

Regular article

Computer-based interventions for drug use disorders: A systematic review

Brent A. Moore, (Ph.D.)^{a,b,*}, Tera Fazzino, (M.A.)^b, Brian Garnet, (B.A.)^b,
Christopher J. Cutter, (Ph.D.)^{a,b}, Declan T. Barry, (Ph.D.)^{a,b}

^aYale University School of Medicine, New Haven, CT

^bAPT Foundation, New Haven, CT

Received 15 June 2010; received in revised form 4 October 2010; accepted 8 November 2010

Abstract

A range of innovative computer-based interventions for psychiatric disorders have been developed and are promising for drug use disorders due to reduced cost and greater availability compared to traditional treatment. Electronic searches were conducted from 1966 to November 19, 2009, using MEDLINE, Psychlit, and EMBASE. Four hundred sixty-eight nonduplicate records were identified. Two reviewers classified abstracts for study inclusion, resulting in 12 studies of moderate quality. Eleven studies were pilot or full-scale trials compared to a control condition. Interventions showed high acceptability despite substantial variation in type and amount of treatment. Compared to treatment-as-usual, computer-based interventions led to less substance use and higher motivation to change, better retention, and greater knowledge of presented information. Computer-based interventions for drug use disorders have the potential to dramatically expand and alter the landscape of treatment. Evaluation of Internet- and telephone-based delivery that allows for treatment-on-demand in patients' own environment is needed. © 2011 Elsevier Inc. All rights reserved.

Keywords: Drug abuse; Computer; Intervention; Systematic review

Automated computer-based treatment is a promising vehicle for providing behaviorally based interventions for drug use disorders. These systems offer a number of potential advantages, including low cost, greater accessibility and 24-hour availability, opportunity for more frequent and/or longer therapeutic contact, greater confidentiality, increased flexibility and convenience, and increased opportunities for practicing skills (Budman, 2000; Marks, Shaw, & Parkin, 1998; Nadelson, 1987). Such systems may even be preferred by some clients who dislike therapy or have concerns about confidentiality and may be particularly useful in rural or remote settings, where access to psychotherapy for substance use disorders may be limited and accompanied by increased stigma (Connors, Tonnigan, & Miller, 2001; Hall & Huber, 2000).

Automated computer-based systems also offer more consistent and precise delivery of interventions across patients. This standardization can be of value therapeutically and, from a scientific perspective, may permit a detailed examination of active components. The current systematic review evaluated computer-based interventions for drug use disorders.

Computer-based interventions have been shown to be effective for psychiatric disorders, such as depression and anxiety (Cavanagh & Shapiro, 2004; Kaltenthaler, Parry, Beverley, & Ferriter, 2008; Reger & Gahm, 2009; Spek et al., 2007), and health issues, such as diabetes, poor nutrition, and sexual risk behaviors (Montani, Bellazzi, Quaglini, & d'Annunzio, 2001; Portnoy, Scott-Sheldon, Johnson, & Carey, 2008; Ybarra & Bull, 2007). Computer-based interventions for anxiety have shown moderate to large mean effect sizes compared to wait-list controls or placebo (weighted, Hedges' $g = .76$ to $.88$, and unweighted, Cohen's $d = .96$; Cavanagh & Shapiro, 2004; Reger & Gahm, 2009; Spek et al., 2007). In contrast, mean effect sizes for depression (unweighted $d = .27$, weighted $g = .34$),

* Corresponding author. Division of Substance Abuse, Department of Psychiatry, Yale University School of Medicine, 495 Congress Ave. Second Floor, New Haven, CT 06519. Tel.: +1 (203) 285 2700; fax: +1 (203) 781 4681.

E-mail address: brent.moore@yale.edu (B.A. Moore).

sexual risk behavior (unweighted $d = .26$ to $.35$), poor nutrition (unweighted $d = .15$), and health maintenance (unweighted $d = .18$) have also been significant, although substantially smaller (Cavanagh & Shapiro, 2004; Noar, Black, & Pierce, 2009; Portnoy et al., 2008; Spek et al., 2007).

Computer- and internet-based systems for addressing substance use disorders have also been developed in recent years, with encouraging evidence suggesting positive treatment outcomes (Carroll et al., 2008; Carroll & Rounsaville, 2007; Copeland & Martin, 2004; Marsch, Bickel, & Grabinski, 2007; Myung, McDonnell, Kazinets, Seo, & Moskowitz, 2009). Much of the research has focused on alcohol abuse and tobacco. For tobacco, meta-analyses have shown abstinence rates from computer-based interventions are about 1.5 times higher than control conditions (Myung et al., 2009). Computer-based alcohol-related interventions are generally well received (Bewick et al., 2008) and significantly improve alcohol use outcomes compared to no treatment and assessment-only interventions (Carey, Scott-Sheldon, Elliott, Bolles, & Carey, 2009; Elliott, Carey, & Bolles, 2008). However, estimated effect sizes for alcohol-related interventions tend to be lower than those for tobacco (Carey et al., 2009; Portnoy et al., 2008). This may be due to differences in length of respective computer-based interventions since interventions in tobacco studies (e.g., 10–12 weeks) tend to be longer than those in alcohol studies (e.g., short assessment with personalized feedback). Moreover, within computer-based smoking cessation trials, those with longer interventions appear to be associated with higher effect sizes (Myung et al., 2009).

To our knowledge only one systematic review included illicit drug abuse. Portnoy et al. (2008) presented a meta-analysis of 11 studies of alcohol and drug use disorders, only 1 of which evaluated drug use. Thus, the aim of the current study was to conduct a systematic review of computer-based interventions for illicit drug use disorders.

1. Methods and materials

1.1. Search strategies

Studies were identified in the Ovid MEDLINE and PsychINFO databases from 1966 to November 19, 2009, using the subject headings and text words found in Table 1. The computer-related terms were combined with the intervention terms using the “adj5” operator for Ovid and the “w/5” operator for Scopus, and those results were combined with the drug-related terms using the Boolean “and” operator. The abstracts of all results of the search were independently reviewed for possible inclusion by three of five authors (B. M., B. G., T. F.). Studies were included if they (a) reported findings of a research study (not a review, letter, etc.), (b) involved a computer-based intervention, and (c) enrolled patients with a substance-related disorder that was not alcohol or tobacco. Computer-based interventions were defined as those in which the primary treatment was provided by an automated, computer-based system rather than therapy or treatment in which a computer is used as the method of providing therapist-based treatment (e.g., video or audio conferencing, e-mail contact, or therapist-based texting). Study inclusion/exclusion agreement between authors was measured using kappa, and disagreement was settled by consensus between all authors.

Full manuscripts of articles chosen for possible inclusions were independently reviewed by two authors (D. B., C. C.) and were evaluated based on the same criteria above. Discrepancies were settled by review and consensus between all authors.

1.2. Data extraction

Data about study methodology and outcomes were extracted independently by two reviewers using a custom-designed data collection form. Briefly, data were collected on (a) study design, (b) subject selection, (c) inclusion/

Table 1
Specific MeSH terms and text words in MEDLINE, EMBASE, and PsychINFO

Concept	MeSH terms	Text words
Computer related	Therapy, computer-assisted/ ^a or online therapy/ ^b or computer assisted therapy/ ^b	Computer assist* or computer tailor* or computer base* or computer guide* or computer administer* or computerized or computerized or internet assist* or internet tailor* or internet base* or internet guide* or web assist* or web tailor* or web base* or web guide* or interactive voice or automated telephone or automated phone orivr or tivv or; interapy or software base* or software assist* or interactiv*
Intervention		Intervention or therapy or treatment
Drug-related	Exp addiction/ or exp drug users/ or exp methadone maintenance/	Substance abuse or substance related disorder* or drug abuse or “drug use” or addiction or opioid or opiate or heroin or stimulant* or cocaine or marijuana or cannabis or amphetamine* or methamphetamine* or sedative* or hallucinogen* or ecstasy or mdma or inhalant* or ketamine or polydrug or tobacco or smoking or alcohol or drinking

Note. MeSH = Medical Subject Headings.

^a MEDLINE term.

^b PsychINFO term.

exclusion criteria, (d) sample description (N , group n 's, age, gender, education, race/ethnicity), (e) setting, (f) intervention details (modality, duration, number of sessions, length of sessions, type of therapy), and (g) outcomes.

Because of the heterogeneous nature of the studies (in terms of populations, research designs, and outcome measures), it was not deemed appropriate to combine the data using meta-analysis.

1.3. Assessment of study quality

Two authors independently assigned a quality index score according to a 31-point scale proposed by Downs and Black (1998), which assesses reporting, external validity, bias (internal validity), confounding (external validity), and power. Interrater agreement on this scale was assessed by computing Pearson's product–moment correlation coefficient.

2. Results

2.1. Literature search results

A total of 468 unique abstracts were identified by the literature search described above (230 from MEDLINE, 209

from PsychINFO, and 291 from EMBASE). Of these, 18 were initially categorized for possible inclusion and 439 for exclusion; 11 were reevaluated by all authors due to discrepancies, of which 7 were categorized for possible inclusion, leading to a total of 25 articles being initially considered for possible inclusion. The level of agreement for studies excluded after the initial title and abstract review was substantial ($\kappa = 0.75$).

Of the 25 articles categorized for possible inclusion, 11 were initially categorized for inclusion and 6 for exclusion; 7 were reevaluated by all authors due to discrepancies, of which 1 was categorized for inclusion. The level of agreement for studies excluded at this stage was moderate ($\kappa = 0.56$). A summary of the search and reasons for exclusion are detailed in Fig. 1.

2.2. Study characteristics

2.2.1. Summary of findings

Study characteristics (samples, treatment, and outcomes) are provided in Tables 2–4. Sample sizes of the studies ranged from 19 to 909 ($M = 163$, $Mdn = 102$). Consistent with national data about treatment admissions for substance-related disorders, participants in the studies selected for this systematic review were generally in their 20s to

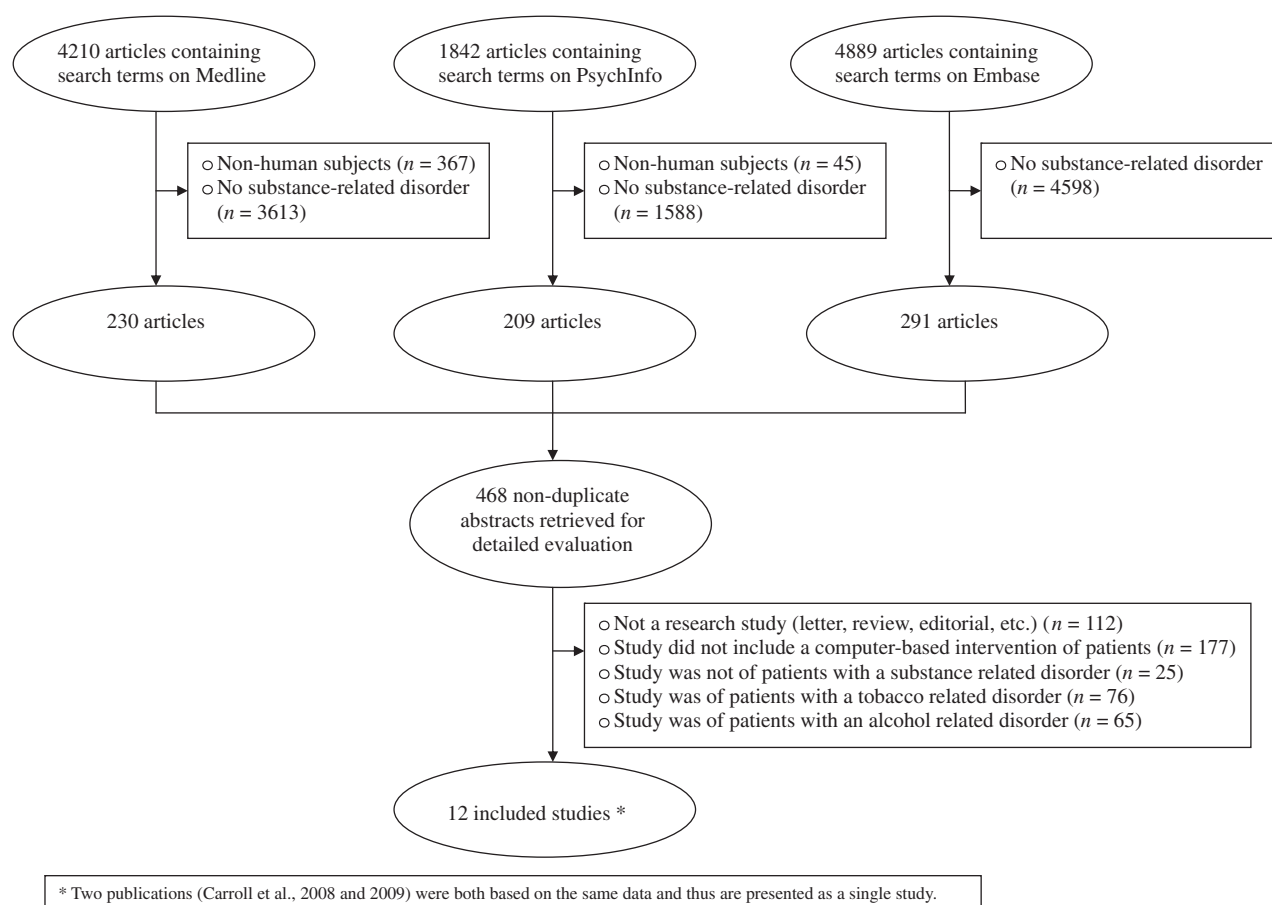


Fig. 1. Flowchart of the process of selecting studies designed to evaluate computer-based interventions for drug abuse.

Table 2
Subject characteristics for studies designed to evaluate computer-based interventions for drug use

Author (year)	Population	<i>n</i>	Age (<i>M</i> ± <i>SD</i>), years	Gender (% male)	Race/Ethnicity	Drug
Barber (1990)	Inmates in drug treatment units in Melbourne, Australia	30	NP	NP (male and female)	NP	Opioids
Bickel et al. (2008)	Substance abuse treatment seeking, already in substance abuse treatment	135	28.6 ± 8.3	56	96% White	Opioids
Carroll et al. (2008, 2009)	Outpatient substance abuse treatment seeking	77	41.6 ± 10.2	57	34% White 46% AA 12% Hispanic 6% Native American	69% cocaine 16% opioids 18% alcohol 7% cannabis
Chopra et al. (2009)	Outpatient substance abuse treatment seeking	127	32 ± 11.1	58	98% White	Opioids
Grohman and Fals-Stewart (2003)	Residential substance abuse treatment seeking	120	32 ± 5.2	71	52% White 32% AA 13% Hispanic 3% other	65% cocaine 60% alcohol 29% opiate 17% cannabis 23% other
Grohman et al. (2006)	Veterans recently enrolled in treatment	19	47 ± 5.2	89	39% White 58% AA 5% Hispanic	74% cannabis 68% alcohol 58% cocaine 58% other
Hall and Huber (2000)	Already in substance abuse treatment	909	32 ± 1.4	77	83% White	85% alcohol 59% cannabis
Kay-Lambkin et al. (2009)	Outpatient substance abuse treatment seeking	97	35 (range = 18–61)	46	93% white	Alcohol or cannabis
Marsch and Bickel (2004)	Currently in substance abuse treatment	30	36 ± 1.37	63	90% White 3% AA 7% Hispanic	IV opioid
Ondersma et al. (2005)	Postpartum women recruited from hospital's obstetrics department	30	23 ± 5.6	0	97% AA	37% cannabis 27% cocaine, amphetamines, opiates, hallucinogens, or inhalants
Ondersma et al. (2007)	Postpartum women recruited from hospital's obstetrics department	107	25 ± 5.6	0	97% AA	Cannabis and other
Ruggiero et al. (2006)	Probability sample of adults in New York City following September 11 attacks	285	42 ± 13.6	47	73% White 9% Asian 6% AA 9% Hispanic 3% other	Any illicit drug

Note. NP = not provided; AA = African American; IV = intravenous.

early 30s, included men and women, and were composed of individuals from different racial/ethnic groups, with most being White and male (SAMHSA—Office of Applied Studies, 2009). Participants in the two studies were postpartum women (Ondersma, Chase, Svikis, & Schuster, 2005; Ondersma, Svikis, & Schuster, 2007), those in three studies were predominantly male (Grohman & Fals-Stewart, 2003; Grohman, Fals-Stewart, & Donnelly, 2006), and subjects in the remaining seven studies were male and female. Drug of abuse also varied across the studies. Four studies evaluated opioid users exclusively (Barber, 1990; Bickel, Marsch, Buchhalter, & Badger, 2008; Chopra et al., 2009; Marsch & Bickel, 2004), whereas the other studies included more than one type of drug user (five cocaine, eight cannabis, six alcohol and five other). Two included studies were conducted in Australia

(Barber, 1990; Kay-Lambkin, Baker, Lewin, & Carr, 2009) and the rest in the United States.

Characteristics of the computer-based interventions varied in presentation modality, length, number of sessions, and therapist involvement. All but two studies involved presentation of material via an on-site computer. One study evaluated a Web-based system accessed via a home computer (Ruggiero et al., 2006), whereas another evaluated an interactive voice response (IVR) system accessed through a regular telephone (Hall & Huber, 2000). Four studies used single-session or brief interventions (Barber, 1990; Ondersma et al., 2005, 2007; Ruggiero et al., 2006), and one used 3–5, 30-minute sessions over 1 week (Marsch & Bickel, 2004), based on motivational enhancement and/or psychoeducation. With the exception of the IVR study, the remaining involved multiple sessions similar in frequency

Table 3
Treatment characteristics for studies designed to evaluate computer-based interventions for drug use

Author (year)	Setting	Treatment delivery modality	Length of intervention	No. of sessions (length)	Therapist involvement	Experimental treatment description
Barber (1990)	Prison (drug treatment unit)	On-site computer	NP	1 (NP)	No	Motivational, psychoeducation
Bickel et al. (2008)	Outpatient research clinic	On-site computer	23 weeks	69 (20–30 minutes)	Yes	CRA with contingency management
Carroll et al. (2008, 2009)	Outpatient substance abuse clinic	On-site computer	8 weeks	6 (45 minutes)	No	CBT
Chopra et al. (2009)	Outpatient substance abuse clinic	On-site computer	12 weeks	36 (30 minutes)	Yes	CRA with contingency management
Grohman and Fals-Stewart (2003)	Residential substance abuse treatment program	On-site computer	2 months	24 (50 minutes)	No	Cognitive rehabilitation
Grohman et al. (2006)	Outpatient substance abuse clinic (VA)	On-site computer	3/4 weeks	10 (30 minutes)	Not specified	Cognitive rehabilitation
Hall and Huber (2000)	Outpatient substance abuse clinic	IVR through telephone	NP	NP	Yes	Voice message system with psychoeducation component
Kay-Lambkin et al. (2009)	Outpatient substance abuse clinic	On-site computer	3 months	9	Yes	CBT and ME
Marsch and Bickel (2004)	Research setting	On-site computer	1 week	3–5 (30 minutes)	No	Psychoeducation
Ondersma et al. (2005)	Hospital	On-site computer	Single session	1 (20 minutes)	No	Brief motivational enhancement
Ondersma et al. (2007)	Hospital	On-site tablet PC	Single session	1 (20 minutes)	No	Brief motivational enhancement
Ruggiero et al. (2006)	Unsupervised at home	Home computer	Unclear	1 (1–30 minutes)	No	Brief motivational enhancement

Note. NP = not provided; ME = motivational enhancement; PC = personal computer; VA = Veterans Administration Studies Evaluating Drug Use Outcomes.

and length to traditional therapy sessions (6 to 69 sessions, 20–50 minutes in length) and were based on behavioral interventions of cognitive-behavioral therapy (CBT: Carroll et al., 2008, 2009; Kay-Lambkin et al., 2009), community reinforcement approach (CRA: Bickel et al., 2008; Chopra et al., 2009), or cognitive rehabilitation (Grohman & Fals-Stewart, 2003; Grohman et al., 2006). Therapists were involved in the computer-based treatment in three studies, although therapist time and frequency of contact were limited compared to treatment-as-usual (TAU) conditions (Bickel et al., 2008; Chopra et al., 2009; Kay-Lambkin et al., 2009). All but one study (Ruggiero et al., 2006) used a randomized design with a control group.

2.2.2. Hierarchy of treatment outcomes

Drug use outcomes were evaluated in six studies (see Table 4: Bickel et al., 2008; Carroll et al., 2008, 2009; Chopra et al., 2009; Kay-Lambkin et al., 2009; Ondersma et al., 2005, 2007), with four including urinalysis data (Bickel et al., 2008; Carroll et al., 2008, 2009; Chopra et al., 2009; Ondersma et al., 2007). Except for one brief intervention study (Ondersma et al., 2005), computer-based treatment showed better drug use outcomes (both self-report and urinalysis) than TAU. Reported or estimated effect sizes based on reported data for these primary outcomes during treatment were $d = 1.11$, 0.45 , and 0.46 for self-reported drug use (Carroll et al., 2008, Kay-Lambkin et al., 2009, and Ondersma et al., 2007, respectively) and $d = 0.36$, 0.59 ,

and 0.36 for urinalysis data (Bickel et al., 2008; Carroll et al., 2008; Ondersma et al., 2007, respectively). Of five studies that evaluated treatment retention, three showed no differences (Bickel et al., 2008; Carroll et al., 2008; Chopra et al., 2009), and two showed improved retention compared to TAU (Grohman & Fals-Stewart, 2003; Grohman et al., 2006). Three studies that also directly compared the same therapeutic content delivered either via computer or a therapist/counselor showed similar treatment response (Bickel et al., 2008; Kay-Lambkin et al., 2009; Marsch & Bickel, 2004). Lasting effects of treatment, examined by follow-up assessments after the end of the intervention, were evaluated in five studies, with all five reporting better outcome for the computer-based intervention (Carroll et al., 2009; Grohman & Fals-Stewart, 2003; Kay-Lambkin et al., 2009; Marsch & Bickel, 2004; Ondersma et al., 2007).

Ratings of satisfaction with the computer-based system were evaluated in five studies, with two studies (Hall & Huber, 2000; Marsch & Bickel, 2004) reporting that the computer-based treatment was preferable to control conditions and the other three (Carroll et al., 2008; Ondersma et al., 2005; Ruggiero et al., 2006) reporting high ratings of participant satisfaction.

2.2.3. Study quality

Individual quality scores for each study are presented in Table 4. The quality of the articles varied from 6 to 24 with a

Table 4
Hierarchy of treatment outcomes for studies designed to evaluate computer-based interventions for drug use

Author (year)	Study quality	Analysis types	Control group	Attrition rate	Primary outcome measures	Results
Studies evaluating drug use outcomes						
Bickel et al. (2008)	21	Intent to treat	TAU and therapist-delivered CRA	Computer CRA, 62% Therapist CRA, 58% Standard, 53%	<ul style="list-style-type: none"> Urine toxicology (3c/week) Helping alliance questionnaire Patient-therapist contact time 	<ul style="list-style-type: none"> Both CRA groups were abstinent for significantly longer than TAU No differences No differences Substantially contact time for computer CRA
Carroll et al. (2008, 2009)	20	Intent to treat, treatment exposed	TAU	Experimental, 33% Control, 312% 82% during posttreatment follow-up	<ul style="list-style-type: none"> Retention Urine toxicology (number positive, percent positive, longest continuous abstinence) Follow-up urine toxicology (1, 3, and 6 month) Self-reported drug use (total days abstinent, consecutive days abstinent) Satisfaction 	<ul style="list-style-type: none"> No differences Fewer positive utoxes Lower percent of positive utoxes Longer duration of continuous abstinence Significantly lower Proportion of positive utoxes at 1 month No differences at 3 and 6 months No difference Longer consecutive days abstinent High mean ratings
Chopra et al. (2009) ^a	19	Intent to treat	TAU	Voucher contingency, 85% Medication contingency, 60% TAU, 76%	<ul style="list-style-type: none"> Retention Urine toxicology (longest continuous abstinence, total weeks abstinence) 	<ul style="list-style-type: none"> Greater retention rate for VC compared to MC, but not TAU MC and VC more continuous weeks abstinent from opioids VC more weeks abstinent from opioids
Kay-Lambkin et al. (2009)	20	Intent to treat	Therapist delivered CBT, Single brief intervention	Computer, 72% Therapist, 66% Single BI, 70%	<ul style="list-style-type: none"> Depression Self-reported alcohol use Self-reported cannabis use 	<ul style="list-style-type: none"> No difference No difference Greater reduction for computer and therapist than single BI
Ondersma et al. (2005)	18	Intent to treat	Assessment only	Experimental, 33% Control, 20%	<ul style="list-style-type: none"> Self-reported drug use Motivation to change Satisfaction 	<ul style="list-style-type: none"> No difference No difference High mean ratings
Ondersma et al. (2007)	24	Intent to treat, completers only	Assessment only	Experimental, 29% Control, 29%	<ul style="list-style-type: none"> Urine toxicology (3 months) Self-reported drug use frequency 	<ul style="list-style-type: none"> No difference Greater reduction for all substances
Studies evaluating outcomes other than drug use						
Barber (1990)	6	Intent to treat	TAU	NP	<ul style="list-style-type: none"> Self-efficacy 	<ul style="list-style-type: none"> Greater improvement
Grohman and Fals-Stewart (2003)	18	Intent to treat	TAU and computer-assisted typing tutorial	Experimental, 62% TAU, 82% Typing group, 82%	<ul style="list-style-type: none"> Retention Graduation rate 	<ul style="list-style-type: none"> Longer retention Higher graduation rate

Grohman et al. (2006)	13	Intent to treat	TAU	NP	<ul style="list-style-type: none"> • Retention • Neuropsychological tests (Weeks 2 and 4) • Therapist ratings of patient behavior (Week 2) • Cost • Satisfaction 	<ul style="list-style-type: none"> • Longer retention • No difference • Better overall attitude
Hall and Huber (2000)	11	Intent to treat	TAU, offsite case manager	NP	<ul style="list-style-type: none"> • Cost • Satisfaction 	<ul style="list-style-type: none"> • 50% less labor cost • Greater satisfaction than offsite case management • Less satisfaction than TAU
Marsch and Bickel (2004)	18	Completers only	Counselor-facilitated instruction	0	<ul style="list-style-type: none"> • Drug- and sex-related risk behaviors • HIV/AIDS-related knowledge • Requested HIV test location • Satisfaction • Module completion 	<ul style="list-style-type: none"> • No difference • Greater knowledge accuracy • More requested test location • Greater interest • Of eligible only 25% completed cannabis module
Ruggiero et al. (2006)	15	Completers only	None	50%	<ul style="list-style-type: none"> • Satisfaction 	<ul style="list-style-type: none"> • Majority satisfied

Note. MC = medication contingency; VC = voucher contingency; BI = brief intervention; NP = not provided.

^a Computer-delivered CRA was confounded with contingency management (medication or voucher). Both conditions were compared to Standard care.

mean of 16.9 (*SD* = 4.9), and the interrater reliability was excellent (*r* = .88).

3. Discussion

Computer-based interventions for drug use disorders show initial evidence of efficacy during treatment and some evidence effects continue after treatment. Despite heterogeneity of samples, methods, and intervention types, studies evaluated showed improved self-reported and urinalysis outcomes for computer-based interventions compared to control conditions. In addition, computer-based interventions were associated with high levels of client satisfaction as measured by direct assessment, and participants exhibited similar levels of engagement and retention as those in therapist-provided treatments. Despite the promising findings, research of computer-based treatments for drug use disorders is still clearly in its infancy, when publication bias may be stronger. Most studies were primarily prototype testing. Although a few randomized controlled trials with drug use outcomes and relevant controls have been published (Bickel et al., 2008; Carroll et al., 2008, 2009; Chopra et al., 2009; Kay-Lambkin et al., 2009; Ondersma et al., 2007), these are still small-scale efficacy trials, for which effect sizes are less stable. In particular, studies comparing content delivered via computer versus therapist are inadequately powered to detect what may be clinically meaningful differences or to clearly establish that treatments are comparable.

Despite these limitations, the positive early findings clearly call for larger efficacy and effectiveness trials. In designing these larger scale efficacy trials, standardization is needed for outcome measures and control conditions. Such standardization would facilitate comparison across efficacy trials. For example, inclusion of biologically verified point prevalence follow-up measures would allow comparison across clinical trials and would provide clinically relevant data. Similarly, given variability in drug use profiles, measures such as days or weeks of abstinence would provide improved comparability across drugs of abuse than measures of reductions in quantity or frequency. Ideally, uniformity is needed in control conditions not only to provide a consistent standard of care across comparable studies but also to evaluate controls for time and attention. TAU controls are less ideal due to low fidelity and high variability both within and across studies. Additional studies that compare computer-based treatments to the same content delivered via therapist are needed to further evaluate comparability. However, these studies need to be sufficiently powered to provide confidence intervals to not only evaluate differences between conditions but also establish treatment equivalence within a clinically meaningful range. Finally, given the great potential for computer-based treatments to be cost-effective, research evaluating the relative cost-benefit and cost-efficacy of computer-based and therapist-delivered interventions is needed.

Comparisons with reviews of computer-based treatments for tobacco and alcohol studies suggest that different types of systems have been emphasized for varying drugs of abuse. Most of the computer-based alcohol interventions have focused on brief interventions using assessment with personalized feedback. Many of these studies have focused on at-risk populations, such as college students (Elliott et al., 2008), who are not currently dependent or seeking treatment. For tobacco, there are many smoking cessation programs intended for extended use throughout abstinence (e.g., Stomp Out Smoking, Not on Tobacco, Clearing the Air, and Comprehensive Health Enhancement Support System for Smoking Cessation and Relapse Prevention; Myung et al., 2009). In this review, most of the trials that included standard drug abuse outcomes involved longer intervention periods consistent with traditional drug abuse treatment. Although these variations in systems address the need for a range of interventions at different points in the drug use disorder trajectory, systematic reviews have generally compared all computer-based intervention equally (Carey et al., 2009; Elliott et al., 2008; Myung et al., 2009). Future reviews should address the target population and the length of intervention, as well as other factors.

Despite variations in drug of abuse, stage of drug use disorder addressed, and outcome measures used, most studies to date have reported delivering the intervention via a computer on-site rather than via the Internet, telephone, or mobile access. Such alternative delivery options offer a number of advantages that deserve exploration. First, patients can use the systems in their own environment, perhaps even during cravings or other high-risk situations. Mobile telephones are often taken everywhere and could be an easy access point for treatment on demand. Second, patients can learn the material at their own pace, repeating material as frequently as they wish, or move on quickly to new material, rather than waiting for access to an on-site computer. Finally, “outgoing” systems can contact individuals via e-mail, text, or telephone, rather than being limited to patient-initiated contact. These types of interventions have been shown to be effective for other disorders requiring behavioral change, such as diabetes (Cole-Lewis & Kershaw, 2010). Although they have not been evaluated for drug use disorders, electronic contact from businesses and other organizations is common practice and would likely not be out of the ordinary for users. Outgoing messages, combined with patient-initiated contact, may improve patient satisfaction, retention, and overall treatment response.

Based on the findings of the current review, computer-based interventions are a promising development for drug use disorders. They have the potential to dramatically expand and alter the landscape of treatment due to their low cost, consistent presentation, and easy accessibility and availability. By expanding treatment options and availability, such systems may make treatment more attractive for the large percentage of abusing and dependent individuals who do not seek treatment. Such systems may also be more easily

implemented in a range of contexts including traditional treatment, brief intervention for at-risk populations, stepped-care management, and long-term reengagement in settings such as primary care.

In addition, a range of patient- and provider-level factors likely influence effective implementation of computer-based treatments. Familiarity with computers, provider acceptance and support, age, gender, and learning styles are only a few of the possible variables that may affect client acceptance of, preference for, and overall treatment response to computer-based treatments. Similarly, computers can collect a wealth of process information, such as duration, patient choice, and response to directed items throughout any specific treatment episode. Additional exploration is needed on such factors to identify potential mechanisms of action and to provide more detailed evaluation of patient change.

Acknowledgments

The research was supported by the National Institute on Drug Abuse Grants K01 DA022398 (B. M., T. F., and B. G.) and K23 DA024050 (D. B.). This study was presented in part at the 70th annual scientific meeting of the College on Problems of Drug Dependence (June 2009), Reno, NV.

References

- *Barber, J. G. (1990). Computer-assisted drug prevention. *Journal of Substance Abuse Treatment*, 7, 125–131.
- Bewick, B. M., Trusler, K., Barkham, M., Hill, A. J., Cahill, J., & Mulhern, B. (2008). The effectiveness of Web-based interventions designed to decrease alcohol consumption—A systematic review. *Preventive Medicine*, 47, 17–26.
- *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 & Clinical Psychopharmacology*, 16, 132–143.
- Budman, S. H. (2000). Behavioral health care dot-com and beyond: Computer-mediated communications in mental health and substance abuse treatment. *American Psychologist*, 55, 1290–1300.
- Carey, K. B., Scott-Sheldon, L. A. J., Elliott, J. C., Bolles, J. R., & Carey, M. P. (2009). Computer-delivered interventions to reduce college student drinking: A meta-analysis. *Addiction*, 104, 1807–1819.
- *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. *American Journal of Psychiatry*, 165, 881–888.
- *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 & Alcohol Dependence*, 100, 178–181.
- Carroll, K. M., & Rounsaville, B. J. (2007). A vision of the next generation of behavioral therapies research in the addictions. *Addiction*, 102, 850–862.
- Cavanagh, K., & Shapiro, D. A. (2004). Computer treatment for common mental health problems. *Journal of Clinical Psychology*, 60, 239–251.
- *Chopra, M. P., Landes, R. D., Gatchalian, K. M., Jackson, L. C., Buchhalter, A. R., Stitzer, M. L., et al. (2009). Buprenorphine medication versus voucher contingencies in promoting abstinence from opioids and cocaine. *Experimental and Clinical Psychopharmacology*, 17, 226–236.

- Cole-Lewis, H., & Kershaw, T. (2010). Text messaging as a tool for behavior change in disease prevention and management. *Epidemiologic Reviews*, 32, 56–69.
- Connors, G. J., Tonnigan, J. S., & Miller, W. R. (2001). A longitudinal model of intake symptomatology, AA participation and outcome: Retrospective study of the Project MATCH outpatient and aftercare samples. *Journal of Studies on Alcohol*, 62, 817–825.
- Copeland, J., & Martin, G. (2004). Web-based interventions for substance use disorders: A qualitative review. *Journal of Substance Abuse Treatment*, 26, 109–116.
- Downs, S. H., & Black, N. (1998). The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *Journal of Epidemiology and Community Health*, 52, 377–384.
- Elliott, J. C., Carey, K. B., & Bolles, J. R. (2008). Computer-based interventions for college drinking: A qualitative review. *Addictive Behaviors*, 33, 994–1005.
- *Grohman, K., & Fals-Stewart, W. (2003). Computer-assisted cognitive rehabilitation with substance-abusing patients: Effects on treatment response. *Journal of Cognitive Rehabilitation*, 21, 10–17.
- *Grohman, K., Fals-Stewart, W., & Donnelly, K. (2006). Improving treatment response of cognitively impaired veterans with neuropsychological rehabilitation. *Brain & Cognition*, 60, 203–204.
- Hall, J. A., & Huber, D. L. (2000). Telephone management in substance abuse treatment. *Telemedicine Journal and e-Health*, 6, 401–407.
- Kaltenthaler, E., Parry, G., Beverley, C., & Ferriter, M. (2008). Computerised cognitive-behavioural therapy for depression: Systematic review. *British Journal of Psychiatry*, 193, 181–184.
- *Kay-Lambkin, F. J., Baker, A., 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, 378–388.
- Marks, I., Shaw, S., & Parkin, R. (1998). Computer-aided treatments of mental health problems. *Clinical Psychology: Science and Practice*, 5, 151–170.
- *Marsch, L. A., & Bickel, W. K. (2004). Efficacy of computer-based HIV/AIDS education for injection drug users. *American Journal of Health Behavior*, 28, 316–327.
- Marsch, L. A., Bickel, W. K., & Grabinski, M. J. (2007). Application of interactive, computer technology to adolescent substance abuse prevention and treatment. *Adolescent Medicine*, 18, 342–356.
- Montani, S., Bellazzi, R., Quaglini, S., & d'Annunzio, G. (2001). Meta-analysis of the effect of the use of computer-based systems on the metabolic control of patients with diabetes mellitus. *Diabetes Technology & Therapeutics*, 3, 347–356.
- Myung, S. K., McDonnell, D. D., Kazinets, G., Seo, H. G., & Moskowitz, J. M. (2009). Effects of Web- and computer-based smoking cessation programs: Meta-analysis of randomized controlled trials. *Archives of Internal Medicine*, 169, 929–937.
- Nadelson, T. (1987). The inhuman computer/the too-human psychotherapist. *American Journal of Psychotherapy*, 41, 489–498.
- Noar, S. M., Black, H. G., & Pierce, L. B. (2009). Efficacy of computer technology-based HIV prevention interventions: A meta-analysis. *Aids*, 23, 107–115.
- *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, 305–312.
- *Ondersma, S.J., Svikis, D.S., & Schuster, C.R., (2007). Computer-based brief intervention a randomized trial with postpartum women.[erratum appears in American Journal of Preventive Medicine (2007), 32, 549]. *American Journal of Preventive Medicine*, 32, 231–238.
- Portnoy, D. B., Scott-Sheldon, L. A. J., Johnson, B. T., & Carey, M. P. (2008). Computer-delivered interventions for health promotion and behavioral risk reduction: A meta-analysis of 75 randomized controlled trials, 1988–2007. *Preventive Medicine*, 47, 3–16.
- Reger, M. A., & Gahm, G. A. (2009). A meta-analysis of the effects of Internet- and computer-based cognitive-behavioral treatments for anxiety. *Journal of Clinical Psychology*, 65, 53–75.
- *Ruggiero, K. J., Resnick, H. S., Acierno, R., Coffey, S. F., Carpenter, M. J., Ruscio, A. M., et al. (2006). Internet-based intervention for mental health and substance use problems in disaster-affected populations: A pilot feasibility study. *Behavior Therapy*, 37, 190–205.
- SAMHSA—Office of Applied Studies. (2009). *Treatment Episode Data Set (TEDS) Highlights—2007 National Admissions to Substance Abuse Treatment Services*. Rockville, MD: (Vol. HHS Publication No. (SMA) 09-4360).
- Spek, V., Cuijpers, P., Nyklicek, I., Riper, H., Keyzer, J., & Pop, V. (2007). Internet-based cognitive behaviour therapy for symptoms of depression and anxiety: A meta-analysis. *Psychological Medicine*, 37, 319–328.
- Ybarra, M. L., & Bull, S. S. (2007). Current trends in Internet- and cell phone-based HIV prevention and intervention programs. *Current HIV/AIDS Reports*, 4, 201–207.

* Study included in review.