Journal of Urban Health: Bulletin of the New York Academy of Medicine, Vol. 93, No. 5
doi:10.1007/s11524-016-0077-2

Recent Internet Use and Associations with Clinical Outcomes among Patients Entering Addiction Treatment Involved in a Web-Delivered Psychosocial Intervention Study

B. Tofighi, A. N. C. Campbell, M. Pavlicova, M. C. Hu, J. D. Lee, and E. V. Nunes

ABSTRACT *The acceptability and clinical impact of a web-based intervention among patients entering addiction treatment who lack recent internet access are unclear. This secondary analysis of a national multisite treatment study (NIDA Clinical Trials Network-0044) assessed for acceptability and clinical impact of a web-based psychosocial intervention among participants enrolling in community-based, outpatient addiction treatment programs. Participants were randomly assigned to 12 weeks of a web-based therapeutic education system (TES) based on the community reinforcement approach plus contingency management versus treatment as usual (TAU). Demographic and clinical characteristics, and treatment outcomes were compared among participants with recent internet access in the 90 days preceding enrollment (N = 374) and without internet access (N = 133). Primary outcome variables included (1) acceptability of TES (i.e., module completion; acceptability of web-based intervention) and (2) clinical impact (i.e., self-reported abstinence confirmed by urine drug/breath alcohol tests; retention measured as time to dropout). Internet use was common (74 %) and was more likely among younger (18–49 years old) participants and those who completed high school ($p < .001$). Participants randomized to TES ($n = 255$) without baseline internet access rated the acceptability of TES modules significantly higher than those with internet access ($t = 2.49$, $df = 218$, $p = .01$). There was a near significant interaction between treatment, baseline abstinence, and internet access on time to dropout ($\chi^2(1) = 3.8089$, $p = .051$). TES was associated with better retention among participants not abstinent at baseline who had internet access ($X^2(1) = 6.69$, $p = .01$). These findings demonstrate high acceptability of this web-based intervention among participants that lacked recent internet access.*

KEYWORDS *Addiction, Health information technologies, Web-based treatment, Disparities, Computer-assisted treatment, Substance use disorders*

INTRODUCTION

People with substance use disorders experience pervasive health disparities. These disparities can be intensified in the presence of other demographic (e.g., age, race) and psychosocial (e.g., socioeconomic status, education) characteristics which create greater

Tofighi and Lee are with the Department of Population Health Medicine, New York University School of Medicine, 227 E.30th St. 718, 10016, New York, NY, USA; Campbell and Nunes are with the New York State Psychiatric Institute, Department of Psychiatry, Columbia University Medical Center, New York, NY, USA; Pavlicova is with the Mailman School of Public Health, Department of Biostatistics, Columbia University, New York, NY, USA; Hu is with the Department of Psychiatry, Columbia University College of Physicians and Surgeons, New York, NY, USA.

Correspondence: B. Tofighi, Department of Population Health Medicine, New York University School of Medicine, 227 E.30th St. 718, 10016, New York, NY, USA. (E-mail: Babak.tofighi@nyumc.org)

vulnerability.[1] Barriers to the initiation of and retention in addiction treatment for vulnerable populations stem from the shortage of specialty treatment programs and perceived stigma by persons requiring treatment.[2–4] Service delivery in public sector, outpatient addiction treatment settings is further compromised by the need for increased staffing, funding, and access to evidence-based behavioral interventions.[5]

Computer- and mobile-assisted web-based interventions are uniquely positioned to deliver complex, evidence-based behavioral interventions for the treatment of substance use disorders with high fidelity and minimal disruption to clinical work flow.[6–9] Web-based platforms streamline exposure to standardized behavior change and educational content within and beyond traditional clinical settings at the convenience and privacy of users.[6,7,10] Web-based psychosocial interventions have demonstrated efficacy,[11,12] and most recently in a national multi-site trial, effectiveness of the Therapeutic Education System (TES), grounded in the community reinforcement approach and including prize-based motivational incentives.[7]

As barriers to internet use are strongly patterned by demographic (e.g., older age, less education) and clinical (e.g., mental illness) characteristics, clarifying the representativeness of individuals willing to participate in an intervention (i.e., reach) is necessary.[13–16] To date, evidence is lacking of actual reach for web-based interventions due to limited real-world trials.[16] Further, there is limited data characterizing recent internet access among vulnerable populations seeking community-based outpatient treatment for substance use disorders. Therefore, it is not known if lack of recent internet access is associated with lower acceptability and clinical impact of web-based psychosocial interventions.[17,18]

The National Drug Abuse Treatment (NIDA) Clinical Trials Network (CTN) is comprised of a broad range of addiction treatment researchers and community-based service providers. Findings from NIDA CTN multisite studies are uniquely positioned to characterize reach and provide information on ways health systems may leverage novel interventions to expand treatment capacity for vulnerable patient populations. We conducted a secondary analysis of a national multisite web-based psychosocial addiction treatment study to explore if lack of recent internet access and use was associated with demographic and clinical characteristics. The analysis tested three hypotheses: (1) the lack of recent internet access will be more prevalent among vulnerable patient subgroups (i.e., not Caucasian, not employed, and less than a high school education); (2) lack of recent internet access will be associated with more years of substance use and lower neurocognitive test scores; and (3) lack of recent internet access will be associated with lower acceptability and less abstinence among participants randomized to receive the web-based intervention.

METHODS

Study Design

Details pertaining to the study's design, site selection, and site characteristics have been reported previously.[7,19] The study enrolled participants seeking treatment for illicit substance or alcohol use disorders at 10 community-based, outpatient addiction treatment programs in the USA between June 2010 and August 2011. Programs offered a minimum of two therapeutic group or individual sessions per week that lasted for at least 2 h.

Eligible participants were adults (18 years or older) within the first 30 days of their current treatment episode who self-reported illicit substance use in the

preceding 30 days, were proficient in English, and were planning to remain in the treatment program for at least 3 months. Eligible participants ($N = 507$) were randomized to treatment as usual (TAU) ($n = 252$) or to TAU plus the experimental intervention Therapeutic Education System (TES) ($n = 255$), a web-based psychosocial treatment that consisted of 62 interactive multimedia modules grounded in the community reinforcement approach plus prize-based motivational incentives contingent on abstinence and treatment participation.[20] TES substituted for 2 h of weekly group or individual counseling, but did not entirely replace TAU.

Modules were accessed via computers provided to clinical sites and remotely via the internet at any desired location. Research staff assisted patients with setting up usernames, passwords, access to the modules, and any other emerging technical questions. During the 12-week treatment phase of the study, module completion and negative urine or breath alcohol screens were rewarded with vouchers drawn from a virtual "fishbowl" that included congratulatory messages and prizes ranging in value from $1 to $20 and rarely $80–100.

Measures

Demographic characteristics included age, sex, race/ethnicity, education level, insurance, and employment status. Clinical characteristics included the following: (1) baseline abstinence based on urine drug and breath alcohol screens; (2) days of substance use (drug/alcohol) in the 90 days preceding baseline assessment (timeline follow-back method);[21] (3) age of onset for first substance use; (4) primary substance of abuse; (5) screening for psychiatric disorders including attention deficit hyperactivity disorder (ADHD), posttraumatic stress disorder (PTSD), major depressive disorder, and anxiety disorders (i.e., panic, social, and generalized anxiety disorders);[22] (6) psychological distress level (Brief Symptom Inventory-18);[23] (7) perception of physical health (EQ5D Quality of Life questionnaire);[24] (8) social functioning;[25] (9) medical service utilization during the prior 90 days (i.e., doctor visits, emergency department visits, and hospital admissions); and (10) cognitive function (i.e., working memory, immediate/delayed memory, logical association of familiar concepts, and spatial recognition) (the MicroCog computerized assessment of cognitive functioning).[26] Internet access was assessed at baseline and categorized as a binary variable, "no internet access in the past 90 days" and "any use in the past 90 days."

Outcome variables included acceptability of web-based TES, abstinence in the last 4 weeks of the study, and treatment retention. Acceptability of the web-based intervention was assessed in two ways: (1) number of modules completed during the study period and (2) mean score (scale 0–10) across five indicators assessing how useful, interesting, novel, easy to understand, and satisfying the intervention was early in the treatment phase of the study (week 4). Abstinence was assessed using self-reported drug and alcohol use collected using the timeline follow-back[27] and biological urine drug and breath alcohol screens for each of eight half-weeks comprising the final month of treatment. Retention was defined as number of weeks to dropout and measured based on the last face-to-face treatment visit (0–11).

Statistical Analysis

The sample was categorized into participants with internet access and without internet access in the 90 days prior to baseline. Descriptive statistics consisted of percentages, means, and standard deviations. The t test or χ^2 test were used to compare the differences in baseline demographic and clinical characteristics between

participants with and without internet access. A p value smaller than 5 % was considered statistically significant. Covariates found to be statistically significant in bivariate analysis were subsequently included in multivariable analysis to determine which variables accounted for the most variation in internet access.

Abstinence during the last 4 weeks of the treatment phase was analyzed using a longitudinal logistic mixed effect model combined with GEE. The model included the following variables: baseline internet access (yes/no), baseline abstinence (yes/no), treatment assignment (TAU or TES), and time. Interaction between all four variables was tested. Prior studies have demonstrated the importance of including baseline abstinence as predictor of improved clinical outcomes.[28,29] The correlation between the repeated measurements within subject was modeled using the first-order autoregressive correlation structure. Missing data (38 subjects were removed from the analyses because they were missing all eight half-weeks of abstinence data) were assumed missing at random. Site and subjects were treated as random effects.

Acceptability of the TES was analyzed only for subjects randomized to TES ($n = 230$) using a mixed effect model with the following variables: baseline internet access (yes/no) and baseline abstinence (yes/no). The interaction between the two variables was also tested. Site was treated as a random effect. Retention in treatment (time to dropout) was graphically represented using Kaplan-Meier survival curves and analyzed using Cox proportional hazards model. The model included the following variables: baseline internet access (yes/no), baseline abstinence, and treatment assignment (TAU or TES). Interactions between all three variables were tested. Interaction terms were omitted from the final model if the corresponding p value was larger than 5 %. All relevant hypothesis tests were performed as two sided. All analyses were conducted using SAS version 9.3.

RESULTS

Demographic Characteristics and Internet Access

Of 507 randomized participants, 26 % (133/507) reported no internet access in the 90 days prior to baseline. Overall, there were significant differences between the internet access subgroups by race/ethnicity ($X^2(3) = 22.44$, $p < .001$), age ($X^2(2) = 39.67$, $p < .001$), and education ($X^2(1) = 25.28$, $p < .001$) (see Table 1). Compared to White respondents, Black (odds ratio [OR] = 0.31, $p < .001$), Hispanic/Latino (OR = 0.49, $p < .001$), and "Other"/multi-racial (OR = 0.51, $p = .03$) participants were more likely to report lack of internet access. Younger participants (18–29 years old) were significantly more likely to report internet access compared to respondents aged 50 years and older (OR = 7.53, $p < .001$). Respondents that completed high school were significantly more likely to have access to the internet versus participants that had not graduated from high school (OR = 3.00, $p < .001$). There were no significant associations between lack of internet access and sex, employment status, and health insurance access.

Clinical Characteristics and Internet Access

Table 2 presents associations between baseline clinical features of the randomized sample and internet access ($N = 507$). Participants with no internet access were more likely to have a higher age of onset of substance dependence (OR = 0.96, $p = .002$). There were no significant associations between having internet access and baseline abstinence, days of drug and alcohol use in the preceding 90 days, primary

TABLE 1 Baseline demographic characteristics among participants with and without internet access in the 90 days prior to study entry ($N = 507$)

Demographic characteristics	No internet access, $n = 133$ (26.23 %)	Internet access, $n = 374$ (73.77 %)	Test statistic	p value
	N (%)		X^2 or OR (95 % CI)	
	N (%)		X^2 or OR (95 % CI)	
Age			$X^2(2) = 39.67$	<.0001
50+ years old (REF[a])	25 (18.80 %)	33 (8.82 %)		
30–49 years old	91 (68.42 %)	172 (45.99 %)	1.43 (0.80–2.55)	.2238
18–29 years old	17 (12.78 %)	169 (45.19 %)	7.53 (3.67–15.48)	<.0001
Race/ethnicity			$X^2(3) = 22.44$	<.0001
White (REF)	48 (36.09 %)	219 (58.56 %)		
Black	46 (34.59 %)	66 (17.65 %)	0.31 (0.19–0.51)	<.0001
Hispanic/Latino	17 (12.78 %)	38 (10.16 %)	0.49 (0.26–0.94)	<.0001
Other/multi-racial	22 (16.54 %)	51 (13.64 %)	0.51 (0.28–0.92)	.0319
Sex				
Male (REF)	85 (64.39 %)	229 (61.23 %)		
Female	47 (35.61 %)	145 (38.77 %)	1.15 (0.76–1.73)	.5197
Education (%)				
<High school (REF)	52 (39.10 %)	66 (17.65 %)		
≥High school	81 (60.90 %)	298 (82.35 %)	3.00 (1.93–4.64)	<.0001
Employment (%)			$X^2(3) = 4.33$	.2279
Unemployed (REF)	45 (33.83 %)	99 (26.47 %)		
Part-time	27 (20.30 %)	90 (24.06 %)	1.96 (0.87–4.41)	
Employed	47 (35.34 %)	156 (41.71 %)	1.95 (1.00–3.82)	
Other	14 (10.53 %)	29 (7.75 %)	0.75 (0.27–2.06)	
Insurance (%)				
Uninsured (REF)	32 (24.06 %)	85 (25.47 %)		
Insured	101 (75.94 %)	278 (74.53 %)	0.93 (0.59–1.47)	.7477

"REF" is the reference condition relative to OR and corresponding 95 % confidence interval for other categories

substance of use, and other psychiatric and medical health measures (i.e., depression and/or psychological distress, physical health, and social functioning). There were significant associations between internet access and cognitive functioning, whereby participants without internet access demonstrated greater impairment on the following domains: (1) (numbers forward) (OR = 0.50, $p = .01$); (2) delayed memory (wordlist 2 total score) (OR = 0.54, $p = .03$); and (3) logical association of familiar concepts (analogies) (OR = 0.61, $p = .02$). In the multivariable model, which included all variables statistically significant at the bivariate level, only age ($X^2(2) = 28.80$, $p < .001$) and education ($X^2(1) = 17.21$, $p < .001$) remained significantly associated with having internet access (see Table 3). Having internet access was associated with younger age and having a high school education or greater.

Internet Access, Module Completion, and TES Acceptability

Among TES participants ($n = 255$), the interaction of baseline abstinence and having internet access on TES module completion was not significant ($F(1, 242) = 2.09$, $p = .15$). In the final model, the number of completed TES modules was significantly higher among participants abstinent at baseline ($t(243) = 3.19$, $p = .01$); however, baseline internet access was not significantly associated with module completion

TABLE 2 Baseline clinical characteristics among participants with and without internet access in the 90 days prior to study entry ($N = 507$)

Clinical characteristics	No internet access, $n = 133$	Internet access, $n = 374$	$X^2(df)$ and odds ratio (95 % CI)	p value
	Mean (SD) or N (%)			
Baseline drug/alcohol abstinence	71 (53.38 %)	204 (54.55 %)	1.05 (0.71–1.56)	.8171
Days of substance use (90 days)	44.08 (27.46)	44.81 (26.99)	1.00 (0.99–1.01)	.7909
Ever substance dependence	121 (90.98 %)	342 (91.44 %)	1.06 (0.53–2.12)	.8697
Age of onset (dependence)[a, b]	24.31 (10.12)	21.50 (7.72)	0.96 (0.94–0.99)	.0022
Primary substance			$X^2(5) = 9.14$	.1036
Opioids (REF)	25 (18.80 %)	83 (22.19 %)		
Alcohol	28 (21.05 %)	76 (20.32 %)	0.82 (0.44–1.52)	
Cocaine	37 (27.82 %)	65 (17.38 %)	0.53 (0.29–0.97)	
Other stimulants	19 (14.29 %)	50 (13.37 %)	0.79 (0.40–1.58)	
Marijuana	23 (17.29 %)	91 (24.33 %)	1.19 (0.63–2.26)	
Other	1 (0.75 %)	9 (2.41 %)	2.71 (0.33–22.42)	
Current positive major depression disorder screen	33 (24.81 %)	73 (19.52 %)	0.74 (0.46–1.18)	.1983
Current positive PTSD screen	32 (24.24 %)	73 (20.00 %)	0.78 (0.49–1.25)	.3069
Current positive anxiety disorder screen	72 (54.14 %)	176 (47.06 %)	0.75 (0.51–1.12)	.1614
Current positive ADHD screen	38 (28.57 %)	87 (23.26 %)	0.76 (0.49–1.18)	.2232
Brief symptom inventory total	14.62 (14.03)	13.13 (11.98)	0.99 (0.98–1.01)	.2402
Physical health (0–100)	73.29 (20.65)	72.78 (19.32)	1.00 (0.99–1.02)	.7990
Social adjustment scale total	2.25 (0.55)	2.15 (0.47)	0.69 (0.46–1.02)	.0603
MicroCog subtest scaled scores (% impaired)				
Numbers forward avg	37 (27.82 %)	60 (16.04 %)	0.50 (0.31–0.79)	.0034
Numbers reversed	43 (32.33 %)	91 (24.33 %)	0.67 (0.44–1.04)	.0733
Wordlist 1	58 (43.94 %)	133 (35.56 %)	0.70 (0.47–1.05)	.0885
Wordlist 2	25 (18.94 %)	42 (11.23 %)	0.54 (0.32–0.93)	.0261
Analogies avg	78 (58.65 %)	173 (46.46 %)	0.61 (0.41–0.91)	.0145
Object match A	24 (18.05 %)	72 (19.46 %)	1.10 (0.66–1.83)	.7219
Object match B	41 (31.06 %)	107 (28.92 %)	0.90 (0.59–1.39)	.6432
Clocks	3 (2.26 %)	12 (3.21 %)	1.44 (0.40–5.17)	.5797

"REF" is the reference condition relative to OR and corresponding 95 % confidence interval for other categories

[a] $n = 44$ participants excluded who were not dependent on a substance (12 no internet, 32 internet)

[b] Odds of internet access and age of dependence was assessed per year of greater age

($t(243) = 0.86$, $p = .39$). In terms of where participants completed TES modules (onsite or offsite), those without internet access were less likely to complete any modules offsite (24.62 %) compared to participants with internet access (44.62 %) (OR = 2.47, CI 1.31–4.65, $p = .01$). Participants without internet access on average completed 3.68 modules (SD = 11.47) offsite compared to an average of 12.23 modules (SD = 21.29) offsite among participants with internet access.

Among TES participants, there was no significant interaction between baseline abstinence and internet access on the outcome of TES acceptability at week 4 ($F(1,217) = 0.91$, $p = .34$), assessed via five indicators and scored from 0 to 10. In the final model, baseline internet access was significantly associated with TES

TABLE 3 Logistic regression on internet access of selected baseline clinical and demographic characteristics ($N = 507$)

Variables[a]	Adjusted odds ratio (95 % CI)	Test statistic	*p* value
Age[b]		$X^2(2) = 28.80$	<.0001
50+ years old (REF) ($n = 58$)			
30–49 years old ($n = 263$)	1.66 (0.88–3.14)		.1214
18–29 years old ($n = 186$)	7.24 (3.22–16.26)		.0001
Race/ethnicity		$X^2(3) = 7.38$	.0607
White (REF) ($n = 267$)			
Black ($n = 112$)	0.49 (0.28–0.84)		
Hispanic/Latino ($n = 55$)	0.64 (0.31–1.33)		
Other/multi-racial ($n = 73$)	0.57 (0.29–1.11)		
Education			
<High school (REF) ($n = 118$)			
≥High school ($n = 379$)	2.87 (1.74–4.71)		<.0001
Age of onset (dependence) ($N = 507$)	0.99 (0.97–1.02)		.6360
MicroCog (% impaired) ($N = 507$)			
Numbers forward avg total score	0.69 (0.40–1.17)		.1684
Wordlist 2 total score	0.65 (0.36–1.19)		.1619
Analogies avg total score	0.95 (0.60–1.52)		.8299

"REF" is the reference condition relative to OR and corresponding 95 % confidence interval for other categories

[a]Variables statistically significant in bivariate analysis ($p < .05$) were included (see Tables 1 and 2)

[b]Odds of internet access and age of dependence was assessed per year of greater age

acceptability; participants without baseline internet access rated the acceptability of TES modules at week 4 significantly higher than those with internet access ($t = 2.49$, $df = 218$, $p = .01$). Average acceptability at week 4 was 8.69 (SD = 1.20) for participants without internet access ($n = 60$) compared to 8.06 (SD = 168) for participants with internet access ($n = 170$).

Internet Access and Clinical Outcomes

Abstinence (in the last 4 weeks of the treatment phase) was tested as a function of baseline internet access, treatment assignment (TES vs TAU), baseline abstinence, and time ($N = 507$). The interaction of treatment assignment, baseline abstinence, baseline internet access, and time was not significant ($F(1, 2443) = 3.16$, $p = .08$) and neither were any lower level interactions. In the final model, internet access was not significantly associated with abstinence ($F(1,2450) = 0.06$, $p = .81$), while main effects of baseline abstinence ($F(1,2450) = 58.49$, $p < .001$) and treatment assignment ($F(1,2450) = 6.59$, $p = .01$) were significant. Baseline abstinence was associated with abstinence in the last 4 weeks of treatment, as was assignment to the TES arm.

Retention, measured by weeks to dropout, was analyzed using a Cox proportional hazard model. The three-way interaction among baseline internet access, treatment assignment, and baseline abstinence was borderline significant ($X^2(1) = 3.8089$, $p = .051$). TES was superior to TAU only among participants not abstinent at baseline and who had internet access ($n = 170$) ($X^2(1) = 6.69$, $p = .01$). There was no difference by internet access for those participants in TES who entered the study abstinent ($n = 275$) ($X^2(1) = 0.04$, $p = .84$). Figure 1a, b further illustrates retention outcomes among the TES group ($n = 255$) by abstinence at baseline and internet access.

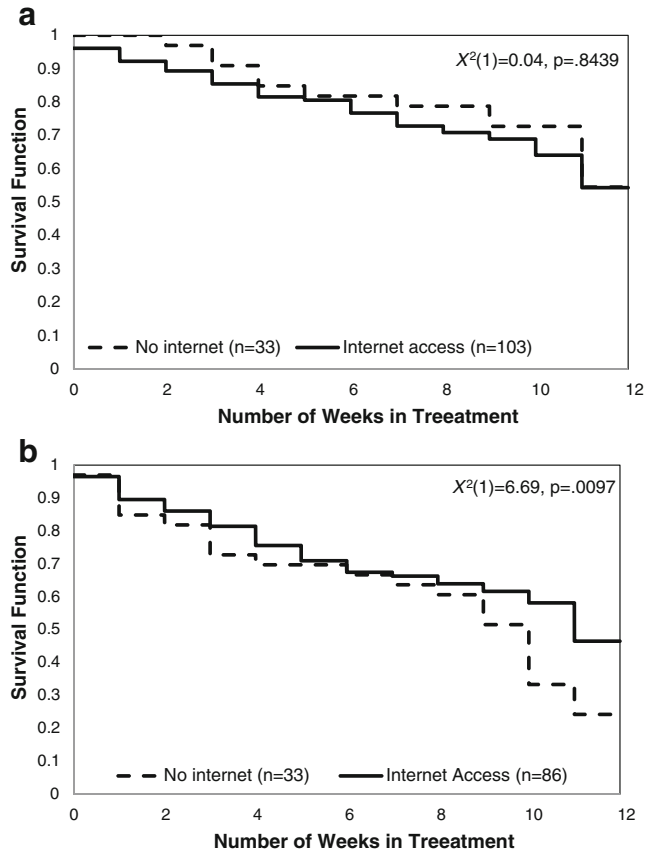

FIG. 1 Kaplan-Meier plot of time to treatment program dropout for TES participants among baseline abstinent ($n = 136$ (**a**)) and non-abstinent ($n = 119$ (**b**)) participants with and without internet access.

DISCUSSION

This study explores the association between internet access and demographic and clinical outcomes among a national multi-site sample of patients entering community-based, outpatient addiction treatment. Overall, the data are encouraging for the potential to use technology-based interventions among diverse outpatient addiction treatment populations. Rates of internet access (in the 90 days prior to enrollment) (74 %) were similar to the general population (79 %).[30] Further, there was high acceptability of the web-based intervention especially among participants reporting no recent internet access.[15] Findings also suggest that a lack of recent internet access was not associated with abstinence or retention outcomes.

Demographic Characteristics

The results partially support our hypothesis that demographic features associated with lack of internet access in national surveys (e.g., older age and less education) extend to this sample.[15,17] The design and deployment of web-based psycho-social interventions for older adults is especially important as the demand for addiction treatment for this subgroup is anticipated to increase by 50 % between 2000 and

2020.[31] Cost and complexity of utilizing the internet are barriers to use among older adults.[32] Nonetheless, most older patients prefer to receive specialized computer or mobile device training (77 %) and have demonstrated rates of engagement with web- and computer-based interventions comparable to younger populations.[33,34]

Adults with substance use disorders who have lower levels of education have been shown to have poorer treatment outcomes and may be at particular risk for similar outcomes using web-based interventions.[1,4] Prior studies have reported that while most web-related content is written at the 10th grade level or higher, the average American reads at an 8th grade level or less, and this has been associated with a poorer understanding of web-based health information.[15,35] In this study, research support staff assisted patients during their initial use of the web-based TES intervention. In addition, modules used precision learning strategies that required participants to complete quiz items correctly in order to proceed to subsequent modules. Additional design strategies that may increase use or acceptability include the use of redundancy with pertinent intervention content, table of contents and navigation bars, graphic images that complement text content, and prompts that clarify erroneous responses.[13] Additional studies are required to assess retention and use of a web-based TES content among low-literate adults with substance use disorders.

We anticipated lower rates of internet use among unemployed, non-Caucasian, and uninsured participants based on potential structural barriers,[2,17,18]; however, none of these findings bore out in this analysis. These results may be attributed to the increasing popularity of smartphone ownership among lower income populations.[36] While non-Caucasian and lower income status populations may lack access to home desktop computers or broadband internet connections, smartphones are expanding internet access among vulnerable populations.[36,37] Nationally, more American adults now access the internet via mobile browsers and smartphone applications (55 %) compared to computer-based web-browsing.[28]

These encouraging trends prioritize the study of web-based interventions to address fragmented care delivery for vulnerable populations with substance use disorders.[16] In particular, tailoring behavior change intervention content with regard to demographic characteristics has demonstrated improved clinical outcomes in print communication and should be assessed further in computer-assisted, web-based psychosocial interventions.[29]

Clinical Characteristics

We found greater cognitive impairment on several MicroCog scales associated with reduced internet access. Reduced cognitive functioning among patients entering addiction treatment negatively impacts retention.[26] However, promising findings by Acosta et al. indicate that a web-based TES intervention may mitigate negative treatment outcomes attributed to reduced cognitive functioning clients enrolled in methadone maintenance treatment.[10] Similarly, computer-assisted cognitive rehabilitation interventions have improved treatment outcomes for adults with cognitive dysfunction secondary to alcohol use.[38]

Internet access did not differ by primary substance of use, baseline drug abstinence versus non-abstinence, recent days of drug and/or alcohol use, or by psychiatric or medical health measures. Specialty treatment settings are in a unique position to expand capacity by leveraging web-based interventions for patients presenting with a range of substance use and psychiatric disorders.[39]

Internet Access, TES Acceptability, and Clinical Impact

Participants without internet access, compared to those with internet access, rated the TES modules significantly higher at week 4 of treatment. Individuals without internet access may be less familiar with more appealing website designs while regular internet users may have found the modules outdated or less esthetically engaging.

Non-abstinent participants with internet access randomized to the TES interventions showed significantly greater retention compared to participants without internet access. A lack of internet access in the preceding 90 days among participants actively using drugs and alcohol may be attributed to lower cognitive functioning, competing time demands (including trying to secure funds to obtain drugs, use drugs, and recover from its effects), extended periods in controlled settings prior to study enrollment, or limited social support which may have precluded patients' access to the internet. Therefore, extending periods of intensive web-based TES training, easing access to computers within the clinic to complete modules, and accessing to clinic staff that may assist clients with questions pertaining to the TES may enhance engagement with web-based interventions and drive improved clinical outcomes.[40] Given the borderline significance ($p = .051$) of the overall interaction, however, additional research is needed to replicate and better understand this finding.

Limitations

Study strengths include a large, diverse population with uniform access to care, and detailed real-world assessments following use of a web-based psychosocial intervention. However, several limitations must be noted. First, results may not generalize to opioid treatment programs, inpatient detoxification settings, and long-term rehabilitation programs. Second, internet access was defined as "any use in the past 90 days." This is a broad definition that may have incorrectly categorized individuals that regularly accessed the internet, but for various circumstances such as incarceration or homelessness had been unable to do so in the recent past. A more nuanced assessment of internet use, including how the internet is accessed (e.g., desktop computer, tablet devices, mobile phones) and frequency of use, would have also been useful. However, we felt it was beyond the scope of the current analysis, since we wanted to characterize variables associated with lack of recent internet access as well as the acceptability and clinical impact of the web-based intervention among this subgroup. Lastly, the increased uptake of smartphones, tablet devices, and other devices among vulnerable populations since the study was performed may underestimate the current rates of internet access. This may be particularly relevant given that those participants who lacked internet access in the 90 days prior to enrollment were more likely to rate the acceptability of the TES modules highly.

CONCLUSION

Expanding the capacity of publicly funded community-based addiction treatment programs with acceptable evidence-based health information technologies is imperative. The suitability of providing access and training to web-based interventions within clinics may mitigate barriers to access among vulnerable populations lacking remote internet access. Studies must also assess patient-, clinician-, and administrator-level factors that may facilitate the integration of web-based interventions as a part of routine care. Lastly, computer- versus mobile-assisted

web-based module access patterns and preferences must be further evaluated among vulnerable patient populations. Leveraging the increasing popularity of smartphone ownership among lower-income and non-Caucasian patient populations may expand access to psychosocial interventions and drive improved treatment outcomes.

ACKNOWLEDGMENTS

Authors' Contributions. Drs. Tofighi, Campbell, and Nunes completed the background literature search. Drs. Hu and Pavlicova completed the statistical analyses. Drs. Tofighi and Lee wrote the first draft of the manuscript. All authors contributed to and have approved the final manuscript.

COMPLIANCE WITH ETHICAL STANDARDS

Funding. Funding was provided by Web-Delivery of Evidence-Based, Psychosocial Treatment for Substance Use Disorders NIDA UG1 DA013035.

REFERENCES

1. Swendsen J, Conway KP, Degenhardt L, et al. Socio-demographic risk factors for alcohol and drug dependence: the 10-year follow-up of the national comorbidity survey. *Addiction*. 2009; 104(8): 1346–55.
2. Saloner B, Le Cook B. Blacks and Hispanics are less likely than whites to complete addiction treatment, largely due to socioeconomic factors. *Health Aff (Millwood)*. 2013; 32(1): 135–45.
3. Hansen HB, Siegel CE, Case BG, Bertollo DN, DiRocco D, Galanter M. Variation in use of buprenorphine and methadone treatment by racial, ethnic, and income characteristics of residential social areas in New York City. *J Behav Health Serv Res*. 2013; 40(3): 367–77.
4. Brorson HH, Ajo Arnevik E, Rand-Hendriksen K, Duckert F. Drop-out from addiction treatment: a systematic review of risk factors. *Clin Psychol Rev*. 2013; 33(8): 1010–24.
5. Walley AY, Alperen JK, Cheng DM, et al. Office-based management of opioid dependence with buprenorphine: clinical practices and barriers. *J Gen Intern Med*. 2008; 23(9): 1393–8.
6. Litvin EB, Abrantes AM, Brown RA. Computer and mobile technology-based interventions for substance use disorders: an organizing framework. *Addict Behav*. 2013; 38(3): 1747–56.
7. Campbell AN, Nunes EV, Matthews AG, Stitzer M, Miele GM, Polsky D, Turrigiano E, Walters S, McClure EA, Kyle TL, et al. Internet-delivered treatment for substance abuse: a multisite randomized controlled trial. *Am J Psychiatry*. 2014; 171(6): 683–90.
8. Gustafson DH, McTavish FM, Chih MY, et al. A smartphone application to support recovery from alcoholism: a randomized clinical trial. *JAMA Psychiatry*. 2014; 71(5): 566–72.
9. Marsch LA, Guarino H, Acosta M, et al. Web-based behavioral treatment for substance use disorders as a partial replacement of standard methadone maintenance treatment. *J Subst Abus Treat*. 2014; 46(1): 43–51.

10. Acosta MC, Marsch LA, Xie H, Guarino H, Aponte-Melendez Y. A web-based behavior therapy program influences the association between cognitive functioning and retention and abstinence in clients receiving methadone maintenance treatment. *J Dual Diagn*. 2012; 8(4): 283–93.
11. Bickel WK, Marsch LA, Buchhalter AR, Badger GJ. Computerized behavior therapy for opioid-dependent outpatients: a randomized controlled trial. *Exp Clin Psychopharmacol*. 2008; 16(2): 132–43.
12. Carroll KM, Kiluk BD, Nich C, et al. Computer-assisted delivery of cognitive-behavioral therapy: efficacy and durability of CBT4CBT among cocaine-dependent individuals maintained on methadone. *Am J Psychiatry*. 2014; 171(4): 436–44.
13. Zarcadoolas C, Blanco M, Boyer JF, Pleasant A. Unweaving the web: an exploratory study of low-literate adults' navigation skills on the world wide web. *J Health Commun*. 2002; 7(4): 309–24.
14. Tsai J, Klee A, Rosenheck RA, Harkness L. Internet use among veterans with severe mental illness. *Psychiatr Serv*. 2014; 65(4): 564–5.
15. Center PR: internet user demographics. In: Pew Research Center. vol. Pew Research Center, January 12, 2014 edn. *Pew Research Center: Pew Research Center*; 2014.
16. Bennett GG, Glasgow RE. The delivery of public health interventions via the internet: actualizing their potential. *Annu Rev Public Health*. 2009; 30: 273–92.
17. McClure EA, Acquavita SP, Harding E, Stitzer ML. Utilization of communication technology by patients enrolled in substance abuse treatment. *Drug Alcohol Depend*. 2013; 129(1–2): 145–50.
18. López L, Green AR, Tan-McGrory A, King R, Betancourt JR. Bridging the digital divide in health care: the role of health information technology in addressing racial and ethnic disparities. *Jt Comm J Qual Patient Saf*. 2011; 37(10): 437–45.
19. Campbell AN, Nunes EV, Miele GM, et al. Design and methodological considerations of an effectiveness trial of a computer-assisted intervention: an example from the NIDA clinical trials network. *Contemp Clin Trials*. 2012; 33(2): 386–95.
20. Roozen HG, Boulogne JJ, van Tulder MW, et al. A systematic review of the effectiveness of the community reinforcement approach in alcohol, cocaine and opioid addiction. *Drug Alcohol Depend*. 2004; 74(1): 1–13.
21. Sobell LC, Sobell MB. *Timeline followback: a technique for assessing self-reported ethanol consumption*. In: Allen J, Litten RZ, eds. Measuring Alcohol Consumption: Psychosocial and Biological Methods. Totowa: Humana Press; 1992. p. 41–72.
22. Spitzer RL, Kroenke K, Williams JB. Validation and utility of a self-report version of PRIME-MD: the PHQ primary care study. Primary care evaluation of mental disorders. Patient health questionnaire. *JAMA*. 1999; 282(18): 1737–44.
23. Wang J, Kelly BC, Booth BM, Falck RS, Leukefeld C, Carlson RG. Examining factorial structure and measurement invariance of the Brief Symptom Inventory (BSI)-18 among drug users. *Addict Behav*. 2010; 35(1): 23–9.
24. The EuroQol Group. EuroQol—a new facility for the measurement of health-related quality of life. *Health Policy*. 1990; 16(3):199–208. http://www.sciencedirect.com/science/article/pii/0168851090904219. Accessed 01 Apr 2016.
25. Weissman MM, Bothwell S. Assessment of social adjustment by patient self-report. *Arch Gen Psychiatry*. 1976; 33(9): 1111–5.
26. Aharonovich E, Hasin DS, Brooks AC, Liu X, Bisaga A, Nunes EV. Cognitive deficits predict low treatment retention in cocaine dependent patients. *Drug Alcohol Depend*. 2006; 81(3): 313–22.
27. Sobell LC, Maisto SA, Sobell MB, Cooper AM. Reliability of alcohol abusers' self-reports of drinking behavior. *Behav Res Ther*. 1979; 17(2): 157–60.
28. Mobile apps overtake PC internet usage in U.S. [http://money.cnn.com/2014/02/28/technology/mobile/mobile-apps-internet/]. Accessed 25 March 2016.
29. Noar SM, Benac CN, Harris MS. Does tailoring matter? Meta-analytic review of tailored print health behavior change interventions. *Psychol Bull*. 2007; 133(4): 673.

30. Americans' internet access: 2000–2015. [http://www.pewinternet.org/2015/06/26/americans-internet-access-2000-2015/]. Accessed 25 March 2016.
31. Gfroerer J, Penne M, Pemberton M, Folsom R. Substance abuse treatment need among older adults in 2020: the impact of the aging baby-boom cohort. *Drug Alcohol Depend*. 2003; 69(2): 127–35.
32. Carpenter BD, Buday S. Computer use among older adults in a naturally occurring retirement community. *Comput Hum Behav*. 2007; 23(6): 3012–24.
33. Mayhorn CB, Stronge AJ, McLaughlin AC, Rogers WA. Older adults, computer training, and the systems approach: a formula for success. *Educ Gerontol*. 2004; 30(3): 185–203.
34. Older adults and technology use. [http://www.pewinternet.org/2014/04/03/older-adults-and-technology-use/]. Accessed 25 March 2016.
35. Birru MS, Monaco VM, Charles L, Drew H, Njie V, Bierria T, et al. Internet usage by low-literacy adults seeking health information: an observational analysis. *J Med Internet Res*. 2004;6(3):p.e25.
36. Smith A. *African Americans and technology use. A demographic portrait*. Pew Research Center. [http://www.pewinternet.org/files/2014/01/African-Americans-and-Technology-Use.pdf]. Accessed 01 Apr 2016.
37. Lopez MH, Gonzalez-Barrera A, Patten E. *Closing the digital divide: Latinos and technology adoption*. Washington: Pew Research Center; 2013.
38. Bates ME, Buckman JF, Nguyen TT. A role for cognitive rehabilitation in increasing the effectiveness of treatment for alcohol use disorders. *Neuropsychol Rev*. 2013; 23(1): 27–47.
39. Griffiths KM, Christensen H. Review of randomised controlled trials of internet interventions for mental disorders and related conditions. *Clin Psychol*. 2006; 10(1): 16–29.
40. Dahne J, Lejuez CW. Smartphone and mobile application utilization prior to and following treatment among individuals enrolled in residential substance use treatment. *J Subst Abus Treat*. 2015; 58: 95–9.