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SYSTEMATIC REVIEW

Effectiveness of health education in improving treatment adherence among patients with chronic communicable diseases: A systematic review and meta-analysis

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Abstract

Introduction: Chronic communicable diseases, such as tuberculosis, HIV, hepatitis B, and hepatitis C, remain major global health challenges. Effective treatment adherence is crucial for improving patient outcomes and health education plays a key role in enhancing adherence. However, evidence for the most effective educational interventions remains limited.

Objective: This study aimed to evaluate the effectiveness of health education interventions in improving treatment adherence among patients with chronic communicable diseases.

Methods: A systematic review and meta-analysis were conducted following the preferred item for systematic review and meta-analysis (PRISMA) guidelines. Comprehensive searches were performed in PubMed, CINAHL, Scopus, and the Web of Science for studies published between 2015 and 2024. Eligible studies included randomised controlled trials. Quality assessment was conducted using the Joanna Briggs Institute critical appraisal tools. Statistical analysis was performed using the Mantel-Haenszel method to estimate odds ratios (OR) and standardised mean differences (SMD) with 95% confidence intervals (CI) using a random effects model. Meta-regression was conducted to explore potential sources of heterogeneity.

Results: Seventeen studies involving 4,157 participants were included. Health education interventions significantly improved treatment adherence compared to usual care (OR 2.42; 95% CI: 1.58–3.72; p <0.0001). Subgroup analyses showed the highest effectiveness in remote-based interventions (OR 5.65; 95% CI: 2.37–13.47), among patients with tuberculosis (OR 6.52; 95% CI: 3.59–11.84), and in upper-middle-income

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countries (OR 4.54; 95% CI: 1.54–13.39). Meta-regression indicated that younger participant age and intervention type were significant moderators, with media-based and remote-based showing greater effectiveness.

Conclusion: Health education interventions significantly improve treatment adherence among patients with chronic communicable diseases, particularly those with tuberculosis and hepatitis C. Remote-based models, such as mHealth platforms and digital reminders, demonstrate the highest effectiveness, especially in low- and middle-income countries where stigma and limited healthcare access remain key barriers.

KEYWORDS

chronic communicable diseases, health education, hepatitis B, hepatitis C, HIV, medication adherence, treatment adherence, tuberculosis

INTRODUCTION

Chronic communicable diseases continue to represent a major global public health burden, affecting millions of individuals and placing considerable strain on healthcare systems worldwide [1]. According to the World Health Organization (WHO), leading chronic communicable diseases such as tuberculosis (TB), human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS), hepatitis B (HBV), and hepatitis C (HCV) remain significant contributors to global morbidity and mortality, all requiring long-term pharmacological treatment and management [2–4].

The prevalence of chronic infection such as TB, HIV, and viral hepatitis remain a global issue. TB has reemerged as a leading infectious disease burden, causing more deaths annually than any other infectious agent, with an estimated 10.8 million new cases and 1.25 million deaths in 2023 [4]. As of the same year, approximately 39.9 million people living with HIV in 2023, including 1.3 million new infections and 630,000 AIDS-related deaths [5]. Moreover, 296 million individuals were living with chronic HBV in 2019, leading to 820,000 deaths annually, while chronic HCV affected 58 million people and caused 290,000 deaths each year [6].

One of the main reasons for the continued rise in the prevalence and mortality of these diseases is inadequate adherence to prescribed medical treatments [7–9]. The effective management of these conditions often necessitates prolonged drug therapy, making treatment adherence a critical determinant of successful outcomes compared to acute communicable diseases such as influenza or cholera, which typically require shorter treatment durations and have more immediate symptom resolution [10, 11]. The chronic nature of TB, HIV/AIDS, HBV, and HCV involves complex, long-term regimens that increase the risk of non-adherence. Nonadherence can lead to disease progression, treatment failure, increased transmission, reduced survival rates, and an overall decline in patients' quality of life [12].

A significant barrier to adherence is limited patient knowledge about the disease and its treatment [13, 14]. Studies have shown that a lack of understanding among patients regarding their medications and health conditions contributes to non-adherence [13], highlighting the need for effective educational interventions. Such interventions aim to improve adherence rates by enhancing patients' knowledge about disease progression, the importance of medication timing and consistency, potential side effects, and the consequences of treatment interruption [15].

Health education plays a pivotal role in addressing barriers to adherence [15]. It empowers individuals to manage side effects and navigate obstacles during treatment effectively [16, 17]. This intervention may reduce common barriers to chronic infection treatment, such as misperceptions of treatment benefits, alleviating fear, and addressing a lack of motivation [18, 19].

Despite health education being promising, evidence on the effectiveness of health education in improving treatment adherence for chronic communicable diseases remains limited. Burke et al., [10] focused solely on psychoeducation, excluding broader health education approaches and lacking a meta-analytic synthesis. Zhou et al., [20] focused on chronic viral hepatitis, leaving gaps in the understanding of the role of health education in other chronic communicable diseases that require long-term treatment (more than 3 months). To address these gaps, this study aimed to evaluate the effectiveness of health education interventions in improving treatment adherence among patients with TB, HIV/AIDS, HBV, and HCV. Specifically, it aims to (1) compare the effectiveness of different types of health education interventions, (2) assess their impact across disease types, (3) explore variations in outcomes by country income levels, and (4) conduct a meta-regression analysis to identify factors contributing to heterogeneity in treatment adherence outcomes.

METHODS

Study design

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines [21]. The methodological approach adopted in this study was designed to obtain a more precise and reliable account of health education treatment adherence to people with chronic communicable diseases. The study was registered with PROSPERO under registration number CRD42024627948.

Search strategy

The CINAHL, PubMed, Scopus, and Web of Science databases were systematically searched for relevant studies published between 2015 and 2024 up to September 21, 2024. The search strategy utilised the following keywords: ("Chronic Infectious Disease" OR "Communicable Disease" OR "Infectious Disease" OR "Chronic Infection" OR "Long Term Infection" OR "HIV" OR "TB" OR "Tuberculosis" OR "Hepatitis C" OR "Hepatitis B") AND ("Health Education" OR "Patient Education" OR "Educational Intervention") AND ("Medication Adherence" OR "Medication Compliance" OR "Treatment Adherence" OR "Medication-taking Behaviour" OR "Patient Adherence"). Further details regarding the keywords and search strategy are provided in Supplementary Material 1. In addition, a manual search was conducted to identify additional studies that may not have been captured through electronic database searches, ensuring a comprehensive and inclusive review of relevant literature [22].

Eligibility

Inclusion criteria

Population (P): This review included participants aged ≥ 18 years who were diagnosed with chronic communicable diseases, specifically HIV/AIDS (all stages), HBV (all conditions), HCV (all conditions), and tuberculosis (both pulmonary and extra pulmonary, excluding latent TB).

Intervention (I): This review included RCTs evaluating health education interventions to improve treatment adherence for chronic communicable diseases. Health education is defined as the process of providing individuals with information, skills, and motivation to make informed decisions about their health.

Comparison (C): Studies that included any alternative intervention or usual care.

Outcome (O): The primary outcome was medication adherence, which was reported as dichotomous or continuous data. Medication adherence refers to any measurable improvement in participants' adherence to prescribed treatment regimens following a health education intervention.

Exclusion criteria

Studies were excluded if they: (1) focused on non-chronic communicable diseases, latent TB, or populations with comorbidities where outcomes were not disease-specific; (2) addressed prevention rather than disease management or health education; (3) did not report medication adherence rates; (4) were not RCTs or quasi-experimental designs; or (5) were reviews, pilot studies, commentaries, conference abstracts, or those lacking full-text availability.

Study selection

Three independent reviewers (I. N. C., A. P. R., A. H. Z.) screened the titles and abstracts followed by a full-text review, with the assistance of Covidence systematic review software to identify duplicate records and determine eligibility based on the predefined inclusion and exclusion criteria. In cases of conflict among the reviewers, discrepancies were resolved by L. L.

Data extraction

Two independent reviewers (A. P. R. and A. H. Z.) extracted data from the eligible articles and cross-checked the results to ensure accuracy. The extracted data were compiled into a Microsoft Excel table that included details such as the authors, country, type of infectious disease, study setting, study design, number of participants, age, intervention, and adherence characteristics (event rate by participant, adherence cut-off points, and adherence outcomes). The event rate by participants was defined as the total number of participants in each group and those who achieved adherence outcomes exceeding the specified cut-off points. Countries were classified by income level according to the World Bank database (2023) as high-income countries (HICs), upper-middle-income countries (UMICs), lower-middle-income countries (LMICs), and low-income countries (LICs). Diseases were categorised as HCV, HBV, HIV, and TB. Interventions were grouped into four categories: (1) Behavioural-based education, which included various forms of structured counselling and motivational education; (2) Peer-support education, involving interventions led or supported by peers; (3) Media-based education, which utilised audiovisual materials or digital platforms; and (4) Remote-based education, encompassing interventions delivered via phone, video, or SMS. The classification was informed by the primary components and modes of delivery described in each included study.

Quality assessment

Two independent reviewers (I. J. W. and M. A. M.) assessed study quality using the tools and checklists provided by the Joanna Briggs Institute (JBI) [23]. The checklist included 13 items for RCT studies and 9 items for quasi-experimental studies. Each study's raw score was calculated by dividing the number of "Yes" responses by the total number of items. Scores below 50% indicated a high risk of bias, scores between 50% and 69% indicated a moderate risk of bias, and scores of 70% or higher indicated a low risk of bias [24].

Statistical analysis

The collected data were analysed using Review Manager (RevMan) version 5.4. Continuous data for adherence outcomes were determined using the mean and standard deviation

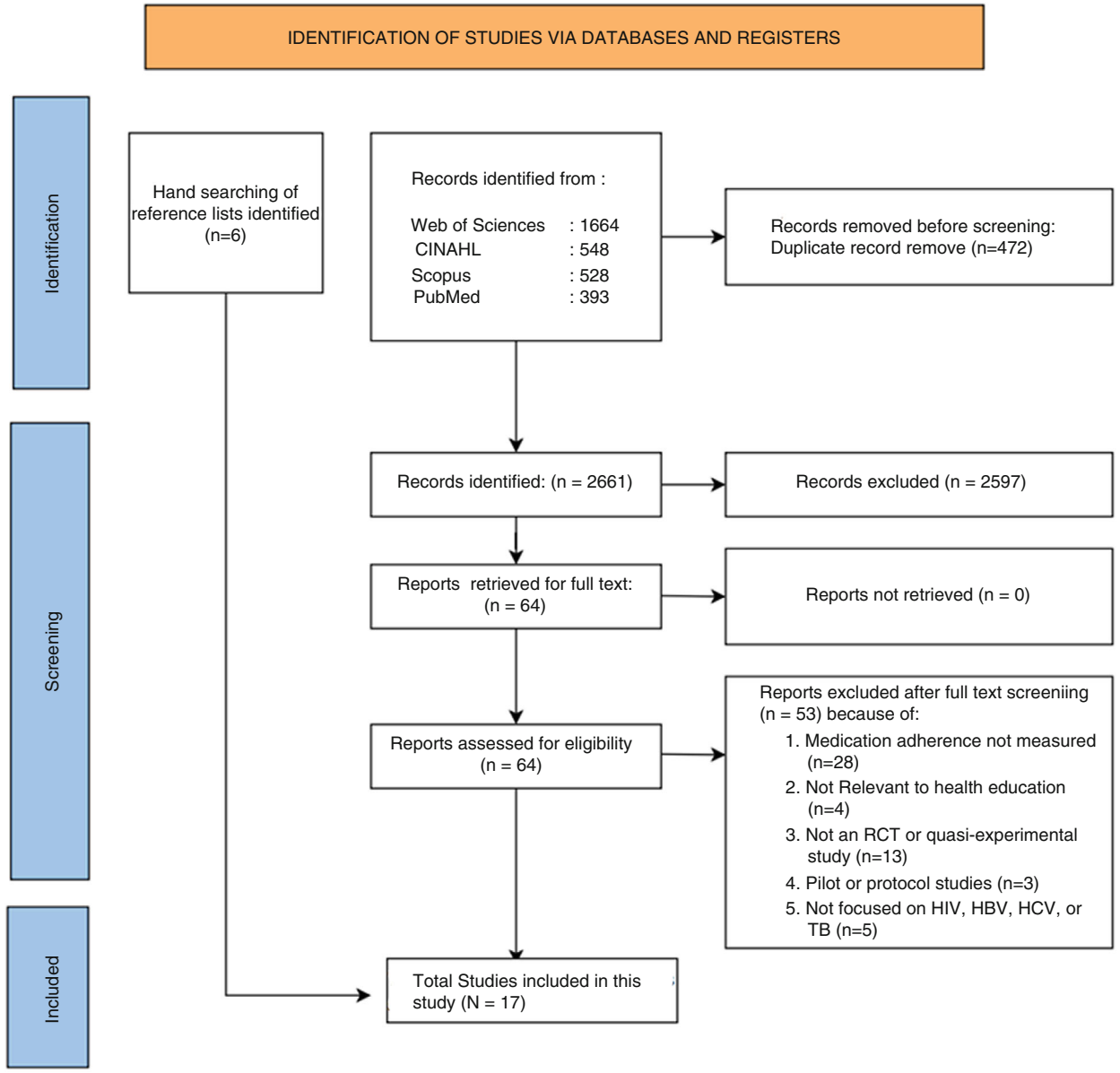

FIGURE 1 PRISMA flow diagram. Adapted from Page et al. [21] Creative Commons.

to assess the pooled effectiveness of health education. This assessment was conducted using a random-effects model. The odds ratio (OR) was calculated with a 95% confidence interval (CI) to measure the effect size for dichotomous data. For continuous data, standardised mean difference (SMD) was applied. Sensitivity analysis was conducted to evaluate the impact of studies identified as potential outliers on the overall findings. This study used the I^2 statistic to assess heterogeneity, and applied thresholds of 0%, 25%, 50%, and 75% to indicate insignificant, low, moderate, and high levels of heterogeneity, respectively [25]. A subgroup analysis with a random-effects model was conducted to address the high heterogeneity and determine how the effects of an intervention differ among various groups within the study population [26]. Subgroup analysis was conducted based on the type of infection, income level, study region, study design, treatment adherence cut-off points, and type of intervention. This study also conducted meta-regression using a restricted-maximum likelihood random effects method to address heterogeneity and explore covariates, such as mean age, weeks of intervention, type of intervention, type of disease, income level of the country, and study design. However, the number of parameters to be estimated is larger than the number of observations, this study used stepwise methods to determine fit models. Therefore, two continuous variables (mean age and weeks of intervention) and one categorical variable (type of intervention) were included in the meta-regression analysis, as this model demonstrated the lowest Akaike information criterion (AIC) value compared to alternative models. Lastly, funnel plots and Egger's tests were used to assess the publication bias of the included studies.

TABLE 1 Characteristics of included studies ($n = 17$).

Variable	Number of studies (*N*)	References
Country		
Indonesia	4	[27–30]
South Africa	1	[31]
United States	3	[32–34]
Kenya	1	[35]
Pakistan	1	[36]
India	1	[37]
China	2	[38, 39]
Malaysia	1	[40]
Estonia	1	[41]
South Korea	1	[42]
Iran	1	[43]
Income level		
LMICs	5	[29, 35–37, 39]
UMCs	7	[27, 28, 30, 31, 38, 40, 43]
HICs	5	[32–34, 41, 42]
Type of disease		
HIV	8	[30–35, 41, 43]
TB	6	[27–29, 37, 38, 40]
HCV	3	[36, 39, 42]
Age (years old)		
<40	8	[27, 29–31, 34, 35, 40, 41]
>40	9	[28, 32, 33, 36–39, 42, 43]
Sample size		
IG	2021 participants	NA
CG	2110 participant	NA
Total	4132 participants	NA
Observation period		
1 months	1	[27]
6 weeks	1	[29]
2 Months	1	[41]
3 Months	3	[30, 42, 43]
6 months	1	[35]
10 months	1	[32]
12 months	5	[31, 33, 38–40]
24 months	1	[34]
35 months	1	[36]
NR	2	[28, 37]
Treatment adherence rate (cut of point) %		
>80	3	[30, 35, 36]
>85	2	[32, 34]
>95	7	[27, 31, 33, 37, 40, 41, 43]
100	3	[28, 38, 42]
NR	2	[29, 39]
Measurement		
Self-reported measures	10	[28–31, 33, 35, 38, 40, 41, 43]
Pill-count	4	[27, 31, 34, 42]
Pharmacy refill/ treatment record review	2	[36, 37]
Electronic monitoring	1	[34]
Study design		
RCT	10	[31–33, 35, 36, 38, 40, 41, 43, 44]
Quasi experiment	7	[27–30, 37, 39, 42]
Intervention type		
Remote-based interventions	4	[37, 38, 42, 43]
Behavioural-based interventions	6	[28, 29, 31, 32, 34, 41]
Media-based interventions	4	[27, 30, 33, 36]
Peer-support interventions	3	[35, 39, 40]

Abbreviations: CG, control group; HICs, high-income countries; HIV, Human Immunodeficiency Virus; HCV, hepatitis C virus; IG, intervention group; LMICs, low- and middle-income countries; NR, not reported; RCT, randomised controlled trial; TB, tuberculosis; UMICs, upper-middle-income countries.

RESULTS

Study selection

The study selection process, illustrated in Figure 1, began with identifying 3,133 records through database searches and an additional six studies through manual searching. After removing 472 duplicates, 2661 records were screened, resulting in the exclusion of 2597 studies. Subsequently, 64 full-text studies were assessed for eligibility, and 53 were excluded for various reasons (see Figure 1). Ultimately, 11 studies from database searches and 6 studies from hand-searching, totalling 17 studies, were included in this study.

Study characteristics

The included studies were conducted across 11 countries with 4157 participants (see Table 1). Most studies focused on HIV ($n = 8$), followed by TB ($n = 6$) and HCV ($n = 3$). These studies were conducted across different income levels, including HICs ($n = 5$), UMICs ($n = 7$) and LMICs ($n = 5$). The interventions were categorised into four types:

remote-based ($n = 4$), behavioural-based ($n = 6$), media-based ($n = 4$), and peer-support ($n = 3$). The study durations ranged from short-term (1–3 months) to long-term (12–35 months). Treatment adherence outcomes were reported using cut-off points ranging from >80% to 100%, reflecting variability in adherence measurements across the studies. Furthermore, medication adherence was measured using a variety of methods, including pill counts ($n = 4$), self-reported questionnaires ($n = 10$), electronic monitoring devices ($n = 1$), and prescription refill records (2). The detailed characteristics of the included studies, such as study design, country and income level, participant age, sample size, type of infectious disease, intervention details, observation period, and adherence measurement, are summarised in Supplementary File 2.

Effectiveness of health education on treatment adherence in chronic communicable diseases

The forest plot in Figure 2 shows the estimated OR for the effectiveness of health education on medication adherence. The present study showed that health education significantly improved treatment adherence among patients with chronic communicable diseases compared to usual care, with a pooled OR of 2.42 (95% CI: 1.58, 3.72, $p < 0.0001$). However, the initial analysis showed high heterogeneity among the included studies ($I^2 = 82\%$), indicating substantial variability. Three studies, Karuniwati et al. [28], Noroozi et al. [43], and Herawati et al. [27], reported exceptionally high odds ratios (OR = 16.63, 22.94, and 11.21, respectively) and were identified as potential outliers. To assess their

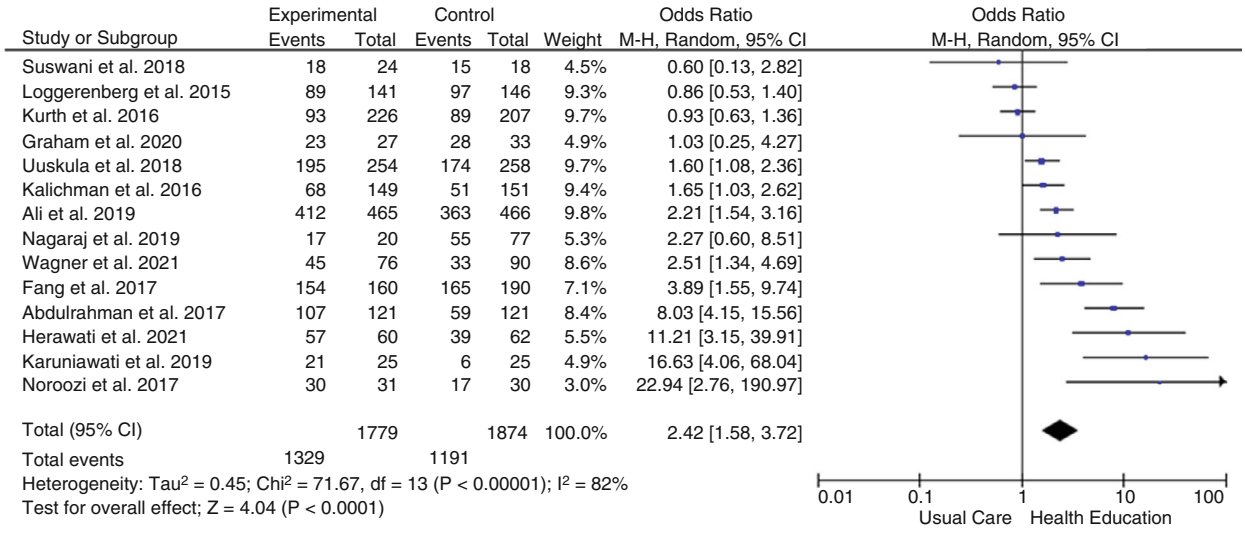

FIGURE 2 Estimate odd ratio for the effectiveness of health education on treatment adherence in chronic communicable diseases compared to usual care.

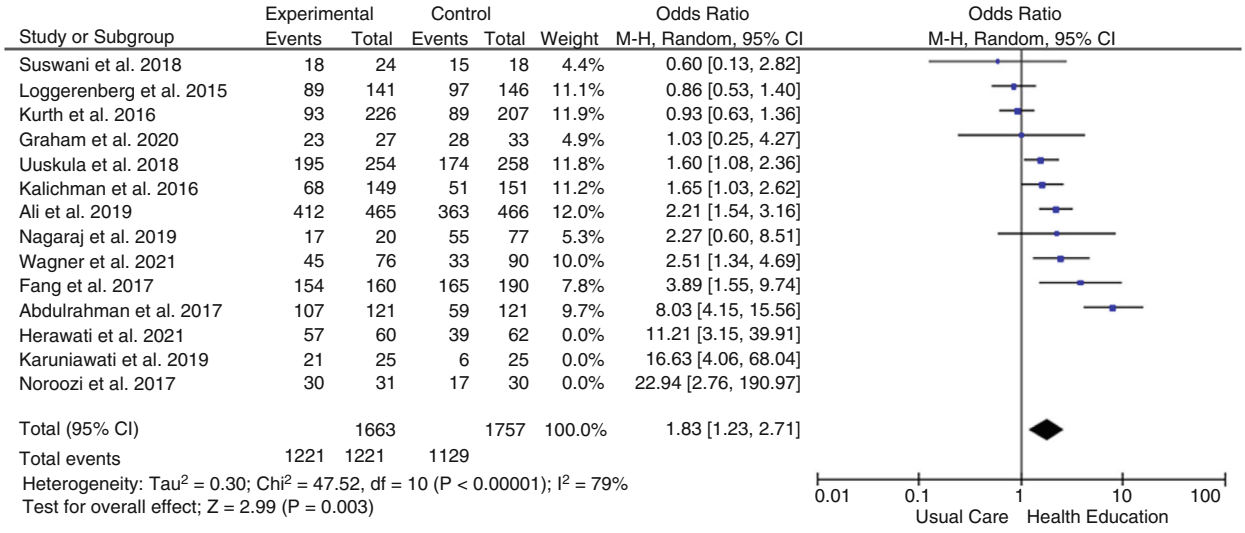

FIGURE 3 Sensitivity analysis of estimate odd ratio for the effectiveness of health education on treatment adherence.

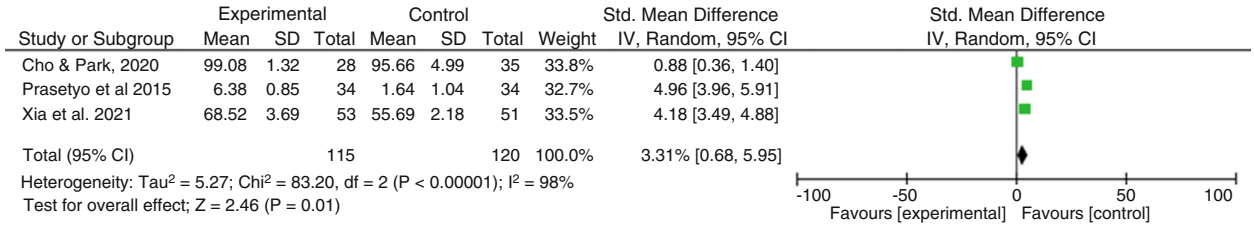

FIGURE 4 Estimate of mean difference for effectiveness of health education on treatment adherence in chronic communicable diseases.

impact, a sensitivity analysis was conducted excluding these studies. Although the reduction in heterogeneity was modest ($I^2 = 79\%$), the pooled effect remained statistically significant, with health education showing improved treatment adherence (OR = 1.83, 95% CI: 1.23–2.71, $p = 0.003$) (see Figure 3).

For continuous data, the present study showed that health education was statistically significant compared with usual care (SMD 3.31;95% CI: 0.68, 5.95, $p = 0.01$). However, heterogeneity was extremely high ($I^2 = 98\%$), indicating considerable variability among the included studies (Figure 4).

Subgroup analysis of the effectiveness of health education in improving treatment adherence among people with chronic communicable diseases

Subgroup analysis by the model of health education showed that remote-based interventions were the most effective in improving treatment adherence (OR, 5.65; 95%CI: 2.37, 13.47, $p < 0.0001$). Behavioural education also showed significant improvement (OR = 1.93, 95% CI: 1.11–3.33, $p = 0.02$). However, media-based and peer-support interventions are less effective. By the infectious diseases type, showed that health education was most likely effective for improving treatment adherence among people with TB (OR = 6.52, 95% CI: 3.59–11.84, $p < 0.00001$), followed by HCV (OR = 2.21, 95% CI: 1.54–3.16, $p = 0.0001$). However, there was no significant effect among people with HIV (OR = 1.40, 95% CI: 0.95–2.06, $p = 0.09$).

Subgroup by country income level, health education was most likely to be significantly effective in UMICs (OR = 4.54, 95% CI: 1.54–13.39, $p < 0.00001$), followed by LMICs (OR = 2.12, 95% CI: 1.51–2.97, $p < 0.0001$). However, there was no significant effect on the HICs. Interestingly, subgroup analysis by study design showed that although the pooled OR was higher in quasi-experimental studies (OR = 2.84) compared to RCTs (OR = 1.70), the effect in quasi-experimental studies was not statistically significant ($p = 0.46$). In contrast, the effect observed in RCTs was statistically significant ($p = 0.004$). This may be due to the smaller number of quasi-experimental studies included in the review (n = 4) and their wider confidence intervals, indicating greater uncertainty. These findings reinforce the strength of evidence provided by RCTs, which remain the gold standard due to their methodological rigor and ability to minimise bias in estimating intervention effects.

Lastly, due to variability in the operational definitions of adherence across studies, a subgroup analysis was conducted. Studies using a cut-off of ≥95% showed the strongest pooled effect (OR = 3.37, 95% CI: 1.69–6.71, $p = 0.0005$), followed by those with ≥85% to <95% (OR = 1.92, 95% CI: 1.29–2.87, $p = 0.001$). In contrast, studies using lower thresholds of 80–<85% reported a non-significant effect (OR = 1.48, 95% CI: 0.68–3.21, $p = 0.32$), with low heterogeneity ($I^2 = 28.2\%$). These findings indicate a dose-response relationship, where higher adherence cut-offs are associated with greater intervention effects. Clinically, this underscores the importance of targeting ≥95% adherence, particularly for HIV and TB, where suboptimal adherence compromises treatment success.

Subgroup analyses are presented in Table 2, and detailed forest plots for each subgroup analysis are provided in Supplementary File 3. After performing subgroup analysis, there was significantly reduced heterogeneity between health education models, country income level, study design, and treatment adherence cut-off point (I^2= 37.2%, 53.3%, 0%, and 28.2%, respectively). Despite reducing the heterogeneity, substantial heterogeneity was observed among the types of infectious diseases (I^2=88.9%).

Meta-regression analysis of intervention effectiveness

A meta-regression was conducted to explore potential sources of heterogeneity. Due to overparameterization, several categorical variables (e.g., disease type, income level, study design) were excluded. The model including intervention type yielded the lowest AIC and was retained. As shown in Table 3, the simple model (Model 1), which included mean age and intervention duration, did not significantly explain between-study heterogeneity (QM [df = 2] = 0.0683, $p = 0.9664$; $R^2 = 0.00\%$; $I^2 = 90.14\%$). In contrast, the full model (Model 2), which added intervention type, explained 51.3% of the heterogeneity and reduced I^2 to 77.25%. In this model, younger participant age was significantly associated with greater intervention effectiveness ($\beta = -0.2679$, $p = 0.0051$).

Regarding intervention type, media-based ($\beta = 2.84$, $p = 0.0088$) and remote-based interventions ($\beta = 4.73$,

TABLE 2 Subgroup analysis of the effectiveness of health education on treatment adherence among people with chronic communicable diseases ($n = 14$).

Variable	Number of studies	OR	95%CI	*p*-value	Heterogeneity (I^2, *p*-value)
Type of health education					
Media-based	4	1.86	0.79, 4.36	0.15	37.2%, 0.19
Behavioural based	5	1.93	1.11, 3.33	0.02	
Remote-based	3	5.65	2.37, 13.47	<0.0001*	
Peer-support	2	3.18	0.43, 23.62	0.26	
Infectious diseases					
HIV	8	1.4	0.95, 2.06	0.09	88.9%, 0.0001
Tuberculosis	5	6.52	3.59, 11.84	<0.00001*	
HCV	1	2.21	1.54, 3.16	0.0001*	
Country income level					
LMICs	3	2.12	1.51, 2.97	<0.0001*	53.3%, 0.12
UMICs	7	4.54	1.54, 13.39	<0.00001*	
HICs	4	1.50	1.02, 2.21	0.12	
Study design					
RCT	10	1.70	1.18, 2.44	0.004*	0%, 0.46
Quasi-experiment	4	2.84	0.76, 10.63	0.46	
Treatment adherence cut-off points					
80–<85%	3	1.48	0.68, 3.21	0.32	28.2%, 0.25
≥85%–<95%	2	1.92	1.29, 2.87	0.001*	
≥95%	9	3.37	1.69, 6.71	0.0005*	

Abbreviations: HICs, high-income countries; HIV, Human Immunodeficiency Virus; HCV, hepatitis C virus; I^2, heterogeneity statistic; LMICs, low- and middle-income countries; OR, odds ratio; *p*-value, probability value; RCT, randomised controlled trial; UMICs, upper-middle-income countries; 95% CI, 95% confidence interval.

TABLE 3 Meta-regression for covariate factors of medication adherence.

Moderator	Estimate	*p*-value	95% CI	Significance
Model 1				
1. Age (years)	−0.0024	0.9703	−0.1307 to 0.1258	$p > 0.05$
2. Intervention duration (weeks)	−0.0019	0.8094	−0.0171 to 0.0134	$p > 0.05$
Model 2				
1. Age (years)	−0.2679	0.0051	−0.4556 to −0.0802	$p < 0.01$
2. Intervention duration (weeks)	0.012	0.1885	−0.0059 to 0.03	$p > 0.05$
3. Intervention type				
a. Counselling	1.1065	0.2428	−0.7503 to 2.9632	$p > 0.05$
b. Media-based	2.8382	0.0088	0.7152 to 4.9611	$p < 0.01$
c. Remote-based	4.7252	0.0019	1.7357 to 7.7148	$p < 0.01$

Note: τ^2 (heterogeneity); R^2 (explained heterogeneity); QM: test of moderators. Model 1 results: $\tau^2 = 0.8263$; $I^2 = 90.14\%$; $R^2 = 0.00\%$; $p = 0.9664$ Model 2 results: $\tau^2 = 0.2109$; $I^2 = 77.25\%$; $R^2 = 51.29\%$; $p = 0.0759$.

$p = 0.0019$) showed significantly higher effects than face-to-face or other formats, while counselling-based interventions were not significant ($\beta = 1.11$, $p = 0.2428$). These findings suggest that population characteristics (e.g., age) and the type of health education intervention play important roles in explaining variability in treatment adherence outcomes. Visual summaries of the regression, including scatterplots for continuous moderators and boxplots for intervention types, are provided in Supplementary File IV.

Risk of bias of included studies

Most of the included studies demonstrated a low risk of bias, with a detailed assessment of individual studies presented in

Table 4. The included RCTs achieved scores ranging from 76.92% to 100%, while quasi-experimental studies scored between 88.89% and 100%. Notably, studies by Fang et al. [38] and Uuskula et al. [41], both of which scored 76.92%, revealed methodological concerns despite meeting the threshold for low bias. Among RCTs, the most common sources of bias were observed in Domains 4 to 6, which relate to bias due to blinding of participants, delivering the treatment, and outcome assessors. These issues likely reflect the nature of the interventions, where complete blinding was difficult or impractical to achieve. In quasi-experimental studies, the overall risk of bias was low across domains; however, two studies Herawati et al., [27] and Prasetyo et al, [29] were rated as high risk in Domain 8, which relates to the reliability of outcome measurement. Figures 5 and 6 provide domain-by-domain evaluations for each included study, clearly indicating whether each domain was judged as low, unclear, or high risk of bias.

TABLE 4 Risk of bias assessment.

Author, published year	JBI critical appraisal tool	Study design
[40]	(13/13) 100%	RCT
[36]	(13/13) 100%	RCT
[42]	(9/9) 100%	Quasi-experimental
[38]	(10/13) 76,92%	RCT
[35]	(12/13) 92,3%	RCT
[27]	(8/9) 88,89%	Quasi-experimental
[32]	(13/13) 100%	RCT
[28]	(9/9) 100%	Quasi-experimental
[33]	(12/13) 92,3%	RCT
[31]	(13/13) 100%	RCT
[37]	(8/9) 88,89%	Quasi-experimental
[43]	(13/13) 100%	RCT
[29]	(8/9) 88,89%	Quasi-experimental
[30]	(8/9) 88,89%	Quasi-experimental
[41]	(10/13) 76,92%	RCT
[34]	(11/13) 84,62%	RCT
[39]	(9/9) 100%	Quasi-experimental

Abbreviations: JBI, Joanna Briggs Institute; RCT, randomised controlled trial.

Publication bias

The analysis of publication bias revealed a symmetrical funnel plot for estimated effect size (Figure 7). Egger's regression test showed no evidence of small-study effects on the odds ratio estimates ($p = 0.998$), suggesting a lack of publication bias. The trim-and-fill method yieled a logit-transformed effect size of 0.922 (95% CI: 0.409 10 1.434, $p = 0.0004$). There were no imputed missing studies, with the estimated number missing studies on the right side being zero (SE = 2.3980). Thus, there is no significant evidence of publication bias in this meta-analysis.

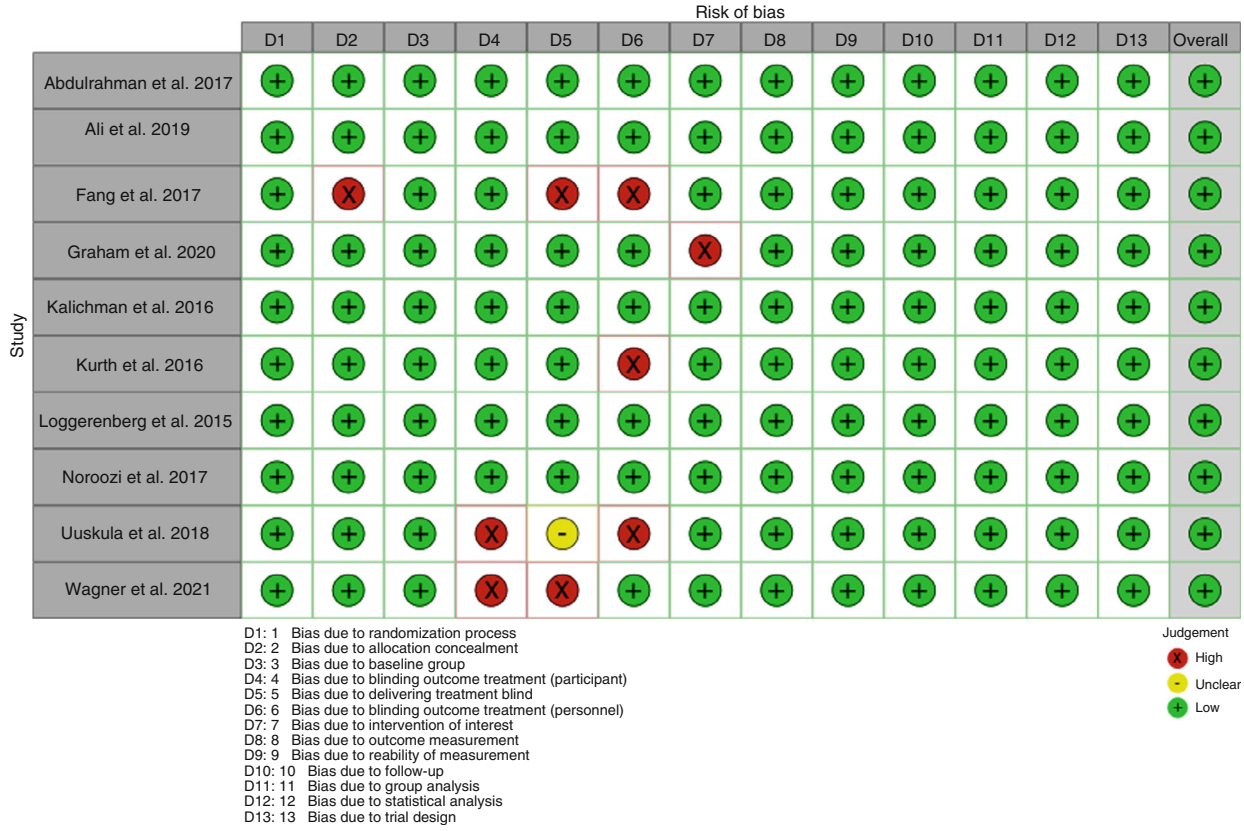

FIGURE 5 Risk of bias for RCT studies.

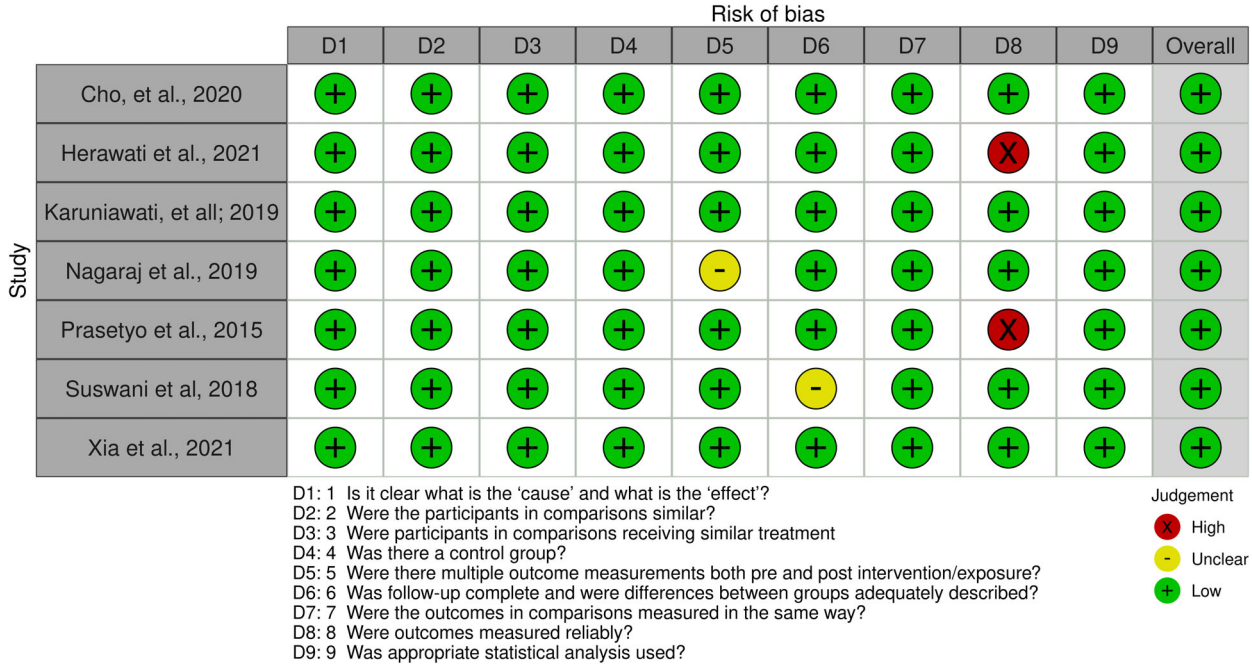

FIGURE 6 Risk of bias for quasi-experimental studies.

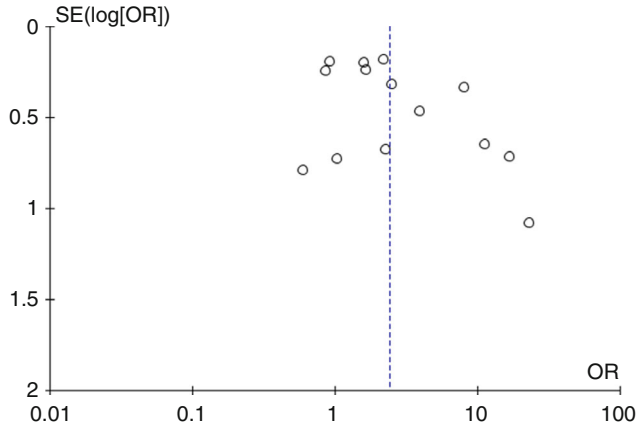

FIGURE 7 Funnel plots analysis of the included studies.

DISCUSSION

Principal finding

This systematic review and meta-analysis are the first to assess the potential of health education interventions to improve treatment adherence among individuals with chronic communicable diseases. The key findings of this meta-analysis are as follows: (1) health education are effective in improving treatment adherence; (2) remote-based and behavioural-based education models are more effective than other types of health education interventions; (3) health education are particularly effective in improving treatment adherence among people living with TB and HCV; (4) health education are highly recommended for individuals with chronic communicable diseases in both UMICs and LMICs; and (5) the effectiveness of these interventions is strongly observed in studies with adherence standards approaching perfection (>95%). Previous reviews have supported the role of health education, particularly psychoeducation, in enhancing adherence to treatment regimens for such conditions. However, unlike previous systematic reviews that narrowly focused on psychoeducation [10], this review provides a comprehensive exploration of the broader role of health education, encompassing diverse approaches and delivery methods across various patient populations and settings.

This meta-analysis demonstrated that health education improve treatment adherence by approximately 2.5 times compared with usual care. The findings of this study are consistent with previous systematic reviews [10]. Health education plays a critical role in enhancing patients' readiness for care and adherence to treatment, which are essential for achieving long-term treatment outcomes [34]. It has the potential to reduce the stigma associated with infectious diseases, fostering more inclusive and supportive environments [45]. Furthermore, health education helps individuals develop emotional resilience and coping skills to address psychosocial challenges linked to their conditions [46].

Health education is effective in enhancing health literacy, which is critical for managing the complexity and severity of chronic communicable diseases [47]. Improved health literacy empowers patients to understand their condition and treatment, enabling informed decision making and active engagement in care. Effective health literacy fosters a deeper understanding of treatment protocols, enhances motivation, and builds the capacity to adhere to prescribed regimens [48]. These benefits of good health literacy contribute not only to

improved treatment adherence but also to improved quality of life and overall health, reduce complications, opportunistic infections, and infection transmission [49, 50]. This is mainly because health education can provide a deeper understanding of their overall physical well-being; thus, it can improve their awareness to follow their regimen therapy.

This meta-analysis revealed that remote-based interventions demonstrated the highest pooled effect size, confirming their superior effectiveness in improving treatment adherence. These findings are consistent with a prior meta-analysis by Esmaeili et al. [51], which demonstrated the benefits of telehealth interventions, although without focusing specifically on health education. Remote-based models leverage digital technologies and telecommunications to deliver scalable, accessible, and flexible solutions, particularly for underserved populations [38, 43]. Features such as teleconsultations, automated reminders, and personalised content enhance patient engagement and adherence [38, 43]. Although challenges such as digital literacy, privacy concerns, and internet access remain, technological advancements are increasingly addressing these issues, making remote-based health education both feasible and impactful.

Behavioural-based education also significantly improved treatment adherence by fostering habit formation and enhancing patient motivation. This is supported by previous systematic reviews, such as [10], which emphasise the effectiveness of psychoeducational strategies for improving adherence in individuals with chronic communicable diseases [52]. In contrast, media-based models showed limited impact, likely due to a lack of personalisation and interactivity [30, 33]. Peer support models were similarly less effective, potentially due to inconsistent support quality and stigma associated with shared disease status [35, 53].

These findings align with global strategies such as the WHO End TB Strategy The WHO strategy emphasises patient-centred, integrated care (Pillar 1) and innovation through remote interventions like telemedicine (Pillar 3). Behavioural-based education supports counselling and psychosocial care, reinforcing Pillars 1 and 2 in TB and HIV programmes [6, 54].

This review further found that health education interventions were more effective in improving adherence among individuals with TB and HCV than among those with HIV. These differences likely stem from disease-specific factors such as treatment duration, medication complexity, side effect profiles, and psychosocial influences [55–57]. For HCV, the treatment duration is typically short (8–12 weeks), yet patients may experience side effects such as fatigue and depression, contributing to non-adherence [58]. Tailored education and goal setting have been shown to support adherence in this group [39, 42].

TB treatment, which spans 6–9 months and involves multidrug regimens, poses challenges including hepatotoxicity and neuropathy, with discontinuation rates reaching up to 23% during the intensive phase [59]. Nevertheless, adherence in TB is often higher than in HIV, aided by finite treatment duration and the widespread implementation of Directly Observed Treatment, Short course (DOTS). When integrated with counselling, symptom monitoring, and psychosocial support, health education in TB care can significantly enhance adherence [47, 60]. Digital tools such as mobile applications and teleconsultations also facilitate TB education by mitigating stigma and improving access [38, 40].

By contrast, HIV care requires lifelong adherence to ART, with ≥95% adherence needed to maintain viral suppression [61]. Routine counselling is already a standard component of HIV care, potentially reducing the added benefit of supplementary health education. Moreover, adherence among PLWHA is frequently undermined by persistent psychosocial barriers, including mental health conditions, substance use, stigma, and socio-economic challenges [62–67]. These findings underscore the importance of tailoring health education interventions to the specific clinical and contextual realities of each disease to maximise their impact on treatment adherence.

In this review, although the pooled effect for HIV-specific interventions was not statistically significant, a trend towards improved adherence supports the UNAIDS 95–95–95 targets, which aim for 95% diagnosis, treatment, and viral suppression among people living with HIV [5]. Health education remains essential for ART literacy [68], treatment motivation [69], and retention in care [70]. Heterogeneity in HIV-related outcomes may reflect differences in populations, intervention types, and health system capacities, underscoring the need for culturally tailored strategies, as emphasised in the Global AIDS Strategy 2021–2026.

The present meta-analysis also demonstrated that health education interventions improved treatment adherence among people in UMICs and LMICs but not significantly in HICs. Middle-income countries benefit from stronger healthcare infrastructure and greater investment in public health education, which supports treatment adherence, because in this setting the communicable diseases such as TB and HIV are most prevalent [6]. In contrast, low- and middle-income countries face significant challenges, such as limited health literacy, high disease burden, social stigma, and unequal access to healthcare facilities, all of which hinder treatment adherence [13, 71]. Health education interventions appeared to be less effective in improving medication adherence in HICs, possibly due to the already well-established healthcare infrastructure [72], which provides broad access to medications, skilled healthcare professionals, and routine patient education. In such settings, patients often possess higher baseline levels of health literacy and adherence, leaving less room for traditional educational interventions to produce significant additional improvements [73]. Moreover, non-adherence in HICs may be driven more by behavioural, psychological, or systemic factors, such as medication fatigue, mental health issues, or fragmented care, rather than by a lack of knowledge alone [72, 74].

The types of infections prevalent in each setting significantly influenced the effectiveness of health education

interventions. In this review, all diseases examined in HICs were HIV related [32–34, 41]. Health education may show less benefit for HIV care in HICs, because education and counselling are already standard components of HIV management [75]. Patients in HICs typically receive comprehensive counselling during routine clinical visits, reducing the added impact of standalone health education interventions [75, 76]. In contrast, tropical infections such as TB are rare in HICs but are more prevalent in LMICs and UMICs [77]. In these settings, health education programmes targeting TB and HCV play a critical role in addressing knowledge gaps, improving treatment adherence, and reducing stigma [27, 37]. The higher prevalence of TB and HCV in LMICs and UMICs likely explains the stronger impact of health education in these contexts.

Implication to practice

The findings of this study highlight the significant role of health education interventions in improving treatment adherence and success among patients with chronic communicable diseases, aligning with global health initiatives, such as EndTB, triple elimination, and Zero HIV Transmission. For TB and HCV, health education interventions have demonstrated a strong impact by addressing adherence barriers, which is crucial for treatment success and reducing disease transmission. Approaches such as remote-based education and behavioural interventions effectively enhance adherence by tackling psychological and logistical challenges and ensuring that patients complete their treatment regimens.

A multifaceted approach combining remote-based interventions with behavioural-based and peer support strategies may further improve outcomes. Behavioural interventions can address psychological and motivational barriers [28, 32, 41, 44]. In the context of HIV, where lifelong adherence to ART is essential for viral load suppression, health education fosters patients' understanding, motivation, and resilience. However, the challenges of managing HIV, including stigma and complexity of lifelong care, underscore the need for tailored educational and psychosocial support. Integrating these educational programmes into routine clinical care, complemented by community-based models, can strengthen adherence and advance the goal of achieving zero HIV transmission.

Another critical recommendation is tailoring health education for specific diseases. For TB, combining remote-based interventions with structured approaches such as DOT can ensure comprehensive care [78, 79]. For HIV and hepatitis C, personalised educational support that addresses the complex regimens and side effects is essential. Lastly, strengthening the health education infrastructure, particularly in resource-limited settings, and adopting innovative approaches such as mobile health combined with behavioural-based education tailored to individual needs can significantly accelerate progress towards achieving these critical milestones.

Limitations

This review aimed to provide the latest evidence by focusing on studies published within the last 10 years. However, several limitations should be acknowledged. First, the literature search was limited to English-language publications, potentially excluding relevant studies in other languages. Second, there was an underrepresentation of studies on HBV and HCV, with only three studies on HCV and none on HBV included in the final dataset. This limited representation reduces the generalisability of the findings to these disease populations. Future research should specifically investigate the effectiveness of health education interventions for HBV and HCV, particularly in LMICs where these diseases remain highly prevalent yet underresearched. Third, there was considerable variability in how adherence was measured across studies, which may affect the comparability of results and the strength of the overall conclusions. Fourth, variability in adherence definitions across studies (e.g., >80%, >85%, >95%, and 100%) may limit the comparability and interpretation of the pooled results. Although subgroup analyses were conducted, these differing thresholds likely reflect disease-specific clinical targets and may influence the clinical relevance of the findings. Due to the limited number of studies sharing the same cutoff, stratified meta-analysis by adherence threshold was not feasible. Fifth, the included diseases, TB, HIV/AIDS, HBV, and HCV, differ in clinical characteristics such as treatment duration, drug regimens, and side effect profiles, which can influence adherence in ways that health education alone may not address. Due to inconsistent reporting, this review could not fully account for these factors, and the observed differences in intervention effectiveness may partly reflect these unmeasured variations. A further limitation is that several included studies measured adherence over short periods (1–3 months), which may not fully capture long-term adherence patterns essential for managing chronic communicable diseases. Short follow-up durations may overestimate intervention effects and limit understanding of sustained adherence. Future research should include longer follow-up periods to better assess the durability of intervention impacts.

CONCLUSION

This systematic review and meta-analysis highlight the significant role of health education interventions in improving treatment adherence among people with chronic communicable diseases, particularly those with TB and HCV. Remote-based models, such as mHealth and digital reminders, appear especially effective in addressing barriers like stigma and limited access in LMICs. These findings underscore the value of integrating health education with broader support strategies to enhance adherence outcomes.

AUTHOR CONTRIBUTIONS

L. L. contributed to the conceptualisation, methodology, formal analysis, data curation, writing the original draft, and project administration. I. J. W. and M. A. M. were

responsible for the quality assessment, critical review, data analysis, subgroup analysis, and visualisation. I. N. C., A. P. R., and A. H. Z. conducted the article screening and data extraction. A. P. R. and R. W. wrote the introduction and reviewed and edited the discussion. A. M. conducted the Egger test, applied the trim-and-fill method, and supervised subgroup analyses. S. M. provided supervision, performed critical reviews, managed the project administration, and contributed to the discussion. All the authors contributed equally to the writing of this manuscript and have read and approved the final version.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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