The Efficacy of Adherence Interventions for Chronically Ill Children: A Meta-analytic Review

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Abstract

Children with chronic illness, on average, have low rates of adherence to their medical regimens despite the possible medical and psychological consequences. Many different interventions have been developed to increase adherence in this population, and the results are mixed. Some studies show strong results, while others only slightly increase adherence. The purpose of this meta-analysis was provide quantitative information about the overall effectiveness of adherence interventions for children with a chronic illness, as well as statistically evaluate potential moderators of the effectiveness of interventions (e.g., behavioral vs. educational interventions, age of child). Overall, adherence interventions for children with chronic illnesses appear to effectively increase adherence and maintain benefits at follow-up. Additionally, these adherence interventions overall appear to have some positive health benefits. Some intervention and methodological variables, such as study design and assessment method, had a significant effect on effect sizes. However, most of the data included in this meta-analysis should be interpreted with caution because of high levels of heterogeneity within the data. This suggests that more targeted summaries of the research (i.e., adolescents with asthma) would provide more useful information about the effectiveness of adherence interventions.

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Introduction

Low adherence to medical regimens is common among children with a chronic illness. On average, children take about 50% of the medication prescribed for their chronic illness (Drotar, 2000; Rapoff & Barnard, 1991). This low rate has persisted despite the development of more effective medications, increased attention to provider-patient communication, more available patient education, and greater awareness of adherence issues. The significance of this relatively low level of adherence is particularly salient when considering the evidence of harm due to nonadherence. The body of scientific knowledge about adherence is increasing, and adherence interventions are continually being designed and tested. As the evidence accumulates, it is important to evaluate the adherence intervention literature to better understand which techniques work best. By doing so, resources can be focused on the most effective interventions to tackle the complex problem of adherence.

Adherence has been defined as "the extent to which a person's behavior coincides with medical or health care advice" (Haynes, 1979, pp. 1-2). This definition is useful because it highlights the fact that adherence is a continuum (Rapoff, 1999). For example, few patients take all or none of their medications. Using the term adherence rather than compliance also emphasizes that the patient takes an active role in medical decisions, rather than passively agreeing to the provider's orders (Rapoff, 1999). Additionally, nonadherent patients may be making reasoned decisions about

their medical care (Adams, Dreyer, Dinakar, & Portnoy, 2004). For example, patients may choose to experience more symptoms in order to take less medication (Heath, Singer, O'Shaughnessy, Montaner, & Hogg, 2002). This decision can appear rational when considering the possible long term or dangerous side-effects of some medications.

Despite the fact that choosing to be nonadherent is sometimes understandable and rational, nonadherence has been linked to many negative health effects. In pediatric asthma, adherence rates vary from 50% to 80% (Bender et al., 2000). Nonadherence to asthma medications has been linked to increased rates of emergency room visits, hospitalization, and missed school days (Bauman et al., 2002). Increasing evidence also suggests that nonadherence to inhaled corticosteroids (prescribed to reduce inflammation in the lungs) can lead to permanent airway restructuring or scarring of the lungs (Pascual & Peters, 2005). For children with diabetes, nonadherence to insulin delivery and blood glucose monitoring can lead to poor glycemic control, with short term consequences of weight loss, poor concentration, or diabetic ketoacidosis and long term consequences of diabetes related kidney, eye, and skin complications (Johnson et al., 1992; Sochett & Daneman, 1999). Nonadherent children with organ transplants (rates of 6 to 9%) are at a great risk of losing their organ graft (Falkenstein, Flynn, Kirkpatrick, Casa-Melley, & Dunn, 2004; Serrano-Ikkos, Lask, Whitehead, & Eisler, 1998). Children with juvenile rheumatoid arthritis (JRA) who are nonadherent to nonsteroidal anti-inflammatory medicines (nonadherence rates of about 50%) are likely to have more pain episodes that

interfere with quality of life and may also cause permanent damage to their joints (Rapoff, Belmont, Lindsley, & Olson, 2005). In short, nonadherence to medications for pediatric chronic illnesses can be linked to many health complications, as well as reductions in quality of life. In fact, nonadherence to medications, including adult and child populations, was estimated to cost at least $100 billion annually in the United States (Berg, Dischler, Wagner, Raia, & Palmer-Shevlin, 1993).

Because of the many possible negative effects of nonadherence, there is a strong interest in developing interventions to increase adherence. In general, adherence intervention strategies are divided into three groups: behavioral, educational, and organizational (La Greca & Schuman, 1995). Many treatments combine two or more of these techniques. Other strategies include addressing psychological issues that may interfere with adherence, such as family systems problems, depression, or general child noncompliance (i.e., refusal to follow most of parent's directions).

Behavioral Interventions

Behavioral interventions use techniques such as modifying the environment to encourage adherence, shaping adherent behaviors, and providing positive and negative consequences for adherence. Often these techniques are taught to parents to implement at home. For example, da Costa and colleagues taught families to implement a token system wherein the child could earn or lose privileges based on having taken his or her asthma medication (da Costa, Rapoff, Lemanek, & Goldstein, 1997). Researchers sometimes assist parents in implementing these techniques during

home visits. In one such project, nurses went to the homes of children with human immunodeficiency virus (HIV) and provided HIV education as well as behavioral components such as teaching parents how to better organize and remember the child's medications (i.e., using weekly medication boxes) and providing rewards to children for taking their medications (Berrien, Salazar, Reynolds, & McKay, 2004). Additionally, some researchers have evaluated the use of behavioral techniques in office sessions. For example, Anderson, Ruggiero, and Adams (2000) report using shaping and rewards (i.e., parental attention, cookies, and stickers) to teach a young boy with HIV how to swallow pills, because the boy's fear of pill swallowing was the major impediment to adherence for that family. Each of these studies reported that the interventions resulted in improved adherence.

Educational Interventions

Prompted by evidence that nonadherence can be the result of a family not understanding the physician's orders, the purpose of the medical regimen, or how to use medical equipment, educational interventions seek to provide education to the family on these and other relevant topics. Educational interventions can range from handouts given by nurses at the end of clinic visits to intensive home-based teaching programs. In one published intervention, children with diabetes were given video games, which were designed to teach the importance of adherence to diabetes self-management tasks (Brown, Lieberman, Gemeny, Fan, Wilson, & Pasta, 1997). In another example of an educational intervention, general practitioners used an asthma information book and structured education sessions to teach parents of preschool

children about appropriate asthma medication use (Mesters, van Nunen, Crebolder, & Meertens, 1995). In both studies, the researchers reported a significant decline in unscheduled urgent doctor visits and an increase in self-reported appropriate medication use.

Organizational Interventions

Organizational strategies seek to reduce nonadherence by decreasing barriers to medical care and medication use. Some specific techniques include helping families find transportation to doctor appointments, teaching good communication skills to medical staff, and reducing the complexity and negative side-effects of the medical regimen (Rapoff, 1999). In general, fewer studies are published highlighting these types of interventions. However, at least two studies have shown that by reducing the frequency of medication dosing, adherence is improved in children with asthma (Tinkelman, Vanderpool, Carroll, Page, & Spangler, 1980) and children with JRA (Rapoff, Purviance, & Lindsley, 1988a).

Measurement of Adherence

In examining the many methods, modalities, and structures of adherence interventions for children with a chronic illness, the most important evaluative question is whether or not the intervention successfully reduces nonadherence. However, before change in adherence levels can be determined, experimenters must develop ways to assess treatment regimen behaviors. One of the simplest and quickest ways to assess treatment adherence rates is to obtain the self-report of the parent and child. However, self-report is generally considered an overestimate of adherence

behavior, because it is influenced by recall errors and social desirability (Quittner, Espelage, Ievers-Landis, & Drotar, 2000). Another easy, but perhaps more direct measure, of adherence is pill counts, wherein the researcher counts the number of pills left in a medicine bottle and compares it to the number of pills that should be left if the patient was completely adherent. However, this is an inexact measurement system, as there is no way to discern if the pills were taken on the correct schedule or if the pills were "dumped" by the patient in anticipation of the pill count (Rapoff, 1999). Blood assays of medication levels are considered good indicators of recent medication use, but can only be used with certain medications and are expensive (Rapoff, 1999). Electronic monitoring is generally considered to provide the most informative and accurate data (Vrijens & Urquhart, 2005). By using electronic monitors on pill bottles, inhalers, or other medical devices, researchers can determine the time and date of medication use. The drawbacks of this technique include the expense of the monitors, the possibility that being monitored will change medication taking rates, inability to detect medication consumption on most models, and the limited availability of devices to measure all types of adherence (Vitolins, Rand, Rapp, Ribisl, & Sevick, 2000). Thus, researchers have many options when it comes to measuring adherence. In order to balance the strengths and weaknesses of each method, researchers have been encouraged to use multiple techniques (Modi, Lim, Yu, Geller, Wagner, & Quittner, 2006).

Adherence intervention researchers sometimes use physiological or health outcomes, such as lung functioning in children with asthma, as an indicator of

appropriate medication use. However, adherence does not necessarily have a direct relationship with changes in health status (DiMatteo, Giordani, Lepper, & Croghan, 2002; Johnson et al., 1992). Thus, health outcomes are often seen as secondary outcomes of interventions. Other secondary outcomes sometimes measured are quality of life, health care utilization and costs, and functional impact of the chronic illness (e.g., school days missed). Although these secondary outcomes may not be directly related to increasing adherence, considering changes in these domains is important in understanding the full effect of an intervention (La Greca & Bearman, 2001).

Intervention Outcome Research

In general, the consensus in the literature is that effective interventions are available for increasing adherence to the treatment regimens for childhood chronic illnesses. Lemanek, Kamps, and Chung (2001) evaluated adherence interventions using the Chambless empirically-supported treatment criteria (Task Force, 1995). They concluded that behavioral interventions are "probably efficacious" for some medical regimen components (e.g., taking doses of a medication). Additionally, education, self-monitoring, and combination interventions are "promising," particularly when the intervention can be adapted to meet the individual's specific needs. However, the Lemanek et al. review covered only adherence interventions for three conditions (i.e., asthma, JRA, and type-1 diabetes). Rapoff (1999) made similar conclusions after a systematic literature review. Specifically, he stated that behavioral interventions appear to have the most empirical support. Additionally, although

educational and organizational techniques may be useful, these interventions are likely more efficacious when combined with behavioral techniques.

Although both of these reviews provide good summaries of the existing literature, the overall quantitative power and effectiveness of adherence interventions cannot be determined from these and other reviews. A meta-analysis is the best technique to provide that information (Rosenthal, 1995). Several meta-analytic reviews have been published on adherence interventions for adults. Most of these are disease specific (e.g., HIV: Amico, Harman, & Johnson, 2006; hypertension: Takiya, Peterson, & Finley, 2004), but at least two published studies have examined the relative effectiveness of adherence interventions across many patient conditions and adherence measures (Peterson, Takiya, & Finley, 2003; Roter, Hall, Merisca, Nordstrom, Cretin, & Svarstad, 1998). The Peterson et al. (2003) meta-analysis concluded that effects of adherence interventions were generally small, despite intensive and complex interventions. In contrast, the Roter et al. (1998) meta-analysis indicated that, for the studies included, the overall effect sizes for increased adherence ranged from small to large. Roter and colleagues also concluded that combined-type interventions (e.g., educational and behavioral) were more effective than single-type interventions. This difference in conclusions may be because Roter et al. (1998) included both randomized and nonrandomized studies, where as Peterson et al. (2003) only included randomized clinical trials. Both meta-analyses had notable limitations. First, both combined acute and chronic illnesses, and the Peterson et al. (2003) meta-analysis also included psychiatric illnesses. Combining acute and chronic illnesses is

problematic since the medication regimens for chronic illness have different barriers for adherence than acute illness medications (Rapoff, 1999). In fact, a meta-analysis conducted with only acutely ill children reached some similar conclusions (i.e., combined-type interventions are more effective than single-type) but also had some significantly different results (e.g., the interventions did not have a significant positive effect on health outcomes), suggesting that there are some important differences between adherence interventions for chronically ill children and acutely ill children (Wu & Roberts, 2008) Additionally, both meta-analyses combined studies targeting children and adults. Because interventions for children include aspects not necessary in adult interventions, such as parental involvement and developmentally appropriate education, adult-based research should not be assumed to provide similar results as child-based research. Thus, a meta-analysis that focuses only on chronically ill children will provide more accurate results by reducing some of the extra variance that is created by combining disparate groups.

Only one meta-analysis was found in the literature that focused specifically on adherence interventions for children with chronic illnesses. Analyzing 70 studies, Kahana, Drotar, and Frazier (2008) concluded that the mean effect size of all the included adherence outcomes was in the small range. Similar to conclusions from literature reviews, they found that behavioral and multi-component interventions had stronger effects (medium range) than those interventions that just used educational techniques (small range). There were some limitations in this meta-analysis. For example, most single subject design studies were excluded from this meta-analysis,

even though these studies are important in adherence intervention research because of their utility for studying chronic illness groups that are relatively rare and for providing interventions that are uniquely matched to a family's individual needs (Rapoff, 2001). The Kahana et al. (2008) meta-analysis also did not include any data about health outcome results from the interventions, although improved health outcomes is an important goal of adherence interventions. Perhaps the most striking drawback is that most of the summary adherence data presented in this meta-analysis had high levels of heterogeneity, meaning that the variance between the combined effect sizes was significantly more than expected based on chance and sampling error. In other words, the effect sizes likely did not represent a singular construct. In fact, a mean effect size with significant heterogeneity should only be interpreted with caution (Durlak, 2003). Although the authors attempted to understand the heterogeneity by examining moderators, the problem with heterogeneity was not fully addressed by Kahana et al. (2008) when interpreting the implications of their data.

The current meta-analysis provides an expanded view of the adherence intervention research by including more single-subject design studies and health outcome data. Additionally, since there is no consensus in the research community on the best procedures for all steps of a meta-analysis, slightly different decisions were made for this meta-analysis than those made for the Kahana et al. (2008) meta-analysis. In fact, of the studies included in this meta-analysis, only 19 out of 71 were also in the Kahana et al. (2008) meta-analysis. The reason for this significant difference in studies sampled is unclear but is most likely due to differences in

inclusion criteria. For example, Bonner et al. (2002) was included in the Kahana et al. (2008) meta-analysis, but excluded from this one because it was considered a self-management intervention (see exclusion criteria below). These procedural differences do not represent significant flaws in either study, but rather provide slightly different representations of the adherence intervention literature. Additionally, these differences could affect some of the statistical results. Thus, having more than one meta-analysis on the effectiveness of adherence interventions for chronically ill children deepens the understanding of this research area. For example, in the adult literature, the Roter et al. (1998) and Peterson et al. (2003) studies sampled different types of adherence intervention studies (i.e., only the Peterson et al. study included adherence to psychiatric medications). Thus, taken together these two studies cover a wider range of adherence intervention research and allow for more complex conclusions.

In summary, the present meta-analysis attempted to provide a quantitative summary of the research on adherence interventions for children with chronic illnesses. Additionally, this meta-analysis evaluated the influence of different intervention methods, assessment types, methodological variables, and participant characteristics on study effect sizes. Health outcome and follow-up data were also analyzed.

Method

Literature Search

Computerized and manual methods were used to identify studies to be included in this meta-analysis. The computer searches were conducted using PubMed (an enhanced version of MEDLINE) and PsycINFO, which includes psychology dissertation abstracts. The searches included all years included in the databases up to November 2006. For each database, a total of thirty-six searches were completed. In the first set of eighteen searches, the keyword "adherence" was paired with each of the following second keywords: "treatment," "strategies," "improve," "interventions," "education," and "medication." Each of these pairs was combined with the following third keywords: "child," "adolescent," and "pediatric." For the second set of eighteen searches, the word "compliance" was substituted for "adherence." This created a 2 x 6 x 3 search pattern. Additionally, a manual search was conducted of the 1990 to 2006 issues of journals which were expected to contain the most adherence intervention studies (i.e., *Journal of Pediatric Psychology*, *Pediatrics*, and *Children's Health Care*). The starting date of 1990 was selected because the majority of adherence intervention studies have been published in the last fifteen years (Peterson et al., 2003). Manual searches were also conducted using the reference section of Rapoff's literature review (1999), as well as other reviews (e.g., Lemanek et al., 2001). Solicitation letters were sent to the primary authors of studies to request additional data when effect sizes could not be calculated from published results. Only

studies or abstracts written in English were retained for review, because translation of non-English articles would have been prohibitively expensive and time consuming.

A total of 340 studies were collected using this search process. Of these studies, eighteen were dissertations. Dissertations were included in the literature review for several reasons. First, it is important for unpublished research to be included because of the possibility of publication bias, which is the tendency for authors not to submit and editors not to accept nonsignificant findings (Durlak, 2003). In fact, Lipsey and Wilson (1993) statistically proved the existence of this phenomenon in their large meta-analysis on psychological treatments by demonstrating that unpublished studies had similar but overall slightly lower effect sizes than published studies. Thus the inclusion of unpublished studies provides a better estimate of the true mean effect. The potential for publication bias can also be determined by comparing the effect sizes of these unpublished studies to those of the published studies, such that significant differences would suggest the possibility of a problematic publication bias (Greenhouse & Iyengar, 1994). Dissertations, compared to unpublished conference proceedings, can be considered to have been rigorously reviewed by a group of experts, similar to the peer-review system of journal articles. Additionally, the *Dissertation Abstract International* database facilitates a thorough search of this population of studies, whereas nothing similar exists for other areas of unpublished research.

Inclusion and Exclusion Criteria

To be included in the meta-analysis, a study had to meet the following criteria:

1. The study participants were diagnosed with a chronic illness. The following definition of chronic illness has been adopted by the World Health Organization (Sabaté, 2001) and was also used for this study: chronic illnesses "have one or more of the following characteristics: they are permanent, leave residual disability, are caused by nonreversible pathological alteration, require special training of the patient for rehabilitation, or may be expected to require a long period of supervision, observation or care" (Timmreck, 1982, p. 102). If the designation of an illness was in question (i.e., infectious, acute, or chronic), the Center for Disease Control and Prevention's website (www.cdc.gov) was consulted for their classification of the illness. This technique was used to exclude malaria, tuberculosis, and amblyopia.
2. The study was a treatment or intervention that used a systematic attempt to alter specific behaviors related to carrying out medical regimens. Medical regimens could include taking medications, following diets, and doing prescribed exercises. Adherence must be one of the primary aims of the study, not a secondary product of a self-management intervention. Self-management programs "attempt to provide individuals with chronic conditions the knowledge, skills, and self-efficacy necessary to take an active role in the management of their medical condition" by teaching or encouraging "self-monitoring, medication compliance, environmental

control, relaxation, and problem solving" (Meade, Creer, & Mahan, 2003, p. 165).

3. The study quantitatively measured adherence, so that the statistical effect of the intervention on adherence could be determined. For example, if health outcome data were included (i.e., emergency room visits, A1C results for diabetes), but there were no data about whether the medication was taken appropriately, then the study was not included.
4. The study sought to increase adherence in children, which was defined as people under the age of 21 years old. If the study included both children and adults, it had to provide separate data for the children to be included.

As mentioned previously, the initial literature search identified 340 potential studies for inclusion. All but 71 of these studies were excluded. Studies were excluded for the following reasons: self-management interventions (n = 52), not chronic illness (n = 50), inadequate data (n = 49), not an adherence intervention (n = 43), included adults (n = 28), correlational study (n = 21), review articles (n = 18), and data reported in another publication (i.e., dissertation data excluded because published later in a peer-reviewed journal; n = 8).

Coding

Two independent raters were trained to code information about study sample size and characteristics, study methodology, intervention types, outcome measures, and the statistics needed to compute effect sizes. One of these raters was the author of this meta-analysis (MG), and the other rater was a trained research assistant. Using

methods recommended by Stock (1994), ten studies were used to refine the coding system and train the raters. Discrepancies in the coding were resolved by discussing the criteria and refining them if necessary. For the couple of occasions that a discussion between the two raters was not adequate in resolving the uncertainty, Michael Rapoff, Ph.D., an expert in the field of adherence interventions, was consulted. Interrater reliability was determined by having both raters code 20% of the included studies. Kappa was calculated as a measure of agreement for categorical data and ranged from .96 to 1.0, with a mean kappa of .99, indicating a high level of rater agreement (Orwin, 1994). Intercoder correlation was used for continuous variables and ranged from .80 to 1.0, with a mean r^2 of .95, indicating a high level of rater agreement. See Appendix A for the coding form.

Intervention-Related Variables. The interventions were divided into four categories: (a) educational, (b) behavioral, (c) organizational, (d) psychological/other, (e) educational and behavioral, and (f) all other combinations. An intervention was coded as "educational" if information or teaching was provided about the chronic illness or medical regimen. "Behavioral" interventions used techniques to encourage adherence, shape adherent behaviors, or provide positive and negative consequences for adherence. "Organizational" interventions were those that used techniques the health care provider could implement to reduce barriers to adherence, such as reducing the complexity of the regimen. The "psychological/other" category included interventions for psychological diagnoses (e.g., depression) and family therapy that

was not primarily focused on the medical regimen, but were hypothesized to increase adherence.

Outcome-Related Variables. Outcome measures were coded into three categories: (a) direct measures, (b) indirect measures, and (c) subjective measures. The only direct measure of adherence included was blood or urine tests that indicated medication levels in the child. Indirect measures were those that measured regimen adherence in an objective way, including electronic medication monitors and pill counts. Subjective measures included self-report measures, medication use record keeping, and 24 hour recall. Health outcome data were also collected. Examples of health outcomes included pain ratings, functional disability, lung function tests, and health care utilization.

Methodology-Related Variables. Methodological variables were coded for two purposes. First, the quality of the reviewed literature is important to consider when making conclusions about the strength of the meta-analysis. Second, methodological features may be important moderators of the adherence outcomes (Durlak, 2003). The methodological variables that were coded for the purpose of this meta-analysis include type of publication (e.g., journal article, dissertation), treatment attrition rates, length of the treatment, type of research design (e.g., randomized control trial, within-subject, single subject), and nature of the control group (e.g., treatment as usual, alternative treatment).

Possible Moderator Variables. In order to include other variables that may influence outcomes, some variables were coded because of their potential as

moderators. These variables were chosen because previous research in adherence suggests that they may affect adherence rates and the efficacy of adherence interventions. These variables included the age, gender, ethnicity, and socioeconomic status of the participating children.

Effect Size Estimates

Because the outcome variables for this meta-analysis were inherently continuous and each study used different measures or scales, the recommended effect size (ES) estimate for this meta-analysis is the standardized mean difference effect size (Lipsey & Wilson, 2001). This ES, also known as the *d* statistic ES, was derived by dividing the difference between two groups (e.g., pre-post or treatment-control) by the pooled standard deviation. (See Appendix B for this equation and others used in this meta-analysis.) Lipsey and Wilson (2001) provided multiple equations which were used to derive the standardized mean difference ES from various types of outcome statistics that were reported by studies, including *F*-tests, *t*-tests, and correlations.

For small sample sizes, the standardized mean difference ES has been found to be upwardly biased, particularly for sample sizes under 20. Hedges (1981) developed a simple correction for this bias. Thus, for all studies in this meta-analysis that had samples sizes less than 20, this correction was used. Additionally, studies with larger sample sizes are considered to be a more precise reflection of the population ES. Thus, in order to weight for sample size, Durlak (2003) recommended weighting each ES by the inverse of its variance, using an equation derived by

Hedges and Olkin (1985). All of the ESs used in this meta-analysis were reported in weighted form.

Maintaining Independence. Independence within datasets is necessary for most statistical methods and also for maintaining the integrity of the conclusions drawn from a meta-analysis. Several steps were taken to maintain independence. First, if multiple articles were published using the same participants, these articles were combined and considered as one study. Second, the problem of multiple endpoints per study was considered. For example, many adherence interventions report several different types of outcome, such as self-report, electronic monitoring, and functional disability. In general, there are three ways to handle this situation (a) using generalized least squares approaches (see Gleser & Olkin, 1994), (b) selecting one of the effect sizes to represent each study, and (c) computing an average effect size for each study (Faith, Allison, & Gorman, 1996).

Although the generalized least squares approach accounts for the most within-study correlation and variance, this approach requires data that are not available for the adherence literature (e.g., the actual variance between two outcome measures). Additionally, this method is most robust when the studies all use the same treatments and outcome measures (Gleser & Olkin, 1994). Selecting an effect size to represent each study is potentially problematic because neither research nor expert consensus has concluded that one form of adherence outcome is a better reflection of true adherence than any other outcome measure. Additionally, the preferred method of measuring adherence outcomes differs depending on the chronic illness group, the

medication regimen, and the intervention type (Quittner et al., 2000). Thus, for the purpose of this meta-analysis, effect sizes were averaged within studies or within the subgroup being reported (i.e., the subjective measure effects).

Single-case Studies. Because single-subject designs are used in adherence intervention research to study relatively rare chronic illness groups and individualized or targeted interventions (Rapoff, 2001), single-case studies were included in this meta-analysis. For those studies that did not provide sufficient statistics for calculating effect size (e.g., means and standard deviations), measurements were taken from graphs to use as individual data points. Specifically, a ruler was used to measure the distance between each data point and the *x*-axis of the graph (Faith et al., 1996). Effect sizes were calculated by finding the difference between the baseline mean scores and treatment mean scores. When assuming equality of variance across baseline and treatment phase, this difference is divided by the pooled within-phase standard deviations (Busk & Serlin, 1992). This technique was used for this meta-analysis both because of its accepted validity and because it provides a statistic that can be compared with the other effect sizes obtained in this meta-analysis. However, even though all of the effect sizes used the same metric (*d*), group studies were not combined with single-case studies. This procedure was used because the two research designs provide fundamentally different estimates (i.e., within-person variation vs. averaged change data; Faith et al., 1996).

Two statistical models can be used to combine and summarize effect sizes: fixed-effects or random-effects. According to Hedges and Vevea (1998), the model

should be chosen based on the type of inference desired. Specifically, fixed-effects models only contain within-group sampling error estimates and thus, can only provide information about the studies included in the meta-analysis. On the other hand, random-effects models include both within-group sampling error and between-study error measurements. In other words, random-effects assume that the studies included in the meta-analysis are a random sample of all possible studies, and that the results of the meta-analysis can be generalized to other studies similar to those included in the analyses. Thus, the random-effects model was used in this meta-analysis whenever combining the results of multiple studies.

Homogeneity Testing

Homogeneity tests, using the *Q* statistic, were used to determine whether all of the effect sizes reflected the same population. In other words, the *Q* statistic established whether it is appropriate to group all of the studies into one analysis based on the assumption that they all estimate the same effect (Durlak, 2003). The *Q* statistic assesses whether the variability in the effect sizes is greater than expected based on chance and sampling error. This statistic is distributed as a chi square variable with degrees of freedom (*df*) equal to the number of studies minus one (Lipsey & Wilson, 2001). A nonsignificant *Q*-value indicates homogeneity.

The *Q* statistic can also be used to perform a statistical test which is analogous to an analysis of variance (ANOVA; Lipsey & Wilson, 2001). For this test, *Q* statistics are calculated for separate groupings of effect sizes (e.g., asthma and diabetes). Next, similar to ANOVAs, the within group homogeneity is compared to

the between group homogeneity. If the resulting *Q* statistic is nonsignificant, then the effect sizes for the two groups are significantly different.

Interpreting the Results

Two techniques were used to interpret the significance of the effect sizes. First, since the effect sizes used are *d* statistics, the generally accepted criteria for small (.20), medium (.50), and large (.80) effects were used (Cohen, 1988). These criteria have been empirically confirmed by Lipsey and Wilson (1993). Second, 95% confidence intervals (CI) were calculated for each group of effect sizes. If a CI included zero, then the effect size was considered not statistically significant.

Results

Description of Studies

Study Design Characteristics. Of the 71 included studies, 34 (48.6%) used a comparison group design (i.e., experimental versus control group), 17 (24.3%) used a within subject design (i.e., pre-post studies), and 19 (27.1%) used a single-subject design. Of the comparison group studies, the control group was assigned an alternative treatment in 11 studies (32.4%), treatment as usual in 20 studies (58.8%), and waitlist in 3 studies (8.8%). Because the single-subject design studies were analyzed separately from the other studies, the remainder of the study descriptions provides separate data for the single subject studies. Of the non-single-subject design studies (n = 51), 16 studies involved asthma (31.4%), 15 with type 1 diabetes (29.4%), 5 with CF (9.8%), 3 each with HIV/ AIDS or post-transplant (5.9%), 2 each with hyperlipidemia, JRA, and sickle cell disease (3.9% each), and one each with

epilepsy, hemophilia, and phenylketonuria (2.0% each). The percentage of attrition from the beginning of the study to the end of treatment was reported by 36 studies (70.6% of the studies), and attrition rates ranged from 0% to 49% (M = 13.3, SD = 12.8). Of the single-subject design studies (n = 19), 7 studies involved type 1 diabetes (36.8%), 3 each with JRA and CF (15.8% each), 2 with asthma (10.5%), and one each with epilepsy, lung disease, various rheumatic diseases, and sickle cell (5.3% each). See Tables 1 and 2 for a description of all included studies.

Nine (12.7%) of the included studies were dissertations. The dissertations had a weighted mean effect size of 0.49, with a 95% confidence interval of 0.26 - 0.72. The remaining published studies had a weighted mean effect size of 0.57, with a 95% confidence interval of 0.49 - 0.63. Although the dissertations had a slightly smaller mean effect size, both effect sizes are considered in the medium range. Additionally, the confidence intervals overlap considerably, suggesting that the dissertations do not represent a significantly different population of studies than the published studies. Thus, they were included in all subsequent analyses.

Demographic Characteristics. The mean age of the youth included in each study ranged from 2 to 15 years (M = 9.9, SD = 3.7). Thirty-eight studies provided information about the participating children's gender. The percentage of males ranged from 24% to 91% (M = 51.7, SD = 14.2). Only 22 studies (43%) reported quantifiable information about the ethnicity of the participants. Of these studies, the percentage of minority group participants ranged from 0% to 100% (M = 39.1, SD = 31.4). Fifteen studies (29.4%) reported the average time since diagnosis of a chronic illness for the

Table 1. Description of Studies Included in the Meta-Analysis

Authors	Diagnosis	Intervention Type	Mean Age	Months since Diag.	% of Males	% of Mino -rity	Outcome Measures	Regimen Targeted	Length of Treat- ment (days)	Attrition Rate
Bartlett, Lukk, et al. (2002)	Asthma	Educational, Behavioral				100	Electronic	Medication	28	0
Burkhart, Dunbar-Jacob, et al. (2002)	Asthma	Behavioral	9.6			2	Electronic	Medication	35	0
Chan, Callahan, et al. (2003)	Asthma	Educational, Behavioral	7.6		50		Diary, Refill	Medication	90	
Chaney, Clements, et al. (2004)	Asthma	Organizational	3.2	26.4	68.8		Parent report	Medication	14	0
Hederos, Janson, et al. (2005)	Asthma	Educational	2.3		60		Pill count	Medication	21	0
Iqbal, Ritson, et al. (2004)	Asthma	Organizational	1.9		91		Electronic	Medication	30	14
Joseph, Adams, et al. (2003)	Asthma	Organizational	7.7		50	4	Parent report, Diary	Overall Mgmt	1	7.6
*Kamps (2003)	Asthma	Educational, Behavioral	9		67	47	Electronic	Medication	56	25
LeBaron, Zeltzer, et al. (1985)	Asthma	Educational, Behavioral	10.6		74	17.3	Urine test, Child report, Physician report	Medication	90	
Marosi & Stiesmeyer (2001)	Asthma	Educational, Behavioral	12.9		76.2		Child report	Medication, Monitoring	180	19
Smith, Seale, et al. (1994)	Asthma	Educational, Behavioral, Organizational	7.4		60.2		Parent report	Medication	1	10.1

Table 1. Continued

Authors	Diagnosis	Intervention Type	Mean Age	Months since Diag.	% of Males	% of Mino -rity	Outcome Measures	Regimen Targeted	Length of Treat- ment (days)	Attrition Rate
Smith, Seale, et al. (1986)	Asthma	Educational, Behavioral, Organizational	10	85.2	43.3		Parent report	Medication	1	32.1
Tinkelman, Vanderpool, et al. (1980)	Asthma	Organizational	14		40		Pill count, Blood test	Medication	1	
van Es, Nagelkerke, et al. (2001)	Asthma	Educational, Behavioral	13.7	124.8	51.8		Self-report	Medication	365	23.2
Volvovitz, Dunenas - Meza, et al. (2000)	Asthma	Organizational	8.8				Self-report	Medication	42	
*Walders (2003)	Asthma	Educational, Behavioral, Organizational	7.4		69.8	88.9	Self-report	Medication	60	27
Goldbeck & Babka (2001)	CF	Educational, Behavioral	7	12	44		Child report, Diary	Medication, Overall Mgmt	90	0
Powers, Byars, et al. (2003)	CF	Educational, Behavioral					Diary	Diet	365	33
Stark, Bowen, et al. (1990)	CF	Educational, Behavioral	8.6		40	0	Diary	Diet	36	
Stark, Knapp, et al. (1993)	CF	Educational, Behavioral	5.6		33		Diary	Diet	168	0
Stark, Mulvihill, et al. (1996)	CF	Educational, Behavioral	6.8				Diary	Diet	35	
*Shope (1979)	Epilepsy	Educational, Behavioral	9		50	67	Blood test	Medication	14	23.9

Table 1. Continued

Authors	Diagnosis	Intervention Type	Mean Age	Months since Diag.	% of Males	% of Mino-rity	Outcome Measures	Regimen Targeted	Length of Treat-ment (days)	Attrition Rate
Greenan-Fowler, Powell, et al. (1987)	Hemophilia	Behavioral	11				Diary	Exercise	84	20
Berrien, Salazar, et al. (2004)	HIV/ AIDS	Educational, Behavioral	10.5		44	11	Parent report, Refill	Medication	90	8.1
Ellis, Naar-King, et al. (2006)	HIV/ AIDS	Educational, Behavioral, Organizational	11.3		62	84	Parent report	Medication	211	5
Shingadia, Viani, et al. (2000)	HIV/ AIDS	Organizational	2.9	34.8	35.3	83	Self-report	Medication	1	
Berg-Smith, Stevens, et al. (1999)	Hyper-lipidemia	Educational, Behavioral			50		24-hr recall	Diet	60	0
Lauer, Obarzanek, et al. (2000)	Hyper-lipidemia	Educational	9.4		54.6		24-hr recall	Diet	1095	11.2
Rapoff, Belmont, et al. (2002)	JRA	Educational, Behavioral	8.4		32	6.5	Electronic	Medication	300	37
Stark, Davis, et al (2006)	JRA	Educational, Behavioral	6.4		24.4		Diary	Diet	60	24.7
Gleason, Michals, et al. (1992)	Phenyl-ketonuria	Educational, Behavioral					Blood test	Diet	120	0
Berkovitch, Papadouris, et al. (1998)	Sickle Cell	Educational, Behavioral	3.1				Electronic	Medication	60	48.8
Treadwell, & Weissman (2001)	Sickle Cell	Educational, Affective	11.7				24-hr recall	Medication	4	

Table 1. Continued

Authors	Diagnosis	Intervention Type	Mean Age	Months since Diag.	% of Males	% of Mino -rity	Outcome Measures	Regimen Targeted	Length of Treat- ment (days)	Attrition Rate
Beck, Fennell, et al. (1980)	Transplant	Educational, Behavioral	14.6		48	38	Pill count	Medication	180	
Fennell, Foulkes, Boggs (1994)	Transplant	Educational, Behavioral	12		58.6	27.6	Pill count, Blood test	Medication	4	
*Foulkes-Jamison (1995)	Transplant	Educational, Behavioral	12			28	Pill count, Blood test	Medication		
*Barnard (1986)	Type 1 Diabetes	Educational, Behavioral, Organizational	12.7	52	25		Child report	Medication, Monitoring	45	
*Coupland (1992)	Type 1 Diabetes	Educational, Behavioral	14.6	68.6	48		Child report, Diary	Medication, Monitoring, Diet, Exercise	70	9
Delamater, Smith, et al. (1991)	Type 1 Diabetes	Educational, Behavioral	14.9	78	46.2	30.8	Child report, 24-hr recall	Overall Mgmt	60	18.8
Ellis, Frey, et al. (2005)	Type 1 Diabetes	Behavioral, Affective, Organizational					24-hr recall, Electronic	Medication, Monitoring, Diet	180	13
Francis, Grogan, et al. (1990)	Type 1 Diabetes	Behavioral, Affective	12			75	Diary	Monitoring		
Harris, Harris, et al. (2005)	Type 1 Diabetes	Behavioral, Affective		74.4	66.7	33.3	Parent report, Child report	Overall Mgmt	45	0
Howe, Jawad, et al. (2005)	Type 1 Diabetes	Educational, Organizational	12.1		53.7	48	Parent report	Overall Mgmt	180	

Table 1. Continued

Authors	Diagnosis	Intervention Type	Mean Age	Months since Diag.	% of Males	% of Mino -rity	Outcome Measures	Regimen Targeted	Length of Treat- ment (days)	Attrition Rate
Kumar, Wentzell, et al. (2004)	Type 1 Diabetes	Behavioral	13.6				Electronic	Monitoring	30	
Lawson, Cohen, et al. (2005)	Type 1 Diabetes	Educational, Organizational	15.2	6.5	56.5		Child report, Electronic	Medication, Monitoring, Diet, Overall Mgmt	180	0
Mendez & Belendez (1997)	Type 1 Diabetes	Educational, Behavioral	13.5	4.1	48		Self-report	Overall Mgmt	84	27
*Szumowski (1991)	Type 1 Diabetes	Educational, Behavioral	6	35	52.3		24-hr recall	Medication, Monitoring, Diet, Exercise	60	12.5
*Webb (2000)	Type 1 Diabetes	Behavioral	10.2	60	35	4.5	Parent report	Overall Mgmt	84	7.5
Wysocki, Green, & Huxtable (1989)	Type 1 Diabetes	Behavioral	14.3	68.4	56.7		Electronic	Monitoring	112	0
Wysocki, Harris, et al. (2000)	Type 1 Diabetes	Behavioral, Affective	14.1	66	54	42	Self-report	Overall Mgmt	168	16.1
Wysocki, Harris, et al. (2006) & Wysocki, Greco, et al. (2001)	Type 1 Diabetes	Behavioral, Affective	14.4		44.3	22.7	24-hr recall	Medication, Monitoring, Diet, Exercise, Overall Mgmt	90	3.7

Note: * indicates the publication is a dissertation.

Table 2. Description of Single-Subject Studies Included in the Meta-Analysis

Authors	**Diagnosis**	**Intervention Type**	**Mean Age**	**Months since Diagnosis**	**% Males**	**% Mino-rity**	**Outcome Measures**	**Regimen Targeted**	**Length of Treatment (days)**
da Costa, Rapoff, et al. (1997)	Asthma	Educational, Behavioral	9		50		Electronic	Medication	32
*Spaulding (2001)	Asthma	Behavioral	12.4		20		Electronic	Medication	40
*Bernard (2005)	CF	Educational, Behavioral	10.7		0		Electronic, Diary	Exercise	75
Hagopian & Thompson (1999)	CF	Behavioral	8		100		Diary	Medication	
Piazza-Waggoner, Ferguson, et al. (2006)	CF	Educational, Behavioral	1.8		0		Diary	Diet	96
Amari, Grace, et al. (1995)	Epilepsy	Behavioral	15		0		Diary	Diet	51
Rapoff, Lindsley, et al. (1984)	JRA	Behavioral	7	48	0		Diary	Medication, Overall Mgmt	112
Rapoff, Purviance, et al (1988a)	JRA	Educational, Behavioral	8.7	25	0		Pill count	Medication	1
Rapoff, Purviance, et al (1988b)	JRA	Behavioral, Organizational	14	25	100		Pill count	Medication	105
Reimers, Piazza, et al. (1998)	Pulmonary disease	Behavioral	2.7		100		Diary	Medication	
Pieper, Rapoff, et al. (1989)	Rheumatic diseases	Educational, Behavioral	15.3		0	100	Pill count	Medication	1
Gorski, Slifer, et al. (2004)	Sickle Cell	Educational, Behavioral	14		100	100	Diary	Overall Mgmt	

Table 2. Continued

Authors	Diagnosis	Intervention Type	Mean Age	Months since Diagnosis	% Males	% Mino-rity	Outcome Measures	Regimen Targeted	Length of Treatment (days)
Carney, Schechter, et al. (1983)	Type 1 diabetes	Educational, Behavioral	11.6	80	66	0	Diary	Monitoring	60
Gross (1983)	Type 1 diabetes	Educational, Behavioral		100			Diary	Monitoring	
Gross, Magalnick, et al. (1985)	Type 1 diabetes	Behavioral	11.4	57.6	42.8		Diary	Medication, Monitoring	56
Lowe & Lutzker (1979)	Type 1 diabetes	Educational, Behavioral	9		0		Diary	Monitoring, Diet, Overall Mgmt	50
Schafer, Glasgow, et al. (1982)	Type 1 diabetes	Behavioral	17.3	6.7	33		Diary	Medication, Monitoring, Exercise, Overall Mgmt	84
Silverman, Haines, et al. (2003)	Type 1 diabetes	Behavioral	14.3		83.3	0	24-hr recall, Electronic	Medication, Monitoring, Diet	42
Snyder (1987)	Type 1 diabetes	Behavioral	14	96	100		Diary	Overall Mgmt	49

Note: * indicates the publication is a dissertation.

children in the study. Time since diagnosis ranged from 4 to 125 months (M = 53.0, SD = 33.4). Eighteen studies (35.3%) provided information about socioeconomic status (SES) of the included samples, but SES was based on a wide range of indices (e.g., Hollingshead index, parental income, etc.). Because so few studies provided SES information and the information was so varied, these data were not aggregated or used in any analyses.

Demographic Characteristics – Single Subject. The mean age of the youth included in each single subject study ranged from 2 to 17 years (M = 11.0, SD = 4.3). All of the studies provided information about the participants' gender. The percentage of males ranged from 0% to 100% (M = 47.1, SD = 44.1). Only 4 studies (21%) reported information about the ethnicity of the participants. Two studies had 0% minority participants and two studies had 100% minority participants. Seven studies (36.8%) reported the average time since diagnosis of a chronic illness for the children in the study. Time since diagnosis ranged from 7 to 96 months (M = 48.3, SD = 32.1). None of the studies provided information about the socioeconomic status (SES) of the included samples.

Intervention Characteristics. Almost half of the studies utilized a combined educational and behavioral treatment techniques (n = 24, 47.0%). About one fourth utilized a single approach: organizational (n = 6, 11.8%), behavioral (n = 5, 9.8%), and educational (n = 2, 3.9%). The remainder of the studies (n = 13, 25.4%) used a variety of combinations (i.e., organizational and educational, psychological and

educational, etc.). The length of the treatments ranged from 1 to 1095 days (M = 167.5, SD = 109).

Intervention Characteristics – Single Subject. Almost half of the single subject studies utilized a combined educational and behavioral treatment technique (n = 9, 47.4%). The same number of studies utilized a behavioral approach alone (n = 9, 47.4%). Only one study (5.3%) used another combination (i.e., behavioral and organizational). The length of the treatments ranged from 1 to 112 days (M = 56.9, SD = 33.2).

Non-independent Data. Because studies could focus on more than one aspect of a medical regimen (i.e., diet and medication) and could include multiple outcome measures, the following data are not independent and were considered as such in subsequent analyses. The regimens targeted in the non-single subject studies included: medication (n = 32, 46.4%), diet (n = 13, 18.8%), overall disease management (n = 10, 14.5%), monitoring (n = 10, 14.5%), and exercise (n = 4, 5.8%). Adherence was measured primarily through subjective methods (n = 40, 63.5%). These data were obtained through child report (n = 14), parent report (n = 9), diary (n = 9), and 24-hour recall (n = 8). Twenty-seven percent of the data (n = 17) were derived from indirect measures (electronic monitor, n = 10; pill count, n = 7). The remainder of the data was from direct measures (i.e., blood and urine tests; n = 6, 9.5%).

Non-independent Data – Single Subject. The regimens targeted by the single subject studies included: medication (n = 11, 34.4%), monitoring (n = 9, 28.1%),

overall disease management (n = 5, 15.6%), diet (n = 4, 12.5%), and exercise (n = 3, 9.4%). Adherence data were obtained primarily through diary methods (n = 23, 71.9%). The remainder of the data was obtained through electronic monitoring (n = 4, 12.5%), pill count (n = 3, 9.4%), and 24-hour recall (n = 2, 6.3%).

Follow-up and Health Outcome Data. Of the included studies, 10 (19.6%) included follow-up adherence data. The average length of follow-up was 8 months, with a range from 3 to 13 months. Thirty-one studies (60.8%) included health outcome data. Most of the health outcome data were direct measures (n = 27, 56.3%), which included A1C (n = 15), body mass index (BMI; n = 6), and pulmonary function tests (PFT; n = 6). The remainder of the health outcome data included disease activity estimates (n = 13, 27.1%), healthcare utilization (n = 4, 8.3%), and quality of life measures (n = 4, 8.3%). Of the studies that included health outcome data, 13 provided follow-up health outcome data. Length of follow-up ranged from 0.5 to 24 months, with a mean of 9.2 months. This follow-up data were derived from A1C (n = 7), BMI (n = 3), PFT (n = 4), and disease activity estimates (n = 3).

Follow-up and Health Outcome Data – Single Subject. Most of the single subject studies (n = 14, 70.0%) included follow-up adherence data. Seven studies (35.0%) included health outcome data. The health outcome data included A1C (n = 3), PFT (n = 3), quality of life (n = 2), BMI (n = 1), and disease activity estimates (n = 1). Of the studies that included this data, four provided follow-up health outcome data. The follow-up data were derived from A1C (n = 2), PFT (n = 2), and disease activity estimates (n = 1).

Adherence Outcomes

The weighted-mean effect across all of the adherence outcomes was in the medium range (Mean *d* = .58, 95% confidence interval (CI) = 0.51 – 0.65). However, there was a significant amount of heterogeneity among the effect sizes (*Q* = 194.96, see Table 3), suggesting that the overall mean effect size combines data that likely do not represent the same phenomena. Thus, in order to appropriately interpret these data, they should be broken down into meaningful groups so as to attempt to gain homogeneity (Durlak, 2003). Weighted mean effect sizes and *Q* statistics of homogeneity are presented for potential moderators in Tables 3, 4, 5, 6, and 7. The *Q* statistic was also used to evaluate between group homogeneity in order to determine whether the moderator groups represented statistically significant different effect sizes.

Heterogeneity continues to be a problem in the data, particularly when the data are divided by methodological design and diagnostic group. Some homogeneity emerges when the effect sizes are divided by intervention type, suggesting that this may be a meaningful way to interpret the results. Specifically, the studies using a single intervention method had higher mean effect sizes (Educational only: Mean *d* = .56, Behavioral only: Mean *d* = .51, Organizational only: Mean *d* = .50) than the studies with Combined Educational and Behavioral interventions (Mean *d* = .36). By this grouping, the strongest mean effect sizes were in studies using all other combinations (Mean *d* = .76). However, a follow-up analysis of between group differences was

Table 3. Effect Size Estimates

	# of Effect Sizes	Mean effect size	95% Confidence Interval	*Q*	Between Group *Q*
All Adherence Effects	51	0.58	0.51 – 0.65	194.96**	
Methodological Design					-12.3
Pre-post	17	0.59	0.46 – 0.73	76.34**	
Experimental vs. Control	34	0.53	0.45 – 0.61	130.92**	
Diagnosis					-9.83
Asthma	16	0.58	0.47 – 0.69	136.22**	
Type 1 Diabetes	15	0.42	0.26 – 0.58	32.19**	
Others combined	19	0.57	0.45 – 0.69	36.38**	
Intervention Type					2.07
Educational only	2	0.56	0.41 – 0.72	0.07	
Behavioral only	5	0.51	0.22 – 0.80	5.15	
Organizational only	6	0.50	0.35 – 0.66	13.70*	
Educational and Behavioral	24	0.36	0.22 – 0.51	33.74	
Others combined	13	0.76	0.61 – 0.90	140.23**	
Control Type					8.18*
Alternative Treatment	11	0.43	0.29 – 0.57	3.15	
Treatment As Usual	20	0.56	0.46 – 0.66	118.64**	
Waitlist	3	1.09	0.64 – 1.54	0.95	

*$p < .05$, **$p < .01$, + indicates data are not independent, so between group *Q* cannot be calculated.
Note: *Q* scores that are statistically significant indicate heterogeneity in effect size grouping.

Table 3. Effect Size Estimates Continued

	# of Effect Sizes	Mean effect size	95% Confidence Interval	*Q*	Between Group *Q*
Regimen Type					+
Diet	13	0.48	0.37 – 0.60	50.13**	
Exercise	4	0.22	-0.12 – 0.55	8.06*	
Medication	32	0.59	0.50 – 0.68	188.54**	
Overall Disease Management	10	0.33	0.14 – 0.52	20.74*	
Monitoring	10	0.11	-0.07 – 0.28	63.71**	
Outcome Type					+
Direct Measures (blood/ urine)	6	0.20	-0.08 – 0.48	7.58	
Indirect Measures	17	0.56	0.40 – 0.72	15.51	
Pill count	7	0.60	0.34 – 0.86	8.08	
Electronic monitor	10	0.49	0.28 – 0.70	5.24	
Subjective Measures	40	0.56	0.48 – 0.63	562.79**	
Child report	14	0.35	0.24 – 0.47	38.78**	
Parent report	9	1.57	1.35 – 1.79	401.97**	
Diary	9	0.54	0.23 – 0.84	14.60	
24-hour recall	8	0.45	0.33 – 0.57	16.83*	

*$p < .05$, **$p < .01$, + indicates data are not independent, so between group *Q* cannot be calculated.
Note: *Q* scores that are statistically significant indicate heterogeneity in effect size grouping.

Table 4. Follow-up Adherence Effects

	# of Effect Sizes	Mean effect size	95% Confidence Interval	*Q*	Between Group *Q*
All Follow-up Adherence Effects	10	0.48	0.28 – 0.69	20.22*	
Methodological Design					0.10
Pre-post	4	0.56	0.04 – 1.07	17.36**	
Experimental vs. Control	6	0.47	0.25 – 0.69	2.76	
Diagnosis					1.02
Type 1 Diabetes	4	0.38	0.10 – 0.66	4.69	
Others combined	6	0.59	0.30 – 0.89	14.51*	
Intervention Type					-0.67
Educational only	6	0.64	0.35 – 0.93	19.42**	
Others combined	4	0.58	0.34 – 0.82	1.47	
Control Type					0.75
Alternative Treatment	2	0.61	0.22 – 0.99	0.67	
Others combined	4	0.40	0.12 – 0.67	1.34	
Regimen Type					+
Diet	4	0.86	0.35 – 1.38	15.47**	
Exercise	3	0.79	0.19 – 1.38	2.59	
Medication	2	0.47	0.09 – 0.85	0.002	
Overall Disease Management	6	0.27	0.03 – 0.51	7.85	

*$p < .05$, **$p < .01$, + indicates data are not independent, so between group *Q* cannot be calculated

Table 4. Follow-up Adherence Effects Continued

	# of Effect Sizes	Mean effect size	95% Confidence Interval	*Q*	Between Group *Q*
Outcome Type					+
Child report	3	0.22	-0.11 – 0.54	3.06	
Parent report	3	0.35	0.01 – 0.70	4.67	
Diary	7	0.83	0.44 – 1.22	18.09**	

*$p < .05$, **$p < .01$, + indicates data are not independent, so between group *Q* cannot be calculated

Table 5. Health Outcome Effect Sizes

	# of Effect Sizes	Mean effect size	95% Confidence Interval	*Q*	Between Group *Q*
All Health Outcome	31	0.40	0.31 – 0.50	182.40**	
Methodological Design					68.82**
Pre-post	8	1.27	1.05 – 1.50	45.23**	
Experimental vs. Control	23	0.22	0.12 – 0.32	68.35**	
Diagnosis					28.46**
Asthma	7	0.86	0.67 – 1.05	59.20**	
Type 1 Diabetes	15	0.29	0.13 – 0.45	47.58**	
Others combined	9	0.24	0.10 – 0.39	47.16**	
Intervention Type					24.69**
Educational or Behavioral only	5	0.16	0.02 – 0.30	6.20	
Educational and Behavioral	15	0.74	0.55 – 0.94	69.37**	
Others combined	11	0.50	0.34 – 0.66	82.14**	
Control Type					-53.44
Alternative Treatment	10	0.43	0.29 – 0.57	3.15	
Treatment As Usual	11	0.56	0.32 – 0.80	118.64**	

*$p < .05$, **$p < .01$, + indicates data are not independent, so between group *Q* cannot be calculated

Table 5. Health Outcome Effect Sizes Continued

	# of Effect Sizes	Mean weighted effect size	95% Confidence Interval	*Q*	Between Group *Q*
Regimen Type					+
Diet	13	0.18	0.07 – 0.29	88.00**	
Medication	22	0.61	0.49 – 0.73	208.42**	
Overall Disease Management	6	0.26	0.01 – 0.51	14.36*	
Monitoring	7	0.36	0.16 – 0.55	2.85	
Outcome Type					
Direct Measures	27	0.18	0.10 – 0.27	66.46**	
A1C	15	0.28	0.12 – 0.44	47.63**	
Body Mass Index	6	0.10	-0.05 – 0.26	14.65*	
Pulmonary Function Test	6	1.01	0.74 – 1.28	23.71**	
Indirect Measures	13	0.70	0.57 – 0.84	191.16**	
Healthcare Utilization	4	1.41	1.01 – 1.80	16.39**	
Subjective Measures	4	0.24	-0.09 – 0.57	0.48	

*$p < .05$, **$p < .01$, + indicates data are not independent, so between group *Q* cannot be calculated

Table 6. Health Outcome Follow-up Effect Sizes

	# of Effect Sizes	Mean effect size	95% Confidence Interval	*Q*	Between Group *Q*
All Health Outcome Follow-up	13	0.36	0.16 – 0.56	24.02*	
Methodological Design					0.01
Pre-post	8	0.36	0.13 – 0.58	18.91**	
Experimental vs. Control	5	0.38	-0.06 – 0.82	5.10	
Diagnosis					6.48
Type 1 Diabetes	8	0.18	-0.06 – 0.42	7.37	
Others combined	5	0.73	0.38 – 1.08	10.17*	
Intervention Type					1.04
Educational only	7	0.51	0.16 – 0.85	15.59*	
Others combined	6	0.29	0.04 – 0.53	7.39	
Control Type					-10.18
Alternative Treatment	4	0.60	0.26 – 0.94	12.17**	
Others combined	4	0.16	-0.13 – 0.46	3.12	
Regimen Type					+
Diet	6	0.60	0.21 – 0.99	51.67**	
Medication	3	0.61	0.20 – 1.01	2.43	
Overall Disease Management	7	0.09	-0.16 – 0.33	1.34	

*$p < .05$, **$p < .01$, + indicates data are not independent, so between group *Q* cannot be calculated

Table 6. Health Outcome Follow-up Effect Sizes Continued

	# of Effect Sizes	Mean effect size	95% Confidence Interval	*Q*	Between Group *Q*
Outcome Type					+
Direct Measures	14	0.17	-0.01 – 0.34	13.75	
A1C	7	0.17	-0.08 – 0.42	6.90	
Body Mass Index	3	0.11	-0.40 – 0.62	0.92	
Pulmonary Function Test	4	-0.35	-1.02 – 0.32	4.81	
Disease Activity	3	1.01	0.62 – 1.40	32.28**	

*$p < .05$, **$p < .01$, + indicates data are not independent, so between group *Q* cannot be calculated

Table 7. Single Subject Effect Sizes

	# of Effect Sizes	Mean effect size	95% Confidence Interval	*Q*	Between Group *Q*
All Single Subject Adherence	20	1.53	1.07 – 1.98	9.94	
Intervention Type					0.63
Behavioral only	9	1.41	0.81 – 2.01	5.01	
Educational and Behavioral	9	1.74	1.01 – 2.46	4.30	
Single Subject Follow-up	14	1.44	0.99 – 1.89	21.85	
Single Subject Health Outcome	7	0.74	0.19 – 1.29	8.05	
Single Subject Health Outcome Follow-up	4	0.87	0.17 – 1.58	0.41	

*$p < .05$, **$p < .01$

not significant, suggesting that these differences in mean effect size are not statistically significant.

Among the studies using a comparison control group methodological design, the data exhibited some homogeneity and significant between group differences. Specifically, studies using a waitlist design had a significantly stronger mean effect size (Mean *d* = 1.09) than those using an alternative treatment (Mean *d* = .43) or treatment as usual (Mean *d* = .56). There was also some homogeneity when the data were organized by outcome type. The effect sizes were homogeneous within direct (i.e., blood/ urine tests) and indirect (i.e., pill count and electronic monitoring) measures, but not within the subjective measures (i.e., child and parent report). Interestingly, when direct measures are used to measure adherence, the mean effect size suggests that adherence interventions are not successful at increasing adherence, as indicated by the confidence interval, which includes zero.

Heath Outcome Effect Sizes. The weighted-mean effect across all of the health outcomes was in the medium range (Mean *d* = .40, 95% CI = 0.31 – 0.50). However there was a significant amount of heterogeneity, suggesting that the overall mean effect size is not an appropriate way to represent the average effectiveness of adherence interventions on health outcomes. Thus the data were divided into groups based on potential moderators. On doing so, several trends emerge. Specifically, health outcome measurements from studies using a pre-post design had a stronger mean effect size (Mean *d* = 1.27) than the studies using a comparison group design (Mean *d* = .22). Additionally, positive health outcomes were stronger in studies

focused on children with asthma (Mean *d* = .86) compared to those targeting children with Type 1 diabetes (Mean *d* = .29) or those targeting other diagnoses (Mean *d* = .24). Finally, different than the adherence outcome effect sizes, the health outcome data indicated the strongest results from studies using a combination of educational and behavioral interventions (Mean *d* = .74) and single intervention-type studies had the weakest results (Mean *d* = .16).

Follow-up Effect Sizes. The weighted-mean effect across all of the follow-up adherence data was in the medium range (Mean *d* = .48, 95% CI = 0.28 – 0.69). However, there was a significant amount of heterogeneity, suggesting that the overall mean effect size is not an appropriate way to interpret the long term effectiveness of adherence interventions. Thus, the data were divided into groups based on potential moderators. Overall, there was some homogeneity in these data, but no significant between group differences. The best way to understand these data may be to consider the regimen component measured. Specifically, the strongest follow-up mean effect size was in adherence to diet (Mean *d* = .86). The next strongest adherence effects were in exercise regimens (Mean *d* = .79) and medication regimens (Mean *d* = .47). The weakest follow-up mean effect size was in overall disease management (Mean *d* = .27).

Health Outcome Follow-up Effect Sizes. The weighted-mean effect across all of the follow-up health outcome data was in the medium range (Mean *d* = .36, 95% CI = 0.16 – 0.56). However there was a significant amount of heterogeneity, suggesting that the overall mean effect size is not an appropriate way to evaluate the

average long term ability of adherence interventions to change health outcomes. Thus, the data were divided into groups based on potential moderators. There was some homogeneity in all of the different ways the data were grouped. There was both homogeneity and between group significant differences when the data were divided by diagnostic group, such that health outcome long-term follow-up was not significant for Type 1 diabetes (Mean d = .18, 95% CI = -0.06 – 0.42) whereas the long term health outcome data were significant and strong for other diagnostic groups (Mean d = .73).

Single Subject Effect Sizes. The weighted-mean effect across all of the single subject adherence data was in the large range (Mean d = 1.53, 95% CI = 1.07 – 1.98). This effect size is homogeneous, so it can be considered an appropriate estimate of the average effectiveness of single subject adherence interventions. The weighted-mean effect of the single subject follow-up adherence data was also in the large range (Mean d = 1.44, 95% CI = 0.99 – 1.89) and homogeneous. The single subject health outcome mean effect was in the large range (Mean d = 0.74, 95% CI = 0.19 – 1.29) and homogeneous. The follow-up single subject health outcome mean effect was in the large range (Mean d = 0.87, 95% CI = 0.17 – 1.58) and homogeneous.

Other Moderating Variables. Correlations were calculated between the effect sizes and various potential moderating variables. See Table 8 for a list of all correlations. Most of the correlations were not statistically significant. However, the percentage of males included in the study was significantly negatively correlated with adherence (r^2 = -.34) and health outcome (r^2 = -.38) effect sizes. In other words, the

Table 8. Correlations between Study Effect Sizes (ES) and Moderating Variables

Correlated variables	r^2	Significance
Overall Adherence Data		
ES: Mean Age	-.12	$t(43) = -0.82$
ES: Attrition Rate	.06	$t(33) = 0.34$
ES: Time since Diagnosis	-.09	$t(13) = -0.34$
ES: % of Males	-.34	$t(35) = -2.12$*
ES: % of Minority	-.14	$t(22) = -0.61$
ES: Length of Treatment	-.14	$t(46) = -0.97$
Follow-up Data		
ES: Mean Age	-.28	$t(7) = -0.77$
ES: Attrition Rate	-.32	$t(7) = -0.9$
ES: % of Males	-.32	$t(6) = -0.83$
ES: Length of Treatment	-.13	$t(8) = -0.36$
ES: Length of Follow-up	-.07	$t(8) = -0.21$
Health Outcome Data		
ES: Mean Age	-.06	$t(26) = -0.31$
ES: Attrition Rate	.42	$t(23) = 2.13$*
ES: Time since Diagnosis	-.10	$t(9) = -0.31$
ES: % of Males	-.38	$t(24) = -2.04$*
ES: % of Minority	.06	$t(12) = 0.06$
ES: Length of Treatment	-.05	$t(28) = -0.26$
Health Outcome Follow-up		
ES: Mean Age	-.27	$t(10) = -0.90$
ES: Attrition Rate	.24	$t(8) = 0.70$
ES: % of Males	-0.56	$t(10) = -2.13$
ES: Length of Treatment	-.17	$t(10) = -0.17$
ES: Length of Follow-up	.61	$t(11) = 0.61$
Single Subject Data		
ES: Mean Age	-.15	t(16) = -0.59
ES: % of Males	-.12	t(17) = -0.51
ES: Length of Treatment	.36	t(13) = 1.41
Single Subject Follow-up Data		
ES: Mean Age	-.22	t(11) = -0.73
ES: Attrition Rate	.41	t(12) = 1.54
ES: Length of Treatment	.71	t(10) = 3.16*

*$p < .05$, **$p < .01$

more males in the study the less effective the intervention was at increasing adherence or improving health outcomes. However, this correlation did not remain significant in the follow-up data. Attrition rate was significantly correlated with health outcome effect size (r^2 = .42), such that the higher the attrition, the better the health outcomes. Additionally, the length of treatment was significantly correlated with effect size in single subject follow-up data (r^2 = .71). So, as the treatment length increased, the effectiveness of the intervention at follow-up increased.

Fail-Safe N-statistic

As recommended by Begg (1994), in order to evaluate the possible problem of publication bias, Rosenthal's "file drawer" statistic was calculated (Rosenthal, 1991). This statistic provides a number of null result studies that would be needed to make the overall weight-mean effect size no longer significant. Rosenthal's statistic suggests that overall mean effect size of this meta-analysis (Mean *d* = .58, 95% CI = 0.51 – 0.65) is likely not the result of publication sampling bias, because 245,400 null result studies would have to be in "file drawers" to reduce this effect size to a non-significant result.

Discussion

The results of this meta-analysis suggest that adherence interventions not only increase adherence, but also generally lead to improved health outcomes, both at the completion of the intervention and at follow-up. That is, overall, the effect size analyses are very positive and suggest that interventions for children with chronic illnesses are generally effective at increasing adherence to treatment regimens. In

fact, the medium level effect sizes are maintained at follow-up. The health outcome analyses are also promising. Methodological variables seem to have some effect on the effect size estimates of studies. Specifically, effect sizes were significantly higher when studies used waitlist control groups, compared to alternative treatments or treatment as usual. Additionally, effect sizes differed depending on the outcome measured used, such that direct measures of adherence actually showed no significant positive effect on adherence and parent reported data showed the most significant effects.

The health outcome analyses revealed some interesting trends. Specifically, interventions targeting asthma regimen adherence had significantly better health outcomes than those interventions targeting children with type 1 diabetes or other diagnoses. Additionally, health outcomes were significantly better when interventions used a combined educational and behavioral approach, compared to using a single behavioral or educational approach. This finding is particularly interesting because the combined educational and behavioral treatments did not appear to be significantly different than other techniques at increasing adherence. The follow-up adherence and health outcome results are difficult to interpret due to the small number of studies that provided this information, which led to low homogeneity and few between group differences.

Most attempts to summarize the information by combining the data into single effect size estimates were hampered by significant levels of heterogeneity (except in the case of single-subject studies). Heterogeneity persisted even when the effect sizes

were divided in ways that were suggested by previous research to be meaningful. This heterogeneity does not indicate that the mean effect size estimates are meaningless, but does cast serious doubt on the usefulness of combining all adherence intervention research as though it represented a single construct. For example, the tasks required for children and families to successfully follow asthma treatment regimens are quite different than the tasks required to correctly follow cystic fibrosis treatment regimens. Even within the asthma adherence literature, there are differences between the structure of interventions necessary to help a family with a preschool aged child with asthma and those families with an adolescent with asthma (Graves, Adams, & Portnoy, 2006). On the other hand, research in any given area of adherence likely is somewhat generalizable. For example, understanding gained about enhancing adherence in diabetes can inform research about increasing adherence to post-transplant medications. However, attempting to evaluate what the important factors are in successful adherence interventions by combining all disease types with all regimen types and all age groups seems to create too much variance and thus make it difficult to come to any useful conclusions.

As further illustration of this point, it is noted that there were no problems with heterogeneity in the single-subject studies. An examination of the characteristics of these studies suggests some possible reasons. First, variance in the type of intervention was much smaller in the single-subject designs, because almost half of the studies used behavioral techniques alone and almost all of the other studies used educational and behavioral techniques combined. In the non-single-subject studies,

although almost half used combined educational and behavioral, the other half included a wide range of other techniques. The single-subject studies had a similarly lower variance in the kinds of outcome assessment techniques used and the diagnoses of the included children. Thus, overall mean effect size estimates appear to be more meaningful when there is less variance in the characteristics of the included studies.

Previous Research

Some significant methodological differences exist between this meta-analysis and the Kahana et al. (2008) meta-analysis. Kahana et al. (2008) excluded most single subject design studies and did not consider health outcome data. By including this information into this current meta-analysis, some unique and important information was provided about adherence intervention outcomes. Other differences include different sampling techniques and exclusion criteria, which created differences in the studies that were included in the two meta-analyses. Additionally, in the Kahana et al. (2008) meta-analysis some studies contributed more than one effect size to aggregate mean effect size. Thus, instead of combining all effect sizes in a study, Kahana et al. (2008) opted to separate some outcome statistics in specific circumstances, such as when the outcomes measured different adherence constructs (leading to 90 independent effect sizes, although only 70 studies were included). Despite these differences potentially affecting results, the general conclusions are the same. First, adherence interventions are generally successful at increasing adherence (overall adherence ES for this meta-analysis = 0.58, 95% CI = 0.51 – 0.65; Kahana et al. overall adherence ES = 0.34, 95% CI = 0.30–0.38). Second, methodological and

participant characteristics seem to have an effect on intervention effectiveness. Third, a significant amount of heterogeneity exists in the data.

These general conclusions can also be drawn when comparing this meta-analysis to those conducted on adult or acutely ill populations. For example, combination intervention techniques have strong results in this and other meta-analyses, especially when compared to single-type interventions (Kahana et al., 2008; Roter et al., 1998; Wu & Roberts, 2008). Additionally, direct measures of adherence consistently show smaller effect sizes when compared to indirect methods of assessment (DiMatteo, 2004; Roter et al., 1998; Wu & Roberts, 2008). Finally, all of the meta-analyses that reported heterogeneity statistics also reported that, not only was the total effect-size estimate not homogeneous, neither were most of the other effect-size estimates (Kahana et al., 2008; Peterson et al., 2003; Wu & Roberts, 2008).

Clinical Implications

By reviewing multiple meta-analyses on similar topics, a pattern begins to emerge about adherence interventions. Although the presence of significant heterogeneity suggests that conclusions should be drawn cautiously, some clinical recommendations can be posited from the areas in which multiple meta-analyses seem to agree. First, similar to the conclusions drawn from literature reviews (i.e., Rapoff, 1999; Lemanek et al., 2001), the evidence appears to be that adherence interventions are most successful when utilizing multiple approaches (e.g., educational and organizational, or behavioral and organizational). Additionally, direct

measures of adherence sometimes provide significantly different data than indirect or subjective measures. Thus, whenever possible, clinicians should utilize direct measures of medication use (e.g., blood titers) to understand a patient's mediation taking behaviors and evaluate the effectiveness of adherence treatment. Finally, since participant characteristics (e.g., age, gender, diagnosis) seem to significantly impact the effectiveness of adherence interventions overall, it is likely necessary for clinicians to considers these characteristics and adapt interventions to meet the specific needs of each patient.

Future Directions

Based on the results of this meta-analysis, some recommendations can be made for future research. First, in order to provide useful information about what kinds of adherence interventions are most effective, basic research on adherence interventions will need to continue. As the research base grows, then more focused meta-analyses can be conducted that evaluate specific areas of adherence interventions, such as interventions for adolescents with asthma or school-age children with diabetes.

Second, the ability to summarize and evaluate research would be significantly enhanced if important data were uniformly reported in all intervention research, such as by using guidelines for the Consolidated Standards of Reporting Trials (CONSORT; Moher, Schultz, & Altman, 2001). Fortunately, recent efforts by editors to encourage authors to include important methodological and demographic information appear to be having positive effects. Specifically, a review of articles in

pediatric and clinic psychology journals published in 2005 compared to 1997, showed significant improvement in the reporting of demographic, methodology, and ethical details (Raad, Bellinger, McCormick, Roberts, & Steele, 2008). However, progress is still needed. For example, in the *Journal of Pediatric Psychology*, almost 10% of articles did not report the gender of their participants and more than 30% did not report the SES.

When considering adherence intervention research, particularly important data to report include: demographic information about study participants (i.e., ethnicity, SES, gender), information about the medical conditions of study participants (i.e., time since diagnosis, severity of disease, comorbid conditions), and intervention or treatment variables (i.e., attrition rate, length or intensity of treatment). (See more suggestions in Kahana et al., 2008.) Additionally, because the health outcome data provided some different results than the adherence data, assessing health outcomes appears to be an important way to evaluate the effectiveness of adherence interventions and should be included in intervention research. Because different results were also obtained depending on the measure of adherence used, researchers are encouraged to follow recommendations made previously by Quittner et al. (2000) and measure adherence using multiple methods from multiple sources. However, the most significant differences in effect sizes appeared in this meta-analysis when direct measures of adherence were compared to the effect sizes of all other assessment techniques. Thus, efforts should be made to include direct measures, such as blood

medication titers, whenever possible because these data appear to provide unique information about adherence (Rapoff, 1999).

Limitations

As discussed in length previously, the results of this meta-analysis, especially overall effect sizes, should be interpreted with caution due to the high levels of heterogeneity in the data. Additionally, because many studies did not include information that was used for evaluating the effects of moderators, some of the analyses were conducted with only a small percentage of the overall studies. (For example, the correlation between study effect size and length of treatment only included 13 studies.) Thus, some of those results may not be accurate reflections of the whole field of adherence intervention research. However, this lack of important study information was true of most pediatric and child psychology research from the time most of these studies were published (mean year of publication = 1996, median year of publication = 1999). For example, in a review of all empirical articles published in 1997 in four pediatric and child psychology journals, it was discovered that 13.8% of the articles did not include gender information and 71.9% not report attrition (Sifers, Puddy, Warren, & Roberts, 2002). In the included studies for this meta-analysis, 25% did not report gender of participants and 29.4% did not report attrition. Finally, it is unclear whether the different methodological decisions made for this meta-analysis constitute limitations compared to other adherence intervention meta-analyses.

In summary, this meta-analysis provides important information on the current state of adherence intervention research. Adherence interventions appear to be generally effective. However, adherence intervention research includes such a wide variety of chronic conditions, intervention techniques, and other participant variables that it is difficult to draw conclusions about the research results as a whole. Instead, continued research on focused areas of adherence interventions will likely be the best way to understand the most effective ways to help children be more adherent to their treatment regimens.

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Note: * indicates the publication was included in the meta-analysis

Appendix A

Article Coding Form

Study # _____
Coded by: _____
Reliability by : _____

888 Coded for "other," 999 Coded for "can't tell"

Publication's authors: _____

Type of publication (if two separate reports are being used to code a single study, code the more formally published report)

____ (1) Book
____ (2) Journal Article
____ (3) Book Chapter
____ (4) Thesis or Doctoral Dissert.

Attrition *n* = _____, Percent of Original Sample Size_____

Final Study Sample Size: _____ (participants used in analyses)
Treatment Group Sample Size: _____
Control Group Sample Size: _____

Subject Age: Mean: _____, Standard Deviation: _____

Percentage of Minority Participants: _____

Primary Minority Group Included:

____ (1) African American
____ (2) Asian American
____ (3) Hispanic
____ (4) Native American

Primary Socioeconomic Status of Population:

____ (1) Lower Class
____ (2) Lower Middle Class
____ (3) Higher Middle Class
____ (4) Upper Class

Type of assignment to conditions

____ (1) Random, after matching, stratification, blocking, etc.
____ (2) Random, simple
____ (3) Non-random, post-hoc matching
____ (4) Non-random, other

If no control group:

____ (5) Within-subject study design
____ (6) Single-subject design

Nature of control group

____ (1) Receives nothing; no evidence of any treatment or attention
____ (2) Waitlist; delayed treatment
____ (3) Treatment as usual (typical medical care w/o any extra intervention)
____ (4) Alternative treatment

Diagnosis of Participants

____ (1) Asthma
____ (2) Cancer
____ (3) Cardiovascular disease
____ (4) Cerebral Palsy
____ (5) Cystic Fibrosis
____ (6) Diabetes – Type 1
____ (7) Diabetes – Type 2
____ (8) Epilepsy
____ (9) Hemophilia
____ (10) High Blood Pressure
____ (11) HIV/ AIDS
____ (12) Hyperlipidemia
____ (13) Irritable Bowel Diseases
____ (14) Juvenile Rheumatoid Arthritis (JRA)
____ (15) Renal Diseases
____ (16) Rheumatic Diseases (except JRA)
____ (17) Sickle Cell Disease
____ (18) Transplant

Adherence Outcome Measures

Direct measures

____ (1) Blood/urine/saliva tests for medication presence

Indirect measures

____ (2) Refill records
____ (3) Pill count
____ (4) Mechanical or electronic monitors

Subjective measures

____ (5) Self-report (parent)
____ (6) Self-report (child)
____ (7) Diary/ Record keeping
____ (8) Physician rating
____ (9) 24-hour recall (parent)
____ (10) 24-hour recall (child)

Health Outcomes

____ (1) Blood Pressure
____ (2) Survival
____ (3) Pain
____ (4) Incidents of disease flare-up
____ (5) Weight change
____ (6) Functional disability
____ (7) A1C levels
____ (8) Lung functioning tests (PFT)
____ (9) Quality of life
____ (10) Disease severity estimates
____ (11) Emergency/ Last minute appointments
____ (12) Appointment keeping
____ (13) ER visits
____ (14) Hospitalization

Intervention Strategies (code all that were used in the study)

Educational strategies

Individual

____ (1) Audiovisual
____ (2) Computer Programs
____ (3) Home visits; explicitly educational
____ (4) Mail
____ (5) Oral
____ (6) Telephone education
____ (7) Visual
____ (8) Written
____ (9) Modified for individual's specific needs

Group Education

____ (10) Group
____ (11) Family
____ (12) Other_____

Organizational strategies

____ (13) Physician education
____ (14) Physician updated on patient
____ (15) Nurse education
____ (16) Change to regimen to reduce barriers (e.g., simplification)
____ (17) Increase accessibility to health care
____ (18) Increase consumer friendliness
____ (19) Nurse/ physician phone contact
____ (20) Other_____

Behavioral strategies

____ (21) Calendar
____ (22) Computerized discharge
____ (23) Contracting or verbal agreement
____ (24) Demonstration dose
____ (25) Family problem-solving training
____ (26) Feedback
____ (27) Graphing adherence
____ (28) Group skill building
____ (29) Increased parental supervision
____ (30) Medical diaries
____ (31) Medication monitor
____ (32) Memory aids
____ (33) Obtrusive pill count
____ (34) Pill boxes
____ (35) Reminder (mail)
____ (36) Reminder (telephone)
____ (37) Rewards/ Consequences
____ (38) Skill building (supervised exercise)
____ (39) Other_____

Other/ Affective strategies

____ (40) Counseling for psych d/x's (i.e., depression)
____ (41) Group counseling for psych d/x's
____ (42) Family support/ therapy
____ (43) Other_____

Intervention Type

____ (1) Education alone
____ (2) Behavior alone
____ (3) Affective/ Other alone
____ (4) Organizational alone
____ (5) Education and behavior
____ (6) All other combinations

Length of treatment in days: _____

Study # _____
Effect size: _____
Coded by: _____
Reliability by : _____

Effect Size #: _____

Effect Size Coding

Use one per effect size coded in each study. For example, two separate pages would be used for post-test and 6-month follow-up or for different outcome variables.

Effect Size Type

____ (1) Post-test Comparison
____ (2) Follow-up Comparison

Outcome (Compliance) Measure the Effect Size is Based On (use number from above list and write a brief descriptor): _____

Type of data effect size base on:

____ (1) Means and SD
____ (2) *t*-value or *F*-value
____ (3) Chi-square
____ (4) Frequencies or proportions, dichotomous
____ (5) Frequencies or proportions, polychotomous
____ (6) Mean gain scores
____ (7) Other, specify:_____

Page number where data for this effect size was found: _____

Raw difference favors (shows more success for) which group?

____ (1) Treatment group
____ (2) Neither (exactly same)
____ (3) Control group

When means and standard deviations are reported:

Treatment:
Sample Size _____
Mean _____
Standard Deviation_____

Control:
Sample Size _____
Mean _____
Standard Deviation_____

When proportions or frequencies are reported:

n of treatment group with successful outcome: ___/ total *n* of trmt group ____
n of control group with successful outcome: ___/ total *n* of control group ____

When significance test information is reported:

t-value: _____
F-value: _____ df:_____
Chi-square value (*df* = 1): _____

Appendix B

Selected Equations Used for the Meta-analysis

Standardized mean difference ES:

$$\overline{ES} = \frac{\overline{X}_{G1} - \overline{X}_{G2}}{s_{pooled}} \qquad s_{pooled} = \sqrt{\frac{s_1^2(n_1 - 1) + s_2^2(n_2 - 1)}{n_1 + n_2 - 2}}$$

Correction for small sample sizes:

$$ES'_{sm} = ES_{sm}\left[1 - \frac{3}{4N - 9}\right]$$

Weighting ES by inverse variance (*sm* = standardized mean difference, *se* = standard error):

$$se = \sqrt{\frac{n_1 + n_2}{n_1 n_2} + \frac{\overline{ES}_{sm}^{\,2}}{2(n_1 + n_2)}} \qquad w = \frac{1}{se^2}$$

Logit proportion effect size:

ES_l = ln [p/(1-p)] *p* = proportion of subjects in category of interest
n = total number of subjects

Standard error for proportions:

$$se = \sqrt{(1/np) + 1/[n(1-p)]}$$

Weighting for proportions:

$$w = np(1-p)$$

Random effects variance component:

$$\hat{v}_\theta = \frac{Q_T - k - 1}{\sum w - \left(\frac{\sum w^2}{\sum w}\right)}$$

where Q_T is the full group *Q* statistic, and *k* is the number of effect sizes

Random-effects weights:

$$w_i^* = \frac{1}{se_i^2 + \hat{v}_\theta}$$

Random-effects weighted mean effect size:

$$\overline{ES} = \frac{[\sum(w^* \times ES)]^2}{\sum w^*}$$

Standard error:

$$se = \sqrt{(1/\sum w^*)}$$

Z-test for the Mean ES

$$Z = \overline{ES} / se$$

95 % confidence interval for Mean ES

$$Lower = \overline{ES} - 1.96(se)$$
$$Upper = \overline{ES} + 1.96(se)$$

Homogeneity test or *Q* statistic:

$$Q = \sum(w \times ES^2) - \frac{[\sum(w \times ES)]^2}{\sum w}$$

Comparing two independent groups of effect sizes:

Within group homogeneity:

$Q_W = Q_{Group\_1} + Q_{Group\_2}$ $\quad df = k - j$

where k is the number of effect sizes, and
j is the number of groups

Between group homogeneity:

$Q_B = Q_T - Q_W$ $\quad df = j - 1$ where Q_T is the full group Q statistic

If the between groups *Q* is significant, then the grouping variable accounts for significant variability in effect sizes.

Equations taken from "Practical Meta-analysis" by Wilson (2000)