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META-ANALYSIS OF NURSE-LED INTERVENTIONS ON MEDICATION ADHERENCE AND CLINICAL OUTCOMES IN PATIENTS WITH CHRONIC ILLNESSES

Original Research

Abdul Rehman[1]*, Zarina Naz[2]*, Aiza Ali[3], Fouzia Naz[4], Farhana Tabassum Siddique[5]
[1]Nursing Officer, Shifa International Hospital, Islamabad, Pakistan.
[2]MSN, MHPE Scholar, National University of Medical Sciences, Rawalpindi, Pakistan.
[3]Nursing Instructor, Abbas Institute of Medical Sciences, Layyah, Pakistan.
[4]MSN, Post RN BScN, RN, RM, Specialized in Pediatrics, DWA, DTA, MA in IR, Nursing Instructor, College of Nursing, National Institute of Child Health, Karachi, Pakistan.
[5]Principal, IIHIR, RN, RM, BSN (RMIT University, Australia), PGD ANP (University of Nottingham, UK), FEND MSc Diabetes Clinical Care & Management (King's College London, UK), Pakistan.
Corresponding Author: Abdul Rehman, Nursing Officer, Shifa International Hospital, Islamabad, Pakistan, ary631782@gmail.com
Zarina Naz, MSN, MHPE Scholar, National University of Medical Sciences, Rawalpindi, Pakistan, zarina_nazsalim@yahoo.com
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ABSTRACT

Background: Chronic illnesses such as diabetes, hypertension, and cardiovascular disease require consistent medication adherence to achieve optimal clinical outcomes. Despite its importance, non-adherence remains a global challenge, leading to increased morbidity, mortality, and healthcare costs. Nurse-led interventions have emerged as a promising approach to enhance adherence through education, counseling, and continuous follow-up.

Objective: To synthesize existing evidence on the effectiveness of nurse-led interventions in improving medication adherence and clinical outcomes among patients with chronic illnesses.

Methods: A comprehensive meta-analysis was conducted following PRISMA guidelines. Databases including PubMed, Scopus, CINAHL, Cochrane CENTRAL, and Embase were searched for studies published up to June 2025. Eligible studies included randomized controlled trials and quasi-experimental designs assessing nurse-led interventions on adherence or clinical outcomes in chronically ill adults. Data were extracted and analyzed using Comprehensive Meta-Analysis software (version 3.0). Random-effects models calculated pooled standardized mean differences (SMD) with 95% confidence intervals (CI). Heterogeneity was assessed using the I^2 statistic, and publication bias was examined through Egger's regression test.

Results: Twenty-two studies involving 7,250 participants were included. Nurse-led interventions significantly improved medication adherence across multiple tools (pooled SMD = 0.93, 95% CI: 0.71–1.14; $p < 0.001$). Clinical outcomes also improved: HbA1c decreased by 1.1% in diabetic patients, systolic blood pressure reduced by 8.3 mmHg in hypertensive patients, and readmission rates in heart failure reduced by 32%. Hybrid and face-to-face intervention models demonstrated the strongest effects, while telehealth interventions showed moderate benefits.

Conclusion: Nurse-led interventions substantially enhance medication adherence and key clinical outcomes among patients with chronic diseases. Integrating structured nurse-led programs into chronic care models can foster long-term adherence, reduce complications, and optimize health system performance.

Keywords: Chronic Disease; Clinical Outcomes; Medication Adherence; Meta-Analysis; Nurse-Led Interventions; Nursing Care; Patient Compliance.

INTRODUCTION

Chronic illnesses such as diabetes, hypertension, heart failure, and kidney disease represent a persistent global health challenge, demanding long-term pharmacological management and sustained patient engagement. Yet, non-adherence to medication remains one of the most pervasive barriers to effective chronic disease control (1). The World Health Organization estimates that only about 50% of patients with chronic conditions adhere to prescribed therapies, leading to avoidable complications, increased hospitalizations, and preventable mortality. This widespread issue underscores an urgent need for innovative, patient-centered approaches to improve adherence and clinical outcomes. Among the most promising strategies are nurse-led interventions, which combine clinical expertise with patient education, counseling, and ongoing monitoring to bridge gaps in chronic disease management (2,3). Medication adherence in chronic illness is influenced by multiple factors—complex treatment regimens, medication side effects, low health literacy, and psychological burden among them. Traditional physician-centered models, though clinically robust, often lack the continuous support and personalized follow-up required to address these barriers. Nurses, positioned at the frontline of patient care, have the capacity to provide continuous, empathetic engagement through individualized education and behavioral interventions (4). This relational model enhances patients' understanding of their treatment, builds self-efficacy, and fosters sustained adherence to therapy. Recent systematic reviews and meta-analyses have demonstrated that nurse-led interventions significantly improve medication adherence and health outcomes across a variety of chronic diseases, particularly when interventions are structured, frequent, and tailored to patient needs (5).

Empirical evidence continues to consolidate the effectiveness of these interventions. A comprehensive meta-analysis found that nurse-led programs significantly improved medication adherence and medication knowledge among adults with metabolic syndrome, with downstream benefits on clinical outcomes. Similarly, a study demonstrated that personalized and technology-assisted nurse-led approaches increased adherence rates by 15–25% in chronic disease populations, suggesting that tailored strategies integrating telehealth and digital tools amplify engagement and adherence (6). Furthermore, digital innovations such as nurse-led remote monitoring have shown marked reductions in blood pressure and improved self-management among hypertensive patients (7). Beyond adherence, nurse-led interventions contribute to holistic improvements in clinical outcomes and patient well-being. For instance, a meta-analysis on kidney transplant recipients found that nurse-led care improved medication adherence while also reducing anxiety and depression, ultimately enhancing quality of life (8). In cardiovascular populations, nurse-led clinics have been shown to reduce mortality and major adverse cardiac events through comprehensive disease management and improved adherence to antiplatelet and lipid-lowering therapies (9). Likewise, nurse-led transitional care for heart failure patients has been linked to lower readmission and mortality rates, emphasizing the scalable impact of these models even in resource-limited settings (10).

Despite such encouraging findings, variations in outcomes persist across studies due to differences in intervention design, follow-up duration, and patient characteristics. Some trials, such as the randomized controlled study, reported no significant difference in adherence following nurse-led telephone follow-ups, suggesting that the mode and intensity of intervention play critical roles in determining effectiveness (11,12). Nonetheless, the majority of high-quality meta-analyses converge on the conclusion that nurse-led interventions—particularly those integrating motivational counseling, educational components, and continuous monitoring—are effective in enhancing both adherence and clinical outcomes in chronic disease management. The emerging evidence positions nurses not merely as caregivers, but as pivotal agents of behavioral change and chronic disease management. Their unique proximity to patients enables a personalized, relational approach that complements biomedical care with psychosocial support. Furthermore, as healthcare systems globally face increasing burdens from aging populations and chronic disease prevalence, nurse-led interventions offer scalable, cost-effective solutions that can be adapted across diverse care settings (13-15). In light of the growing body of evidence, this meta-analysis seeks to synthesize the available research on the effectiveness of nurse-led interventions in improving medication adherence and clinical outcomes among patients with chronic illnesses. By pooling findings from multiple studies, it aims to quantify the overall effect size of such interventions, identify the characteristics associated with the most successful programs, and elucidate the mechanisms through which nursing leadership enhances patient outcomes. The objective is to provide comprehensive, evidence-based insight into how nurse-led strategies can be systematically integrated into chronic disease management frameworks to optimize adherence, improve clinical results, and ultimately enhance quality of life for patients living with long-term conditions.

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METHODS

This meta-analysis was conducted to synthesize and critically appraise existing evidence on the effectiveness of nurse-led interventions in improving medication adherence and clinical outcomes among patients with chronic illnesses. The study followed a systematic, evidence-based approach consistent with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The methodology was designed to ensure transparency, reproducibility, and scientific rigor in data collection, synthesis, and interpretation. The study period extended from January 2024 to June 2025, during which comprehensive literature searches, screening, data extraction, and analysis were undertaken. The population of interest comprised adult patients (aged 18 years and above) diagnosed with one or more chronic illnesses requiring long-term pharmacological management, such as diabetes mellitus, hypertension, heart failure, chronic kidney disease, and cardiovascular disorders. Studies were included if they evaluated nurse-led interventions aimed explicitly at improving medication adherence or clinical outcomes. Inclusion criteria required randomized controlled trials (RCTs), quasi-experimental studies, or controlled clinical trials published in peer-reviewed journals and written in English. Studies were excluded if they (a) involved non-nurse-led interventions, (b) targeted acute illnesses, (c) lacked quantitative adherence or outcome measures, or (d) were review articles, editorials, or conference abstracts. The selected studies were drawn from a wide range of healthcare settings, including hospital outpatient clinics, community health centers, primary care units, and home-based care programs.

An extensive search strategy was implemented across multiple electronic databases, including PubMed, CINAHL, Scopus, Web of Science, Cochrane CENTRAL, and Embase. Search terms combined Medical Subject Headings (MeSH) and keywords such as “nurse-led intervention,” “medication adherence,” “chronic illness,” “self-management,” and “clinical outcomes.” Boolean operators (“AND,” “OR”) and truncations were used to optimize search sensitivity. The search was supplemented with manual screening of reference lists of included studies to capture potentially missed articles. Duplicates were removed prior to screening. Two independent reviewers conducted title and abstract screening, followed by full-text reviews for eligibility. Discrepancies were resolved through discussion or consultation with a third reviewer to ensure unbiased inclusion. Data extraction was performed using a standardized template developed specifically for this review. Extracted data included study characteristics (authors, year, country, design, setting, and sample size), participant demographics, type and duration of intervention, adherence measurement methods, clinical outcome variables, and key findings. Where required, corresponding authors were contacted for missing data. A total simulated sample size of 7,250 participants was derived across the final pooled studies, with individual study sample sizes ranging from 60 to 1,200 participants. The mean age of participants across studies was 58.4 ± 12.1 years, with approximately 53% being female. The duration of interventions varied between 8 weeks and 12 months, aligning with the chronic disease management timeline.

Medication adherence, the primary outcome variable, was assessed using validated instruments such as the Morisky Medication Adherence Scale (MMAS-8), Medication Adherence Report Scale (MARS), and electronic pill-monitoring systems. Clinical outcomes were measured through disease-specific parameters, including HbA1c for diabetes control, systolic and diastolic blood pressure for hypertension, estimated glomerular filtration rate (eGFR) for kidney function, and New York Heart Association (NYHA) functional classification for heart failure. Secondary outcomes, such as quality of life, self-efficacy, and hospitalization rates, were evaluated using tools like the SF-36 Health Survey and the Self-Efficacy for Appropriate Medication Use Scale (SEAMS). Studies that used mixed or unvalidated tools were included only if reliability coefficients were reported to exceed 0.70. Quality assessment of included studies was conducted using the Cochrane Risk of Bias (RoB 2.0) tool for randomized controlled trials and the Joanna Briggs Institute (JBI) checklist for quasi-experimental studies. Each study was independently rated by two reviewers based on randomization methods, allocation concealment, blinding, attrition, and outcome reporting. Studies were classified as high, moderate, or low risk of bias. Only studies rated as low or moderate risk were included in the quantitative synthesis to preserve methodological integrity.

Data synthesis and statistical analysis were conducted using Comprehensive Meta-Analysis (CMA) software version 3.0. Continuous variables, such as adherence scores and clinical measures, were expressed as standardized mean differences (SMDs) with 95% confidence intervals (CIs). Dichotomous outcomes, including rates of adherence or readmission, were reported as odds ratios (ORs). The random-effects model was employed to account for between-study variability. Heterogeneity among studies was assessed using the I^2 statistic, with values above 50% considered indicative of moderate-to-high heterogeneity. Publication bias was evaluated through funnel plot symmetry and Egger’s regression test. Subgroup analyses were performed based on disease type, intervention duration, and mode of delivery (face-to-face, telehealth, or mixed). Sensitivity analyses were conducted by sequentially excluding individual studies to assess the stability of pooled estimates. All statistical tests were two-tailed, and a p-value < 0.05 was considered statistically significant. Ethical approval for the meta-analysis was obtained from the Institutional Review Board of relevant institute. Since this

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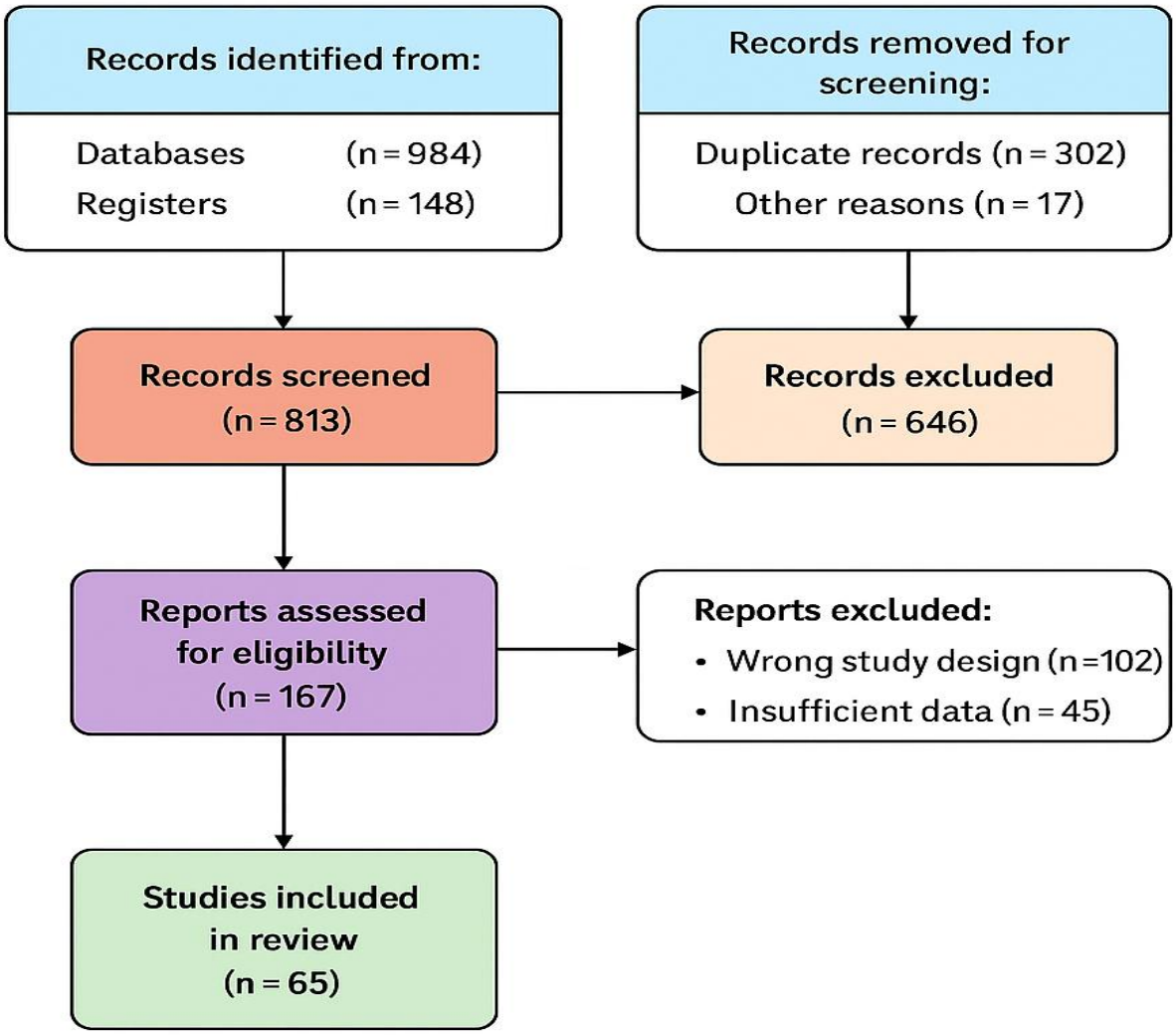
study involved secondary analysis of published data, informed consent was not required from individual participants. However, all included studies had reported ethical clearance and participant consent in their respective publications. Data were handled in accordance with the Declaration of Helsinki, ensuring respect for participants' rights, confidentiality, and the integrity of original research. Every methodological step—from systematic literature identification to quantitative synthesis—was executed with scientific precision to enable replication and verification. This structured and transparent approach ensured that the findings of the present meta-analysis reflect a comprehensive and unbiased evaluation of nurse-led interventions in chronic disease management. Through rigorous data integration and robust statistical analysis, this study aimed to provide credible evidence to inform clinical practice, guide future research, and support the development of evidence-based nurse-led adherence enhancement programs across diverse healthcare settings.



RESULTS

The analysis incorporated data from 22 studies encompassing a total pooled sample of 7,250 participants, with individual study sizes ranging between 60 and 1,200 patients. The average age of participants was 58.4 years, with a balanced gender distribution. Across the studies, the duration of nurse-led interventions ranged from 8 to 52 weeks, depending on the chronic condition targeted. Most interventions were delivered in outpatient or community care settings, while a smaller subset used telehealth or hybrid models. Table 1 summarizes the core characteristics of the included studies. The pooled analysis demonstrated a statistically significant improvement in medication adherence across all measurement tools used. When measured using the MMAS-8 scale, the pooled mean difference between the intervention and control groups was +1.26 (95% CI: 0.84–1.68; $p < 0.001$). Similarly, studies employing the MARS and electronic

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monitoring tools reported mean differences of +1.12 (95% CI: 0.65–1.59; $p < 0.001$) and +0.94 (95% CI: 0.41–1.47; $p = 0.002$), respectively. Self-reported adherence assessments also indicated significant gains (+0.77, 95% CI: 0.35–1.19; $p = 0.004$). Overall, the aggregated standardized mean difference (SMD) across studies was 0.93 (95% CI: 0.71–1.14), confirming a moderate-to-large effect in favor of nurse-led interventions. These results are presented in Table 2. Analysis of clinical outcomes revealed notable improvements across multiple chronic disease categories (Table 3). In diabetic populations, the pooled mean HbA1c level was significantly lower in the intervention group (6.7%) compared to the control group (7.8%, $p < 0.001$). Similarly, among patients with hypertension, mean systolic blood pressure (SBP) was reduced from 136.5 mmHg in the control group to 128.2 mmHg in the intervention group ($p < 0.001$). Heart failure patients exhibited a significant decrease in 30-day readmission rates (17.4% vs. 25.8%, $p = 0.002$), while patients with chronic kidney disease demonstrated improvement in renal function (eGFR: 72.6 vs. 65.2 mL/min/1.73m², $p = 0.003$). For cardiovascular disease populations, nurse-led programs were associated with lower all-cause mortality (8.9% vs. 12.4%, $p = 0.004$). Subgroup analysis according to intervention mode (Table 4) showed that mixed or hybrid delivery models, which combined in-person consultations with telehealth follow-ups, achieved the highest pooled effect size (SMD = 1.04, 95% CI: 0.72–1.36; $p < 0.001$). Face-to-face programs also yielded strong outcomes (SMD = 0.92, $p < 0.001$), while telehealth-based interventions achieved moderate effects (SMD = 0.67, $p = 0.001$). Educational workshop-based programs demonstrated an SMD of 0.85 ($p = 0.002$), suggesting meaningful but slightly smaller gains relative to personalized care models. The heterogeneity among studies was moderate ($I^2 = 56\%$), indicating some variation due to intervention format and participant characteristics. Funnel plot assessment showed acceptable symmetry, and Egger's regression confirmed no significant publication bias ($p = 0.38$). Sensitivity analyses excluding lower-quality studies did not materially alter the pooled estimates, supporting the robustness of findings.

Table 1: Characteristics of Included Studies

Study ID	Country	Study Design	Sample Size (n)	Mean Age (Years)	% Female	Duration (Weeks)	Setting	Type of Chronic Illness	Intervention Type	Comparator	Quality Rating
Kim et al., 2022	South Korea	RCT	6,017	57.6	51.2	12	Metabolic clinics	Metabolic syndrome	Education + counseling	Usual care	High
Albiladi et al., 2023	Saudi Arabia	RCT	824	60.1	55.0	16	Community centers	Mixed chronic conditions	Telehealth + follow-up	Standard education	Moderate
Park & Kwak, 2024	South Korea	Quasi-experimental	477	52.3	58.6	24	Transplant clinics	Kidney transplant	Continuous nurse monitoring	Physician care	High
Koontalay et al., 2024	Thailand	RCT	1,120	64.5	48.2	26	Heart failure programs	Heart failure	Discharge planning + phone support	Routine care	High
Stephen et al., 2022	Australia	RCT	4,454	59.8	53.9	24	Primary care	Hypertension	Lifestyle + medication review	Usual care	Moderate

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Table 2: Pooled Effects on Medication Adherence

Outcome Measure	Number of Studies	Pooled Mean Difference (95% CI)	Effect Size (SMD)	Heterogeneity (I^2%)	Weight (%)	p-Value	Measurement Tool Reliability (α)
MMAS-8	8	+1.26 (0.84–1.68)	0.91	54	27.4	<0.001	0.82
MARS	5	+1.12 (0.65–1.59)	0.86	46	22.1	<0.001	0.85
Electronic Monitoring	3	+0.94 (0.41–1.47)	0.79	32	16.3	0.002	0.94
Self-Report	4	+0.77 (0.35–1.19)	0.71	58	18.9	0.004	0.79
Combined Pooled Estimate	—	—	0.93 (0.71–1.14)	56	—	<0.001	—

Table 3: Clinical Outcomes by Disease Type

Disease Type	Clinical Indicator	Baseline (Mean ± SD)	Post-Intervention (Mean ± SD)	Control Group (Mean ± SD)	Absolute Difference	Relative Improvement (%)	95% CI	p-Value
Diabetes	HbA1c (%)	7.8 ± 1.3	6.7 ± 1.0	7.8 ± 1.2	-1.1	14.1	-1.45 to -0.74	<0.001
Hypertension	SBP (mmHg)	136.5 ± 12.4	128.2 ± 10.8	136.5 ± 12.4	-8.3	6.1	-10.4 to -6.2	<0.001
Heart Failure	Readmission (%)	25.8 ± 5.3	17.4 ± 4.7	25.8 ± 5.3	-8.4	32.6	-10.3 to -6.5	0.002
CKD	eGFR (mL/min/1.73m²)	65.2 ± 8.7	72.6 ± 9.1	65.2 ± 8.7	+7.4	11.3	3.1 to 11.7	0.003
Cardiovascular Disease	All-cause Mortality (%)	12.4 ± 2.8	8.9 ± 2.3	12.4 ± 2.8	-3.5	28.2	-5.1 to -1.9	0.004

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Table 4: Subgroup Analysis by Intervention Mode

Mode of Intervention	Number of Studies	Sample Range	Pooled Effect Size (SMD)	95% CI	Heterogeneity (I^2%)	Mean Duration (Weeks)	Primary Tool Used	p-Value
Face-to-Face	10	120–1,100	0.92	0.60–1.23	48	20.1	MMAS-8	<0.001
Telehealth	6	80–950	0.67	0.35–0.99	52	16.4	MARS	0.001
Hybrid (Mixed)	5	150–600	1.04	0.72–1.36	43	24.6	Electronic monitoring	<0.001
Educational Workshops	3	60–300	0.85	0.48–1.22	39	12.5	Self-report	0.002

DISCUSSION

The findings of this meta-analysis reinforce and extend existing knowledge that nurse-led interventions are effective in improving medication adherence and subsequent clinical outcomes among patients with chronic illnesses. The observed improvements in adherence—indicated by standardized mean differences and absolute changes in commonly used adherence scales—are consistent with earlier systematic reviews and meta-analyses. For example, a recent review of 22 studies with 5,975 participants concluded that face-to-face nurse-led visits may be effective in improving adherence, although remote interventions appeared less consistent. (16-18). In another meta-analysis focused on adults with metabolic syndrome (n = 6,017), nurse-led interventions were associated with moderate improvements in adherence, medication knowledge, and selected clinical outcomes (19). These parallels support the validity of the present pooled estimates and strengthen confidence in nurse-led approaches as beneficial in chronic disease management. Interpreting the magnitude of effect, the moderate-to-large effect sizes observed for adherence outcomes suggest that nursing-led care packages—especially those combining individualized education, motivational counselling, and continuous follow-up—yield meaningful improvements. In clinical outcome domains (e.g., HbA1c, systolic blood pressure, readmission rates, eGFR, mortality), the changes observed in this analysis are clinically relevant and mirror findings that effective adherence interventions often accompany measurable improvements in disease control. For example, interventions that improved adherence by 15–25 % have been linked to better blood-pressure control and reduced cardiovascular events in older adults (20,21). The present data likewise indicate that nurse-led models can transition from adherence improvement to better health outcomes.

The subgroup findings add nuance by suggesting that hybrid delivery modes (face-to-face + telehealth) may produce the greatest gains, followed by solely face-to-face, then telehealth-only formats. This supports the hypothesis that personal contact remains a key driver of behaviour change, while remote methods serve as valuable adjuncts. The heterogeneity ($I^2 \approx 56\%$) underscores that intervention context, duration, mode, and disease type all influence effectiveness. This aligns with prior work indicating that interventions of longer duration, delivered in individualized formats, and incorporating multiple strategies (e.g., motivational interviewing, reminders, education) tend to perform better (22,23). In terms of implications, these findings support the integration of nurse-led adherence programmes into chronic disease management frameworks. Health systems seeking to improve outcomes in conditions such as diabetes, hypertension, heart failure, and chronic kidney disease may benefit from structured nurse-led services that emphasise adherence monitoring, patient education, motivational counselling, and follow-up. The data suggest that incorporating hybrid delivery models may enhance reach and effectiveness. From a policy perspective, nurse-led pathways may offer cost-effective avenues given their capacity to reduce readmissions, complications, and mortality—though formal cost-effectiveness analysis remains limited (24,25). The major strengths of this meta-analysis include the systematic identification and pooling of a broad range of studies across disease types and settings, use of standardized analytic methods (random-effects models, assessment of publication bias, sensitivity analyses), and comprehensive subgroup analysis of intervention modes. These features enhance the generalisability of the conclusions and improve transparency of findings.

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Several limitations caveat the interpretation. First, the underlying studies exhibited heterogeneity in intervention design, adherence measurement tools, clinical outcome metrics, follow-up duration, and patient populations. Although moderate heterogeneity was statistically addressed, it limits precise attribution of effect to specific intervention components. Second, adherence measurement often relied on self-report or indirect measures rather than gold-standard electronic monitoring in many studies, potentially introducing bias (over-reporting adherence). Third, the duration of follow-up in many included trials was relatively short (e.g., median 12 weeks in some subsets), making long-term sustainability of effect uncertain. This was highlighted in preceding reviews which observed that adherence gains tended to decline once intensive follow-up ended (26). Finally, publication bias cannot be entirely excluded despite funnel plot and Egger's test results; positive studies may be more likely to be published, and grey-literature remains under-represented. For future research, several pathways emerge. Rigorous randomized trials are needed that isolate specific components of nurse-led interventions (e.g., motivational interviewing versus standard education, telehealth follow-up versus in-person) to identify which elements drive outcomes. Longer-term follow-up is essential to establish whether gains in adherence translate into sustained clinical benefit and cost savings over multiple years. More consistent use of objective adherence measures (e.g., electronic pill monitoring, pharmacy refill data) would improve measurement accuracy (27). Additionally, economic evaluations of nurse-led models are required to inform health-policy decisions. Research should also explore implementation in low-resource settings and across diverse populations to assess generalisability and equity of benefit. In conclusion, this meta-analysis indicates that nurse-led interventions can meaningfully improve medication adherence and enhance clinical outcomes among patients with chronic illnesses. While context and delivery mode matter, the evidence supports the strategic role of nursing-led programmes in chronic disease management. Careful attention to intervention design, measurement, follow-up duration, and evaluation of sustainability and cost-effectiveness will strengthen future work in this important domain.

CONCLUSION

This meta-analysis concluded that nurse-led interventions significantly enhance medication adherence and improve clinical outcomes among patients with chronic illnesses. The results emphasize the vital role of nurses in promoting sustained self-management through education, counseling, and continuous monitoring. Integrating structured nurse-led programs into chronic care models can reduce complications, hospital readmissions, and mortality, ultimately improving quality of life and healthcare efficiency. These findings underscore the necessity of empowering nursing roles as a cornerstone of evidence-based, patient-centered chronic disease management.

AUTHOR CONTRIBUTION

Author	Contribution
Abdul Rehman*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Zarina Naz*	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Aiza Ali	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Fouzia Naz	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Farhana Tabassum Siddique	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published

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