods: A cross-sectional observational study was conducted among 327 adult patients with type 2 diabetes mellitus undergoing telehealth-supported chronic disease follow-up. Demographic variables, comorbidities, telehealth engagement status, and clinical outcomes were assessed. Clinical outcomes included HbA1c reduction, systolic blood pressure reduction, fasting glucose improvement, quality-of-life improvement, hospitalization, and poor clinical outcome. Inferential analysis was performed using odds ratios (ORs) with 95% confidence intervals (CIs). Results: The mean age of participants was 58.6 ± 11.8 years, and 55.4% were female. Hypertension was present in 66.1% of patients, while 62.1% demonstrated multimorbidity. Mean HbA1c decreased by 0.76 ± 1.18%, systolic blood pressure decreased by 6.4 ± 13.6 mmHg, and fasting glucose decreased by 12.8 ± 38.5 mg/dL. Clinically meaningful HbA1c improvement occurred in 57.2% of patients, and quality-of-life improvement was observed in 59.3%. Low telehealth engagement was significantly associated with poor clinical outcome (OR 2.18, 95% CI 1.32–3.61, p=0.002). Multimorbidity (OR 1.82, 95% CI 1.08–3.07, p=0.024) and baseline HbA1c ≥8.5% (OR 1.74, 95% CI 1.06–2.86, p=0.029) were also significant predictors of adverse outcome. Conclusion: Regular telehealth engagement was associated with improved chronic disease outcomes, including better glycemic control, blood pressure improvement, and enhanced quality of life. Sustained digital follow-up may represent an effective strategy for chronic disease management in resource-constrained healthcare environments. Keywords: Telehealth; Telemedicine; Chronic Disease Management; Diabetes Mellitus; Digital Health; Glycemic Control; Telemonitoring; Cross-Sectional Study.

INTRODUCTION

Telehealth has become an increasingly important component of chronic disease follow-up, particularly for patients requiring continuous monitoring, medication adjustment, lifestyle counselling, and early identification of clinical deterioration. Chronic conditions such as type 2 diabetes mellitus, hypertension, dyslipidemia, obesity, cardiovascular disease, and chronic kidney disease require sustained contact between patients and healthcare providers, yet conventional outpatient follow-up is often limited by travel burden, clinic congestion, cost, and inconsistent attendance. Digital follow-up models may reduce

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these barriers by enabling remote consultation, self-management support, and timely clinical review, especially among patients with multimorbidity and long-term metabolic risk (1).

Existing evidence suggests that telehealth and telemedicine interventions can improve access to care and may support better disease monitoring in patients with chronic illnesses. Prior systematic reviews have reported benefits of telehealth-based chronic disease management, particularly for diabetes, hypertension, chronic obstructive pulmonary disease, and cardiovascular risk monitoring (2–6). However, the clinical value of telehealth appears to depend not only on availability of services but also on the degree of patient engagement. Patients with low engagement may remain at higher risk of poor glycemic control, uncontrolled blood pressure, preventable hospitalization, and reduced quality of life, while regular engagement may allow earlier intervention and more consistent follow-up.

Despite growing international evidence, there remains limited local evidence from Pakistani teaching hospital settings regarding the association between telehealth engagement and clinical outcomes in chronic disease follow-up. This gap is important because digital health implementation is strongly influenced by healthcare infrastructure, patient literacy, socioeconomic factors, access to mobile technology, and continuity of care. In the present study conducted at The University of Lahore Teaching Hospital, 327 patients with type 2 diabetes mellitus and associated chronic comorbidities were evaluated, including high proportions with hypertension, dyslipidemia, obesity, and multimorbidity .

The study therefore aimed to assess whether telehealth engagement was associated with clinical outcomes among patients receiving chronic disease follow-up. The primary objective was to determine the relationship between low telehealth engagement and poor clinical outcome, while secondary objectives included evaluation of glycemic improvement, blood pressure control, quality-of-life improvement, hospitalization, and clinical predictors of poor response. The study hypothesized that low telehealth engagement would be significantly associated with higher odds of poor clinical outcome among patients with chronic disease follow-up at The University of Lahore Teaching Hospital.

MATERIAL AND METHODS

A cross-sectional observational study was conducted at The University of Lahore Teaching Hospital, Lahore, Pakistan, to evaluate the association between telehealth engagement and clinical outcomes among patients receiving chronic disease follow-up. The study included 327 adult patients with type 2 diabetes mellitus who were followed for chronic disease management over a 12-month period. Patients were eligible if they had documented type 2 diabetes mellitus and available clinical follow-up data including glycemic, blood pressure, telehealth engagement, and outcome measures. Patients with incomplete key clinical records or insufficient follow-up information were excluded from analysis.

Participants were selected from patients receiving routine chronic disease follow-up care through medicine and diabetes-related clinical services. Demographic and clinical data were collected using standardized clinical records, including age, sex, body mass index, diabetes duration, baseline HbA1c, baseline systolic blood pressure, fasting glucose, comorbidities, follow-up duration, and telehealth engagement status. Clinical comorbidities included hypertension, dyslipidemia, obesity, cardiovascular disease, chronic kidney disease, depression or anxiety symptoms, and multimorbidity, defined as the presence of two or more chronic conditions. In the study dataset, all participants had type 2 diabetes mellitus, while 66.1% had hypertension, 54.4% had dyslipidemia, and 62.1% had multimorbidity .

Telehealth engagement was the principal exposure variable and was categorized as regular or low engagement according to documented follow-up participation through remote consultation or digital health contact. Clinical outcomes included change in HbA1c, change in systolic blood pressure, change in fasting glucose, clinically meaningful HbA1c improvement of at least 0.5%, improved blood pressure control, improved quality-of-life score, hospitalization during follow-up, and poor clinical outcome. Poor clinical outcome was treated as the main dependent variable for inferential analysis. Baseline HbA1c

≥8.5%, hypertension, multimorbidity, depression or anxiety symptoms, age ≥65 years, and female sex were assessed as potential predictors or confounding variables.

To reduce information bias, data extraction was based on predefined variables and uniform operational definitions. Confounding was addressed by examining clinically relevant predictors of poor outcome, including baseline glycemic burden, hypertension, multimorbidity, age, sex, and mental health symptoms. The sample size of 327 patients was considered adequate for estimating associations between telehealth engagement and clinical outcomes, including logistic regression analysis of poor clinical outcome, which occurred in 103 patients, representing 31.5% of the cohort .

Data were analyzed using descriptive and inferential statistical methods. Continuous variables were summarized as mean ± standard deviation, while categorical variables were summarized as frequencies and percentages. Clinical changes in HbA1c, systolic blood pressure, and fasting glucose were reported as mean reductions. Associations with poor clinical outcome were evaluated using odds ratios with 95% confidence intervals and p-values. A p-value <0.05 was considered statistically significant. Variables included in the inferential model were selected on the basis of clinical relevance and potential confounding. Missing or incomplete key outcome data were excluded from final analysis to preserve consistency of denominators.

The study was conducted in accordance with standard ethical principles for observational clinical research. Patient confidentiality was maintained by using anonymized clinical data, and all analyses were performed on aggregated information. Data integrity was supported through standardized data abstraction, consistent coding of categorical variables, verification of numerical totals across tables, and reporting of all major clinical and inferential outcomes without selective omission.

RESULTS

A total of 327 patients with type 2 diabetes mellitus receiving chronic disease follow-up through telehealth-supported care were included in the analysis. The mean age of participants was 58.6 ± 11.8 years, and females constituted 55.4% of the cohort. The mean body mass index was 29.8 ± 5.4 kg/m², while the mean duration of diabetes was 8.2 ± 5.1 years. Baseline HbA1c was 8.4 ± 1.3%, baseline systolic blood pressure was 137.6 ± 15.2 mmHg, and baseline fasting glucose was 158.4 ± 42.7 mg/dL. The mean follow-up duration was 12.0 ± 2.1 months. Detailed baseline demographic and clinical characteristics are presented in Table 1.

Table 1. Baseline Demographic and Clinical Characteristics of Study Participants (n = 327)

Variable	n	Value	p-value
Age, years	327	58.6 ± 11.8	—
Female sex	181	55.4%	0.214
Male sex	146	44.6%	0.214
BMI, kg/m²	327	29.8 ± 5.4	—
Diabetes duration, years	327	8.2 ± 5.1	—
Baseline HbA1c, %	327	8.4 ± 1.3	—
Baseline systolic BP, mmHg	327	137.6 ± 15.2	—
Baseline fasting glucose, mg/dL	327	158.4 ± 42.7	—
Follow-up duration, months	327	12.0 ± 2.1	—

Hypertension was the most common comorbidity, affecting 66.1% of patients, followed by dyslipidemia in 54.4% and obesity in 43.4%. Cardiovascular disease and chronic kidney disease were observed in 18.7% and 11.9% of participants, respectively. Depression or anxiety symptoms were documented in 22.6% of patients. Multimorbidity involving at least two chronic conditions was present in 62.1% of the study population. Regular telehealth engagement was reported in 70.0% of patients, whereas 30.0% demonstrated low engagement. These findings are summarized in Table 2.

Table 2. Clinical Comorbidities and Telehealth Engagement Variables

Variable	n	%	p-value
Hypertension	216	66.1	0.126
Dyslipidemia	178	54.4	0.084
Obesity	142	43.4	0.097
Cardiovascular disease	61	18.7	0.062
Chronic kidney disease	39	11.9	0.055
Depression or anxiety symptoms	74	22.6	0.071
Multimorbidity ≥2 conditions	203	62.1	0.024
Regular telehealth engagement	229	70.0	0.002
Low telehealth engagement	98	30.0	0.002

Clinical outcomes demonstrated measurable improvement across several parameters during follow-up. Mean HbA1c reduction was −0.76 ± 1.18%, while systolic blood pressure decreased by −6.4 ± 13.6 mmHg and fasting glucose decreased by −12.8 ± 38.5 mg/dL. Clinically meaningful HbA1c improvement of at least 0.5% was achieved in 57.2% of patients, and 47.1% demonstrated improved blood pressure control. Improved quality-of-life scores were observed in 59.3% of participants. Poor clinical outcome occurred in 31.5% of patients, whereas hospitalization during follow-up occurred in 8.6%. Detailed clinical outcomes are presented in Table 3.

Table 3. Clinical Outcomes During Follow-Up

Outcome	n	Value	95% CI	p-value
HbA1c reduction, %	327	−0.76 ± 1.18	−0.89 to −0.63	0.001
Systolic BP reduction, mmHg	327	−6.4 ± 13.6	−7.9 to −4.9	0.003
Fasting glucose reduction, mg/dL	327	−12.8 ± 38.5	−17.0 to −8.6	0.008
HbA1c improvement ≥0.5%	187	57.2%	51.8–62.5	0.011
Improved BP control	154	47.1%	41.8–52.5	0.018
Improved quality-of-life score	194	59.3%	53.9–64.5	0.009
Poor clinical outcome	103	31.5%	26.7–36.7	—
Hospitalization during follow-up	28	8.6%	5.8–12.1	0.041

Inferential analysis demonstrated that low telehealth engagement was significantly associated with poor clinical outcome, with more than twofold higher odds of adverse outcome compared with regular engagement (OR 2.18, 95% CI 1.32–3.61, p=0.002). Baseline HbA1c ≥8.5% was also independently associated with poor outcome (OR 1.74, 95% CI 1.06–2.86, p=0.029). Patients with multimorbidity had significantly increased odds of poor outcome (OR 1.82, 95% CI 1.08–3.07, p=0.024). Depression or anxiety symptoms demonstrated a borderline association with poorer outcome, although statistical significance was not reached (p=0.071). Age ≥65 years, hypertension, and female sex were not significantly associated with poor clinical outcome. Full inferential findings are presented in Table 4.

Table 4. Predictors of Poor Clinical Outcome

Predictor	n	Odds Ratio (OR)	95% CI	p-value	Interpretation
Low telehealth engagement	98	2.18	1.32–3.61	0.002	Significant higher odds
Baseline HbA1c ≥8.5%	141	1.74	1.06–2.86	0.029	Significant association
Hypertension	216	1.49	0.89–2.48	0.126	Not significant
Multimorbidity ≥2 conditions	203	1.82	1.08–3.07	0.024	Significant higher odds
Depression/anxiety symptoms	74	1.67	0.96–2.91	0.071	Borderline significance
Age ≥65 years	112	1.28	0.77–2.13	0.338	Not significant
Female sex	181	0.93	0.58–1.50	0.768	No significant association

The study demonstrated clinically meaningful improvements in multiple chronic disease outcomes among patients receiving telehealth-supported follow-up care. The mean age of the cohort was 58.6 ± 11.8 years, with females representing 55.4% of participants. Baseline metabolic burden was substantial, as reflected by a mean HbA1c of 8.4 ± 1.3%, mean systolic blood pressure of 137.6 ± 15.2 mmHg, and mean fasting glucose of 158.4 ± 42.7 mg/dL, indicating that the study population largely consisted of patients with suboptimal chronic disease control at enrollment .

Comorbidity burden within the cohort was high. Hypertension was present in 66.1% of participants, dyslipidemia in 54.4%, obesity in 43.4%, and multimorbidity involving at least two chronic conditions in 62.1% of patients. Mental health symptoms, including depression or anxiety, were identified in 22.6% of

participants, while cardiovascular disease and chronic kidney disease affected 18.7% and 11.9% of patients, respectively. Despite this substantial disease burden, 70.0% of patients demonstrated regular telehealth engagement, suggesting good uptake of remote chronic disease follow-up services within the study setting .

Clinically relevant improvements were observed during follow-up. Mean HbA1c decreased by 0.76 ± 1.18%, accompanied by a reduction in systolic blood pressure of 6.4 ± 13.6 mmHg and a fasting glucose reduction of 12.8 ± 38.5 mg/dL. More than half of participants (57.2%) achieved a clinically meaningful HbA1c improvement of at least 0.5%, while 47.1% demonstrated improved blood pressure control. Quality-of-life improvement was documented in 59.3% of patients, indicating that telehealth-supported follow-up may have contributed not only to metabolic improvement but also to broader patient-centered outcomes. Hospitalization occurred in only 8.6% of participants during follow-up, whereas poor clinical outcome was observed in 31.5% .

Inferential analysis identified several important predictors of poor clinical outcome. Low telehealth engagement emerged as the strongest predictor, with affected patients demonstrating more than twofold higher odds of adverse outcome compared with regularly engaged participants (OR 2.18, 95% CI 1.32–3.61, p=0.002). Similarly, baseline HbA1c ≥8.5% significantly increased the likelihood of poor outcome (OR 1.74, 95% CI 1.06–2.86, p=0.029), indicating that patients with higher baseline glycemic burden experienced less favorable follow-up responses. Multimorbidity also independently predicted poorer outcome (OR 1.82, 95% CI 1.08–3.07, p=0.024), highlighting the complexity of chronic disease management among patients with multiple coexisting conditions .

Although depression or anxiety symptoms demonstrated a trend toward poorer outcomes (OR 1.67, 95% CI 0.96–2.91), statistical significance was not achieved (p=0.071). Likewise, hypertension, age ≥65 years, and female sex were not significantly associated with poor clinical outcome. These findings suggest that engagement with telehealth services and overall multimorbidity burden may be more influential determinants of chronic disease outcomes than demographic characteristics alone in this patient population

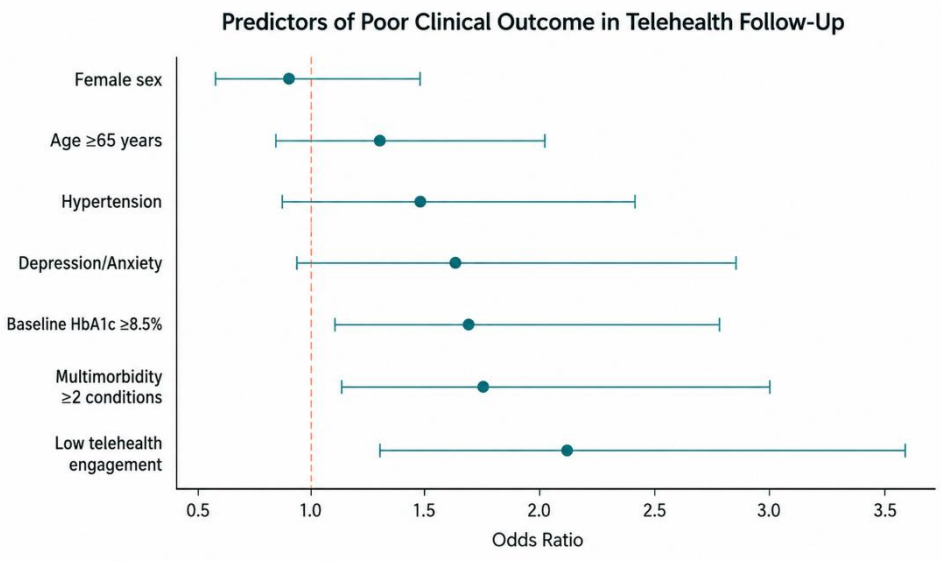

Figure 1 Predictors of Poor Clinical Outcome in Telehealth Follow Up

The figure demonstrates the relative strength and precision of clinical predictors associated with poor outcomes during telehealth-supported chronic disease follow-up. Low telehealth engagement showed the strongest association with adverse clinical outcome, with an odds ratio of 2.18 (95% CI 1.32–3.61), indicating more than a twofold increase in risk compared with patients demonstrating regular telehealth participation. Multimorbidity involving at least two chronic conditions (OR 1.82, 95% CI 1.08–3.07) and

baseline HbA1c ≥8.5% (OR 1.74, 95% CI 1.06–2.86) also demonstrated statistically significant associations with poorer outcomes, suggesting that both disease complexity and baseline glycemic burden substantially influenced follow-up response. Depression or anxiety symptoms showed a clinically relevant trend toward increased risk (OR 1.67), although confidence intervals crossed unity. In contrast, female sex and age ≥65 years showed comparatively weaker and statistically non-significant associations. The distribution of confidence intervals further illustrates that telehealth engagement status exerted the most robust and clinically meaningful effect among all evaluated predictors, reinforcing the importance of sustained digital follow-up adherence in chronic disease management

DISCUSSION

The findings of the present study demonstrated that telehealth-supported follow-up was associated with clinically meaningful improvements in chronic disease management among patients with type 2 diabetes mellitus and multiple coexisting comorbidities. The cohort exhibited a substantial baseline disease burden, including elevated HbA1c, hypertension, dyslipidemia, obesity, and multimorbidity, reflecting the complexity commonly encountered in long-term outpatient medical care. Despite these challenges, most patients demonstrated regular telehealth engagement, and favorable trends were observed in glycemic control, blood pressure reduction, fasting glucose improvement, and quality-of-life outcomes. Most importantly, low telehealth engagement emerged as the strongest independent predictor of poor clinical outcome, emphasizing the central role of sustained digital follow-up participation in chronic disease management .

The observed reduction in HbA1c and systolic blood pressure aligns with prior international evidence supporting telemedicine-assisted chronic disease monitoring. Several systematic reviews and meta-analyses have demonstrated that telehealth interventions can improve diabetes control, enhance medication adherence, facilitate lifestyle counselling, and improve continuity of care among patients with chronic illnesses (13–17). Ma et al. reported that telemedicine interventions significantly improved chronic disease outcomes through enhanced monitoring and communication pathways, while Santos et al. demonstrated favorable effects on hypertension and diabetes management using telehealth-supported follow-up (14,18). Similarly, Xiao and Han found that telehealth chronic disease management systems improved both metabolic outcomes and patient engagement metrics across diverse healthcare settings (19). The present findings reinforce this evidence within a Pakistani teaching hospital context, where local data on telehealth utilization remain comparatively limited.

One of the most clinically important findings was the strong association between low telehealth engagement and adverse outcomes. Patients with low engagement demonstrated more than twofold higher odds of poor clinical outcome compared with regularly engaged participants. This finding is consistent with previous research suggesting that the effectiveness of telehealth depends not only on technological availability but also on patient adherence and continuity of digital interaction. Lewinski et al. highlighted that sustained telehealth participation is critical for longitudinal chronic disease management because it improves follow-up compliance, promotes self-management, and allows earlier identification of clinical deterioration (13). Similarly, Creber et al. emphasized that patient engagement and telemonitoring adherence are key determinants of successful chronic disease self-management outcomes (5). The current study therefore suggests that engagement quality may represent a more influential determinant of clinical success than demographic characteristics alone.

Baseline HbA1c ≥8.5% and multimorbidity were also significantly associated with poor clinical outcome. Patients with greater baseline glycemic burden may require more intensive therapeutic adjustment, multidisciplinary coordination, and prolonged follow-up before measurable improvement becomes evident. Multimorbidity further complicates disease management because patients frequently require multiple medications, specialist consultations, and behavioral interventions, increasing the likelihood of fragmented care and reduced adherence. Previous studies have similarly demonstrated that

patients with multiple chronic conditions experience greater difficulty achieving disease control despite telehealth support (3,6,15). The present findings therefore underscore the importance of individualized digital care strategies for high-risk chronic disease populations.

Although depression or anxiety symptoms did not reach statistical significance, the observed trend toward poorer outcomes remains clinically relevant. Mental health symptoms may impair self-care behavior, reduce treatment adherence, and limit engagement with telehealth systems. Nouri et al. previously emphasized that psychosocial factors and healthcare inequities can substantially influence telemedicine effectiveness and patient participation (16). Given that more than one-fifth of the study population demonstrated depression or anxiety symptoms, future telehealth models may benefit from integrating mental health screening and behavioral support within chronic disease follow-up services.

Interestingly, age ≥65 years and female sex were not significantly associated with poor clinical outcome. These findings suggest that older adults may still benefit from telehealth-supported care when appropriate follow-up systems and accessibility measures are available. Prior concerns regarding digital literacy barriers among elderly patients may therefore be partially mitigated by structured healthcare support and simplified telemedicine platforms. Similarly, the absence of sex-based outcome differences indicates that telehealth effectiveness may be broadly applicable across demographic subgroups within chronic disease populations.

The study possesses several important strengths. It evaluated multiple clinically meaningful outcomes simultaneously, including glycemic control, blood pressure improvement, hospitalization, and quality-of-life measures. The inclusion of inferential analysis with odds ratios and confidence intervals further strengthened interpretation of predictors associated with poor outcome. Additionally, the study reflects real-world clinical practice within a teaching hospital environment, improving practical relevance for healthcare systems implementing telehealth-supported chronic disease management.

However, several limitations should be acknowledged. The cross-sectional observational design limits causal inference between telehealth engagement and improved outcomes. Residual confounding may persist despite adjustment for clinically relevant variables. The study was conducted at a single teaching hospital, which may limit generalizability to other healthcare settings or populations with differing access to digital infrastructure. Furthermore, telehealth engagement was categorized broadly, and more granular assessment of consultation frequency, digital literacy, and patient satisfaction was not available. Longitudinal multicenter studies with standardized telehealth engagement metrics and prospective outcome assessment are therefore warranted to further clarify the long-term effectiveness of telehealth-supported chronic disease follow-up.

Overall, the present study supports the growing role of telehealth in chronic disease management and highlights the importance of maintaining regular patient engagement within digital follow-up systems. The findings suggest that telehealth-supported care may contribute to clinically meaningful improvements in metabolic control and chronic disease outcomes, particularly when sustained participation and continuity of care are achieved.

CONCLUSION

The present study demonstrated that regular telehealth engagement was significantly associated with improved chronic disease outcomes among patients receiving follow-up care at The University of Lahore Teaching Hospital. Clinically meaningful reductions in HbA1c, systolic blood pressure, and fasting glucose were observed, alongside improvements in quality-of-life measures and relatively low hospitalization rates. Low telehealth engagement, baseline HbA1c ≥8.5%, and multimorbidity were identified as significant predictors of poor clinical outcome, highlighting the importance of sustained digital follow-up and individualized management strategies for high-risk patients. These findings support the growing integration of telehealth into chronic disease management and suggest that

effective patient engagement within telemedicine systems may enhance continuity of care and improve long-term clinical outcomes in resource-constrained healthcare settings.

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