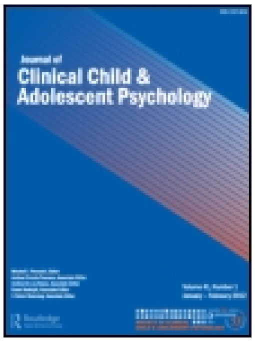

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Comparative Cost Analysis of Sequential, Adaptive, Behavioral, Pharmacological, and Combined Treatments for Childhood ADHD

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We conducted a cost analysis of the behavioral, pharmacological, and combined interventions employed in a sequential, multiple assignment, randomized, and adaptive trial investigating the sequencing and enhancement of treatment for children with attention deficit hyperactivity disorder (ADHD; Pelham et al., 201X; N = 146, 76% male, 80% Caucasian). The quantity of resources expended on each child's treatment was determined from records that listed the type, date, location, persons present, and duration of all services provided. The inputs considered were the amount of physician time, clinician time, paraprofessional time, teacher time, parent time, medication, and gasoline. Quantities of these inputs were converted into costs in 2013 USD using national wage estimates from the Bureau of Labor Statistics, the prices of 30-day supplies of prescription drugs from the national Express Scripts service, and mean fuel prices from the Energy Information Administration. Beginning treatment with a low-dose/intensity regimen of behavior modification (large-group parent training) was less costly for a school year of treatment ($961) than beginning treatment with a low dose of stimulant medication ($1,669), regardless of whether the initial treatment was intensified with a higher "dose" or if the other modality was added. Outcome data from the parent study (Pelham et al., 201X)

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found equivalent or superior outcomes for treatments beginning with low-intensity behavior modification compared to intervention beginning with medication. Combined with the present analyses, these findings suggest that initiating treatment with behavior modification rather than medication is the more cost-effective option for children with ADHD.

Attention deficit hyperactivity disorder (ADHD) is one of the most prevalent (Centers for Disease Control and Prevention, 2010), impairing (Fabiano et al., 2006), costly (Pelham, Foster, & Robb, 2007), and refractory (Barkley, Murphy, & Fisher, 2008) mental health disorders of childhood. Over the past 50 years, a multitude of studies have been conducted on the etiology, nature, treatment, and outcomes of ADHD. One of the most central questions regarding ADHD has long been what constitutes effective treatment. For 50 years, the most common intervention has been medication with a central nervous system stimulant, and many hundreds of studies have documented its short-term effectiveness (Paykina, Greenhill, & Gorman, 2007). Over the past 25 years, behavioral treatment has become the second most commonly used intervention for ADHD, and more than 150 studies have documented its short-term effectiveness (Evans, Owens, & Bunford, 2013; Pelham & Fabiano, 2008; Pelham, Wheeler, & Chronis, 1998). These interventions, and especially the combination of the two, have become the most often recommended treatments for ADHD by leading associations and governmental entities (e.g., CHADD [http://www.chadd.org/]; National Institute of Mental Health, n.d.; Subcommittee on Attention-Deficit/Hyperactivity Disorder, Steering Committee on Quality Improvement and Management, 2011).

Given that there is widespread agreement that medication and behavioral treatment are effective, it is surprising that there are relatively few comparative studies of treatment effectiveness (e.g., pharmacological vs. behavioral vs. combined; cf. MTA Cooperative Group, 1999; for one prominent example, and Fabiano et al., 2007; and Pelham et al., 2014, for more recent examples). Even more important are studies that mimic the adaptive process that clinicians employ in treating ADHD, that is, deciding on a starting treatment, monitoring progress, and adding other treatment when necessary (e.g., more intensive dose of initial intervention or the other modality). Studies of this type are necessary to make decisions about treatments that are effective and useful in the practice world (Murphy, 2005). We employed a sequential, multiple assignment, randomized trial of behavioral and pharmacological treatment for ADHD, investigating whether it is more effective to initiate treatment with behavioral intervention or medication, and whether, in the case of insufficient response, it is more effective to intensify the initial intervention modality or to add the other modality to yield a combined intervention. The methods and results of that paper are reported elsewhere (Pelham et al., 201X). Herein, we evaluate the economic costs and cost-effectiveness of the interventions employed in that trial—the first to our knowledge using this design.

Economic evaluation of treatment costs is important in healthcare. Effective interventions must not only be evidence based but also be sustainable in the settings in which they are implemented (Glasgow, Lichtenstein, & Marcus, 2003). To be sustainable, interventions must be affordable to those funding them. Determining the affordability of an intervention requires measurement of intervention delivery costs. An additional aim of economic evaluation is to identify interventions that represent worthwhile investments for society. Cost-benefit and cost-effectiveness analyses are used to determine which interventions produce the greatest outcome change for the resources spent on them (Drummond, Sculper, Torrance, O'Brien, & Stoddard, 2005; Gold, Siegel, Russell, & Weinstein, 1996). If one intervention is more effective than the other and also more costly, this indicates a trade-off between the additional outcome improvement and additional costs. If two interventions are equally effective, the less costly one is preferred. If one intervention is less costly and more effective, it strictly dominates the alternative (Gold et al., 1996; Van Hout, Gordon, & Rutten 1994). The Patient Protection and Affordable Care Act of 2010 has placed greater emphasis for federal funding on comparative effectiveness research in evaluating the outcomes of interventions, and a new agency has been created to fund this type of research, the Patient Centered Outcome Research Institute (http://www.PCORI.org). Treatment costs have been identified as an important outcome to study as part of the comparative effectiveness research process (Garber & Sox, 2010).

In a review of the economic costs of ADHD, Pelham et al. (2007) found 13 studies with information on the cost of ADHD, with only a small subset including information on costs of treatment. The small number of available studies on treatment costs were from large databases (e.g., Medicaid) that tied clinic-recorded diagnoses to medical costs—typically those of medication. No information was available regarding psychosocial treatment costs, no comparative costs were available, and no information was available on cost-effectiveness.

To our knowledge, the only study that has provided information on comparative costs/cost-effectiveness of treatment for ADHD is the MTA study (Foster et al., 2007; Jensen et al., 2005; MTA Cooperative Group, 1999). Adopting a societal perspective (excluding possible time lost for work by parents), Jensen et al. found that over the 14-month duration of the study, the per-child cost (in 2000 dollars) of medication management was least expensive ($1,180), followed by intensive behavioral treatment ($6,988), followed by these two treatments combined ($7,827). Normalization rates in the study had previously been reported to favor medication (Swanson et al., 2001). Putting the two reports together, medication management was found to be more cost-effective than intensive behavioral treatment (i.e., it was less expensive and more effective). Combination treatment was found to be more expensive and marginally more effective than medication management. Foster et al. (2007) examined the same data to determine if the presence of a comorbid disorder affected the cost-effectiveness results. Adopting a payer perspective, the authors concluded that for patients with only an ADHD diagnosis (32% of the sample), medical management appeared to be the most cost-effective treatment. However, they concluded that for patients with a comorbid disorder, the remaining 68%, when willingness to pay is high, combined treatment might be most cost-effective.

The MTA cost study has several limitations. First, the MTA employed a highly intensive and costly behavioral treatment that is not typical of community practice. Second, since the time of that study, far more costly long-acting stimulant medication preparations have become the norm rather than the inexpensive, immediate-release, generic methylphenidate used in 1980s and 1990s, including the MTA study. Third, the combined treatment arm began both treatments simultaneously and all children received the same high-dose/high-intensity pharmacological and behavioral interventions regardless of need. An updated study of comparative costs for treatments of ADHD is needed to address these limitations.

The purpose of this study was to compare the treatment costs of a sequential, multiple assignment, randomized trial of the effectiveness of medication and behavioral interventions for children with ADHD (Pelham et al., 201X). Participants were randomly assigned to initiate treatment with either medication or behavior therapy. In the case of insufficient response to initial treatment, children were randomly assigned to secondary/adaptive treatments in which either the dose of the initial treatment was increased or the other modality was added to initial treatment. As outlined in the main effectiveness article, analyses address three specific questions: First (Aim 1), how is cost of treatment affected by starting with a low "dose"/intensity of behavior modification versus with a low dose of medication? Second (Aim 2), what are the comparative costs of the four treatment *protocols*, or patterns of initial treatment and conditional secondary/adaptive treatment (e.g., BM: behavioral followed by medication in the event of insufficient response), embedded in the present trial? Third (Aim 3), in the event of insufficient response to one of the initial treatments, how is cost of treatment affected by increasing the dose of that modality versus adding treatment with the other modality?

METHODS

Participants

One hundred fifty-two children with ADHD (76% male, 80% Caucasian), between the ages of 5 and 12, from western New York participated in this investigation. Participants were recruited in three annual cohorts of approximately 50 each for treatment lasting 1 school year. Diagnoses were made using a set of instruments standardly employed for making *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; American Psychiatric Association, 1994) diagnoses of ADHD (i.e., parent and teacher rating scales; parent structured and clinical interviews). A description of the study sample is available in Pelham et al. (201X). A total of 146 children completed the study assessments and were included in these analyses.

Design and Procedure of Treatment Study

This study employed an adaptive treatments design with multiple randomization points to evaluate different treatment strategies in a way that mimics clinical practice. The design is described in detail in the main outcome paper (Pelham et al., 201X), but we review it here briefly.

Treatment algorithm. Figure 1 illustrates the study design. Initially, participants were randomly assigned to

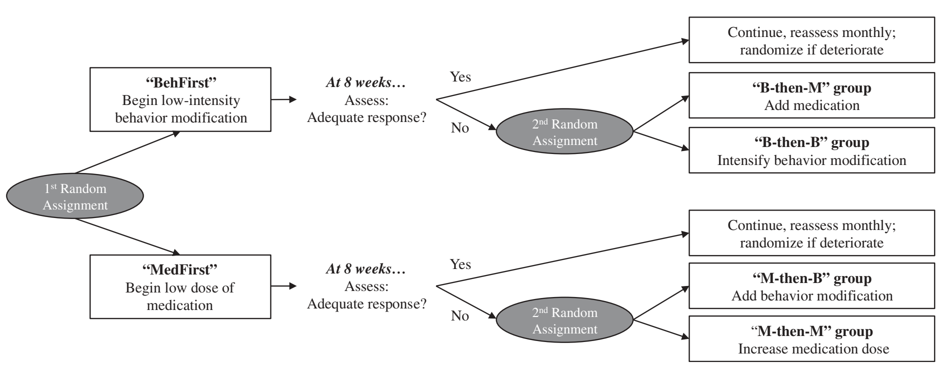

FIGURE 1 Study design.

one of two initial treatments for 8 weeks: low-dose medication (an 8-hr stimulant for school hours equivalent to .15 mg/kg immediate release methylphenidate b.i.d.; Medication First [MedFirst]) or low-intensity clinical behavioral intervention consisting of 8 weekly sessions of group behavioral parent training and three consultation meetings with each child's primary teacher at school to establish a school–home daily report card (Behavior First [BehFirst]). These conditions were selected based on controlled studies (Fabiano et al., 2007; Pelham, Burrows-MacLean, et al., 2005; Pelham et al., 2014) showing that a substantial number of children demonstrated response to these low-intensity/low-dose treatments. After 8 weeks, if response to treatment was insufficient, children were rerandomized to one of two treatment strategies: (a) increase the dose/intensity of the initial treatment or (b) add the other treatment modality to yield a combined treatment condition. After this second randomization, children's progress was evaluated monthly and each child's additional treatment was tailored adaptively according to specific domains and settings of impairment. Table 1 specifies the components that were available in each treatment modality. Treatment components were provided on an as-needed, domain-specific basis, so the components listed represent the menu of treatment options rather than what every child received.

TABLE 1
Intervention Components

Modality	*Initial Treatment*	*Secondary/Adaptive Treatment*
Medication	• 8-hour stimulant equivalent to 0.15 mg/kg methylphenidate b.i.d.	• Increased school dose • Added evening/ weekend doses
Behavior Modification	• 8 weekly sessions of group behavioral parent training (concurrent group social skills training for children) • Monthly booster group parent training sessions • 3 consultation meetings with primary teacher to establish a school–home Daily Report Card	• School-based rewards • Group or individual classroom contingency management systems • Time-out in school • Tutoring • Organizational skills training • Weekly Saturday social skills sessions • Homework skills training • Paraprofessional-implemented school rewards programs • Home-based Daily Report Card

Note: The adaptive components listed represent those offered or recommended as-needed based on individual areas of impairment. Not every child received every component of the adaptive treatment.

Assessing response to treatment. Teachers maintained a daily individualized target behavior evaluation (Pelham, Fabiano, & Massetti, 2005) to serve as an objective measure of treatment response. In addition, each month parents and teachers completed a modified version of the Impairment Rating Scale (Fabiano et al., 2006) that asked the rater whether, *given the treatment currently in place*, he or she believed the child needed additional treatment. These data were reviewed monthly by the clinical team (Pelham et al., 201X). Two clinicians who were not clinically involved in the case and were uninformed of the initial treatment condition were required to agree regarding the need for additional treatment. Children who showed sufficient response to the existing treatment were maintained on that treatment and monitored monthly; whenever deterioration occurred, additional treatment was provided according to the child's group assignment.

Economic Analysis

Procedure. The quantity of intervention inputs over the 10-month (school-year) course of treatment was determined from extensive records of medication and psychosocial services delivered for each child, and the costs of these inputs were computed and summed for each child. These logs contained information on every instance of treatment each child received, including type, date, location, persons present, and duration. Only treatments that were actually delivered were counted; that is, if a treatment was prescribed but parents did not attend a session, the visit was not counted. The value of each input, such as medication costs and hourly wages of personnel used for delivering the intervention, were obtained from publicly available data sources. These records were combined with the addresses of participants' homes, schools, and clinic to calculate the time that clinicians, paraprofessionals, and parents spent commuting to and from treatment, as well as the miles traveled. Thus, for each child the amount of physician time, clinician time, paraprofessional time, teacher time, parent time, medication, and gasoline expended were computed.

The possible treatment components (Table 1) were group, individual, and booster parent training; group, individual, and booster social skills training; school and home visits by the therapist; physician visits; tutoring sessions; a Saturday social skills program; direct, child-based interventions at school; and treatment planning. In the case of services delivered in a group setting, the time spent per child was adjusted to account for this. For example, group behavioral parent training was typically delivered to 16 parents at once, and the time of the clinician leading each session was divided up based on attendance. Thus, if a 90-min session was attended by two families, each family received 45 min of clinician time; if the same session was attended by 10 families, each family received 9 min of clinician time. If both parents attended a session, therapist time was allocated *per family* and the time of both parents was counted separately. In the case of a Saturday program for social skills training, a component of the high-intensity psychosocial treatment, the Center for Children and Families' per-child enrollment cost of $200 was added for each of the subjects that participated at any point.

Providers involved in delivering the intervention included physicians, PhD- and MA-level clinicians, paraprofessionals, teachers, and parents. The mean hourly wages of psychiatrists, psychologists, mental health counselors, paraprofessionals, elementary school teachers, and parents were taken from the Bureau of Labor Statistics's Occupational Employment Statistics 2011 survey (U.S. Department of Labor, 2012). This survey reports only the annual salary of teachers, so teacher salaries were adjusted to hourly wages assuming 1,394 hr worked per year (U.S. Department of Labor, 2011). The paraprofessional salary was approximated using the salary paid to research assistants who worked on the grant. This process resulted in the following hourly wages in 2013 USD: psychiatrist ($85.72), doctoral psychologist ($35.97), mental health counselor ($20.97), paraprofessional ($11.83), teacher ($40.92), and parent ($22.26). It should be noted that although a child psychiatrist provided treatment in this study, the hourly wage for a pediatrician would be nearly identical ($83.01). These figures were then scaled up to reflect full compensation including fringe benefits, where nominal wages were assumed to represent 69.2% of total compensation, per the Bureau of Labor Statistics's economy-wide estimate (U.S. Department of Labor, 2013). The parent wage was exempted from this adjustment, as missed time from work does not entail a loss of fringe benefits. To obtain a nationally representative estimate of medication costs, medication was valued using 30-day supply prices from a large, national pharmacy benefit manager, Express Scripts (http://www.express-scripts.com). Prices ranged from $0.30 to $4.22 per pill for instant-release formulations and $5.12 to $7.56 per pill for extended-release formulations.

Last, the number of miles traveled for clinician visits to schools and parent visits to the clinic was converted to gallons of gasoline using an average fuel efficiency of 23.0 mpg (U.S. Department of Transportation, 2012). Gasoline was valued at $3.14 per gallon after adjusting for inflation the average cost of gas in New York State of $2.94 over the duration of the study (Energy Information Administration, 2013). Using these data, total intervention costs were computed for each child.

Cost analyses. The analyses were performed two ways. The primary set of estimates included only direct costs attributable to the interventions. However, given that parent training and physician visits involved sessions in the clinic and required parental time, secondary analyses included the implicit costs to parents, including the value of their time, calculated using the "all occupation" wage estimate from the Bureau of Labor Statistics (2011). Parent training groups were always held on weekday evenings. Consistent with the analytic plan outlined in Pelham et al. (201X; see also Nahum-Shani et al., 2012, for details and examples of the analysis strategy), treatment costs were compared for initial randomized condition (Behavior Modification First or Medication First) and various combinations of rerandomized (contingent upon response to initial treatment) conditions. The average treatment cost was simply the sum of enumerated cost categories just described divided by the number of children in the condition.

Although adaptive treatments were determined and administered separately for home and school settings, costs could not be easily separated by domain (e.g., additional parent training sessions may be held if teachers report impairment related to homework completion), so for these analyses the only subjects labeled as "responders" were those who never required additional treatment in either home or school.

Analysis Overview

Our analyses largely parallel those described by Nahum-Shani and colleagues (2012); we direct readers to that article and to the main outcomes article (Pelham et al., 201X) for more details. The analysis of costs included a series of comparisons to test different treatment paths and protocols. Each comparison is described next.

Main effect of initial treatment assignment (Aim 1). First, treatment costs for those that started with medication (MedFirst group) and those that started with behavioral treatment (BehFirst group) were compared using independent samples, two-tailed *t*-tests.

Pairwise comparisons among smart-embedded treatment protocols (Aim 2). Second, costs were compared across each of the four treatment protocols embedded in the SMART design—BB, BM, MB, and MM. The first letter denotes that protocol's initial treatment and the second letter denotes that protocol's secondary/adaptive treatment, to be implemented in the event of insufficient response to the initial treatment. For example, the BM protocol entailed starting the participant with behavioral treatment and then adding medication if and only if there was insufficient response. It is important to note that the protocols do not reflect the actual treatment received but rather *the set of rules followed*. For example, a participant that began with behavioral treatment, responded, and was never rerandomized is consistent with both the BM and BB protocols, and thus should be included in both groups for the analyses. This idea of being consistent with a particular embedded protocol is a subtle but important aspect of the SMART design that is discussed in detail elsewhere. We used an effects coding scheme and generalized estimating equations to achieve all the pairwise comparisons of protocols in a single model using SAS PROC GENMOD with robust standard errors, as described in the appendices of Nahum-Shani et al. (2012). We also gave weights of 2 to the responders to initial treatment and weights of 4 to the insufficient responders in order to account for the systematic undersampling of the latter in each protocol due to the second rerandomization (see Nahum-Shani et al., 2012).

Comparison of secondary/adaptive treatments given insufficient response to initial treatment (Aim 3). Third, supplemental comparisons were performed within each of the initial treatment arms to determine if, given insufficient response to an initial intervention, it is less costly to augment (i.e., increase the dose of) that treatment or add the other treatment. These analyses consisted of independent samples, two-tailed *t*-tests that compared (a) B-then-B versus B-then-M and (b) M-then-M versus M-then-B. Responders to the initial treatment were excluded from these supplemental comparisons.

Sensitivity analysis. The purpose of a sensitivity analysis is to determine the extent to which the conclusions reached in the baseline analyses are sensitive to variability in model parameters, assumptions, or outliers (Drummond et al., 2005). Two sets of sensitivity analyses were thus performed. First, the top 10% in terms of total cost were dropped from the sample in order to determine if group differences were being driven by a small number of high-cost cases. Given the adaptive nature of the treatment upon second randomization, a small number of children received a very large amount of services relative to the initial dose of treatment (e.g., a large number of individual parent-training sessions; more frequent physician visits and movement to higher cost, 12-hr medication formulations). Second, the wage of a doctoral psychologist ($35.97 per hour) was used for all clinician time instead of the wage for a mental health counselor. The assigned clinicians in the study were predominately master's-level clinicians, but the only previous study of comparative costs for ADHD, the MTA, employed exclusively doctoral-level clinicians, so this sensitivity analysis facilitates a comparison between the results of the two studies. For all of the comparisons just discussed, independent-samples, two-tailed *t*-tests were performed to determine the statistical significance of observed differences in treatment costs.

RESULTS

Comparison of Costs by Initial Assignment (Aim 1)

Cost estimates based on initial treatment assignment are reported in Table 2. As shown in the table, BehFirst was significantly less costly than MedFirst—with and without implicit parent time costs included. Predictably, medication and physician costs were higher for those starting with medication, and clinician, teacher, parent, and gasoline costs were higher for those starting with behavior modification.

Comparison of Costs by Treatment Protocol Followed (Aim 2)

Pairwise tests were used to compare costs for the various adaptive treatment strategies that were included in the study, according to the procedures just outlined. Results are shown in Table 3. Costs for individual intervention components differed as expected, with physician and medication costs higher for the strategies including medication and clinician, paraprofessional, teacher, parents, and gasoline higher for the strategies employing more intensive behavioral treatments. Pairwise tests further illustrate that protocols beginning with behavioral treatments were less costly when parent time costs were not included (Table 3). That is, the BB protocol was significantly less costly than the MM or MB, and the BM protocol was significantly less costly than the MB or MM. These differences were driven mostly by medication costs.

When indirect costs to parents were included, fewer comparisons were significantly different, presumably due to the increased parental time required to attend behavioral parent training classes. However, the BM protocol remained less costly than MB, whereas the MB protocol was more costly than BB.

TABLE 2
Costs by Initial Treatment Assignment

Cost	*Medication First (*N *= 74)*	*Behavioral First (*N *= 72)*
Medication***	1,049 (478 [0, 2111])	300 (465 [0, 1593])
Physician***	246 (120 [0, 567])	87 (109 [0, 381])
Clinician***	201 (200 [0, 1018])	321 (158 [109, 737])
Paraprofessional	53 (199 [0, 1148])	75 (186 [0, 1116)]
Teacher**	120 (114 [0, 676])	178 (147 [46, 817])
Parents***	292 (329 [0, 2031])	694 (315 [63, 1409])
Gasoline*	37 (41 [3, 283])	51 (43 [4, 207])
Total Cost***	1,669 (737 [134, 4891])	961 (641 [191, 2895])
Total Cost IPG*	1,998 (975 [168, 6138])	1,706 (836 [609, 4435])

Note: In 2013 USD. Standard deviation and range are reported in parentheses. IPG = including parent and gasoline costs.

$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

TABLE 3
Costs by Treatment Protocol Followed

Outcome	BB Protocol	BM Protocol	MB Protocol	MM Protocol
Medication	73 (34)	527 (86)	897 (64)	1,205 (83)
Physician	21 (8.7)	$153_{†}$ (17)	$209_{†}$ (17)	283 (20)
Clinician	402_{a} (27)	241_{b} (15)	$311_{a,b}$ (36)	89 (7.4)
Paraprofessional	135_{a} (41)	15 (5.0)	105_{a} (44)	0 (0)
Teacher	232 (27)	124_{a} (15)	161_{a} (23)	78 (7.4)
Parents	783 (49)	605 (48)	420 (67)	161 (13)
Gasoline	58_{a} (7.6)	45_{a} (6.2)	49_{a} (8.1)	24 (3.0)
Total Cost	862_{a} (95)	$1{,}060_{a}$ (109)	$1{,}683_{b}$ (138)	$1{,}654_{b}$ (98)
Total Cost IPG	$1{,}702^{a,†}$ (130)	$1{,}710^{a,‡}$ (140)	$2{,}151^{b,†‡}$ (191)	$1{,}840_{a,b}$ (108)

Note: Values are estimated weighted means with robust standard errors in parentheses. All figures are in 2013 USD. Within each row, means that have no subscript in common are significantly different from each other, $p < .05$. Daggers or double-daggers next to a pair of means indicate the difference was only marginal, $p < 0.10$. IPG = including parent time costs and cost of gasoline.

Comparisons of Costs by Secondary/Adaptive Treatment for Insufficient Responders to Initial Treatments (Aim 3)

Cost comparisons among the four endpoints given insufficient response to initial treatment are reported in Table 4. Although expected differences were found in individual cost categories, total costs were not significantly different for the secondary/adaptive treatments, regardless of whether parent time costs were included.

TABLE 4
Costs by Secondary/Adaptive Treatment Given Insufficient Response to Initial Treatment

Insufficient Response to Initial Behavioral Treatment		
Cost	B-then-B (*N* = 32)	B-then-M (*N* = 32)
Medication***	82 (215 [0, 832])	593 (537 [0, 1593])
Physician***	23 (56 [0, 237])	172 (102 [0, 381])
Clinician***	417 (170 [185, 737])	236 (97 [109, 479])
Paraprofessional**	150 (260 [0, 1116])	15 (31 [0, 131])
Teacher***	249 (173 [47, 817])	127 (99 [46, 529])
Parents*	811 (307 [290, 1407])	611 (303 [63, 1409])
Gasoline	61 (48 [9, 207])	46 (39 [4, 151])
Total Cost	920 (597 [240, 2639])	1,144 (681 [191, 2895])
Total Cost IPG	1,793 (811 [696, 3952])	1,801 (878 [609, 4435])
Insufficient Response to Initial Medication		
Cost	M-then-M (*N* = 34)	M-then-B (*N* = 35)
Medication**	1,221 (523 [0, 2111])	891 (412 [0, 1794])
Physician**	286 (125 [0, 556])	207 (112 [0, 567])
Clinician***	83 (33 [0, 163])	321 (230 [41, 1018])
Paraprofessional*	0 (0 [0, 0])	113 (280 [0, 1148])
Teacher**	79 (47 [0, 267])	168 (146 [50, 675])
Parents***	158 (79 [0, 339])	435 (430 [46, 2031])
Gasoline**	22 (16 [4, 78])	49 (51 [3, 283])
Total Cost	1,669 (620 [114, 2801])	1,700 (883 [153, 4891])
Total Cost IPG	1,850 (687 [168, 3172])	2,183 (1227 [204, 6138])

Note: In 2013 USD. Standard deviation and range are reported in parentheses. M = medication; B = behavior modification; IPG = including parent and gasoline costs.

*$p < .05$. **$p < .01$. ***$p < .001$.

Costs for Responders to Initial Treatments

Behavior modification was significantly less costly than medication for the small number of children who responded to initial treatment and were not rerandomized at any point based on *either* school *or* home functioning due to insufficient response ($N = 5$ for medication and $N = 8$ for behavior modification). Excluding parent time costs, average treatment cost per child was $392 for BehFirst and $1,448 for MedFirst ($p < .001$). When parent time costs were included in secondary analyses, the difference remained statistically significant. Per child costs were $976 for BehFirst and $1,701 for MedFirst ($p < .001$).

Sensitivity Analyses

Excluding top 10% of total costs. As Tables 2, 3, and 4 show, the ranges of cost are very large, with some children having very high costs of treatment. To determine whether the results were being driven by a small number of children who received a large amount of services, the analyses were repeated excluding children in the highest 10% of total costs (Tables 5–6). This results in 15 children being excluded from the sample. Of these, seven were in the MB protocol, four were in the BB protocol, three were in the BM protocol, and one was in the MM protocol. In all of these analyses, the general pattern of results was similar to the initial analyses but the costs for behavioral treatments were reduced, magnifying the differences obtained in the original comparisons and increasing the significance levels of the cost advantage of BehFirst. This reflects the fact that a small number of children received extensive, adaptive behavior modification services, driving up average costs for the entire group.

Employing doctoral psychologists versus master's-level clinicians. A final set of sensitivity analyses assumed that a psychologist was used to deliver all clinician services

TABLE 5
Sensitivity Analyses for Initial Treatment Assignment

Analysis	*Cost*	*Medication First* (N = 74)	*Behavioral First* (N = 72)
Excluding Top 10%	Total cost***	1,525 (573 [2478])	824 (497 [2025])
	Total cost IPG*	1,764 (648 [2906])	1,521 (624 [2870])
Psychologist Wage	Total cost***	1,811 (805 [5390])	1,188 (682 [3233])
	Total cost IPG	2,140 (1070 [6637])	1,933 (893 [4772])

Note: In 2013 USD. Standard deviation and maximum are reported in parentheses. IPG = including parent and gasoline costs.
$^{*}p < .05$. $^{***}p < .001$.

rather than a less expensive mental health counselor. Because clinicians were the providers in the conditions involving behavior modification, costs for treatment endpoints that included more extensive behavior modification increased by more than those that relied less on behavior modification. Few differences in significance emerged in these analyses, although costs were relatively higher; however, treatment costs based on initial assignment were no longer significantly different when parent time costs were included (costs were $2,140 for the medication arm and $1,933 for the behavior modification arm; Table 5).

DISCUSSION

The objective of this study was to measure the costs of different treatment strategies and sequences for children with ADHD. Overall, beginning treatment with a low-dose/intensity regimen of behavior modification was less costly than beginning treatment with a low dose of stimulant medication (Aim 1), regardless of whether implicit parental costs were considered. In pairwise tests of the specific treatment protocols (Aim 2), significant results always favored the protocols beginning with behavioral treatment when implicit costs to parents were excluded. No significant differences in overall costs were found between secondary/adaptive treatments for insufficient responders to initial treatment (Aim 3). The sensitivity analyses generally did not substantively affect these conclusions. The implications of these findings are discussed in detail next.

The finding that treatments involving behavior modification were either less costly or not significantly different from those involving medication may be surprising to some, particularly when compared with the cost results of the MTA (Jensen et al., 2005). The MTA concluded that medication was far less costly and more cost-effective than behavioral treatments, with combined intervention having higher costs than either but only marginally better results than medication alone. However, the present study differed from the MTA in several ways that affect the cost outcomes. First, at the time of the MTA, the current generation of extended-release ADHD medications had not yet been developed, and thus immediate-release, generic methylphenidate was the medication typically prescribed and utilized in that study. In contrast, today and at the time of the present study, nearly all children with a stimulant prescription take 8- to 12-hr extended-release formulations, which we employed and which are at current prices (http://www.express-scripts.com) 7 to 11 times more expensive than immediate release methylphenidate. In addition, the behavioral treatment provided in the MTA was far more intensive than that employed in the present study and employed doctoral-level clinicians. For example, it involved 35 sessions of behavioral parent training—27 small-group sessions (six families per group) and eight individual parent sessions, an average of 14 consultations per child with the child's school teacher and a half-time classroom aide in the child's classroom for 12 weeks, and an intensive 8-week summer treatment program focused on improving peer relationships (MTA Cooperative Group, 1999). All participants assigned to behavioral treatment—even those who concurrently took medication—received the intensive intervention regardless of need. In contrast, in the current study, initial behavioral treatment involved a low dose of behavior modification—eight large-group, parenting sessions with concurrent social skills groups for the children (with an average of 16 families per group) and three teacher consultations to establish a school–home daily report card, with

TABLE 6
Sensitivity Analyses for Pairwise Comparisons of Treatment Protocols

Outcome	*Cost*	*BB Protocol*	*BM Protocol*	*MB Protocol*	*MM Protocol*
Excluding Top 10%	Total cost	701 (63)	945 (96)	$1,412_{a}$ (99)	$1,622_{a}$ (95)
	Total cost IPG	$1,494_{a,†}$ (96)	$1,547_{a,b}$ (114)	$1,720_{b,†}$ (119)	$1,802_{b}$ (105)
Psychologist Wage	Total cost	$1,145_{a}$ (107)	$1,230_{a}$ (113)	$1,903_{b}$ (155)	$1,717_{b}$ (98)
	Total cost IPG	$1,985_{a,b}$ (143)	$1,880_{b,†}$ (145)	$2,371_{a,†}$ (212)	$1,902_{b}$ (108)

Note: Values are estimated weighted means with robust standard errors in parentheses. All figures are in 2013 USD. Within each row, means that have no subscript in common are significantly different from each other, $p < .05$. Daggers next to a pair of means indicates the difference was only marginal, $p < 0.10$. IPG = including parent time costs and cost of gasoline.

interventions provided by master's-level clinicians. *In addition, more intensive behavioral treatment was provided only adaptively where need was indicated due to insufficient response to the initial dose of treatment*. These differences in treatment protocol and medication costs resulted in far lower costs for behavioral treatment and far higher costs for medication in the present study compared to the MTA, especially, as the sensitivity analyses showed, when the children in the top 10% of costs were excluded. Further, our analysis of normalization rates for the different treatments (see Pelham et al., 201X) used procedures comparable to those employed in the MTA and showed comparable rates of normalization for all conditions that involved behavioral intervention, including initial treatment assignment as well as protocols that involved adding medication as the secondary/adaptive treatment. Thus, from multiple perspectives we may conclude that for the type of behavioral and pharmacological treatments employed in the current study, those beginning with behavior modification or including behavior modification as a secondary/adaptive treatment were less costly and equally or more effective than those beginning with medication (see following discussion of implicit parental costs).

When the cost of parents' time and gasoline were included, BB and BM protocols were no longer less costly than MM. Whether parent time costs should be included in an analysis of treatment costs depends on the perspective from which the analysis is being conducted. For example, if costs were being measured to determine how much an insurer would have to reimburse for treatment, parent time costs would be excluded, as the value of parent time is not reimbursed by insurance companies. However, if a societal perspective is adopted that considers the overall cost of treatment, including explicit and implicit costs, the value of parent time might be important to include when treatments differ in the amount of parent time required. That is, if two treatments produced equal outcomes but one required substantially more effort from the parents, the treatment that did not put high demands on the parents' time might be preferred. On the other hand, if parents participate in parent training on a voluntary basis and if parent training leads to more positive outcomes (Pelham et al., 201X), parents may be willing to give their time to the endeavor. Further, if parent training leads to more positive longer term outcomes, an insurer might be more willing to pay for intervention that includes parent training (cf. Foster et al., 2007).

The results reported in Pelham et al. (201X) document that treatments beginning with behavior modification were equally or more effective depending on the outcome measure than treatments beginning with medication. MedFirst was not superior on any measures. These results have implications for the cost-effectiveness of each treatment option. A detailed cost-effectiveness analysis would be needed if treatments beginning with behavior modification are more costly than treatments beginning with medication. In this case, a cost-effectiveness analysis would compute the incremental cost-effectiveness ratio to determine the additional cost per unit of outcome improvement (e.g., additional cost to normalize a child) for the more expensive treatment. However, if treatments beginning with behavior modification are less costly than treatments beginning with medication, then they would by definition be more cost-effective given that outcomes were equivalent or better. In this case, the incremental cost-effectiveness ratio would be negative, indicating that treatments beginning with behavior modification are cost-saving and therefore strictly dominate treatments beginning with medication. Thus, detailed analysis of cost-effectiveness is not needed in the current study to make a recommendation of the preferred treatment approach (Gold et al., 1996; Van Hout et al., 1994).

A number of cost-saving strategies for treatment of ADHD were revealed by the analysis of costs in this study. Among initial responders, costs were significantly lower for those who began treatment with behavior modification. This suggests that a cost-saving strategy would be to begin treatment for ADHD children with a low dose of behavior modification, a treatment algorithm that we have recommended previously (Pelham, 2008) and that has been recommended for all young children with ADHD by the American Academy of Pediatrics (Subcommittee on Attention-Deficit/Hyperactivity Disorder, Steering Committee on Quality Improvement and Management, 2011). This contrasts with the current practice guideline of the American Academy of Child and Adolescent Psychiatry (AACAP Work Group on Quality Issues, 2007), which recommends multiple trials of medication as first lines of treatment, with behavioral interventions added only late in the recommended treatment strategy—an approach that our analysis suggests would maximize costs for ADHD treatments without improving outcomes. Second, providing large-group parent training, instead of individual parent training, as the first line intervention will result in lower costs for ADHD treatment with no apparent loss in effectiveness. Third, using lower cost personnel, such as master's-level mental health counselors instead of doctoral-level psychologists, to deliver the behavioral interventions results in lower costs for similar services. Mental health counselors and licensed clinical social workers provide most of the mental health services in the North America, and it has long been known that they produce effective results when implementing evidence-based interventions (e.g., Henggler, Melton, & Smith, 1992). This practice in mental health is consistent with the shift toward lower cost physician extenders, such as physician assistants and nurse practitioners, in the delivery of primary care (Everett et al., 2013), and our data add to other data documenting that trend is one that lowers healthcare costs for children with ADHD without a loss of effectiveness.

Fourth, the sensitivity analyses revealed that adaptive treatment for insufficient responders to the initial dose was expensive but necessary for only a subset of the children.

Reserving these more intensive interventions for children who have failed to show sufficient response to less intensive treatment should result in substantially lower total costs for treating ADHD at a population level (cf. MTA Cooperative Group, 1999). Although this was typically a relatively small increase in parent sessions or teacher contacts, many of the children with costs in the top 10% were located in a protocol that included adaptive behavior modification. More intensive adaptive behavioral treatments provided to insufficient responders typically included paraprofessional costs (e.g., daily visits to the classroom for several weeks, Saturday treatment program) or frequent individual sessions with parents that are far more costly than typical group parent training sessions. For example, one case included more than $1,100 in paraprofessional costs and $1,150 in parent individual sessions. However, the top 10% of cases were split evenly between MedFirst and BehFirst. The severity of child behavior, comorbid conditions, or family situations were more related to eventual costs of these high-cost individuals than was the initial treatment approach. Of note is that despite the high costs for these individuals, the overall explicit costs for the BB protocol were still significantly lower than for the MM protocol.

Finally, with regard to medication treatment, it is notable that many children were maintained on a low dose of medication during school hours only for the duration of the school year. Carefully assessing medication needs across settings and providing medication only for the hours and doses needed will also reduce costs associated with pharmacological treatments.

This study had limitations—some related to the cost analysis and some related to the design and content of the interventions in the parent study. Hourly wages for personnel were national estimates obtained from publicly available sources. In the real world, wages, salaries, and fringe benefits vary across employers and geographic areas. In addition, the design included monthly physician visits, whereas families may not see their primary care providers with the same frequency (although physician time was only a small portion of the cost of the pharmacotherapy). Overhead costs were not considered, because the interventions employed in this study used existing facilities and therefore did not result in any additional overhead costs.

Our results are necessarily limited to the low dose of initial behavioral intervention that we employed and the targeted but relatively unlimited access to more intensive behavioral treatment for participants who needed more. A higher initial dose (e.g., a few individual parenting sessions, a higher starting dose of medication, more booster parenting sessions), more rapid inclusion or modifications of the most intensive behavioral interventions, or beginning with combined treatment might have led to lower overall costs and/or different degrees of effectiveness and conclusions. Reliance on parent ratings of need for additional treatment in the home setting may have overestimated the need for treatment in that setting, as a single rating of impairment may have triggered a decision to increase treatment. On the other hand, our approach approximated the information clinicians have available to them when making decisions regarding treatment response. As such, our results have clear implications for clinical practice in treatment of ADHD.

These results have important implications for the relative cost-effectiveness of the treatment approaches studied for ADHD. Similar studies are needed of other major childhood disorders (cf. Domino et al., 2008; Domino et al., 2009). Pelham et al. (201X) found that starting with behavioral treatment for ADHD produced more favorable outcomes on the primary outcome measure and more favorable or comparable outcomes on other measures. Given the fact that beginning treatment with behavior modification was also less costly, beginning treatment with a low dose of behavior modification is, by definition, the more cost-effective approach in treating children with ADHD. Further, providing adaptive behavioral treatment was never more costly than medication and sometimes less costly. Because we employed a design that modeled how a clinician would have to select, sequence, and titrate treatments, these results more closely mimic the cost in community settings than previous comparative cost analyses of ADHD treatments.

Currently, medication is far more likely than behavioral treatment to be recommended and used as a first line treatment for ADHD, despite its greater cost, and this approach maximizes the societal cost of ADHD treatments. Our findings together suggest strongly that if current treatment guidelines and parameters for childhood ADHD recommended behavioral treatments as first- *and* even second-line interventions, the societal cost of treating ADHD could be reduced without a loss of effectiveness. Given the high prevalence and high societal cost of ADHD, as well as the current need to reduce the cost of healthcare in the United States, such a shift should be welcomed.

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