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Cost-Effectiveness of an Internet-Delivered Treatment for Substance Abuse: Data from a Multisite Randomized Controlled Trial

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Abstract

Background—Substance misuse and excessive alcohol consumption are major public health issues. Internet-based interventions for substance use disorders (SUDs) are a relatively new method for addressing barriers to access and supplementing existing care. This study examines cost-effectiveness in a multisite, randomized trial of an internet-based version of the community

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Contributors

Authors SMM, ANCC, EVN and DP conceived the study, and were responsible for obtaining and cleaning the data. SMM performed the statistical analyses and wrote the first draft of the manuscript. All authors provided input on the statistical approach, managed the literature searches and summaries of previous related work, performed critical reviews and collaborated with SMM on manuscript revisions. All authors have approved the final manuscript.

Conflict of Interest

Dr. Nunes has received medication for research studies from Alkermes/Cephalon, Duramed Pharmaceuticals, and Reckitt-Benckiser. Dr. Polsky has served on an advisory panel for Pfizer and as a consultant for Accenture. Udi E. Ghitza is an employee of the Center for the Clinical Trials Network, NIDA, which is the funding agency for the National Drug Abuse Treatment Clinical Trials Network. NIDA staff's (Udi E. Ghitza's) participation in this publication arises from his role as a project scientist on a cooperative agreement (this WEB-TX CTN study), which provided the data that were analyzed for this publication, but Udi E. Ghitza has not had and will not have any programmatic involvement with the grants cited. The opinions in this paper are those of the authors and do not represent the official position of the U.S. government. The other authors report no conflicts of interest.

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reinforcement approach (CRA) with contingency management (CM) known as the Therapeutic Education System (TES).

Methods—Economic evaluation of the 12-week trial with follow-up at 24 and 36 weeks. 507 individuals who were seeking therapy for alcohol or other substance use disorders at 10 outpatient community-based treatment programs were recruited and randomized to either treatment as usual (TAU) or TES+TAU. Sub-analyses were completed on participants with a poorer prognosis (i.e., those not abstinent at study entry).

Results—From the provider's perspective, TES+TAU as it was implemented in this study costs \$278 (SE=87) more than TAU alone after 12 weeks. The quality-adjusted life years gained by TES+TAU and TAU were similar; however, TES+TAU has at least a 95% chance of being considered cost-effective for providers and payers with willingness-to-pay thresholds as low as \$20,000 per abstinent year. Findings for the subgroup not abstinent at study entry are slightly more favorable.

Conclusions—With regard to the clinical outcome of abstinence, our cost-effectiveness findings of TES+TAU compare favorably to those found elsewhere in the CM literature. The analyses performed here serve as an initial economic framework for future studies integrating technology into SUD therapy.

Clinical trial registration—NCT01104805.

Keywords

Substance use disorders; Internet-based intervention; Cost effectiveness; Community Reinforcement Approach; Contingency management

1. INTRODUCTION

Improving access to effective treatments for substance use disorders (SUD) is vital, as SUDs are not only burdensome for those who suffer from them, but are major public health problems as well. The annual economic costs of substance misuse and excessive alcohol consumption have been estimated to be over \$220 billion (National Drug Intelligence Center, 2011) and \$260 billion (Bouchery et al., 2011, 2014 USD), respectively. Reducing economic costs will require raising treatment utilization rates by addressing access barriers for patients (e.g., stigma and insufficient knowledge about SUD treatment), the system (e.g., the limited availability of specialty clinics and evidence-based treatment interventions; Kvamme et al., 2013; Murphy et al., 2014; Substance Abuse and Mental Health Services Administration, 2014), and providers (e.g., limited resources, including adjunct behavioral treatments to accompany SUD medications; Albright et al., 2010; Cunningham et al., 2007; Gunderson et al., 2006; Mark et al., 2003a, 2003b; Raven et al., 2010; Walley et al., 2008).

Internet-based interventions for SUDs are a relatively new method for overcoming many of these barriers. We conducted one of the first multisite randomized effectiveness trials for such an intervention (Campbell et al., 2014). The Therapeutic Education System (TES) delivers an internet-based version of the community reinforcement approach (CRA) with a computer-assisted contingency management (CM) component. CM is typically deployed as an add-on to treatment-as-usual (TAU) for SUDs, and provides reinforcers to participants

for targeted behaviors, such as abstinence and treatment attendance. Together, CRA and CM have demonstrated efficacy (Bickel et al., 1997; Garcia-Rodriguez et al., 2009; Higgins et al., 1994, 2003), including as a computer based intervention (Bickel et al., 2008).

Yet, given the resource constraints of SUD treatment providers, evidence of cost-effectiveness and provider-level considerations of costs become essential to decisions on adoption of new evidence-based interventions. The attention to value has been reinforced by new risk-sharing payment models such as Accountable Care Organizations that give medical providers a greater financial stake in addressing the medical consequences of SUDs. The attention to provider-level considerations of costs and productivity are growing with the potential for greater SUD treatment demand from reforms in the Mental Health Parity and Addiction Equity Act.

To address the economic evidence gap for new and effective internet-based interventions for SUD treatment at a time of increased receptivity to cost-effective interventions (Bewick et al., 2008; Moore et al., 2011), we performed an economic evaluation of the multisite TES +TAU trial from both a provider and payer perspective.

2. METHODS

2.1 The TES+TAU versus TAU randomized effectiveness trial (Campbell et al., 2014)

Individuals, ages 18 and older, who were seeking SUD treatment at 10 outpatient community-based treatment programs associated with the National Drug Abuse Treatment Clinical Trials Network were recruited to participate in the study. Because this was an effectiveness trial with a goal of promoting external validity, the programs were selected to ensure diversity in patients, geographic locations, and programming. The details of the program-selection process are reported by Campbell et al. (2012). A total of 507 patients presenting with various SUDs (stimulants ~ 34%, opioids ~ 21%, alcohol ~ 21%, marijuana ~ 22%, and other substances ~ 2%) were randomized between June, 2010 and August, 2011 to receive 12 weeks of TAU (N=252) or TES+TAU (N=255).

TES is comprised of 62 interactive, self-directed multimedia modules based on CRA and an integrated CM program. For the purposes of this study, TES was primarily accessed via computers at the treatment programs (~ 20% of modules were completed off-site). Modules provide participants with information on strengthening skills related to relapse prevention, psychosocial functioning, and prevention of HIV, hepatitis and other sexually transmitted infections (Budney, 1998; Campbell et al., 2014). Each module took approximately 20–30 minutes to complete and participants were asked to complete 4 per week (or 48 modules over the 12-week intervention phase). TES modules were intended to replace approximately 2 hours of standard face-to-face group counseling per week.

TES incentives took the form of earned draws from a virtual “fish bowl” (Petry et al., 2005; Stitzer et al., 2010). Vouchers contained congratulatory messages (about half the time) or prizes with variable value (usually \$1, occasionally \$20, and rarely \$100). Draws were earned for providing negative urine and breath-alcohol screens, and for completing modules (up to 4 per week). Research staff recorded target behaviors into the TES system and

oversaw prize distribution. TAU was the usual intensive outpatient treatment curriculum delivered by each program. Usual treatment was primarily therapeutic groups, with some individual counseling. Most programs offered between 2–6 sessions per week.

Patients were screened for drugs, and self-reported alcohol and drug use twice a week during the 12-week intervention period, then at the 24- and 36-week follow-up visits. Participants in the TES+TAU group were significantly more likely to be abstinent at the end of treatment (OR=1.62; $p=0.01$); this was more pronounced among participants not abstinent at study entry (OR=2.18; $p=0.003$). Moreover, TES+TAU participants had significantly more abstinent half-weeks during the 12-week trial (mean=11.1 vs. 8.8; $p=0.008$), as well as more consecutive abstinent half-weeks (mean=8.0 vs. 5.1; $p=0.001$). Finally, retention in the TES +TAU group was significantly higher than in TAU (hazard ratio=0.72; $p=0.01$) (Campbell et al., 2014).

2.2 Cost measurement

Costs were estimated via the resource costing method, where the unit cost associated with each resource is multiplied by the number of resource units used by a participant. Estimates of per-participant costs were derived by summing these figures across the relevant resources. The number of resource units utilized by each participant was recorded prospectively by research staff on clinical case report forms. The use of medical services was self-reported and collected by research staff via the non-study medical services form monthly during the first 12 weeks and at the 24- and 36-week assessments. All costs were estimated using U.S. prices, adjusted to 2013 U.S. dollars via the Consumer Price Index. Unit costs came from various sources, but most site-specific costs were obtained from a modified DATCAP (French, 2003) completed by an administrator at each program.

Staff time required for TES included orienting patients to the computer modules, and prize management and distribution. Based on site assessments, we estimated the average time allocated to each of these tasks to be 16 minutes per patient for initiation, 2.5 hours per month for prize management and 10 minutes for prize distribution per patient visit. Time for these tasks was valued according to the median annual salary of a case manager as reported by the Bureau of Labor Statistics (BLS) (Bureau of Labor Statistics, 2014), \$28,850, and the BLS' estimated benefit rate of 30.2% for the health care and social assistance industry group. The total annual compensation was estimated to be \$41,332 (\$19.87/hour).

The unit cost for each module of TES completed required several assumptions and steps that are provided in Table 1. First, it should be noted that most of the annual costs of TES do not change with the number of users. Consequently, the price per module was largely a function of how frequently TES was utilized. These fixed costs included the cost of computers (2 per site, with an assumed life span of 3 years), the annual TES license, clinic space utilized for TES purposes (based on the value of the square footage required and the proportion of time the space was allocated to TES), furniture, maintenance and training for counselors. All values were based on the average requirements across study sites collected through the DATCAP survey. The site-specific fixed cost was estimated at \$19,620 per year. We then used assumptions about site-wide utilization (modules per-site per-year) to determine the cost per module. The sites averaged 388 client visits per week, with 1.3 TES modules

completed at each visit. If every client at a given site used TES at this rate, this would result in over 26,000 modules per year. This is not realistic in clinical practice. Thus, we consider 3 levels of utilization for a site: heavy - TES for 50% of all patients; normal - TES for 25%; and light - TES for 13%. Our main analysis assumes normal intensity, resulting in a cost of \$3 per module. Moving from light to heavy results in a per-module range of \$2 to \$6.

Hourly counselor compensation was valued according to the average requirements across study sites, and accounted for annual salary and benefits, overhead costs and the proportion of counselor time allocated to TES+TAU clients, resulting in an hourly cost of \$51.

Medical services that were tracked included residential rehabilitation, hospital detoxification, hospital non-detoxification, medical office, emergency department (ED) and psychiatrist visits, and post-intervention counseling hours. The unit costs for residential (\$511), detox (\$672), hospital non-detox (\$1,247), medical office (\$127) and ED (\$504) visits were obtained from the 2003 MEDSTAT MarketScan database and are based on mean out-of-pocket expenditures and reimbursements for beneficiaries with SUDs between the ages of 12 and 25 (Polsky et al., 2010). The cost of a psychiatrist visit was based on the BLS' estimated mean annual salary for a psychiatrist (\$182,660) (Bureau of Labor Statistics, 2014), and 30.2% benefit rate, resulting in a total annual compensation estimate of \$261,691 (\$126/hour).

2.3 Effectiveness measures

Both a clinical and an economic measure of effectiveness were calculated. The clinical-effectiveness measure of abstinence is a combined measure derived from urine and breath-alcohol screens, and self-reported drug and alcohol use. Abstinence was defined as having a negative urine and breath-alcohol screen, and no self-reported substance use. Observations with missing self-report information, but a positive screen were considered to be not-abstinent. Observations were deemed missing if the urine screen was missing or the urine screen was negative and the self-report was missing. The self-report measure of abstinence at the 24- and 36-week follow-up visits is based the respondent's use during the 30 days prior to assessment. We converted these measures to a measure of time abstinent, the abstinent year. The economic-effectiveness outcome is a measure that weights the amount of time a participant spent in a given health state by the preference-weighted health-related quality-of-life (HRQoL) score associated with that particular state, the quality-adjusted life year (QALY). The HRQoL preference weights were obtained from the EQ-5D (Dolan, 1997; The EuroQol Group, 1990), a generic instrument for assessing HRQoL, which was administered at study entry and at weeks 4, 8, 12, 24 and 36. The EQ-5D produces a preference value for the respondent's current health state that lies between -0.594 (a state perceived to be worse than death) and 1 (a fully functional health state).

2.4 Cost-effectiveness

Our primary outcomes are the incremental cost-effectiveness ratios (ICERs). We took the perspectives of the SUD treatment provider and the payer in order to better inform their decisions; that is, the treatment provider's decision of whether to adopt the intervention, and the payer's reimbursement decisions. For the provider, we calculated the 12-week study-

provided direct medical costs per QALY and abstinent year. These costs included the TES intervention and treatment-related counseling. For the payer's perspective, 12- and 36-week ICERs were calculated measuring the total direct medical costs per QALY and abstinent year. These costs included all provider costs and the costs of non-study medical services.

2.5 Analysis

Patient characteristics at baseline were tested using Fisher's exact test for categorical variables and a t-test for continuous variables. Individual multivariable models were estimated to predict the following cost and effectiveness outcomes: weekly costs of study-provided counseling, medical services, the HRQoL preference weights, the number of abstinent days over the 12-week intervention period, and the probability that the participant was abstinent at week 24 and week 36. All multivariable models were estimated with generalized linear models, weighted where necessary due to missing data. The family and link function were chosen according to the fit of the data (Glick et al., 2007; Manning and Mullahy, 2001; Park, 1966). The method of recycled predictions was used to estimate all predicted means (Glick et al., 2007). A total of 5% of medical-services, 9% of HRQoL and 17% of abstinence data was missing. There were no missing data for the costs included in the provider perspective, given that the use of those resources was recorded as they were provided. The clinical outcomes paper did not report any evidence of non-ignorable missingness (Campbell et al., 2014); therefore, missing data were addressed via inverse probability weighting. Inverse probability weighting has been shown to be effective at removing missing-data bias when the data are missing at random (Seaman and White, 2013).

The total direct medical costs for the provider were calculated by summing the weekly predictions of study-provided counseling and the weekly mean cost of TES. The total direct medical costs for the payer were calculated by summing the weekly provider costs and the predicted medical-service costs. The 12-week estimates were derived by summing the relevant mean costs over the first 12 weeks, while the 36-week costs include the sum of all relevant costs for the 12-week period plus weeks 24 and 36.

Predicted QALYs were calculated by estimating the area under the curve of the predicted HRQoL weights. The predicted number of abstinent days for the 12-week intervention period were calculated by summing the weekly predictions. The predicted probabilities of abstinence for weeks 24 and 36 were used to generate a weighted-mean number of abstinent days over each of the 12-week follow-up periods, which were then added to the 12-week estimate. The final abstinent measure is expressed as a proportion of a year, where a 1 represents 365 days of abstinence. Both the QALY and the abstinent-year measures were annualized for purposes of interpretability and comparison between the 12- and 36-week estimates. Given the differences in findings in the clinical outcomes paper among patients with a relatively poor prognosis (urine drug or breath alcohol positive at study entry; Campbell et al., 2014), additional analyses were completed for the subsample of participants who were not abstinent at study entry.

The above analyses were performed within a nonparametric bootstrap in order to estimate p-values and standard errors while accounting for sampling uncertainty. Acceptability curves were developed to illustrate the probability that the intervention is a good value for different

willingness-to-pay thresholds. The acceptability curves were estimated using parametric methods on the parameters obtained from the non-parametric bootstrap (Glick et al., 2007). For sensitivity analyses we considered how TES costs would vary according to utilization (*light to heavy*), and the size and location of the program.

3. RESULTS

Table 2 contains descriptive statistics for TAU and TES+TAU participants at study entry. Participants in the two groups were very similar. Both were, on average, in their mid-thirties and were predominantly male and white/Caucasian. Approximately half of each group was not abstinent at study entry (TES+TAU=47%, TAU=45%). Regarding the subsample of participants who were not abstinent at baseline, with the exception of the EQ-5D mobility score, which was slightly higher for TES+TAU participants (1.29 vs. 1.14, $p=0.01$), patient characteristics did not differ significantly between study groups.

3.1 Costs

Table 3 contains the predicted mean costs for the provider over the 12-week intervention period. The costs are presented for both the total sample and the subsample of participants who were not abstinent at study entry. The total study-provided direct medical costs for the full sample were \$278 (SE=87; $p=0.002$) higher, on average, for TES+TAU relative to TAU. The average cost of the TES modules completed was \$107 (SE=3), the average value of TES prizes received was \$277 (SE=15) and the average cost associated with prize management and administration was \$33 (SE=0.86), for a total intervention cost of \$417 (SE=4). Similarly, among participants who were not abstinent at study entry, direct medical costs were \$253 (SE=122; $p=0.04$) higher for TES+TAU relative to TAU. The lower direct medical costs for this subgroup were driven by the lower intervention costs: \$323 (SE=6) vs. \$417 (SE=4). The subgroup of individuals not abstinent at study entry used services less intensively and for a slightly shorter stay in treatment.

The predicted mean costs from the payer perspective were estimated over 12 weeks, as well as over the longer follow-up time horizon of 36 weeks. These results are displayed in Table 4 for all participants and the subgroup of those not abstinent at study entry. The large standard error of the medical-services cost variable makes it difficult to draw inferences regarding the medical offsets of this intervention.

3.2 Effectiveness

The predicted effectiveness outcomes for TES+TAU and TAU can be viewed in Tables 3 and 4. The annualized abstinent-years gained over the 12-week intervention period for TES+TAU relative to TAU were 0.13 (SE=0.04, $p<0.001$) for all participants and 0.14 (SE=0.04, $p=0.002$) for participants not abstinent at study entry. By 36-weeks, these figures fell to 0.06 (SE=0.03, $p=0.04$) and 0.07 (SE=0.04, $p=0.10$), respectively. The annualized QALY-gained figure for both TES+TAU and TAU was approximately 0.83 over the 12-week intervention period and 0.84 over 36-weeks. The estimated QALYs gained were very similar for the subgroup not abstinent at study entry. None of the QALY differentials were statistically significant.

3.3 Cost effectiveness

The incremental cost-effectiveness ratios (ICERs) can be viewed in Table 5. The 12-week point estimates for provider cost per abstinent-year are \$9,073 for the full sample and \$7,980 for the subgroup of those not abstinent at study entry. The respective estimates for the payer are \$8,832 and \$11,526; both are associated with greater uncertainty. The 36-week payer ratios are lower at \$3,458 and \$1,120 for the full sample and subgroup, respectively; however, both have a wide confidence interval.

The cost-per-QALY point estimates indicate that TES+TAU is dominated by TAU; however, the signs and wide confidence intervals of the estimates reflect the very small, insignificant, negative difference between QALYs for TES+TAU relative to TAU. Because these ratios do not provide much information in the cost-effectiveness framework, we focus on the ICERs for costs per abstinent-year with regard to illustrating statistical uncertainty. The 12- and 36-week acceptability curves for the full sample and the subgroup can be viewed in Figures 1 and 2, respectively. Using an abstinent-year as the effectiveness endpoint, TES+TAU would be considered a “good value” at most levels of willingness-to-pay. For example, we can be over 95% confident that TES+TAU would be considered cost-effective at a willingness-to-pay of \$20,000 per abstinent year. Unfortunately, a general willingness-to-pay threshold for abstinent-years is not available, unlike for QALYs where the range is typically \$50,000 to \$200,000 per QALY (Hirth et al., 2000).

4. DISCUSSION

TES+TAU, as implemented in a multisite randomized effectiveness trial (Campbell et al., 2014) costs \$278 per treatment episode, relative to TAU, for the SUD treatment provider (see Table 3). This results in cost effectiveness ratios of \$9,073 and \$8,832 per year of abstinence for the provider and payer, respectively, after 12 weeks. We did not detect a medical cost offset from the use of this effective treatment. It is likely the low percentage of high medical-risk participants in this sample reduced the power to do so.

Internet interventions have been shown to be effective for multiple diseases and disorders (Murray et al., 2005; Spek et al., 2007; Wantland et al., 2004), and although the argument for implementation is often one of cost-effectiveness, there is a paucity of detailed evaluations (Tate et al., 2009). As one of the first comprehensive economic analyses of a technology-deployed platform for SUD treatment, this study offers an economic framework for future work integrating technology into SUD therapy.

Given the rapid rate at which technology evolves and the variability in how technology might be deployed, one must be cautious in generalizing these specific findings. First, TES was deployed on a desktop platform, but the growing ubiquity of smart phones offers opportunities for a less expensive deployment, and TES has recently been released as a smartphone and tablet application. Second, the cost of delivering TES is heavily dependent on a number of factors that will vary according to the manner in which it is implemented. Many of the TES costs are fixed; therefore, there is very little cost to the provider for each additional person using the system. The number of patients for whom TES is integrated as a supplement to treatment will dictate costs per patient. Just as critical is the degree to which

TES is designed to serve as a substitute for standard clinical care, thereby providing a cost offset of clinician time and potentially program visits. Depending on billing structure (e.g., fee for service, capitation payments), reducing face-to-face counselor time could be more or less beneficial for providers. For example, if TES could be implemented effectively with less face-to-face counselor time, it would have a greater cost offset than that estimated in this protocol. Under a fee-for-service model, this may be more beneficial to the payer, in which case a new, mutually-advantageous contract between the payer and provider could be developed. Under a capitated payment model, the provider would be the primary beneficiary. However, the effectiveness result in this study may not generalize to a treatment plan that encourages mostly off-site use of TES (~ 20% of modules were completed off-site in this protocol) or replaces more usual face-to-face hours with TES.

Third, different licensing options could result in a larger proportion of the costs being variable, thus changing the economics of implementation. For example, rather than a fixed annual license, the fees could be allocated to each user (i.e., fee for service). Under this model, the strategy for economically successful deployment would be much different, as broad adoption would not be as important as finding those clients who would most benefit from the service.

There was no discernible difference in QALYs between the two treatment arms; however, TES+TAU participants remained in treatment longer and achieved more days of abstinence than TAU participants. Regarding our clinical outcome of abstinent-years, TES+TAU qualifies as cost-effective with a level of confidence exceeding 95% for willingness-to-pay values above \$20,000. That is, if the stakeholder is willing to pay \$20,000 per abstinent-year, we can be 95% confident that TES+TAU would be considered a “good value”. And, in general, the results were more promising for participants who were not abstinent at study entry. Our findings on the cost-effectiveness of CM with regard to an abstinent year compare favorably to those found elsewhere in the CM literature (Murphy et al., 2015; Olmstead and Petry, 2009; Sindelar et al., 2007).

Given that the patient costs associated with TES are driven largely by time in treatment and, as can be seen in Table 3, the mean time in treatment for TES+TAU participants was almost a week longer than for TAU participants, we also considered the costs of the program under the assumption that patients who leave can be replaced with new patients. This is a likely scenario for the reason that treatment programs often operate at capacity (Substance Abuse and Mental Health Services Administration, 2013), in which case the treatment site experiences costs and revenue for their patient census and the financial consequences are not necessarily higher when a patient stays longer. Normalizing the overall average number of weeks in treatment across both arms, such that they reflect the intensity of costs if they occurred over an equal duration, resulted in a larger, statistically significant, counseling cost offset of \$328 for TES+TAU participants relative to TAU, and thus a smaller total cost differential of \$65. These figures are in contrast to the counseling cost offset of \$139 and the total cost differential of \$278 in the non-normalized results.

As discussed above, we are limited in our ability to generalize the TES cost results. Although the amount of missing data was relatively low, it also serves as a limitation.

However, the missingness was addressed using a method that has been shown to perform well when data are missing at random, which they appear to be (Seaman and White, 2013). Another limitation has to do with participants who were not abstinent at baseline, in that this subsample was not randomly assigned to TAU or TES+TAU. Although, we tested for differences in patient characteristics at baseline and found these participants to be similar across study groups.

In the context of existing economic evaluations of contingency-management studies that have examined time-abstinent as an outcome, our cost-per-abstinent-year findings are encouraging. Moreover, depending on providers' and payers' thresholds for defining value with regard to abstinence, TES+TAU has a high likelihood of being considered a wise investment. Due to the variability in potential implementation strategies and evolving technology, it is difficult to generalize the cost differential reported here. Nonetheless, these analyses, using data from a large and diverse patient population, provide a strong framework for future cost-effectiveness analyses of technology-based treatment options for substance use disorders.

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References

- Albright J, Ciaverelli R, Essex A, Tkacz J, Ruetsch C. Psychiatrist characteristics that influence use of buprenorphine medication-assisted treatment. *J Addict Med.* 2010; 4:197–203. [PubMed: 21769038]
- Bewick BM, Trusler K, Barkham M, Hill AJ, Cahill J, Mulhern B. The effectiveness of web-based interventions designed to decrease alcohol consumption—a systematic review. *Prev Med.* 2008; 47:17–26. [PubMed: 18302970]
- Bickel WK, Amass L, Higgins ST, Badger GJ, Esch RA. Effects of adding behavioral treatment to opioid detoxification with buprenorphine. *J Consult Clin Psychol.* 1997; 65:803. [PubMed: 9337499]
- Bickel WK, Marsch LA, Buchhalter AR, Badger GJ. Computerized behavior therapy for opioid-dependent outpatients: a randomized controlled trial. *Exp Clin Pharmacol.* 2008; 6:132.
- Bouchery EE, Harwood HJ, Sacks JJ, Simon CJ, Brewer RD. Economic costs of excessive alcohol consumption in the U.S., 2006. *Am J Prev Med.* 2011; 41:516–524. [PubMed: 22011424]
- Budney, AJ. *Therapy Manuals For Drug Addiction: A Community Reinforcement Plus Vouchers Approach: Treating Cocaine Addiction.* U.S. Department of Health and Human Services, National Institute on Drug Abuse; Washington: 1998.
- Bureau of Labor Statistics. *Occupational Outlook Handbook.* Bureau of Labor Statistics; 2014. (<http://www.bls.gov/ooh/home.htm>)
- Campbell AN, Nunes EV, Matthews AG, Stitzer M, Miele GM, Polsky D, Turrigiano E, Walters S, McClure EA, Kyle TL, Wahle A, Van Veldhuisen P, Goldman B, Babcock D, Stabile PQ, Winhusen T, Ghitza UE. Internet-delivered treatment for substance abuse: a multisite randomized controlled trial. *Am J Psychiatry.* 2014; 171:683–690. [PubMed: 24700332]

- Campbell AN, Nunes EV, Miele GM, Matthews A, Polsky D, Ghitza UE, Turrigiano E, Bailey GL, VanVeldhuisen P, Chapdelaine R. Design and methodological considerations of an effectiveness trial of a computer-assisted intervention: an example from the NIDA Clinical Trials Network. *Contemp Clin Trials*. 2012; 33:386–395. [PubMed: 22085803]
- Cunningham CO, Kunins HV, Roose RJ, Elam RT, Sohler NL. Barriers to obtaining waivers to prescribe buprenorphine for opioid addiction treatment among HIV physicians. *J Gen Intern Med*. 2007; 22:1325–1329. [PubMed: 17619934]
- Dolan P. Modeling valuations for EuroQol health states. *Med Care*. 1997; 35:1095–1108. [PubMed: 9366889]
- French, MT. Drug Abuse Treatment Cost Analysis Program (DATCAP): User's Manual. University of Miami; Florida: 2003.
- Garcia-Rodriguez O, Secades-Villa R, Higgins ST, Fernandez-Hermida JR, Carballo JL, Errasti Perez JM, Diaz SA-h. Effects of voucher-based intervention on abstinence and retention in an outpatient treatment for cocaine addiction: a randomized controlled trial. *Exp Clin Psychopharmacol*. 2009; 17:131. [PubMed: 19586227]
- Glick, H.; Doshi, JA.; Sonnad, SS.; Polsky, D. *Economic Evaluation In Clinical Trials*. Oxford University Press; 2007.
- Gunderson EW, Fiellin DA, Levin FR, Sullivan LE, Kleber HD. Evaluation of a combined online and in person training in the use of buprenorphine. *Subst Abuse*. 2006; 27:39–45.
- Higgins ST, Budney AJ, Bickel WK, Foerg FE, Donham R, Badger GJ. Incentives improve outcome in outpatient behavioral treatment of cocaine dependence. *Arch Gen Psychiatry*. 1994; 51:568–576. [PubMed: 8031230]
- Higgins ST, Sigmon SC, Wong CJ, Heil SH, Badger GJ, Donham R, Dantona RL, Anthony S. Community reinforcement therapy for cocaine-dependent outpatients. *Arch Gen Psychiatry*. 2003; 60:1043–1052. [PubMed: 14557150]
- Hirth RA, Chernew ME, Miller E, Fendrick AM, Weissert WG. Willingness to pay for a quality-adjusted life year: in search of a standard. *Med Decis Making*. 2000; 20:332–342. [PubMed: 10929856]
- Kvamme E, Catlin M, Banta-Green C, Roll J, Rosenblatt R. Who prescribes buprenorphine for rural patients? The impact of specialty, location and practice type in Washington State. *J Subst Abuse Treat*. 2013; 44:355–360. [PubMed: 22939650]
- Manning WG, Mullahy J. Estimating log models: to transform or not to transform? *J Health Econ*. 2001; 20:461–494. [PubMed: 11469231]
- Mark TL, Kranzler HR, Poole VH, Hagen CA, McLeod C, Crosse S. Barriers to the use of medications to treat alcoholism. *Am J Addict*. 2003a; 12:281–294. [PubMed: 14504021]
- Mark TL, Kranzler HR, Song X, Bransberger P, Poole VH, Crosse S. Physicians' opinions about medications to treat alcoholism. *Addiction*. 2003b; 98:617–626. [PubMed: 12751979]
- Moore BA, Fazzino T, Garnet B, Cutter CJ, Barry DT. Computer-based interventions for drug use disorders: a systematic review. *J Subst Abuse Treat*. 2011; 40:215–223. [PubMed: 21185683]
- Murphy SM, Fishman PA, McPherson S, Dyck DG, Roll JR. Determinants of buprenorphine treatment for opioid dependence. *J Subst Abuse Treat*. 2014; 46:315–319. [PubMed: 24209382]
- Murphy SM, McDonell MG, McPherson S, Srebnik D, Angelo F, Roll JM, Ries RK. An economic evaluation of a contingency-management intervention for stimulant use among community mental health patients with serious mental illness. *Drug Alcohol Depend*. 2015; 153:293–299. [PubMed: 26026494]
- Murray E, Burns J, See TS, Lai R, Nazareth I. Interactive Health Communication Applications for people with chronic disease. *Cochrane Database Syst Rev*. 2005; 4
- National Drug Intelligence Center. *The Economic Impact Of Illicit Drug Use On American Society*. United States Department of Justice; Washington, D.C: 2011.
- Olmstead TA, Petry NM. The cost-effectiveness of prize-based and voucher-based contingency management in a population of cocaine-or opioid-dependent outpatients. *Drug Alcohol Depend*. 2009; 102:108–115. [PubMed: 19324501]
- Park RE. Estimation with heteroscedastic error terms. *Econometrica*. 1966; 34:888.

- Petry NM, Peirce JM, Stitzer ML, Blaine J, Roll JM, Cohen A, Obert J, Killeen T, Saladin ME, Cowell M, Kirby KC, Sterling R, Royer-Malvestuto C, Hamilton J, Booth RE, Macdonald M, Liebert M, Rader L, Burns R, DiMaria J, Copersino M, Stabile PQ, Kolodner K, Li R. Effect of prize-based incentives on outcomes in stimulant abusers in outpatient psychosocial treatment programs: a national drug abuse treatment clinical trials network study. *Arch Gen Psychiatry*. 2005; 62:1148–1156. [PubMed: 16203960]
- Polsky D, Glick HA, Yang J, Subramaniam GA, Poole SA, Woody GE. Cost-effectiveness of extended buprenorphine–naloxone treatment for opioid-dependent youth: data from a randomized trial. *Addiction*. 2010; 105:1616–1624. [PubMed: 20626379]
- Raven MC, Carrier ER, Lee J, Billings JC, Marr M, Gourevitch MN. Substance use treatment barriers for patients with frequent hospital admissions. *J Subst Abuse Treat*. 2010; 38:22–30. [PubMed: 19540700]
- Seaman SR, White IR. Review of inverse probability weighting for dealing with missing data. *Stat Methods Med Res*. 2013; 22:278–295. [PubMed: 21220355]
- Sindelar JL, Olmstead TA, Peirce JM. Cost-effectiveness of prize-based contingency management in methadone maintenance treatment programs. *Addiction*. 2007; 102:1463–1471. [PubMed: 17645428]
- Spek V, Cuijpers P, Nyklíček I, Riper H, Keyzer J, Pop V. Internet-based cognitive behaviour therapy for symptoms of depression and anxiety: a meta-analysis. *Psychol Med*. 2007; 37:319–328. [PubMed: 17112400]
- Stitzer ML, Petry NM, Peirce J. Motivational incentives research in the national drug abuse treatment clinical trials network. *J Subst Abuse Treat*. 2010; 38:S61–S69. [PubMed: 20307797]
- Substance Abuse and Mental Health Services Administration. Results from the 2013 National Survey on Drug Use and Health: Summary of National Findings. Substance Abuse and Mental Health Services Administration; Rockville, MD: 2014. NSDUH Series H-48
- Substance Abuse and Mental Health Services Administration. Data on Substance Abuse Treatment Facilities. Rockville, MD: 2013. National Survey of Substance Abuse Treatment Services (N-SSATS): 2012. BHSIS Series S-66, HHS Publication No. (SMA) 14-4809
- Tate DF, Finkelstein EA, Khavjou O, Gustafson A. Cost effectiveness of internet interventions: review and recommendations. *Ann Behav Med*. 2009; 38:40–45. [PubMed: 19834778]
- The EuroQol Group. EuroQol-a new facility for the measurement of health-related quality of life. *Health Policy*. 1990; 16:199–208. [PubMed: 10109801]
- Walley AY, Alperen JK, Cheng DM, Botticelli M, Castro-Donlan C, Samet JH, Alford DP. Office-based management of opioid dependence with buprenorphine: clinical practices and barriers. *J Gen Intern Med*. 2008; 23:1393–1398. [PubMed: 18592319]
- Wantland DJ, Portillo CJ, Holzemer WL, Slaughter R, McGhee EM. The effectiveness of Web-based vs. non-Web-based interventions: a meta-analysis of behavioral change outcomes. *J Med Internet Res*. 2004; 6:e40. [PubMed: 15631964]

Highlights

- Therapeutic Education System (TES) - internet-based substance-misuse intervention.
- We conducted an economic evaluation of a multisite randomized trial of TES.
- Evaluated TES as treatment for alcohol or other substance use disorders.
- TES is likely cost-effective based on the clinical outcome of abstinence.

Figure 1.
Acceptability Curve for Cost per Abstinent Year – All Participants

Figure 2.
Acceptability Curve for Cost per Abstinent Year – Participants Not Abstinent at Study Entry

Table 1

TES Costs

Variable	Annual Average Across Sites
Cost of site resources	
Computers	650
Annual TES license	9,800
Space for TES	5,913
Furniture	245
Maintenance	2,172
Training	840
Total annual fixed costs	19,620
Utilization	
Client visits per week	388
Total weeks of TES per year	52
Number of modules per visit	1.3
Number of modules possible with 100% utilization	26,229
Utilization assumptions - number of modules	
Heavy (50% of all patients)	13,115
Normal (25% of all patients)	6,557
Light (12.5% of all patients)	3,279
Costs per module by utilization rates	
Heavy	2
Normal	3
Light	6

Table 2

Baseline Patient Characteristics

Variable	TES+TAU Mean (SD)	TAU Mean (SD)	P-value
Age	35.59 (10.71)	34.19 (11.05)	0.15
Female	36%	40%	0.31
Race			0.25
White/Caucasian	53%	59%	
Black/African American	27%	19%	
Other	20%	22%	
Medical services in 90 days prior			
Outpatient substance use treatment	1.82 (8.05)	1.12 (6.26)	0.27
Medical office visits	1.01 (2.49)	1.17 (2.10)	0.45
EQ-5D Score	73.13 (20.65)	72.69 (18.63)	0.80
Mobility	1.2 (0.40)	1.15 (0.35)	0.09
Self care	1.03 (0.17)	1.05 (0.22)	0.25
Usual	1.20 (0.43)	1.21 (0.42)	0.87
Pain	1.55 (0.64)	1.57 (0.59)	0.74
Anxiety	1.69 (0.66)	1.63 (0.64)	0.34
Not abstinent at baseline	47%	45%	0.68

Table 3**Predicted Mean Costs and Outcomes - Provider Perspective**

Variable	All Participants				Participants Not-Abstinent at Baseline			
	12-Weeks							
	TES+TAU	TAU	Diff (SE)	P-value	TES+TAU	TAU	Diff (SE)	P-value
Costs								
Intervention cost	417	0	417 (4)	<0.001	323	0	323 (6)	<0.001
TES	107	0	107 (3)	<0.001	94	0	94 (5)	<0.001
Prizes	277	0	277 (15)	<0.001	199	0	199 (15)	<0.001
Prize admin. & monitoring	33	0	33 (0.86)	<0.001	30	0	30 (1)	<0.001
Counseling cost	1,492	1,631	-139 (87)	0.11	1,152	1,222	-70 (121)	0.56
Total direct medical costs	1,909	1,631	278 (87)	0.002	1,475	1,222	253 (122)	0.04
Outcomes								
Abstinent years ^a	0.49	0.36	0.13 (0.04)	<0.001	0.31	0.17	0.14 (0.04)	0.002
QALYs ^a	0.826	0.830	-0.004 (0.013)	0.69	0.796	0.823	-0.027 (0.017)	0.13
Weeks in treatment	8.97	8.00			8.39	7.43		

^a Annualized

Table 4

Predicted Mean Costs and Outcomes - Payer Perspective

Variable	All Participants				Participants Not-Abstinent at Baseline			
	12-Weeks							
	TES+TAU	TAU	Diff (SE)	P-value	TES+TAU	TAU	Diff (SE)	P-value
Costs								
Intervention cost	417	0	417 (4)	<0.001	323	0	323 (6)	<0.001
TES	107	0	107 (3)	<0.001	94	0	94 (5)	<0.001
Prizes	277	0	277 (15)	<0.001	199	0	199 (15)	<0.001
Prize admin. & monitoring	33	0	33 (0.86)	<0.001	30	0	30 (1)	<0.001
Counseling cost	1,492	1,631	-139 (87)	0.11	1,152	1,222	-70 (121)	0.56
Non Study Services	680	688	-8 (71)	0.92	893	781	112 (135)	0.41
Total direct medical costs	2,589	2,319	270 (113)	0.02	2,368	2,003	365 (176)	0.02
Outcomes								
Abstinent years ^a	0.49	0.36	0.13 (0.04)	<0.001	0.31	0.17	0.14 (0.04)	0.002
QALYs ^a	0.826	0.830	-0.004 (0.013)	0.69	0.80	0.82	-0.027 (0.017)	0.13
36-Weeks								
Variable	All Participants				Participants Not-Abstinent at Baseline			
	12-Weeks							
	TES+TAU	TAU	Diff (SE)	P-value	TES+TAU	TAU	Diff (SE)	P-value
Costs								
Intervention	417	0	417 (4)	<0.001	323	0	323 (6)	<0.001
TES	107	0	107 (3)	<0.001	94	0	94 (5)	<0.001
Prizes	277	0	277 (15)	<0.001	199	0	199 (15)	<0.001
Prize admin. & monitoring	33	0	33 (0.86)	<0.001	30	0	30 (1)	<0.001
Counseling	2,528	2,811	-283 (158)	0.07	1,990	2,256	-266 (190)	0.16
Non Study Services	1,514	1,496	18 (131)	0.89	1,807	1,807	-0.5 (284)	1.00
Total direct medical costs	4,459	4,307	152 (207)	0.46	4,120	4,063	57 (335)	0.28
Outcomes								
Abstinent years ^a	0.41	0.35	0.06 (0.03)	0.04	0.30	0.22	0.07 (0.04)	0.10
QALYs ^a	0.841	0.842	-0.001 (0.010)	0.93	0.817	0.837	-0.020 (0.017)	0.26

Annualized
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Table 5

Incremental cost-effectiveness ratios of TES+TAU relative to TAU

	All Participants		Participants Not-Abstinent at Baseline			
	12-Weeks					
	Point Estimate	Lower Interval	Upper Interval	Point Estimate	Lower Interval	Upper Interval
Provider costs/QALY	Dominated^a	62,043	Dominated ^a	Dominated^a	166,260	Dominated ^a
Payer costs/QALY	Dominated^a	45,005	Dominated ^a	Dominated^a	166,514	Dominated ^a
Provider costs/Abstinent year	9,073	3,399	22,787	7,980	160	27,217
Payer costs/Abstinent year	8,832	1,796	22,986	11,526	350	38,257

36-Weeks						
	Point Estimate	Lower Interval	Upper Interval	Point Estimate	Lower Interval	Upper Interval
Payer costs/QALY	Dominated^a	Dominates ^b	94,345 ^c	Dominated^a	31,357	Dominates ^b
Payer costs/Abstinent year	3,458	Dominates ^b	76,244	1,120	Dominates ^b	285,545

^aIndicates TES+TAU was more expensive and less effective than TAU.^bIndicates TES+TAU was less expensive and more effective than TAU^cIndicates TES+TAU was less expensive and less effective than TAU.