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# Interventions to improve treatment adherence among adolescents: A meta-analysis

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## Abstract

**AIM:** To examine the overall effectiveness of interventions designed to improve medical treatment adherence among adolescent patients.

**METHODS:** PubMed and PsycINFO databases were searched to retrieve and analyze empirical journal articles (from 1948-2013). Only peer-reviewed, English language journals that defined a measure of adherence (or compliance), assessed an intervention aimed at improving adherence among adolescents, and provided information to calculate an *r* effect size were included. Studies were excluded if they lacked assessment of the effectiveness of interventions on improving adherence in adolescents as compared to no interventions or standard care. Case studies or journal articles that examined substance abuse or psychological disorders were also excluded. Analyses were conducted with fixed and random-effects methods, and moderators of intervention efficacy were also examined.

**RESULTS:** For each study that met the inclusion criteria ($n$ = 45), an effect size $r$, reflecting the strength and direction of the interventions' relationship to adherence was recorded; a positive $r$ indicated that the intervention increased adolescent adherence, whereas a negative $r$ indicated that the intervention decreased adolescent adherence. The overall effectiveness of adolescent adherence interventions was positive and significant (unweighted mean $r$ = 0.27, 95%CI: 0.21-0.33, $P$ = 0.001). Moderator analyses at the fixed effects level revealed that interventions were less effective when adolescents reported their adherence behaviors, when the type of adherence regimen was a medication regimen, and when the type of intervention was cognitive-modification based.

**CONCLUSION:** These findings contribute to understanding interventions for enhancing adolescent adherence. Future research should continue to examine the specific challenges faced by adolescents and create targeted interventions.



**Key words:** Adolescent; Adherence (compliance); Intervention; Meta-analysis

**Core tip:** Estimates of nonadherence among the adolescent population range from 25%-70%, depending on the disease or condition. Intervention components in patient samples vary widely across studies; thus, it is important to systematically identify elements of interventions that are most effective. Meta-analytic techniques were used in this study to provide a comprehensive, quantitative summary of empirical studies evaluating the effectiveness of interventions aimed at improving treatment adherence among adolescents. This meta-analysis showed that interventions were effective, specifically when the type of regimen was behavioral, whereas cognitive-based interventions were less effective.

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## INTRODUCTION

Patient nonadherence (or noncompliance) to medical treatment involves the degree to which an individual fails to follow specific disease management activities as directed by his or her healthcare provider[1,2]. Nonadherence can occur in the context of a variety of treatment behaviors, such as medication use, electronic pill counts, diet and exercise, and disease management skills[1]. The prevalence of nonadherence can be close to 25% on average, across a variety of diseases, and specific patient populations[2]. For some chronic diseases such as diabetes, that require complex treatment regimens, rates of nonadherence can exceed 50%[2]. Moreover, it is estimated that nearly 240 million medical visits are wasted annually due to nonadherence[2]. Despite these alarming statistics, patients and healthcare providers remain largely unaware that one major cause of poor health outcomes may be patient nonadherence[3,4].

### Adolescent adherence relationship

Adolescence is a unique period of the lifespan in which individuals begin to explore their social identities and seek independence; however, among adolescents coping with illnesses, this autonomy-seeking can bring about confusion, frustration, and conflict with caregivers over prescribed treatment regimens, and consequently, nonadherence. In a study conducted by DiGirolamo *et al*[5] 30% of adolescents with cystic fibrosis reported completing less than half of their daily-prescribed airway clearance regimens that are essential for the prevention of further morbidity and even mortality. In another study of adolescent patients with Type 1 diabetes, 25% reported mismanagement behaviors, such as missing prescribed insulin injections. Similarly, between 50 and 60% of children and adolescents were found to underuse prescribed medications, and less than 10% overused prescribed medications[6,7]. A study by Chappuy *et al*[8] looked at prescription medication adherence in adolescents and found that only 36.2% actually completed their prescribed regimens. Lastly, Guilfoyle *et al*[9] noted that nonadherence to an oral immunosuppressant medication regimen, commonly used to prevent a patient's body from rejecting an organ transplant, is prevalent (approximately 70%) and has been found to significantly compromise the long-term graft survival and life span of adolescents with kidney transplants. Nonadherence is a prevalent and consequential issue for adolescent patients and their families; however, the development of effective interventions to improve adherence behaviors in this age group remains an ongoing challenge. The various types of interventions established to date and their benefits are reviewed below.

### Interventions to improve adherence in adolescents

Studies of current interventions to promote adherence among adolescents have consistently shown that educational interventions alone are not sufficient to change adherence behaviors[10]. In fact, a meta-analysis conducted by Dean *et al*[11] revealed that a multifaceted approach to interventions showed the greatest potential efficacy in improving adherence behaviors. The optimal combination of intervention elements remains unclear, however. Dean *et al*[11] suggest that the combination of education and behavioral methods (*e.g.*, reinforcement) for increasing motivation and providing problem-solving strategies can produce the greatest results. Additionally, in an intervention study conducted by Wysocki *et al*[10], behavioral family systems therapy improved both adherence to treatment and family relationship quality among adolescents, providing evidence for the importance of social support and family cohesion in disease management. Moreover, in a separate intervention conducted by Wysocki *et al*[12], researchers looked at adherence to self-monitoring of blood glucose, utilizing a behavioral intervention that compared two groups: a pill count meter-alone group and a pill count meter-plus-behavioral contract group. Results from this study indicated that both groups showed moderate improvement in measures of diabetic control, demonstrating the value of behavioral reminders and patients' commitment to their own care.

In addition to interventions combining educational and behavioral components, those incorporating cognitive-behavioral principles have also been successful. For example, research by van Es *et al*[13] found that adolescents with asthma demonstrated better treatment adherence if they received both education and group therapy for disease-focused issues, including attitudes toward disease and coping skills. In another study by Magyary *et al*[14], a cognitive-behavioral intervention significantly increased therapeutic adherence and self-responsibility for the management of health conditions in children and adolescents. Although the components of adolescent adherence interventions vary widely from study to study, and aspects have yielded results in particular patient samples, it is important that the overall efficacy of this wide range of interventions is subjected to systematic, quantitative review.

### Present study

The purpose of the present study is to utilize meta-analytic techniques to review and summarize research findings on the effectiveness of interventions designed to improve medical adherence in adolescents. Additionally, potential moderators of the effectiveness of these interventions will be examined. More specifically, this meta-analysis will test the primary hypothesis that there is a positive relationship between adherence interventions and adolescents' adherence to their medical treatment regimens, such that interventions would, on average,

improve adherence among adolescents. Exploratory moderator analyses will also be used to evaluate whether the following factors explain variability in the intervention studies' effect sizes: type of sample (adolescent only versus children and adolescents combined), type of intervention (*e.g.*, educational, behavioral), type of adherence measure (*e.g.*, self-report, electronic), type of treatment regimen (*e.g.*, medication-based, behavioral), type of illness, parental involvement in the intervention, patient gender, and patient ethnicity.

## MATERIALS AND METHODS

### Literature search

A "Top-down" literature search was conducted for the retrieval and analysis of empirical journal articles published from 1948 through 2013. PubMed and PsycINFO databases were searched using combinations of the following keywords: adherence (compliance), persistence AND adolescent, youth, teens, children, interventions, disease management, self-management, randomized control trial. In addition, the reference sections of obtained journal articles were examined for relevant studies.

### Inclusion and exclusion criteria

Studies were included if published in a peer-reviewed, English language journal, if they defined and explained a method of measuring adherence (or compliance), and if they assessed an intervention that aimed to improve adherence to medical treatment among adolescents. Studies were included only if they provided an effect size *r* or statistical information to calculate an effect size representing the magnitude and direction of the interventions' effect on adherence. Meta-analytic techniques were used to extract average *r* effect sizes and assess their significance. Furthermore, relevant journal articles were coded for moderators of the interventions' effectiveness, including: age or age range, total *n*, location of the study (United States or non-United States), type of patient illness, type of intervention, how adherence was measured, type of regimen, whether or not there was parental involvement in the management of care, patient gender, and patient ethnicity. Studies were excluded if they: measured the effectiveness of interventions on adherence in adult patients; did not assess patient adherence to treatment; lacked an intervention to improve adherence; lacked assessment of the effectiveness of an intervention on improving adherence in adolescents; and/or provided no information to calculate an *r* effect size. Finally, case studies or journal articles that examined substance abuse or psychological disorders (*i.e.*, depression, bipolar disorder) were excluded, because treatment adherence in mental health and substance use is beyond the scope of the present research, although it is an important issue for future examination.

### Effect size calculation

An *r* effect size was calculated from Cohen's *d*, *P* or descriptive statistics. If a study reported a significant result but did not report a *P*-value, then the one-tailed *P*-value was assumed to be 0.025. If a study reported results that were non-significant and no exact *P*-value was provided, then the study was conservatively assigned $P = 0.5$ one-tailed, and $r = 0$[15]. An effect size of $r = 0$ indicated that the intervention did not have an effect on adolescent adherence. For studies in which there were multiple measures of adherence, the *r* for each measure was converted to a Fisher's $Z_r$ and they were averaged.

### Statistical analysis

The effect size *r* was used because *r* most clearly illustrates both the *strength* (from 0.00 to 1.00) and *direction* (positive or negative) of the relationship between variables[15,16]. In this meta-analysis, a positive *r* indicates an improvement in adherence as a result of the intervention, whereas a negative *r* indicates a decrease in adolescent adherence to medical treatment as a result of the intervention (relative to control or standard care groups). The effect size *r* was obtained for each of the studies. If statistics were provided that could be transformed into an *r* (*e.g.*, *t*, Z and *P*-value, chi-square, or 1 degree of freedom in the numerator *F*; or means and standard deviations), the appropriate statistical analyses were conducted to yield a Phi, Pearson Product-Moment, or point-biserial correlation coefficient[17]. All calculations involving *r* were performed by transforming *r* to the Fisher's *Z* transformation of *r* and then returning the results back to the scale of *r*.

The random effects model was used to combine effect size statistics using the unweighted mean *r* based on *k* (the total number of studies included). This method allows for the generalization of findings to other studies beyond those that were included in this meta-analysis[15,18]. The fixed effects model was also used to carry out weighted mean analyses and tests of heterogeneity based on *n* (the total number of participants across all studies). All analyses of moderators were first performed using the random effects model; if results were not significant at the random effects level, results from the fixed effects model were provided. Random effects tests of methodological and substantive moderators were conducted to examine the heterogeneity of the study effects. These include: sample type (adolescent and children versus adolescents only), total *n*, location of the study (United States or non-United States), patient illness, type of intervention, how adherence was measured, type of regimen, whether or not there was a parent involved in the management of care, patient gender and patient ethnicity. In addition, for the effects that were significant, the fail safe *n* was calculated (to address the file drawer problem) that indicated the number of studies, new, unpublished or unretrieved with no effect that would be needed in order for significant results to be declared non-significant at $P < 0.05$[17]. The standardized odds ratio and standardized relative risk (including 95%CI) were calculated from the unweighted mean *r* using the binomial effect size display

(BESD). The BESD is a useful tool for effect size estimation that can be used to display changes in success rates (*i.e.*, survival or improvement rates) that are attributable to specific treatment procedures[17]. Preliminary statistical analyses were conducted using SPSS 12.0 (*i.e.*, calculation of means, medians, standard deviations, correlations and *t*-tests). A T1-84 Plus graphing calculator and Excel 2008 v.12.2.3 were used for essential calculation verification.

## Results

Meta-analytic calculations were performed on 45 independent studies to examine the overall effectiveness of interventions aimed at improving adherence to medical treatment among adolescents. Twenty-four of the 45 studies combined the results of the interventions' effectiveness on adherence among both adolescents and pediatric patients. The remaining 21 studies looked at the effectiveness of interventions aimed at improving adherence among adolescents only. Therefore, meta-analytic computations were done for the total sample ($k$ = 45) and also separately for these two groups, constituting a moderator analysis for "sample type". In addition, for each sample ($k$ = 45, and the subgroups of $k$ = 24 adolescents plus children, $k$ = 21 adolescents only) the following statistics were computed: the total number of subjects ($n$), the median $r$ and range, the fixed effects weighted mean $r$ with a 95%CI, the random effects model unweighted mean $r$ with a 95% confidence interval, the fail safe $n$, the standardized odds ratio with a 95%CI, and the standardized relative risk with a 95% confidence interval (Table 1).

### Interventions to improve adherence

Across 45 independent studies, with a total of 3890 participants, the average relationship between an adherence intervention and improvement in adolescent adherence (as compared to a control group or to a group receiving standard care) was positive and significant under the random effects model (unweighted mean $r$ = 0.27, $P$ < 0.001). This demonstrated that interventions aimed at improving adolescent adherence were effective. The median $r$ of 0.23 was close in magnitude to the unweighted mean and to the weighted (by sample size) mean $r$ of 0.18. Effect sizes in the positive direction indicated that interventions aimed at increasing adherence were effective; conversely, effect sizes in the negative direction indicated that these interventions reduced adherence. Within this sample of studies, there were only two negative $r$ effect sizes: -0.24 and -0.05.

Both the fixed (weighted) and random (unweighted) effects models indicated a positive and significant effect of interventions on improving adherence to medical treatment in adolescents (Table 1). The random effects model indicated that adherence interventions were effective [$r$ = 0.27, $t_{(44)}$ = 7.55, $P$ < 0.001]. Therefore, the effectiveness of interventions to improve adherence among adolescents can be generalized to studies outside the present sample. The fixed effects model also indicated that interventions aimed at improving adherence were effective ($r$ = 0.18, 95%CI: 0.15-0.21; $P$ < 0.001). The fail safe $n$ demonstrated that more than 2189 studies with non-significant results would have to be included in order for these results to be rendered non-significant; this number exceeds the tolerance level of 235 unpublished (or otherwise non-retrievable) studies with null results that might possibly exist. The standardized odds ratio, using the BESD, indicated that the odds of being adherent to medical treatment were 3.03 times higher if adolescents participated in an adherence intervention compared with the odds if he/she did not participate in an intervention (95%CI: 2.35-3.94; $P$ < 0.001). The standardized relative risk (also calculated using the BESD) indicated that the risk of poor adherence to medical treatment was 1.74 times higher if adolescents did not participate in an adherence intervention (95%CI: 1.53-1.99; $P$ < 0.001). Furthermore, the effect sizes were significantly heterogeneous ($\chi^2$ = 122.82, $P$ = 2.24 × $10^{-9}$), which indicated that moderators might account for this variation in effect sizes.

### Moderator analyses

Moderator analyses using the random effects model revealed no significant results in studies that combined children and adolescents and in studies of adolescents only. Meta-analytic calculations were applied to each sample type separately and are detailed below.

In the 24 studies that included a combined sample of adolescents and children, there was a moderate, significant and positive effect of interventions using both the fixed (weighted) and random (unweighted) effects models (Table 1). The random effects model indicated that interventions to improve adherence to medical treatment in adolescents were effective [$r$ = 0.32, $t_{(23)}$ = 5.58, $P$ < 0.001]. Additionally, the weighted mean (fixed effects model) yielded a similarly positive result ($r$ = 0.27, 95%CI: 0.22-0.32; $P$ < 0.001). The fail safe $n$ demonstrated that more than 800 studies with non-significant results would have to be included in order for these results to be rendered non-significant. However, the tolerance level suggested that 130 unpublished null studies might possibly exist. The BESD-based, standardized odds ratio indicated that the odds of adhering to medical treatment were 3.77 times higher if patients participated in an adherence intervention as compared to the odds if they had not (95%CI: 2.44-5.99; $P$ < 0.001). The standardized relative risk indicated that the risk of nonadherence to medical treatment was 1.94 times higher if the patient did not participate in an adherence intervention (95%CI: 1.56-2.45; $P$ < 0 001). Furthermore, the 24 effect sizes were heterogeneous, ($\chi^2$ = 53.36, $P$ = 3.28 × $10^{-4}$). Inspection of the distribution of $r$'s revealed a range from $r$ = -0.24 to $r$ = 0.71.

In the comparison subgroup of 21 studies that assessed adolescent patients only, analyses revealed a moderate, yet positive and significant, effect of interventions on improvements in adherence to medical treatment,

**Table 1 Summary of overall meta-analysis results**

| Effect of adolescent adherence interventions | K[4] | Total *n*[5] | Unweighted median *r* (range) | Weighted mean *r*[6] (95%CI) | Unweighted mean *r*[7] (95%CI) | Fail safe *n* | Standardized odds ratio[8] (95%CI) | Standardized relative risk[9] (95%CI) |
|---|---|---|---|---|---|---|---|---|
| Interventions[1] | 45 | 3890 | 0.23 (-0.24-0.71) | 0.18 (0.15-0.21)[b] | 0.27 (0.21-0.33)[b] | 2189 (tolerance level 235) | 3.03 (2.35, 3.94)[b] | 1.74 (1.53-1.99)[b] |
| Adolescent and Children Interventions[2] | 24 | 1476 | 0.32 (-0.24-0.71) | 0.27 (0.22-0.32)[b] | 0.32 (0.22-0.42)[b] | 800 (tolerance level 130) | 3.77 (2.44, 5.99)[b] | 1.94 (1.56, 2.45)[b] |
| Adolescent Only Interventions[3] | 21 | 2414 | 0.18 (-0.05-0.51) | 0.12 (0.08-0.16)[b] | 0.20 (0.13-0.27)[b] | 324 (tolerance level 115) | 2.25 (1.69-3.03)[b] | 1.5 (1.30-1.74)[b] |

[b]$P < 0.01$. [1]Analyses for the entire sample of intervention studies; [2]Analyses for the subgroup of studies that combined adolescent with pediatric samples; [3]Analyses for the subgroup of studies that included adolescent-only samples; [4]Number of samples; [5]Total *n* across all samples; [6]Effect size obtained from the fixed effects model, or weighted by the total number of participants across studies. [7]Effect size obtained from the random effects model, or based on the total number of studies included. [8]The standardized odds ratio depicts the odds of being adherent in the intervention group relative to the control group. Across all analyses, the intervention group had a higher likelihood of improved adherence than the control group (receiving no interventions or standard care). [9]The standardized relative risk can be interpreted as the control group's risk for nonadherence as compared to the intervention group's risk. In each set of analyses, the control group was at significantly greater risk for nonadherence. The Fail Safe *n* exceeds the level of tolerance for future null results making it unlikely that the "file drawer problem" is a source of bias. The binomial effect size display from the unweighted mean effects (random effects model) was used to obtain the standardized odds ratio and relative risk. The heterogeneity test ($k = 45$) for the overall adolescent adherence interventions was significant ($\chi^2 = 122.82$, $P < 0.001$). The heterogeneity test ($k = 24$; adolescent and children samples) for adolescent adherence interventions was significant ($\chi^2 = 53.36$, $P < 0.001$). The heterogeneity test ($k = 21$; adolescent only samples) for the second group of adolescent adherence interventions was also significant ($\chi^2 = 44.53$, $P < 0.001$).

using both the fixed (weighted) and random (unweighted) effects models (Table 1). First, the random effects model indicated that adolescent-only adherence interventions were effective [$r = 0.20$, $t_{(20)} = 5.18$, $P < 0.001$]. The fixed effects model revealed the same significant intervention efficacy, albeit with a slightly smaller effect ($r = 0.12$, 95%CI: 0.08-0.16; $P < 0.001$). In addition, the fail safe *n* demonstrated that more than 324 studies with non-significant results would have to be included in order for these results to be rendered non-significant. The tolerance level suggested that 115 unpublished null studies possibly exist. The standardized odds ratio (BESD-based) indicated that the odds of being adherent to medical treatment were 2.25 times higher if the adolescent participated in an adherence intervention compared with the odds if he/she had not participated in an intervention (95%CI: 1.69-3.03; $P < 0.001$). The standardized relative risk indicated that the risk of nonadherence to medical treatment was 1.50 times higher if the adolescent did not participate in an adherence intervention (95%CI: 1.30-1.74; $P < 0.001$). Furthermore, this set of 21 effect sizes was heterogeneous ($\chi^2 = 44.53$, $P = 1.28 \times 10^{-3}$).

Analysis of other potential moderators of the relationship between interventions and improvements in adherence was conducted. Moderator analysis at the fixed effects level revealed three significant moderators: type of regimen, intervention type, and self-report by adolescents of their own adherence behaviors. For type of regimen, the effectiveness of interventions aimed at improving adherence was moderated by whether or not the intervention was a medication regimen. Specifically, adherence interventions had a greater positive effect on adherence to health behaviors such as diet, exercise, appointment keeping or screening regimens than to medication regimens ($z = -1.77$, $P = 0.039$). In addition, the fixed effects analyses revealed that interventions were less successful at improving adherence in studies where adolescents reported their own adherence behaviors, as compared to having a parent or guardian report adolescent adherence behaviors ($z = -1.91$, $P = 0.038$). Finally, interventions that involved only cognitive modification were less effective in improving adherence than were approaches based on educational intervention, behavioral intervention or a combination of both ($z = -2.14$, $P = 0.160$).

## RESULTS

The present meta-analysis provided a comprehensive, quantitative summary of empirical studies evaluating the effectiveness of interventions aimed at improving medical treatment adherence among adolescents. The main hypothesis, that interventions focused on improving treatment adherence are indeed effective, was supported. Although moderator analyses using the random effects model revealed no significant overall moderators of studies' effect sizes, there were several significant results from the fixed effects approach. In studies where adolescent patients reported their own adherence behaviors, interventions demonstrated reduced efficacy, suggesting the possibility of measurement challenges in this work. Interventions improved non-medication regimen adherence (*e.g.*, diet, exercise, appointment keeping) more than medication adherence, perhaps due to the greater challenges of health behavior change, or because medication regimens may be more difficult to target. Finally, educational and behavioral interventions (both combined and in isolation) were more effective than cognitive approaches. These cognitive approaches often attempt to change adolescents' attitudes and beliefs about risk, and they may be less effective because adolescence is a time of heightened vulnerability to risk taking behaviors[19]. Research suggests that because of the temporal gap between puberty and the slower maturation of the cognitive-control system,

changing the context in which the risky behavior occurs maybe more successful than changing the way adolescents think about risk[19].

## DISCUSSION

These results provided compelling evidence for the success of efforts to address adolescent nonadherence through interventions designed to assist with the complexities of treating chronic illnesses in this age group. It should be noted that although there were no significant differences between studies that combined adolescents and children samples and those that included adolescents alone, future research should continue to look at these age groups separately, as barriers to adherence can differ between children and adolescents[20]. In doing so, interventions aimed at improving adherence can be targeted to better address the specific needs of each group.

### *Strengths, limitations and future directions*

This systematic quantitative review of adolescent adherence interventions sought to explain what aspects of these interventions were the most successful. With regards to comprehensiveness, several search strategies were utilized and all references were carefully cross-checked. Furthermore, although the mean effect sizes were moderate in size, they may be important in clinical application, and therefore should not be underestimated. Research in the medical field commonly reports small, but highly significant findings with major implications for health. For example, the relationship between consumption of aspirin and the occurrence of heart attacks is in the range of $r$ = 0.03-0.04[21,22]. In other words, there is a 3% to 4% risk difference in prevention of a serious health outcome due to consumption of a simple medication such as aspirin, making the application of this finding very important clinically. In the present research, an unweighted mean $r$ of 0.27 reflects a 27 percent difference in the risk of nonadherence between patients who receive an adherence enhancing intervention and those who do not. Adherence interventions, thus, can have a profound impact on improving adherence among adolescents.

Limitations of this research include the possibility that some empirical studies were missed unintentionally. For example, it is possible that statistically significant findings had greater likelihood of publication, but the large fail safe $n$'s in this review made it unlikely that the current results exhibited the "file drawer bias." Additionally, several studies in the meta-analysis combined the results of both adolescents and children in their reports of the interventions' effectiveness on improving adherence. Therefore, results from the present meta-analysis should be interpreted with caution. Future studies should assess adherence behaviors in children and adolescents separately to allow for exploration of potential age-specific factors that may influence adolescents' adherence and interventions' efficacy. Findings from this study (*i.e.*, the positive effects of multi-faceted, educational/behavioral interventions as compared to cognitive approaches, and of parental assessments of adherence) also underscore the importance of shared decision-making and the role that adolescents, healthcare providers, and parents or caregivers play in the management of disease.

In sum, future research should identify the psychological and behavioral aspects and determinants of adolescent adherence. The present review could assist in the development of specific interventions to enhance adolescent adherence to various medical treatments and types of treatment regimens. Future adherence interventions should also measure and seek to determine both mediators and moderators of adherence interventions' effectiveness in order to fine-tune their development and eliminate the less successful elements. Lastly, future studies should recruit adolescent-only samples, thereby providing meta-analytic opportunities to better understand the challenges (or facilitators) of treatment adherence specific to adolescents.

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## COMMENTS

### *Background*

For adolescents coping with illness, autonomy seeking and other aspects of this developmental transition can lead to confusion, frustration, and conflict with caregivers over prescribed treatment regimens, and consequently, nonadherence. Components of adolescent adherence interventions have been found to vary widely from study to study; thus it is important that the overall efficacy of this wide range of interventions is subjected to systematic, quantitative review.

### *Research frontiers*

Interventions are effective at improving adherence among adolescents. However, previous adolescent studies have treated adolescent and child patients as a homogenous group and reported findings based on the combination of adolescents and children. This limits the interpretability of findings; more quantitative reviews are needed that focus on the unique challenges of adolescent nonadherence.

### *Innovations and breakthroughs*

Previous studies have reported inconsistent results on the efficacy of interventions aimed at improving adherence among adolescents. Some research suggests that multifaceted interventions are more effective than single-approach interventions. The present meta-analysis found that cognitive-based interventions were less effective at improving adherence in adolescents than educational and behavioral approaches.

### *Applications*

The study results suggested that interventions aimed at improving treatment adherence in adolescents are effective, specifically when the type of regimen was behavioral. In addition, cognition-based interventions were less effective. Given the unique challenges adolescents face in coping with illness, future research should consider developmentally appropriate intervention aspects.

### *Terminology*

Patient adherence (or compliance) is the degree to which patients follow treatment directives given by clinicians or other health care providers.

### *Peer review*

Patient nonadherence is a worldwide public health concern, linked to poor clinical outcomes and increased medical costs. The paper was well written. It is interesting and novel topic for present social medical questions.

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