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Web-based behavioral treatment for substance use disorders as a partial replacement of standard methadone maintenance treatment

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ABSTRACT

This study is the first experimental trial to evaluate the effectiveness of a Web-based behavioral intervention when deployed in a model where it partially substituted for standard counseling in a community-based specialty addiction treatment program. New opioid-dependent intakes in methadone maintenance treatment ($n = 160$) were randomly assigned for 12 months to either: (1) standard treatment or (2) reduced standard treatment plus a Web-based psychosocial intervention, the Therapeutic Education System (TES). Results demonstrated that replacing a portion of standard treatment with TES resulted in significantly greater rates of objectively measured opioid abstinence (48% vs. 37% abstinence across all study weeks; $F(1, 158) = 5.90$, $p < .05$ and 59% vs. 43% abstinence on weeks participants provided urine samples for testing; $F(1, 158) = 8.81$, $p < .01$). This result was robust and was evident despite how opioid abstinence was operationally defined and evaluated. The potential implications for service delivery models within substance abuse treatment programs and other healthcare entities are discussed.

1. Introduction

Therapeutic tools that harness existing and emerging technologies (e.g., Internet, mobile devices) offer considerable promise in the assessment, prevention, treatment, and recovery management of substance use disorders. Technology-based assessments can enable greater standardization of data collection and greater accuracy in reporting of sensitive data (e.g., substance use; behavior that may place one at risk for HIV, hepatitis, or other infectious diseases) (Kobak, Greist, et al., 1996; Marsch & Bickel, 2004). Technology-based interventions may include computer-assisted psychosocial treatment (e.g., behavior therapy, HIV prevention interventions) as well as tools for ongoing recovery support/relapse prevention (Marsch, 2012; Marsch & Dallery, 2012; Moore, Fazzino, Gernet, Cutter, & Barry, 2011).

Such technologies can expand the self-monitoring of patients and the reach of clinicians through technology-based behavioral monitoring systems and support systems; and can enhance patients' self-learning and self-management through interactive programs and tools. They can also engage patients, clinicians and an extended support network in shared decision-making through use of electronic decision support systems (Ben-Zeev et al., 2012; Marsch, 2011; Marsch, 2012).

Harnessing technology in the treatment and recovery management of substance use disorders may increase the quality, reach, and personalization of care in a manner that is cost-effective. These tools can also ensure fidelity in the delivery of interventions, thus assuring delivery of empirically-supported treatment. This is particularly important, as prior work has shown that training clinicians to deliver evidence-based behavioral treatment is time-consuming, clinicians are often not accurate in their assessment of when they are delivering evidence-based treatment, and intensive ongoing training and supervision are needed to ensure that interventions are delivered with fidelity (Martino et al., 2011; Moyers et al., 2008; Smith et al., 2012). Additionally, by having on-demand access to "just in time" therapeutic support via electronic devices, individuals can prevent costly escalation of substance use and related problems and unnecessary healthcare utilization. Technology-based therapeutic tools may be used in conjunction with various systems of care or as stand-alone tools for individuals who are unable (or do not wish) to access care for problematic

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substance use. Leveraging technology in this way offers great promise for leading to entirely new models for delivery of science-based approaches to addressing substance use disorders.

The promise of this approach is further underscored by the extraordinary rate at which access to the Internet and mobile devices has been growing among a wide array of populations. Over 80% of Americans have Internet access and about 90% subscribe to mobile phone services (Internet & Life Project, 2013). Worldwide, over 90% of individuals subscribe to mobile phone services, resulting in approximately 6.8 billion mobile phone subscriptions (Sanou, 2013). Growing evidence suggests that increased access to these technologies is also evident in many traditionally underserved and health disparity populations (Gibbons et al., 2011). Offering behavioral interventions on a wide array of platforms (e.g., desktop computers, mobile devices) offers great promise to reach large numbers of individuals. A large and rapidly expanding scientific literature has demonstrated the promise and clinical utility of a wide array of interactive, technology-based behavioral interventions targeting mental health disorders, including issues of depression, anxiety, post-traumatic stress disorder, eating disorders, as well as severe mental illness (e.g., Ben-Zeev et al., 2012; Foroushani, Schneider, & Assareh, 2011; Marks, Cavanagh, & Gega, 2007; Newman, Szkodny, Llera, & Przeworski, 2011). Additionally, there is a growing literature focused on how such technology-based tools can be implemented into mental health service delivery models to complement existing services (e.g., Ben-Zeev et al., 2012; Bennett-Levy et al., 2010) as well as methods and metrics for implementation research (e.g., Damschroder et al., 2009; Proctor et al., 2009).

Although a number of studies have evaluated the role of technology in addressing smoking and alcohol use disorders (e.g., Chen et al., 2012; White et al., 2010), only a small (but growing) line of research has demonstrated empirical support for technology-based behavioral interventions targeting chronic illicit substance use disorders. Among these therapeutic tools is a 6-session computerized cognitive behavioral intervention, called the Computer-based Training in Cognitive Behavioral Therapy (or CBT4CBT) program, developed by Carroll and colleagues. This program, which is largely video-based, teaches key cognitive behavioral skills, including coping skills, decision making skills, and understanding patterns of substance use. CBT4CBT has been shown to significantly enhance skills acquisition and substantively reduce substance use when provided as an adjunct to standard outpatient substance abuse treatment with a diverse sample of substance-using individuals (Carroll et al., 2008; Carroll et al., 2009).

The Motivational Enhancement System, a single-session intervention, has been shown to be acceptable and easy to use among postpartum women with substance involvement when provided within a health care setting (Ondersma, Chase, Svikis, & Schuster, 2005) and was associated with a reduction in illicit substance use among this population (Ondersma, Svikis, & Schuster, 2007). Additionally, the SHADE program (Self-Help for Alcohol and Other Drug Use and Depression), a motivational intervention targeting comorbid substance use and depressive disorders, was shown to produce equivalent outcomes to a comparable clinician-delivered intervention (Kay-Lambkin, Baker, Kelly, & Lewin, 2011; Kay-Lambkin, Baker, Lewin, & Carr, 2009). Further, a combined motivational and cognitive behavioral, Web-based intervention for cannabis use disorders was shown to produce comparable outcomes to in-person therapy (Budney et al., 2011).

One of the first technology-based behavioral interventions developed and evaluated in experimental research with individuals with substance use disorders is the Therapeutic Education System (TES) (Bickel, Marsch, Buchhalter, & Badger, 2008). TES is a Web-based psychosocial intervention that is theoretically grounded in the Community Reinforcement Approach (CRA) and Cognitive Behavior Therapy approaches to behavioral treatment of substance use disorders. CRA is an approach to behavior therapy designed to help individuals establish and maintain new patterns of behavior that do not involve substance use but which leverage social, recreational, family and vocational reinforcers to help individuals in their recovery from substance use disorders (Budney & Higgins, 1998).

TES is an interactive, Web-based, self-directed tool composed of 65 modules addressing a broad array of skills and behavior designed to help substance-abusing individuals successfully stop their substance use, gain life skills, and establish new behavioral repertoires that do not involve substance abuse and can be clinically meaningful. TES uses informational technologies to ensure mastery of content (fluency) via individually-paced presentation of content and testing to check for mastery of the material. Core modules focus on cognitive–behavioral and relapse prevention skills training as well as HIV prevention. Optional modules address a broad array of skills and behaviors related to employment status, family/social relations, financial management, communication skills, decision-making skills, management of negative moods and depression, time management, and recreational activities as well as specific content designed for HIV- and/or hepatitis C-positive individuals related to healthy living and effective management of these conditions. TES also includes an (optional) contingency management incentives system, in which individuals can earn monetary vouchers or prizes contingent on documented evidence of reaching some therapeutic goal (e.g., provision of substance-free urine samples).

TES has been evaluated in several experimental trials. In an initial, 23-week efficacy trial, opioid-dependent individuals ($n = 135$) maintained on buprenorphine medication were randomly assigned to one of three behavioral therapy conditions: (1) standard counseling (standard in most methadone-treatment settings in the U.S.), (2) CRA behavioral therapy, delivered with fidelity by highly-trained masters' level clinicians, along with contingency management incentives (delivered contingent on opioid- and cocaine-negative urine samples) or (3) CRA behavioral therapy delivered by TES, along with contingency management incentives (delivered contingent on opioid-and cocaine-negative urine samples). Participants in both the clinician-delivered CRA intervention and the computer-assisted (TES) CRA intervention demonstrated comparable levels of opioid- and cocaine-abstinence, and significantly greater rates of abstinence relative to those in the standard treatment condition (Bickel et al., 2008).

A second randomized trial ($n = 56$) evaluated the clinical utility of the modules on HIV, hepatitis and sexually transmitted infections with young persons in outpatient substance abuse treatment (without any contingency management incentives) as an enhancement to comparable content presented by a trained prevention specialist. Results indicated that the Web-based TES modules on these topics, when provided as an adjunct to an educator-delivered prevention intervention, increased accurate prevention knowledge, increased intentions to carefully choose partners, and was perceived as significantly more useful relative to the educator-delivered intervention when provided alone. Results suggested that these Web-based modules may be effective and engaging and may increase the adoption of effective HIV and disease prevention science (Marsch et al., 2011).

A pilot study randomized cocaine-using individuals ($n = 28$) to either: (1) TES plus standard outpatient treatment or (2) standard outpatient treatment alone for 8 weeks. Results showed that participants who received TES along with standard treatment showed larger increases in CRA-related knowledge and were significantly more likely to use effective coping strategies relative to those who received standard treatment alone (Brooks, Ryder, Carise, & Kirby, 2010).

Although research to date has generated promising data regarding the clinical utility of technology-based therapeutic tools as adjuncts to standard substance abuse treatment or as interventions that may be

offered instead of standard substance abuse treatment, little is known about an integrated model of deployment in which a computerized intervention is included in a treatment setting where it *replaces* a portion of standard substance abuse treatment. If a technology-based therapeutic tool is found to produce comparable or better outcomes when it substitutes for a portion of standard counseling, this could have a number of advantages. First, the technology-based intervention may serve as a "clinician-extender", extending the resources provided by clinicians and treatment programs to provide therapeutic support via technology anytime/anywhere and when clients may be in greatest need of support. This deployment model may also allow a given treatment program to serve a greater number of clients with the same number of clinicians and/or free-up some additional time for clinicians to spend with clients in crises or in greatest need of additional therapeutic support, while containing costs.

The present study is, to our knowledge, the first large experimental trial to evaluate the effectiveness of a computerized behavioral intervention when deployed in a model where it substituted for a portion of standard counseling in a community-based specialty addiction treatment program. Specifically, this study evaluated the empirically supported TES intervention in a community-based, methadone maintenance treatment (MMT) program for clients with opioid dependence. In this research design, new treatment intakes in methadone treatment who agreed to participate in the study were randomly assigned to either: (1) standard treatment at the treatment site or (2) reduced standard treatment plus the Web-based TES (such that half of counseling sessions were conducted with a substance abuse counselor and the other half with TES). Due to limited funding, MMT programs offer the lowest level of drug abuse counseling and services and have the highest client to staff ratios (on average 50 clients to 1 counselor) relative to other types of drug treatment programs (Levine, Reif, Lee, Ritter, & Horgan, 2004). Thus, embedding a technology-based therapeutic tool in this system to reduce burden on clinicians in a manner that may be cost-effective could provide great value to this care system.

The present study also extends prior work by examining the clinical effectiveness of TES when deployed without contingency management incentives (in which incentives are delivered contingent on evidence of drug-negative urine samples or some other therapeutic goal). As noted above, the behavioral therapy model included in TES (CRA) has sometimes been provided along with such incentives. Although the addition of such incentives to behavioral therapy has been shown to enhance patient outcomes, securing the financial resources to support voucher incentives for patients is often challenging for treatment programs (McLellan, 2001). Thus, we decided not to include contingency management interventions along with TES' CRA modules in the planned trial in an effort to minimize cost and test an intervention that is most likely to be integrated into service delivery models in resource-constrained treatment settings. Additionally, CRA delivered without incentives has been shown to be efficacious in the treatment of opioid dependence (Abbott, Weller, Delaney, & Moore, 1998), and this trial allowed us to evaluate the effectiveness of Web-based CRA in an MMT setting.

In addition, this study extended prior work by evaluating participant outcomes for a much longer period of time (12 months per client) than evaluation windows in prior studies of technology-based interventions targeting substance use disorders. This paper reports on the primary clinical effectiveness outcomes of opioid abstinence and treatment retention of this randomized clinical trial.

2. Materials and methods

2.1. Participants and study setting

Participants ($n = 160$) were new clients entering methadone maintenance treatment (MMT) at our study site, a large MMT program (of approximately 500 clients) in an urban part of the northeastern U.S. Participants were ≥18 years of age and within their first 30 days of MMT treatment entry. Participants also had to have sufficient English-language ability to understand the study assessments and the TES intervention. Clients at the study site were informed of the opportunity to participate in a research study at the time they entered MMT. Given that participants were asked to participate in the study for a 12 month period, individuals entering treatment at the study site for a medication-assisted withdrawal only (detoxification) were not eligible to participate.

All clients entering MMT must meet DSM criteria for opioid dependence and eligibility requirements detailed in the Federal Register regarding the use of opioid medications in the treatment of opioid addiction. As per the policy of MMT program, participants' methadone doses were typically stabilized within the first 2 weeks of treatment entry, and they were provided with stable therapeutic maintenance doses of methadone thereafter while in MMT (average of approximately 80–120 mg daily, depending on treatment response).

This study was institutional review board-approved, and all participants provided informed consent before study participation.

2.2. Randomization

As reflected in the CONSORT diagram provided in Fig. 1, a total of 258 individuals were screened for study eligibility and 160 of those individuals were randomly assigned to one of two study conditions in an intent-to-treat research design: (1) standard treatment or (2) reduced standard treatment plus the Web-based Therapeutic Education System (TES). Participants were stratified on past month cocaine use (yes/no) and prior history of methadone, LAAM or buprenorphine treatment (yes/no). Each study condition lasted for 12 months.

The 98 individuals who were screened for study eligibility but who did not go on to participate in the study were excluded for the following reasons: (a) voluntarily declined to participate/not interested ($n = 9$), (b) had been taking methadone medication for >30 days ($n = 40$), (c) had insufficient English-language ability ($n = 2$), (d) planning to leave the MMT study site before 12 months ($n = 7$), (e) did not attend multiple scheduled appointments for baseline assessments ($n = 6$), (f) started but did not finish the baseline assessment ($n = 4$) or (g) some other reason (e.g., research staff unable to contact client during eligibility window, client work schedule conflicted with participation, previously participated in the study [$n = 30$]).

2.3. Standard treatment

Participants in this condition received the standard substance abuse counseling offered at the MMT program. Counseling sessions were generally 1-hour in length and generally occurred once per week for the first 4 weeks then twice monthly thereafter. Counseling occurred more often for patients with recurring drug-positive results. Counseling was offered to participants for the duration of the time they were active clients in the MMT program. All counseling sessions were delivered in individual sessions with Certified Alcohol and Substance Abuse Counselors (CASACs). Counseling focused largely on patients' rehabilitation and compliance with program rules. In general, therapy sessions focused on helping patients understand and comply with program rules, current problems experienced by patients (e.g., employment, recent arrests, illness), and current treatment progress (attendance, urine test results). Counselors also offered limited case management to patients, including recommending social service liaisons and referrals for patients (such as assistance for welfare, legal and medical problems). Patients could also receive HIV educational materials. Counselors had group supervision weekly and individualized supervision with an onsite clinical supervisor at least once monthly. The content and frequency of standard counseling

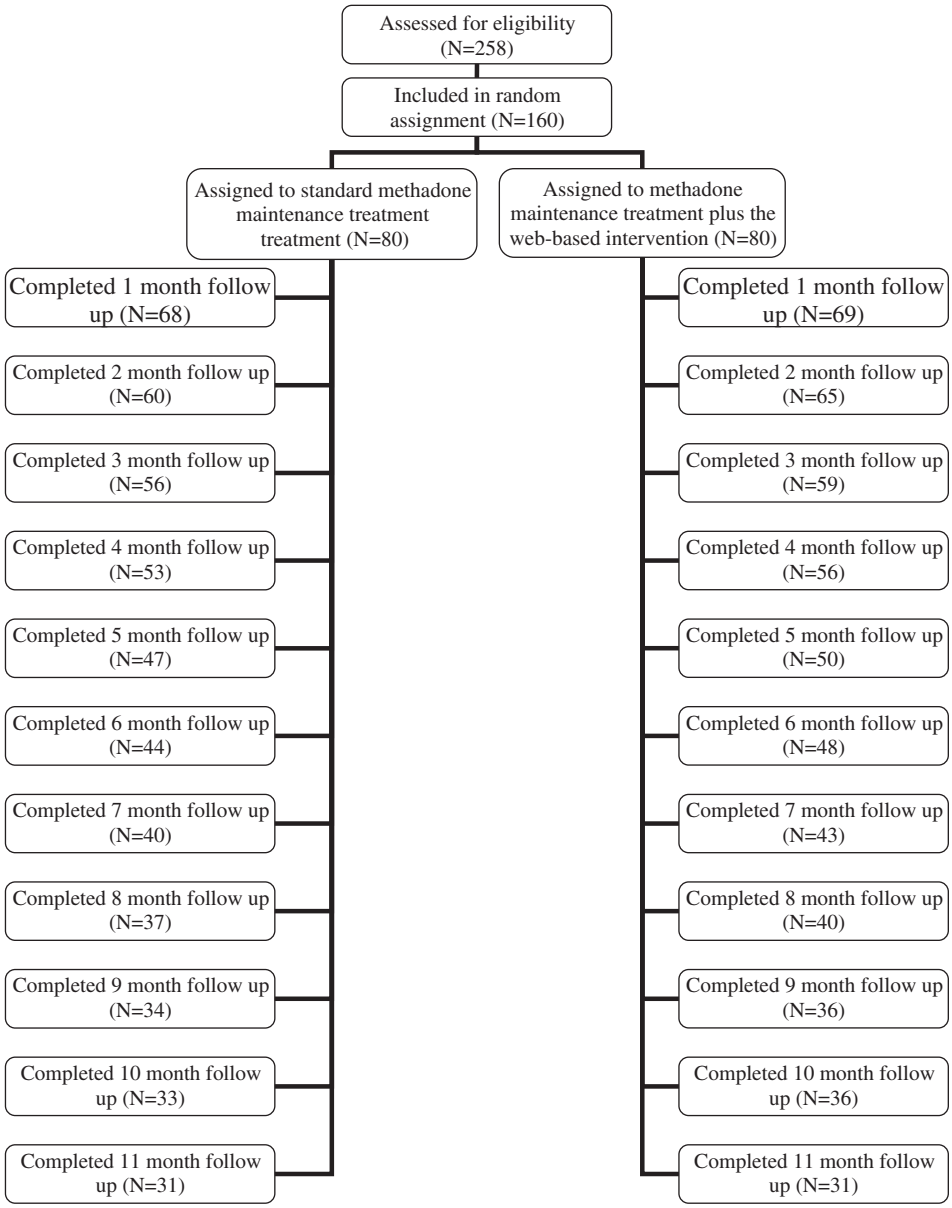

Fig. 1. CONSORT diagram: flow of participants through the study.

offered at this MMT program is similar to counseling offered in the majority of MMT programs (Ball & Ross, 1991) and to the standard counseling provided in the seminal study of psychosocial services in methadone treatment conducted by McLellan and colleagues (McLellan, Arndt, Metzger, Woody, & O'Brien, 1993).

2.4. Reduced standard treatment plus the Web-based Therapeutic Education System (reduced standard + TES)

Participants in this condition received the same standard substance abuse counseling offered to participants in the standard treatment condition with one exception: each client was asked to spend half of each scheduled counseling session with their counselor (30 minutes), and spend the other half of their session using the Web-based TES (30 minutes). Onsite research staff reminded counselors on a weekly basis (verbally and via a written report) which of their clients were in each of the two study conditions and which clients required counseling sessions of reduced length. Importantly, these same onsite research staff regularly monitored when clients in this study condition were due for a TES session and helped facilitate their ending of their abbreviated counseling session and their transition to the computer laboratory to access TES.

Clients in this study condition accessed TES using one of several computers available for this purpose at the treatment program. Each client was provided with a unique username and password for logging into TES. As in the standard treatment condition, sessions typically occurred once per week for the first 4 weeks then twice monthly thereafter (and counseling sessions could occur more often for patients with recurring drug-positive results). This design was intended to ensure that the total required exposure time to psychosocial interventions was balanced across the two study conditions.

TES modules are described above and elsewhere (Bickel et al., 2008). In addition to the standard 65 TES modules, we included two specialized modules for this study designed to teach accurate information about how methadone works and address misconceptions some individuals have about methadone. Each participant in this study condition first completed a computerized training module and a risk assessment survey within TES and then was asked to complete "core" TES modules followed by an individualized set of "optional" modules. A total of 53 of the 67 TES modules were considered to be

core modules which were presented to all participants, while the remaining modules were considered optional. The number and type of optional modules were individualized by participant based on their responses to the risk assessment survey. For example, if participants did not endorse an HIV positive status, the modules for persons living with HIV were not suggested as part of their customized plan for using TES. Note that participants could complete any optional modules of interest/relevance to them even if they were not suggested within their individualized plan for completing modules within TES. Each module was designed to take approximately 15 minutes to complete. Thus, participants were generally asked to complete about 2 modules in each 30 minute session. If a participant completed 2 modules before the 30 minute session had ended, they could choose to end the session or start a new module. An electronic tracking and reporting system allowed clinicians to view activities of their clients within TES, enabling them to integrate participants' use of TES in their counseling sessions if they chose to do so.

2.5. Urine drug testing

Participants in both study conditions provided urine samples once weekly to research staff. Urine sample collection was randomly observed by a research associate of the same sex. Each urine sample was screened for the following substances: THC, cocaine, barbiturates, benzodiazepines, methamphetamine, opiates, methadone, propoxyphene, and oxycodone using point-of-care qualitative urine test cups (Drug Check Drug Test Cup, Drug Test Systems, Dover, NH).

2.6. Compensation

Participants were also asked to complete an array of clinical assessments at baseline and once monthly which were included as secondary outcome measures in this trial (e.g., measuring HIV risk behavior, participant feedback on the interventions, anxiety/depressive states). Participants received $50 for completing their baseline and monthly clinical assessments and $10 for each urine sample provided.

2.7. Statistical analyses

Descriptive statistics were run to characterize the sample, and Wilcoxon rank sum tests for continuous variables and Fisher's exact tests for categorical variables were conducted to assess if characteristics of participants in the two study conditions differed at baseline. Analyses of the primary outcomes of opioid abstinence and treatment retention were based on all randomized participants.

Quasibinomial generalized linear models (McCullagh & Nelder, 1989) were used to compare groups on opioid abstinence outcomes. Quasibinomial generalized linear models are useful for modeling percentage/proportion data, and were used here to compare study conditions on the percentage of follow-up weeks where abstinence was observed. Quasibinomial models were preferred over binomial to allow for possible overdispersion (outcome variance larger than mean), a common characteristic of percentage data. Opioid abstinence was based on urinalysis results for opiates, propoxyphene, and oxycodone, such that all three tests needed to be negative for a designation of an opioid-negative result. A missed test prior to study dropout was treated as positive for opioid use when summarizing abstinence across all study weeks. Opioid abstinence was calculated in several ways: percentage (and number) of total study weeks of opioid abstinence, percentage (and number) of tested study weeks of opioid abstinence (when participants were present and provided a urine sample for testing), percentage (and number) of total study weeks with continuous opioid abstinence, and percentage (and number) of tested study weeks with continuous opioid abstinence. Additionally, a multi-level logistic regression model was conducted to examine if there was an interaction between treatment condition and change in abstinence over time.

Cox proportional hazards regression was conducted to compare retention time across treatment groups. Retention was calculated as the number of days each participant actively participated in the study (date of last contact subtracted from baseline). Additionally, a Fisher's exact test was used to compare groups on the percentage of participants retained through the 52-week study period. Statistical analyses were conducted using both R (R Development Core Team, 2008) and SAS statistical software (SAS Institute, Cary, NC).

3. Results

3.1. Participants

The baseline characteristics of the 160 participants who were randomly assigned to a study condition are presented in Table 1. As shown in this table, participants were mostly male (approximately 75%), mostly unmarried (90.6%), about 1/3 Hispanic/Latino, with diverse racial representation. The average age of participants was in the low 40s (mean = 40.7 years; SD = 9.8), and participants' average years of education was about a high school level (mean = 12.4 years; SD = 1.8). Most participants reported heroin as their primary opioid of choice (96.3%). Participant characteristics at baseline did not differ across study conditions (all p values > .05).

3.2. Exposure to study conditions

Participants in the standard treatment condition completed a mean of 11.74 (SD = 7.6) sessions with their counselor. Participants in the reduced standard + TES condition completed a mean of 11.51 (SD = 7.21) counselor sessions (of reduced length relative to those in the standard treatment condition, as described above). Participants in this condition completed a mean of 27.56 (SD = 24.44) modules within TES. The average length of each TES session was 26.86 minutes (SD = 9.48).

Table 1
Participant characteristics by treatment condition.

Characteristics	Standard condition (n = 80)	TES condition (n = 80)	Total (n = 160)
Age, M (SD)	40.4 (8.9)	40.9 (10.7)	40.7 (9.8)
Gender (n, % female)	23 (28.7%)	17 (21.2%)	40 (25%)
Ethnicity (n, % Hispanic/Latino)	23 (29.5%)	20 (25.3%)	43 (27.4%)
Race			
White (n, %)	33 (41.2%)	37 (47.4%)	70 (44.3%)
Black (n, %)	27 (33.8%)	23 (29.5%)	50 (31.6%)
Other (n, %)	20 (25%)	18 (23.1%)	38 (24.1%)
Marital status (n, % married)	8 (10%)	7 (8.8%)	15 (9.4%)
Years education, M (SD)	12.4 (1.7)	12.4 (2)	12.4 (1.8)
Employment status			
Employed F/T (n, %)	37 (47.4%)	25 (31.3%)	62 (39.2%)
Employed P/T (n, %)	10 (12.8%)	12 (15%)	22 (13.9%)
Not employed (n, %)	31 (39.7%)	43 (53.8%)	74 (46.8%)
Primary opioid (n, % heroin)	77 (96.2%)	77 (96.2%)	154 (96.3%)
HIV+	5 (6.3%)	11 (13.9%)	16 (10.1%)
HCV+	27 (33.8%)	27 (33.8%)	54 (33.8%)
Past 30 days sedative use at baseline (n, %)	24 (30%)	28 (35%)	52 (32%)
Past 30 days amphetamine use at baseline (n, %)	2 (2%)	0 (0%)	2 (1%)
Past 30 days cocaine use at baseline (n, %)	35 (44%)	40 (50%)	75 (47%)
Past 30 days alcohol use to intoxication at baseline (n, %)	20 (25%)	17 (21%)	37 (23%)

Note: No participant characteristics differed across treatment conditions (all p values > .05 based on Fisher's Exact Tests for count data).

3.3. Opioid abstinence

3.3.1. Weeks of opioid abstinence

As shown in Fig. 2, participants in the reduced standard + TES condition had a significantly greater percentage of overall study weeks of abstinence from opioids compared to those in standard treatment (48% for reduced standard + TES vs. 37% for standard; $F(1, 158) = 5.90$, $p < .05$). Participants in the reduced standard + TES condition also had a significantly greater percentage of tested weeks of abstinence from opioids (weeks they provided urine samples for testing) compared to those in standard treatment (59% for reduced standard + TES vs. 43% for standard; $F(1, 158) = 8.81$, $p < .01$).

3.3.2. Consecutive weeks of opioid abstinence

A similar pattern was observed when urinalysis data were evaluated as consecutive weeks of opioid abstinence. Participants in the reduced standard + TES condition had a greater percentage of overall study weeks of continuous abstinence from opioids compared to those in standard treatment, but this difference did not reach statistical significance (22% for reduced standard + TES vs. 17% for standard; $F(1, 158) = 3.35$, $p = .069$). Participants in the reduced standard + TES condition had a significantly greater percentage of tested weeks of continuous abstinence from opioids (weeks they provided urine samples for testing) compared to those in standard treatment (27% for reduced standard + TES vs. 20% for standard; $F(1, 158) = 4.91$, $p < .05$).

3.3.3. Abstinence over time

A multi-level logistic regression model was used to examine the interaction between treatment condition and change in the odds of abstinence over the evaluation period. Changes over time were represented with natural splines (Hastie, 1992) with three degrees of freedom. The interaction between treatment condition and the natural splines was not significant, $\chi^2_{(3)} = 4.02$, $p = .26$, indicating that the advantage of the reduced standard + TES intervention condition over the standard condition was consistent over the evaluation period. In a simplified model with main effects only, the difference in the odds of abstinence was significant, $z = 2.10$, $p < .05$, with participants in the reduced standard + TES intervention condition more likely to be abstinent than participants in the standard condition (OR = 2.04).

3.3.4. Retention

Cox proportional hazards regression showed no significant difference in time to study dropout across the two treatments (HR = 0.94; $z = -0.33$; $p = .74$) (see Fig. 3). Over the 12 month evaluation period, the total percentage of participants retained in treatment for the duration of treatment did not significantly differ across conditions (Fisher's exact test $p = .56$; odds ratio 95% confidence interval [0.50, 1.2]; 61.3% no longer in treatment by the end of the 12 month study period).

4. Discussion

This study was the first large experimental trial with a long follow-up period (12 months per client) to evaluate the clinical effectiveness of a Web-based behavioral intervention (TES) when deployed in a model where it substituted for a portion of standard counseling in a community-based specialty addiction treatment program. Results demonstrated that replacing a portion of standard treatment with TES resulted in significantly greater rates of objectively measured opioid abstinence—a pattern that remained generally consistent over the 12 month evaluation period. This result was robust and was evident despite how opioid abstinence was operationally defined and evaluated.

Results also demonstrated the clinical utility of the CRA-based modules of TES when they were delivered in the absence of contingency management incentives. As noted earlier, CRA has often been provided as part of a packaged intervention along with contingency management incentives. Although CRA has been shown to make an independent contribution to the efficacy of combined CRA and contingency management when delivered by highly trained therapists (Higgins et al., 2003), the present study is the first to demonstrate the effectiveness of computerized CRA in the absence of contingency management incentives.

The greater rates of opioid abstinence observed among participants who received reduced standard treatment + TES may have been a result of the breadth and nature of the content in TES, which is grounded in an empirically-supported behavioral therapy model for substance use disorders (CRA). It also may be due to the interactive nature of TES, which requires ongoing, active participation in the therapeutic process. It may additionally be due to the fluency-based informational technology used in TES modules which ensure mastery of content using individually-paced testing. As noted above, this fluency-building technology is designed to guide all TES users to the same level of mastery of key knowledge and skills within each TES module, despite variability across participants in their baseline level of knowledge and skills. Further, although clients in this study condition had shorter sessions with their counselors compared to those in standard treatment, they benefited from

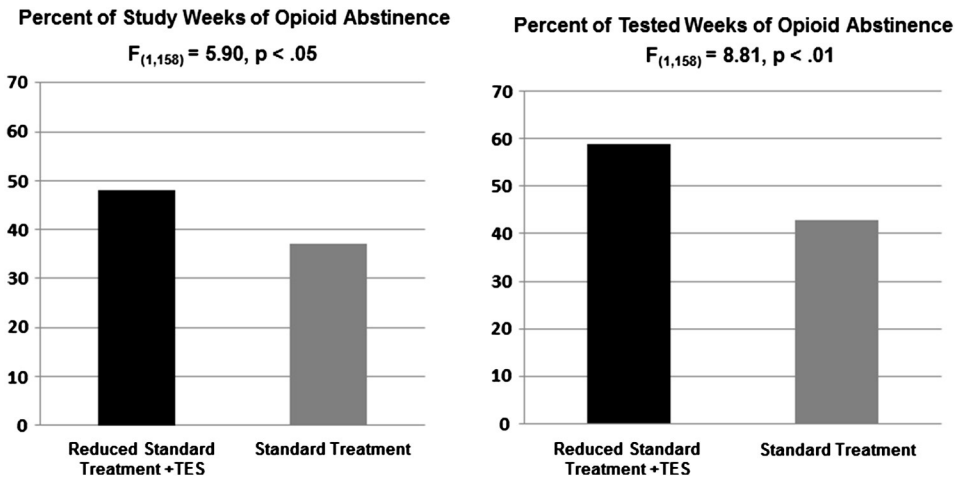

Fig. 2. Percentage of study weeks and percentage of tested study weeks of opioid abstinence by treatment condition.

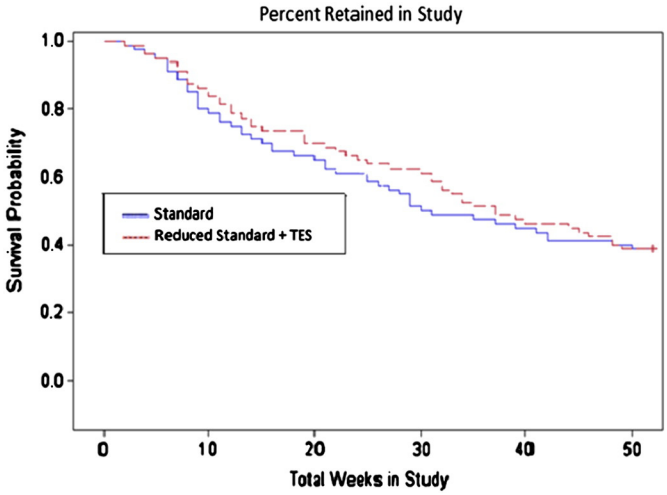

Fig. 3. Retention by treatment condition during the 52-week study.

having both a counselor as well as an interactive therapeutic tool provided by TES. This combination of therapeutic support, via two different modalities, may have contributed to the observed outcomes. This pattern of results could also be due to other reasons and future studies that can seek to identify the mechanisms of outcomes observed in the present study.

These findings could have promising implications for service delivery models embraced by substance abuse treatment programs. If such programs can produce better treatment outcomes among clients by offering a computerized tool as a central part of their service delivery model, this may bring value to an array of stakeholders. That is, clients may be better able to successfully manage their substance use disorders and experience better outcomes from their treatment experience, clinicians may have more time to spend with more challenging clients or be able to see a larger number of clients, and treatment programs may be better able to achieve quality performance metrics in a manner that may be cost-effective.

This study included a number of methodological strengths that have not frequently been evident in trials evaluating computer-assisted interventions targeting substance use disorders (Kiluk et al., 2011). Strengths of the study included randomization to study conditions, use of diagnostic criteria for participant inclusion, evaluation of evidence-based behavioral treatment, an active comparison condition, and procedures in place for ensuring quality control and fidelity of treatment delivery.

This study also had several limitations. Although the participant sample reflected a diverse mix of racial and ethnic groups, the sample was largely male (approx. 75%). Additionally, the sample exclusively consisted of opioid-dependent individuals in outpatient MMT. The extent to which study results will translate to a broader population in different types of substance abuse treatment settings is unclear. Further, attrition rates were high across both groups, with only about 40% of participants in each group retained during the entire duration of the 12 month study window. Thus, conclusions about study results for the entire 12 month evaluation period can only be made for the subset of participants who completed all 12 months of the study. Additionally, the overall, dose of exposure to counselors was modest in the present study. As noted in the results section, participants in both conditions participated in an average of less than 12 counseling sessions during their period of study participation. This is not uncommon in MMT treatment programs in which counselors typically need to schedule sessions with large patient caseloads. Although this study was designed as a parallel groups experimental design, in which the frequency of TES sessions was structured to be comparable to the frequency of counseling sessions, a Web-based program such as TES could be employed by clients in this type of treatment setting at a much higher frequency, thereby offering the opportunity to increase the dose of exposure to psychosocial support.

Future research could seek to address these study limitations. Additionally, future research could be designed to assess if a specific dose of TES is optimally effective and/or if specific TES modules are more effective than others. Further, TES was made available to clients in the present study via computers at the MMT study site. Future research can evaluate the utility of the Web-based TES in a wide array of settings (e.g., home) and platforms (e.g., mobile devices on which TES is now available).

Although these results suggest that technology may be useful as part of service delivery models in an MMT specialty addiction treatment program, the utility of integrating technology into broader care delivery settings in the U.S. will likely also become increasingly evident as the healthcare delivery requirements of the Affordable Care Act (ACA) are implemented nationally over the next few years. There are a number of reasons why this is the case. First, the ACA *requires* that health care settings, which have traditionally focused on the treatment of physical health conditions, must now offer care for substance use disorders and mental health disorders. Second, within the emerging accountable healthcare model, accountable care entities can no longer refuse to treat or transfer elsewhere individuals with substance use disorders but must cover the entirety of their care. Third, the ACA will also expand Medicaid eligibility and provide coverage for the first time to an estimated 32 million individuals who are currently uninsured (Substance Abuse and Mental Health Services Administration, 2010). It is expected that many of the uninsured who will receive insurance for the first time are individuals that are poor and unemployed, with disproportionately high mental health and substance use problems (National Survey on Drug Use and Health, 2010; Substance Abuse and Mental Health Services Administration. Office of Applied Studies, February 4, 2010). As a result of this confluence of factors, there is a tremendous and growing need to care for substance use disorders within the new U.S. health care model in health care settings that do not currently have sufficient capacity in the form of trained clinicians and specialty treatment programs to meet this need. This creates an unprecedented opportunity to leverage effective and cost-effective technology-based solutions in response to this significant challenge.

Given the frequent co-occurrence of substance use disorders with mental health disorders, as well as the large impact that behavioral health disorders have on management of chronic diseases (Cimpean & Drake, 2011; Satin, Linden, & Phillips, 2009; Simon et al., 2005), a technology-based approach to care should ideally include an integrated suite of therapeutic tools that can be responsive to each individuals set of needs (Marsch & Gustafson, 2012). Technology offers an unprecedented level of tailoring and can be designed to assess (on an ongoing basis) each individual's needs and preferences and to provide tools, grounded in the science of health behavior and behavior change, that are optimally responsive to an individual's profile of needs and preferences. TES provides tailoring by allowing users to access modules of greatest clinical relevance and/or interest to them and may be further tailored based on users' clinical trajectory over time. Numerous research opportunities exist to examine the clinical effectiveness and cost-effectiveness of technology as part of healthcare delivery as well as how to best integrate and promote sustained use of empirically supported technology-based innovations in a wide array of care settings.

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References

Abbott, P. J., Weller, S. B., Delaney, H. D., & Moore, B. A. (1998). Community reinforcement approach in the treatment of opiate addicts. *The American Journal of Drug and Alcohol Abuse*, *24*(1), 17–30.

Ball, J. C., & Ross, A. (1991). *The effectiveness of methadone maintenance treatment: Patients, programs, services and outcomes.* New York: Springer-Verlag.

Ben-Zeev, D., Drake, R. E., Corrigan, P. W., Rotondi, A. J., Nilsen, W., & Depp, C. (2012). Using contemporary technologies in the assessment and treatment of serious mental illness. *American Journal of Psychiatric Rehabilitation*, *15*(4), 357–376, http://dx.doi.org/10.1080/15487768.2012.733295.

Bennett-Levy, J., Richards, D., Farrand, P., Christensen, H., Griffiths, K., Kavanagh, D., & White, J. (Eds.). (2010). *Oxford guide to low intensity CBT interventions*. New York: Oxford University Press.

Bickel, W. K., Marsch, L. A., Buchhalter, A. R., & Badger, G. J. (2008). Computerized behavior therapy for opioid-dependent outpatients: A randomized controlled trial. *Experimental and Clinical Psychopharmacology*, *16*(2), 132–143, http://dx.doi.org/10.1037/1064-1297.16.2.132.

Brooks, A. C., Ryder, D., Carise, D., & Kirby, K. C. (2010). Feasibility and effectiveness of computer-based therapy in community treatment. *Journal of Substance Abuse Treatment*, *39*(3), 227–235, http://dx.doi.org/10.1016/j.jsat.2010.06.003.

Budney, A. J., Fearer, S., Walker, D. D., Stanger, C., Thostenson, J., Grabinski, M., et al. (2011). An initial trial of a computerized behavioral intervention for cannabis use disorder. *Drug and Alcohol Dependence*, *115*(1–2), 74–79, http://dx.doi.org/10.1016/j.drugalcdep.2010.10.014.

Budney, A. J., & Higgins, S. T. (1998). *Therapy manuals for drug addiction, a community reinforcement plus vouchers approach: Treating cocaine addiction.* Rockville, MD: National Institute on Drug Abuse.

Carroll, K. M., Ball, S. A., Martino, S., Nich, C., Babuscio, T. A., Nuro, K. F., et al. (2008). Computer-assisted delivery of cognitive-behavioral therapy for addiction: A randomized trial of CBT4CBT. *The American Journal of Psychiatry*, *165*(7), 881–888, http://dx.doi.org/10.1176/appi.ajp.2008.07111835.

Carroll, K. M., Ball, S. A., Martino, S., Nich, C., Babuscio, T. A., & Rounsaville, B. J. (2009). Enduring effects of a computer-assisted training program for cognitive behavioral therapy: A 6-month follow-up of CBT4CBT. *Drug and Alcohol Dependence*, *100*(1–2), 178–181, http://dx.doi.org/10.1016/j.drugalcdep.2008.09.015.

Chen, Y. F., Madan, J., Welton, N., Yahaya, I., Aveyard, P., Bauld, L., et al. (2012). Effectiveness and cost-effectiveness of computer and other electronic aids for smoking cessation: A systematic review and network meta-analysis. *Health Technology Assessment*, *16*(38), 1–205 iii-v. http://dx.doi.org/10.3310/hta16380.

Cimpean, D., & Drake, R. E. (2011). Treating co-morbid chronic medical conditions and anxiety/depression. *Epidemiol Psychiatr Sci*, *20*(2), 141–150.

Damschroder, L. J., Aron, D. C., Keith, R. E., Kirsh, S. R., Alexander, J. A., & Lowery, J. C. (2009). Fostering implementation of health services research findings into practice: A consolidated framework for advancing implementation science. *Implementation Science*, *4*, 50, http://dx.doi.org/10.1186/1748-5908-4-50.

Foroushani, P. S., Schneider, J., & Assareh, N. (2011). Meta-review of the effectiveness of computerised CBT in treating depression. *BMC Psychiatry*, *11*, 131, http://dx.doi.org/10.1186/1471-244x-11-131.

Gibbons, M. C., Fleisher, L., Slamon, R. E., Bass, S., Kandadai, V., & Beck, J. R. (2011). Exploring the potential of Web 2.0 to address health disparities. *Journal of Health Communication*, *16*(Suppl 1), 77–89, http://dx.doi.org/10.1080/10810730.2011.596916.

Hastie, T. J. (1992). Generalized additive models. Chapter 7 of Statistical Models in S eds. J. M. Chambers and T. J. Hastie. Wadsworth & Brooks/Cole (ISBN-13: 978-0412830402).

Higgins, S. T., Sigmon, S. C., Wong, C. J., Heil, S. H., Badger, G. J., Donham, R., et al. (2003). Community reinforcement therapy for cocaine-dependent outpatients. *Archives of General Psychiatry*, *60*(10), 1043–1052, http://dx.doi.org/10.1001/archpsyc.60.9.1043.

Kay-Lambkin, F. J., Baker, A. L., Kelly, B., & Lewin, T. J. (2011). Clinician-assisted computerised versus therapist-delivered treatment for depressive and addictive disorders: A randomised controlled trial. *The Medical Journal of Australia*, *195*(3), S44–S50.

Kay-Lambkin, F. J., Baker, A. L., Lewin, T. J., & Carr, V. J. (2009). Computer-based psychological treatment for comorbid depression and problematic alcohol and/or cannabis use: A randomized controlled trial of clinical efficacy. *Addiction*, *104*(3), 378–388, http://dx.doi.org/10.1111/j.1360-0443.2008.02444.x.

Kiluk, B. D., Sugarman, D. E., Nich, C., Gibbons, C. J., Martino, S., Rounsaville, B. J., et al. (2011). A methodological analysis of randomized clinical trials of computer-assisted therapies for psychiatric disorders: Toward improved standards for an emerging field. *The American Journal of Psychiatry*, *168*(8), 790–799, http://dx.doi.org/10.1176/appi.ajp.2011.10101443 [Epub 2011].

Kobak, K. A., Greist, J. H., et al. (1996). Computer-administered clinical rating scales. A review. *Psychopharmacology*, *127*(4), 291–301.

Levine, H. J., Reif, S., Lee, M. T., Ritter, G. A., & Horgan, C. M. (2004). *Alcohol and Drug Services Study (ADSS). The national treatment system: Outpatient methadone facilities.* Rockville, MD: Office of Applied Studies.

Marks, I. M., Cavanagh, K., & Gega, L. (2007). *Hands-on help: Computer-aided psychotherapy.* New York: Psychology Press.

Marsch, L. A. (2011). Technology-based interventions targeting substance use disorders and related issues: An editorial. *Substance Use & Misuse*, *46*(1), 1–3, http://dx.doi.org/10.3109/10826084.2011.521037.

Marsch, L. A. (2012). Leveraging technology to enhance addiction treatment and recovery. *Journal of Addictive Diseases*, *31*(3), 313–318, http://dx.doi.org/10.1080/10550887.2012.694606.

Marsch, L. A., & Bickel, W. K. (2004). Efficacy of computer-based HIV/AIDS education for injection drug users. *American Journal of Health Behavior*, *28*(4), 316–327.

Marsch, L. A., & Dallery, J. (2012). Advances in the psychosocial treatment of addiction: The role of technology in the delivery of evidence-based psychosocial treatment. *The Psychiatric Clinics of North America*, *35*(2), 481–493, http://dx.doi.org/10.1016/j.psc.2012.03.009.

Marsch, L. A., Grabinski, M. J., Bickel, W. K., Desrosiers, A., Guarino, H., Muehlbach, B., et al. (2011). Computer-assisted HIV prevention for youth with substance use disorders. *Substance Use & Misuse*, *46*(1), 46–56, http://dx.doi.org/10.3109/10826084.2011.521088.

Marsch, L. A., & Gustafson, D. H. (2012). The role of technology in health care innovation: A commentary. *Journal of Dual Diagnosis*, *9*(1), 101–103, http://dx.doi.org/10.1080/15504263.2012.750105.

Martino, S., Ball, S. A., Nich, C., Canning-Ball, M., Rounsaville, B. J., & Carroll, K. M. (2011). Teaching community program clinicians motivational interviewing using expert and train-the-trainer strategies. *Addiction*, *106*(2), 428–441, http://dx.doi.org/10.1111/j.1360-0443.2010.03135.x.

Moore, B. A., Fazzino, T., Gernet, B., Cutter, C. J., & Barry, D. T. (2011). Computer-based interventions for drug use disorders: A systematic review. Computer-based interventions for drug use disorders: A systematic review. *Journal of Substance Abuse Treatment*, *40*(3), 215–223, http://dx.doi.org/10.1016/j.jsat.2010.11.002.

McCullagh, P., & Nelder, J. A. (1989). *Generalized linear models* (2nd Ed.) London: Chapman & Hall.

McLellan, A. T. (2001). Moving toward a "third generation" of contingency management studies in the abuse treatment field: Comment on Silverman et al. (2001). *Experimental and Clinical Psychopharmacology*, *9*(1), 29–32 [discussion 35–29].

McLellan, A. T., Arndt, I. O., Metzger, D. S., Woody, G. E., & O'Brien, C. P. (1993). The effects of psychosocial services in substance abuse treatment. *Journal of the American Medical Association*, *269*(15), 1953–1959.

Moyers, T. B., Manuel, J. K., Wilson, P. G., Hendrickson, S. M. L., Talcott, W., & Durand, P. (2008). A randomized trial investigating training in motivational interviewing for behavioral health providers. *Behavioural and Cognitive Psychotherapy*, *36*(2), 149–162.

National Survey on Drug Use and Health (NSDUH). (2010). Substance abuse treatment need among uninsured workers. A report from the National Household Survey on Drug Use and Health. http://oas.samhsa.gov/2k10/177/177EmpNoInsHTML.pdf.

Newman, M. G., Szkodny, L. E., Llera, S. J., & Przeworski, A. (2011). A review of technology-assisted self-help and minimal contact therapies for anxiety and depression: Is human contact necessary for therapeutic efficacy? *Clinical Psychology Review*, *31*(1), 89–103, http://dx.doi.org/10.1016/j.cpr.2010.09.008.

Ondersma, S. J., Chase, S. K., Svikis, D. S., & Schuster, C. R. (2005). Computer-based brief motivational intervention for perinatal drug use. *Journal of Substance Abuse Treatment*, *28*(4), 305–312, http://dx.doi.org/10.1016/j.jsat.2005.02.004.

Ondersma, S. J., Svikis, D. S., & Schuster, C. R. (2007). Computer-based brief intervention a randomized trial with postpartum women. *American Journal of Preventive Medicine*, *32*(3), 231–238, http://dx.doi.org/ 10.1016/j.amepre.2006.11.003.

Pew Internet & American Life Project. (2013). Internet adoption, 1995–2012. Retrieved April 4, 2013, from http://www.pewinternet.org/Static-Pages/Trend-Data-%28Adults%29/Internet-Adoption.aspx.

Proctor, E. K., Landsverk, J., Aarons, G., Chambers, D., Glisson, C., & Mittman, B. (2009). Implementation research in mental health services: An emerging science with conceptual, methodological, and training challenges. *Administration and Policy in Mental Health*, *36*(1), 24–34, http://dx.doi.org/10.1007/s10488-008-0197-4.

R Development Core Team. (2008). R: A language and environment for statistical computing. Vienna, Austria: The R Project for Statistical Computing Retrieved from. http://www.R-project.org.

Sanou, B. (2013). The World in 2013: ICT Facts and Figures. Retrieved April 4, 2013, from http://www.itu.int/ITU-D/ict/publications/world/world.html.

Satin, J. R., Linden, W., & Phillips, M. J. (2009). Depression as a predictor of disease progression and mortality in cancer patients: A meta-analysis. *Cancer*, *115*(22), 5349–5361, http://dx.doi.org/10.1002/cncr.24561.

Simon, G. E., Katon, W. J., Lin, E. H., Ludman, E., VonKorff, M., Ciechanowski, P., et al. (2005). Diabetes complications and depression as predictors of health service costs. *General Hospital Psychiatry*, *27*(5), 344–351, http://dx.doi.org/10.1016/j.genhosppsych.2005.04.008.

Smith, J. L., Carpenter, K. M., Amrhein, P. C., Brooks, A. C., Levin, D., Schreiber, E. A., et al. (2012). Training substance abuse clinicians in motivational interviewing using live supervision via teleconferencing. *Journal of Consulting and Clinical Psychology*, *80*(3), 450–464, http://dx.doi.org/10.1037/a0028176.

Substance Abuse and Mental Health Services Administration. (2010). HealthCare Reform, Overview of the Affordable Care Act. What are the Implications for Behavioral Health? *SAMHSA News*, *18*(3). http://www.samhsa.gov/samhsanewsletter/Volume_18_Number_3/AffordableHealthCareAct.aspx.

Substance Abuse and Mental Health Services Administration. Office of Applied Studies (2010). *Substance abuse treatment need among uninsured workers. A report from the National Household Survey on Drug Use and Health.* Rockville, MD: The NSDUH Report.

White, A., Kavanagh, D., Stallman, H., Klein, B., Kay-Lambkin, F., Proudfoot, J., et al. (2010). Online alcohol interventions: A systematic review. *Journal of Medical Internet Research*, *12*(5), e62, http://dx.doi.org/10.2196/jmir.1479.