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A novel mhealth application for improving HIV and Hepatitis C knowledge in individuals with opioid use disorder

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A NOVEL *M*HEALTH APPLICATION FOR IMPROVING
HIV AND HEPATITIS C KNOWLEDGE IN INDIVIDUALS
WITH OPIOID USE DISORDER

A Thesis Presented

by

Taylor A. Ochalek

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The Faculty of the Graduate College

of

The University of Vermont

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Abstract

Aims: Untreated opioid use disorder (OUD) is associated with overdose, premature death and infectious disease, including human immunodeficiency virus (HIV) and Hepatitis C (HCV). While prior studies have shown that educational interventions are associated with improvements in HIV and HCV knowledge and reductions in risk behaviors, those examined to date have typically been time- and resource-intensive. We recently developed an HIV+HCV Education intervention which aims to improve HIV and HCV knowledge in a single visit using an automated iPad platform. In this project, we examined its ability, using a within-subject evaluation, to improve knowledge of HIV and HCV transmission and risks among adults with OUD.

Methods: Participants were 25 adults with OUD who were enrolled in a 12-week randomized trial evaluating the efficacy of an Interim Buprenorphine Treatment (IBT) for reducing illicit opioid use while awaiting entry into community-based opioid treatment. Participants completed a baseline HIV+HCV knowledge assessment (Pre-Test) followed by corrective feedback, both administered via iPad. They then completed an interactive HIV flipbook and animated HCV video, also on iPad, followed by a second administration of the knowledge assessment (Post-Test). Finally, to evaluate whether any changes in knowledge persisted over time, the HIV+HCV assessment was administered again at 4 and 12 weeks following study intake.

Results: At baseline (Pre-Test), participants answered 69% and 65% of items correctly on the HIV and HCV assessments, respectively. After completing the educational intervention, participants answered 86% of items correctly on both the HIV and HCV assessments (p 's<.001). These improvements in knowledge also persisted throughout the three-month study, with scores at Week 4 and 12 timepoints significantly greater than baseline (p 's<.001).

Conclusion: An HIV+Hepatitis Education intervention delivered via a portable, automated iPad platform may produce significant and persistent improvements in HIV and HCV knowledge among adults with OUD. These data provide additional support for the use of mobile educational interventions for enhancing HIV and HCV knowledge in individuals at elevated risk for infectious disease.

Support: This trial was supported by NIDA R34 DA3730385 (Sigmon) with additional support by NIDA T32 DA007242 (Higgins).

Table of Contents

List of Tables	iii
List of Figure.....	iv
Comprehensive Literature Review	1
Journal Article.....	7
Introduction.....	9
Methods.....	11
Results.....	15
Discussion.....	17
Table 1	21
Table 2	23
Table 3	24
Table 4	25
Table 5	26
Table 6	27
Table 7	28
Figure Legends.....	29
Figure 1	30
Figure 2	31
Comprehensive Bibliography	32

List of Tables

Table 1: HIV knowledge questionnaire	21
Table 2: HCV knowledge questionnaire.....	23
Table 3: VAS items.....	24
Table 4: Participant baseline characteristics	25
Table 5: HIV+HCV risk behaviors at intake	26
Table 6: Pre- to Post-Test changes in HIV knowledge.....	27
Table 7: Pre- to Post-Test changes in HCV knowledge	28

List of Figures

Figure 1: Previous demonstration of changes in HIV and HCV knowledge.....	30
Figure 2: Changes in HIV and HCV knowledge	31

Comprehensive Literature Review

Rates of opioid abuse, including heroin and prescription opioids, have reached epidemic proportions in the United States (US), resulting in infectious disease, overdoses, premature deaths and vast economic costs (Birnbaum et al., 2011; Clausen, Waal, Thoresen, & Gossop, 2009; Rudd, Aleshire, Zibbell, & Gladden, 2016). Of particular concern is the disproportionate prevalence of human immunodeficiency virus (HIV) and Hepatitis C (HCV) among individuals with opioid use disorder (OUD). Untreated OUD is associated with unprecedented recent outbreaks of HIV and HCV (Dunn et al., 2016; Wang, Zhang, & Ho, 2011). In 2014 alone, for example, HIV accounted for over 13,000 deaths and HCV-related deaths reached a record high of nearly 20,000 (CDC, 2015, 2016).

Improving HIV and HCV knowledge

Risk of contracting and transmitting infectious disease among individuals with OUD and other substance abuse disorders primarily stems from engaging in risky drug use behaviors (e.g., sharing injection equipment like syringes, cookers, and cottons, impaired decision making under drug influence) as well as risky sexual behaviors (e.g., trading sex for drugs, having sex without a condom, having unprotected sex with other drug users). Efforts to enhance HIV and HCV knowledge and decrease risk behaviors in this vulnerable population are critical for reducing the individual and societal consequences associated with infectious disease.

Educational interventions are a widely-used approach for addressing this issue, and interventions to date have generally focused on improving HIV and HCV knowledge (Arain et al., 2016), decreasing self-reported risk behaviors (Copenhaver, Johnson, Lee,

Harman, & Carey, 2006; Meader, Li, Jarlais, & Pilling, 2010), and improving utilization of HIV and HCV screening and treatment (Lubega, Agbim, Surjadi, Mahoney, & Khalili, 2013; Marinho et al., 2016). Overall, educational interventions have been generally associated with increased knowledge, self-reported condom use and entry into screening and treatment services, as well as decreased injection and non-injection drug use and trading of sex for drugs (Coffin, Rowe, & Milo Santos, 2015; Copenhaver, Johnson, Lee, Harman, Carey, et al., 2006; MacArthur et al., 2014; Meader, Li, Des Jarlais, & Pilling, 2010; Shah & Abu-Amara, 2013). Similar findings have been reported for educational interventions focused on HCV. In a recent review of 10 HCV educational interventions, for example, 80% of the studies showed significant improvements in HCV-related knowledge (Shah & Abu-Amara, 2013). Decreases in self-reported engagement in HCV risk behaviors and drug use, as well as increased condom use, were also demonstrated (Coffin et al., 2015). Taken together, the extant data suggest that HIV and HCV educational interventions are associated with improvements in related knowledge, reductions in risk behaviors, and increased utilization of screening and treatment services (Marinho et al., 2016; Munoz-Plaza et al., 2008; Norton et al., 2014; Zeremski et al., 2014). Despite this, however, several features of these interventions have limited their widespread use. First, they are often time- and resource-intensive, typically delivered across multiple lengthy sessions, despite some evidence that brief interventions can produce outcomes that are similar to longer-duration interventions (Meader et al., 2010). They have also traditionally relied on trained peer, staff, or health care professionals for intervention delivery (e.g., nurse, physician, therapist) (Shah & Abu-Amara, 2013). Overall, this labor-intensive approach can increase cost and time burdens. Finally, staff-

delivered assessments and interventions may be less appealing to some individuals due to potential concerns regarding confidentiality or perceived judgment around the sensitive illicit drug use and sexual behaviors being assessed.

Prior studies by our group

Our research group previously developed a single-visit intervention for improving HIV and HCV knowledge in illicit drug abusers. Briefly, the participant first completes an initial, paper-and-pencil assessment of baseline HIV and HCV knowledge (Pre-Test). She or he then views an educational video and meets individually with a master's level therapist to review and discuss the video as well as an informational pamphlet. The therapist then reviews the participant's answers on the Pre-Test, provides corrective feedback for any incorrect answers, and answers any questions the participant has about the content reviewed. Finally, the participant completes the HIV and HCV knowledge assessment a second time (Post-Test).

Across three studies with cocaine- or opioid-dependent individuals, this single-visit, educational intervention was associated with significant increases in HIV and HCV knowledge accuracy (Dunn et al., 2013; Heil, Sigmon, Mongeon, & Higgins, 2005; Herrmann et al., 2013). Data presented in Figure 1 offer a representative illustration of pre- and post-intervention outcomes in our prior study with opioid-dependent individuals, with participants demonstrating an approximately 55% increase in correct answers following the educational session (Dunn et al., 2013).

Automating delivery of HIV+HCV assessments and education

Although our educational intervention was associated with improvements in HIV and HCV knowledge, its in-person delivery involving a master's level therapist may still

limit its use in resource-constrained settings. One exciting recent development that may hold promise for overcoming this limitation is the increasing use of mobile health (*mHealth*) platforms. *mHealth* interventions use portable computerized devices and can extend the reach of health care by permitting delivery of monitoring, education, point-of-care diagnostics and treatment beyond the confines of the medical office (Boyer, Smelson, Fletcher, Ziedonis, & Picard, 2010).

The potential utility of *mHealth* applications for improving knowledge has been evaluated with a variety of medical conditions, including cancer (Coughlin et al., 2016), chronic obstructive pulmonary disease (Sobnath et al., 2017), and alcohol abuse (Gustafson et al., 2014). However, fewer studies have examined their utility in the areas of HIV and HCV knowledge (Catalini, Philbrick, Fraser, Mechael, & Israelski, 2013; Niakan, Mehraeen, Noori, & Gozali, 2017). In one recent study, Festinger and colleagues (2016) evaluated the efficacy of an *mHealth* HIV educational intervention in increasing screening rates and reducing self-reported sexual and drug use risk behaviors in substance abusers participating in drug court in Philadelphia, PA. Compared to an attention control condition, participants who received the educational intervention reported a significantly greater likelihood of HIV testing ($p=0.03$) and condom use ($p<0.01$). Another recent study evaluated an *mHealth* intervention to increase HIV and HCV knowledge and testing among injection drug users attending a community syringe exchange program in Bronx, NY (Aronson, Bennett, Marsch, & Bania, 2017). While improvements in HIV and HCV knowledge were modest, the intervention was associated with a high rate of testing, with 100% and 91% of participants agreeing to HIV and HCV screening, respectively.

While these interventions have generally supported the potential utility of *m*Health-delivered HIV and HCV education, the studies were conducted in urban geographic areas and the educational interventions were not integrated into opioid agonist treatment, which is the standard of care for treating OUD and an ideal platform for delivering HIV and HCV assessments and education. We have been interested in examining whether automated interventions may offer promise for improving infectious disease knowledge among high-risk individuals in the rural and suburban areas struggling with outbreaks of infectious disease as well as limited treatment access for OUD and its associated consequences. Additionally, we are interested in developing and evaluating an educational intervention that could be readily incorporated into a larger treatment program for individuals with OUD.

Present study

The most widely-used and efficacious approach for treating OUD involves maintenance therapy with agonist medications (e.g., methadone, buprenorphine). Opioid agonist treatment (OAT) has been consistently shown to reduce illicit opioid use, other drug use and drug-related overdose (Johnson et al., 2000; Kresina & Lubran, 2011; Schwartz, Gryczynski, O'Grady, et al., 2013), as well as HIV and HCV risk behaviors, infection and transmission (Gowing, Farrell, Bornemann, Sullivan, & Ali, 2011; Norton et al., 2017; Woody et al., 2014). OAT also may provide an ideal setting for the delivery of HIV and HCV education, prevention and screening efforts, as well as efforts to connect patients with community resources for infectious disease testing and management (Carey, Huang, Linas, & Tsui, 2016; Norton et al., 2017; Perlman et al., 2015).

Despite the demonstrated efficacy of OAT for reducing illicit opioid use and infectious disease risk behaviors, opioid treatment clinics often struggle with extremely limited resources, particularly around staff availability and time. There can be lengthy waitlists for methadone or buprenorphine treatment access, particularly in rural geographic areas (Sigmon, 2014), which further increases risk for infectious disease, morbidity, and mortality (Clausen et al., 2009; Peles, Schreiber, & Adelson, 2013). Our research group has been developing and evaluating an interim buprenorphine dosing regimen that integrates buprenorphine with several additional technology-based components with the aim of reducing illicit drug use and other risk behaviors in OUD awaiting entry into a more comprehensive community treatment clinic (Sigmon, Ochalek, Meyer, et al., 2016). One of those technology-assisted components is an HIV+HCV educational intervention, which we adapted from our original therapist-delivered format for automated delivery via an iPad platform. The primary aim of the present project was to examine the effectiveness and acceptability of this novel *mHealth* HIV+HCV educational module for enhancing HIV and HCV knowledge, using a within-subjects design, among waitlisted adults with OUD.

Journal Article

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Conclusion: An HIV+Hepatitis Education intervention delivered via a portable, automated iPad platform may produce significant and persistent improvements in HIV and HCV knowledge among adults with OUD. These data provide additional support for the use of mobile educational interventions for enhancing HIV and HCV knowledge in individuals at elevated risk for infectious disease.

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Introduction

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Risk of contracting and transmitting infectious disease among individuals with OUD and other substance abuse disorders primarily stems from engaging in risky drug use behaviors (e.g., sharing injection equipment like syringes, cookers, and cottons, impaired decision making under drug influence) as well as risky sexual behaviors (e.g., trading sex for drugs, having sex without a condom, having unprotected sex with other drug users). Efforts to enhance HIV and HCV knowledge and decrease risk behaviors in this vulnerable population are critical for reducing the individual and societal consequences associated with infectious disease.

Educational interventions are a widely-used approach for addressing this issue, and interventions to date have generally focused on improving HIV- and HCV-related knowledge (Arain et al., 2016), decreasing self-reported risk behaviors (Copenhaver, Johnson, Lee, Harman, & Carey, 2006; Meader, Li, Jarlais, & Pilling, 2010), and

improving utilization of HIV and HCV screening and treatment (Lubega, Agbim, Surjadi, Mahoney, & Khalili, 2013; Marinho et al., 2016). Overall, educational interventions have been generally associated with increased knowledge, self-reported condom use and entry into screening and treatment services, as well as decreased injection and non-injection drug use and trading of sex for drugs (Coffin, Rowe, & Milo Santos, 2015; Copenhaver, Johnson, Lee, Harman, Carey, et al., 2006; MacArthur et al., 2014; Meader, Li, Des Jarlais, & Pilling, 2010; Shah & Abu-Amara, 2013). However, several features have limited their widespread use. The interventions have often been delivered across multiple lengthy sessions and have also typically relied on delivery by trained peer, staff, or health care professionals (e.g., nurse, physician, therapist) (Shah & Abu-Amara, 2013). These factors can increase cost and time burdens associated with education delivery. Staff-delivered assessments and interventions may also be less appealing to some individuals due to potential concerns regarding confidentiality or perceived judgment around the sensitive illicit drug use and sexual behaviors being assessed.

One recent development that may hold promise for overcoming this limitation is the increasing use of mobile health (*mHealth*) platforms. *mHealth* interventions use portable computerized devices and can extend the reach of health care by permitting delivery of monitoring, education, point-of-care diagnostics and treatment beyond the confines of the medical office (Boyer, Smelson, Fletcher, Ziedonis, & Picard, 2010). Although few studies have examined the utility of *mHealth* approaches in the areas of HIV and HCV knowledge, the limited data to date suggests this approach may be promising for addressing infectious disease knowledge (Aronson et al., 2017; Catalini, Philbrick, Fraser, Mechael, & Israelski, 2013; Festinger et al., 2016; Niakan, Mehraeen,

Noori, & Gozali, 2017).

We recently adapted a single-visit, therapist-delivered educational intervention, which was developed and shown by our group in prior studies to improve HIV and HCV knowledge in illicit drug abusers (Dunn et al., 2013; Heil, Sigmon, Mongeon, & Higgins, 2005; Herrmann et al., 2013), for automated delivery using an iPad platform. As a first step toward examining the potential of this novel *mHealth* application for improving HIV and HCV knowledge in individuals with OUD, we sought here to characterize its effects in the sample of individuals seeking but waitlisted for opioid agonist maintenance.

2. Methods

2.1 Parent trial

The HIV+HCV educational intervention was examined as part of a larger trial evaluating a multi-component interim buprenorphine regimen individuals with OUD. The overarching aim of the parent, 12-week randomized clinical trial was to examine the initial efficacy of interim buprenorphine dosing for reducing illicit opioid use and other risk behaviors during waitlist delays to community treatment. Participants were randomized to Interim Buprenorphine Treatment (IBT; n=25) or a continued waitlist control condition (WLC; n=25). IBT participants visited the clinic bi-monthly for staff-observed medication ingestion and urinalysis, with the remaining doses dispensed via computerized device at home (Med-O-Wheel Secure; Addoz, Finland). They also received daily calls assessing drug use, craving and withdrawal via an Interactive Voice Response (IVR) phone system, as well as IVR-generated random call-backs and HIV+HCV Education. Waitlist control participants remained on the waitlist of their local clinic and did not receive these services. All participants completed 4-, 8- and 12-week

assessments that included the self-report and staff-administered questionnaires and provision of urine specimens. The primary outcomes from this study demonstrated the efficacy of IBT and have been reported previously (Sigmon, Ochalek, Meyer, et al., 2016). Therefore, below we briefly describe the details most relevant to this secondary analysis of the HIV+HCV educational component.

2.2 Participants

To be eligible for the parent trial, participants had to be ≥ 18 years old, meet Diagnostic and Statistical Manual (DSM-5; American Psychiatric Association, 2013) criteria for OUD, and provide an opioid-positive urine specimen at intake. Participants who were pregnant and/or nursing, had a significant psychiatric, and/or had medical illness that interfered with participation were excluded. As only IBT participants received the HIV+HCV education intervention described below, our analyses in this project focused on those individuals randomized to the IBT condition.

2.3 HIV+HCV educational intervention

During Study Week 1, participants completed a baseline assessment (Pre-Test) of HIV and HCV knowledge and perceived risk using an interactive iPad application developed by us (described below), after which the application provided immediate corrective feedback and explanation for any incorrect items. Prior to the intervention, study staff gave the participant a brief (approximately 1-minute) orientation. The participant then reviewed an interactive flipbook (“HIV/AIDS Basics,” Aids.gov) and watched a 15-minute video (“What is Hepatitis C and how is it diagnosed?,” amfAR: The Foundation for AIDS Research), both administered via iPad. The HIV+HCV knowledge assessment was then administered again (Post-Test), with immediate feedback again

provided for any incorrect answers. At the end of the session, a staff member offered condoms, as well as contact information for free HIV and HCV testing resources. To examine the extent to which changes in HIV and HCV knowledge persisted following the single-visit intervention, participants repeated the Post-Test knowledge assessment at two subsequent timepoints (i.e., Study Weeks 4 and 12).

2.4 Measures

The knowledge assessment consisted of a modified version of the Marsch HIV/AIDS Knowledge Test (Marsch et al., 2005), a 50-item assessment of HIV knowledge in three areas (i.e., general knowledge, sexual risk behaviors, drug risk behaviors) (Table 1). Also included was a 17-item test assessing general knowledge of HCV (Dunn et al., 2013; Table 2). Both assessments were administered via iPad and included “True”, “False”, or “Don’t know” response options (Herrmann et al., 2013), with correct responses summed to obtain an overall accuracy score (i.e., percent correct) for each questionnaire.

Participants also completed a series of visual analog scale (VAS) items evaluating their perceived risk of infection and disease knowledge, as well as HIV and HCV risk behaviors (Table 3). On three additional VAS items, participants rated the helpfulness of the HIV iPad flipbook, the helpfulness of the HCV video, and their comfort with the iPad application more generally. Scores for each VAS item ranged from 0 (Not at all) to 100 (Extremely).

2.5 Data analyses

Descriptive statistics were used to characterize participants' baseline demographics and drug use history. The percentage of items correct on the HIV and HCV assessments were calculated for each participant at the Pre-Test, Post-Test, and Week 4 and 12 follow-up assessments, with higher scores indicating greater knowledge accuracy. The significance associated with temporal changes in mean scores was evaluated using a linear mixed model for repeated measures data (SAS, PROC MIXED). Pairwise comparisons among timepoints were performed using a Fisher's LSD procedure. To identify knowledge deficits in specific content areas, McNemar's tests were used to evaluate changes in accuracy on individual items. Analyses of temporal changes on the VAS items paralleled those described above for knowledge scores, with the exception of the three VAS items assessing the perceived helpfulness of the intervention components (i.e., HIV+HCV iPad application, HCV video, iPad) which were descriptively examined at the Post-Test timepoint. Based on our prior estimates of subject to subject variability and expected correlation between time points, the study was estimated to have power $(1-\beta)=.80$ using $\alpha=.05$ to detect a mean difference of less than 10% between any two time points for our primary outcome measures (i.e., 8.5% and 9.6% for HIV and HCV respectively). All statistical analyses were performed using SAS 9.4 (SAS Institute, Cary, NC), with significance determined based on $\alpha=.05$.

3. Results

3.1 Participant characteristics

With regard to participants' drug use characteristics at intake, 64% and 36% of participants reported heroin or prescription opioids as their primary opioid of abuse, respectively (Table 4). Fifty-six percent endorsed the intravenous (IV) route as their primary route of opioid administration, while 28% and 16% reported oral/sublingual and intranasal routes, respectively. Eighty percent of participants endorsed a lifetime history of IV drug use and 40% reported a history of opioid overdose. Of those reporting a lifetime history of overdose, 89% had experienced multiple overdoses. Twenty-eight percent reported past-month use of cocaine.

Related to participants' infectious disease risk more specifically, among those with a history of IV drug use, 30% reported using a syringe or needle after someone and 15% had used an unsterilized syringe or needle (Table 5). Twelve percent of participants' partners were also opioid users, and 67% of those partners reported IV as their primary route of administration. In terms of sexually-transmitted diseases, 14% of participants received a chlamydia diagnosis in their lifetime and 6%, 2%, and 2% of participants had been previously diagnosed with gonorrhea, herpes, and viral warts, respectively. While no participants reported an HIV diagnosis, 22% of participants had received a diagnosis of HCV.

3.2 HIV knowledge

On the baseline (Pre-test) HIV knowledge assessment, participants answered an average of 69% of items correctly (Table 6). Following delivery of the educational intervention, the average percent correct significantly increased to 86% ($t(66) = -9.49$, $p < .001$) (Figure 2, top panel). A similar pattern was seen for the three content areas on General, Sexual Risk and Drug Risk knowledge (Table 6). Examination of individual items showed that significant increases were seen on 13 of the 50 (26%) individual items (Table 6).

At the Week 4 and 12 follow-up timepoints, participants answered 84% and 86% of items on the HIV knowledge assessment correctly, respectively. These scores were significantly greater than the Pre-Test baseline (p 's $< .001$) and did not significantly differ from one another.

3.3 HCV knowledge

On the baseline (Pre-Test) HCV knowledge assessment, participants answered 65% of overall items correctly (Table 7). Following delivery of the educational intervention, the percent of correct items significantly increased to 86% ($t(66) = -6.89$, $p < .001$) (Figure 2, bottom panel). Examination of individual items showed that significant increases were seen on 4 of the 17 (24%) individual items.

At the Week 4 and 12 follow-ups, participants answered 80% and 81% of items on the HCV knowledge assessment correctly, respectively. These scores were significantly greater than baseline (p 's $< .001$) and did not differ from one another.

3.4 Visual analog scale items

Significant Pre- to Post-Test increases were also observed in participants' perceived knowledge of HIV and HCV transmission on the VAS items (range: 0-100), including "How much do you know about how HIV is transmitted?" (54 vs. 82, respectively; $t(60) = -6.65, p < .001$) and "How much do you know about how HCV is transmitted?" (55 vs. 82, respectively; $t(60) = -5.73, p < .001$). Ratings on these items at Study Weeks 4 and 12 remained significantly greater than Pre-Test (p 's $< .001$). Finally, with regard to intervention acceptability more generally, participants' mean ratings on the perceived helpfulness of the intervention components (range: 0-100) were 79, 81 and 89 for HIV+HCV iPad application, Hepatitis C video and iPad, respectively.

4. Discussion

Given the current US opioid public health crisis, there is a critical need to address and reduce infectious disease transmission among individuals with OUD. This sample of waitlisted, opioid-dependent adults presented with considerable risk for contraction or transmission of HIV and HCV. For example, 80% of participants reported a history of IV drug use, 56% identified the IV route as their primary route of opioid use, and 30% had previously shared a needle or syringe. Additionally, 56% of participants reported a history of unprotected sex and 12% had a current partner that also used opioids.

With regard to HIV-related knowledge, participants demonstrated baseline levels of accuracy (69% of items correct) that was generally consistent with prior studies (Copenhaver et al., 2006; Dunn et al., 2013; Heil et al., 2005; Herrmann et al., 2013).

Similar baseline levels were seen on HCV knowledge (65% correct items), which is also consistent with previous studies (Arain et al., 2016; Marinho et al., 2016; Norton et al., 2014; Shah & Abu-Amara, 2013; Zeremski et al., 2016). However, the HCV baseline knowledge scores observed here were higher than those in our prior study among individuals with OUD (Dunn et al., 2013) (65% vs. 47%, respectively). The greater baseline knowledge seen in the present study may be a function of general increases in knowledge among individuals with OUD in the several years since our previous study. Also worth noting is that this study sample reported a greater lifetime history of IV drug use (80% vs. 43%, respectively) and prior opioid treatment (68% vs. 39%, respectively) than the Dunn et al. (2013) sample. Other studies have reported greater HCV knowledge in injection vs. noninjection drug users, perhaps because injection drug users may interact more extensively with treatment or syringe exchange providers and thus encounter some educational content from these programs (Marinho et al., 2016; Strauss et al., 2007).

Our automated HIV+HCV educational intervention was associated with significant improvements in both HIV and HCV knowledge, with 25% and 32% increases in overall score accuracy from Pre- to Post-Test, respectively. The magnitude of HIV knowledge gains is similar to our group's previous interventions with both cocaine- and opioid-dependent adults (Dunn et al., 2013; Heil et al., 2005; Herrmann et al., 2013). Our findings on the degree of HCV knowledge improvements are consistent with (Arain et al., 2016) or higher than (Marinho et al., 2016; Norton et al., 2014; Zeremski et al., 2016) recent studies on this topic by other research groups. In contrast, the increases in HCV knowledge scores were smaller than those seen in our earlier trial with opioid-dependent adults (Dunn et al., 2013) (32% vs. 78%, respectively), likely due

to the higher HCV baseline knowledge scores seen here than in that earlier study.

Improvements in HIV+HCV knowledge persisted over the 12 weeks following the educational intervention. To our knowledge this is the first demonstration of sustained effects of a single-visit, *mHealth* educational intervention on infectious disease knowledge. The mechanism underlying this persistence in knowledge improvements is unclear. For example, how long the effect would remain beyond the 12-week timepoint is an empirical question and could be addressed more definitively in future studies. Overall more direct examination of the duration of improvements in HIV and HCV knowledge following brief *mHealth* interventions is warranted.

Finally, participants rated the educational content and iPad platform favorably, which is also consistent with prior studies evaluating *mHealth* platforms for HIV and HCV education among individuals with OUD (Niakan et al., 2017; Shrestha et al., 2017; Westergaard et al., 2017). These findings provide additional support for the use of technology-assisted educational interventions among individuals seeking treatment for OUD (Miller & Himelhoch, 2013; Shrestha et al., 2017).

Several strengths of this study are worth noting. This is the first educational intervention, to our knowledge, to target HIV and HCV knowledge among the high-risk sample of waitlisted individuals with OUD and the first to demonstrate sustained improvements for several months following the intervention. The study also has several limitations. First, this was a within-subject evaluation conducted within the context of a larger randomized trial that did not include an HIV+HCV education control group. However, our group has previously demonstrated that the improvements in HIV and

HCV knowledge are not likely due to a practice effect from repeated exposure to the knowledge assessments (Herrmann et al., 2013). Second, we did not include measures of sexual and drug-use risk behaviors and thus were unable to directly examine the extent to which this educational intervention influenced frequency of HIV+HCV-related risk behaviors. However, prior studies have reported a strong concordance between HIV and HCV education and reductions in high-risk behaviors, as well as increases in protective health behaviors (Copenhaver et al., 2006; Gilchrist et al., 2017; Meader et al., 2010; Shah & Abu-Amara, 2013). Finally, this study did not include HIV or HCV screening and thus we cannot evaluate whether infectious disease status changed as a function of the educational intervention.

In summary, an automated *mHealth* educational intervention was associated with significant and sustained improvements in knowledge of HIV+HCV transmission and risk behaviors in this extremely vulnerable group of individuals with OUD. This *mHealth* iPad intervention can be implemented with relatively modest financial, time and staff burdens, which may facilitate its use in settings in which resources are limited. Given the continuing opioid epidemic, efforts are urgently needed to reduce HIV and HCV contraction and transmission among individuals with OUD. Mobile health educational interventions may offer a time- and cost-effective approach for addressing these risks.

Table 1.
HIV Knowledge Questionnaire

1. HIV causes AIDS.
 2. Once you have HIV, you have it for life.
 3. Cleaning needles with water will kill HIV.
 4. AIDS is a disease of gay, white men.
 5. HIV can be transmitted from one person to another during vaginal sexual intercourse.
 6. People who are HIV positive always look sick.
 7. Injection drug users are also at risk of Hepatitis C infection; 50-90 % of HIV infected injection drug users are also infected with Hepatitis C.
 8. HIV can be transmitted from one person to another through anal sex, but not through oral sex.
 9. A person can become infected with HIV by sharing needles with other drug users.
 10. A person cannot get AIDS from a toilet seat.
 11. Condoms reduce the risk of transmission of the HIV virus.
 12. HIV can be transmitted from one person to another by sharing “drug works”, such as “cookers” or “cottons”.
 13. A person cannot get AIDS from pre-ejaculatory fluids.
 14. Transferring a drug from one syringe to another can transmit HIV.
 15. AIDS is not always fatal.
 16. An infected mother can give HIV to her infant via breast feeding (milk).
 17. Intranasal or injection drug users are the fastest growing risk group for HIV.
 18. Rubbing injection sites with alcohol can lower the risk of getting AIDS.
 19. AIDS is a preventable disease.
 20. Women on birth control pills cannot get HIV during sexual intercourse.
 21. Putting a needle in a flame before using it will prevent infection from the HIV virus.
 22. Using bleach to clean drug works after each use greatly reduce the risk of getting AIDS
 23. The HIV virus can be transmitted if blood from an infected person gains entry into another person.
 24. The HIV virus is present in vaginal secretions.
 25. The HIV virus can be transmitted by hugging or holding hands.
 26. There is currently no known cure for AIDS.
 27. Needles bought on the street in a sterile wrapper cannot transmit HIV.
 28. It is safe to re-use bleach after someone else has used it to clean their “drug works”.
 29. Wiping of a needle before using it is an effective HIV risk-reducing strategy.
 30. HIV can be transmitted from an infected mother to her child before or during childbirth.
 31. Latex condoms are better than natural skin or lambskin condoms in preventing the spread of HIV.
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32. HIV can be transmitted through menstrual blood.
 33. Vaseline can be safely used to lubricate a condom.
 34. The HIV virus can be transmitted by mosquitoes or bugs.
 35. It is safe to re-use a condom as long as the male did not ejaculate in the condom.
 36. A person who has had a sexually transmitted disease is at increased risk for HIV.
 37. A person can be infected by HIV by giving blood at a blood bank.
 38. If a person is infected with HIV, he or she will feel sick within a few days to a week after infection.
 39. HIV can not be transmitted if an infected needle penetrates the skin only, because the needle must enter the blood stream in order for infection to occur.
 40. AIDS can be transmitted when an infected person coughs or sneezes on another person.
 41. Condoms that are not long enough to cover the whole penis may not be able to prevent the transmission of HIV.
 42. Using oil-based lubricants, such as hand lotion, cold cream, food products or baby oil, with a condom will weaken the condom and increase the likelihood that may break during sex.
 43. Boiling “drug works” for 15 minutes before each use will reduce the likelihood of becoming infected with the AIDS virus.
 44. People with AIDS can be cured if they are given very good medical care.
 45. A person who becomes infected with HIV may not test positive for the virus for up to 4 weeks to 6 months after infection.
 46. Drug users can increase their chances of getting AIDS by sharing water, in which needles or syringes are dipped, with another user.
 47. HIV can be transmitted from IV drug users to their sexual partners.
 48. HIV can be transmitted during a blood transfusion if HIV-contaminated blood is used.
 49. People with AIDS can get severe illnesses, which are not usually a threat to people without AIDS.
 50. AIDS is a homosexual and ethnic disease.
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Table 2.

HCV Knowledge Questionnaire

1. Hepatitis is a virus that causes inflammation of the liver.
 2. It is possible to transmit hepatitis C to other people before you begin to experience any symptoms of the virus.
 3. There is a vaccine available for Hepatitis C.
 4. The risk of transmission of infection through unprotected sex is lower for Hepatitis C than HIV.
 5. There is only one test that can be used to diagnose the Hepatitis C infection.
 6. You can be treated for Hepatitis C, but it is very hard to permanently cure.
 7. People who contract Hepatitis C usually feel sick within 1-2 days of contracting the virus.
 8. Hepatitis C is spread easily through sexual contact.
 9. You can die from Hepatitis C.
 10. It is dangerous to continue drinking alcohol after learning that you have contracted Hepatitis C.
 11. Hepatitis C is primarily transmitted blood to blood.
 12. There are 6 different types of Hepatitis C; the main difference between them is that some are easier to cure than others.
 13. Hepatitis C is spread by forms of social contact, such as kissing, hugging, and touching.
 14. Symptoms of Hepatitis may include fatigue and abdominal pain.
 15. Most individuals with Hepatitis C exhibit no recognizable signs or symptoms.
 16. Hepatitis C can be cured in 100 percent of people who begin treatment.
 17. 30 out of 100 people with chronic Hepatitis C infection may not actually develop liver problems, but can still transmit the infection through blood-to-blood contact.
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Table 3.
VAS items

1. How high of a chance do you think of having HIV?
 2. How high of a chance do you think you have of getting Hepatitis C?
 3. How much do you know about how HIV is transmitted?
 4. How much do you know about how Hepatitis C is transmitted?
 5. What is the likelihood that you will use a condom next time you have sex?
 6. If you were going to have sex and no condom was available, what is the chance that you would refrain from having unprotected sex?
 7. Do you ever use a needle to inject drugs?
 8. What is the likelihood that you will use a new, sterile syringe, cooker, and cotton next time you inject?
 9. If you were going to 'shoot up' and only a used needle was available, what is the chance that you would be able to refrain from using the needle?
 10. How helpful was the Hepatitis C video?
 11. How helpful was this HIV+HCV iPad application?
 12. How comfortable were you with using this iPad?
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Table 4.

Participant baseline characteristics^a (n=25)

Age, yrs	33.6 ± 10.0
Male, %	60
Employed full-time, %	48
Education, yrs	12.4 ± 2.4
Primary past year opioid of abuse, %	
Heroin	64
Prescription opioids	36
Primary route of opioid administration, %	
Oral/sublingual	28
Intranasal	16
Inhalation	0
Intravenous	56
Duration of regular opioid use, yrs	6.4 ± 5.8
Ever used IV, %	80
Past-month cocaine use, %	28
Duration on treatment waitlist, mos	3.3 ± 2.5
Buprenorphine dose, mg	13.2 ± 1.1

^aValues presented as mean ± SD unless otherwise indicated

Table 5.

HIV+HCV Risk Behaviors at Intake (n=25)

Ever used IV, %	80
Age first IV use, (Mean±SD)	26±8.5
Ever used syringe/needle after someone, %	30
Ever used unsterilized syringe/needle, %	15
Partner uses opioids, %	12
Partner's primary route of administration, %	
Intravenous	67
Oral/sublingual	33
Ever received diagnosis, %	
Chlamydia	14
Gonorrhea	6
Herpes	2
Viral warts	2
Syphilis	0

Table 6.
Significant HIV Pre- to Post-Test Improvements

Item	Pre-Test %	Post-Test %	P-value
Total Score	69%	86%	<.001
General Knowledge	72%	88%	<.001
15. AIDS is not always fatal. (F)	28%	56%	0.039
16. An infected mother can give HIV to her infant via breast feeding (milk). (T)	32%	88%	<.001
32. HIV can be transmitted through menstrual blood. (T)	52%	96%	0.001
34. The HIV virus can be transmitted by mosquitoes or bugs. (F)	32%	72%	0.002
44. People with AIDS can be cured if they are given very good medical care. (F)	60%	92%	0.022
Sexual Risk Knowledge	63%	89%	<.001
24. The HIV virus is present in vaginal secretions. (T)	32%	80%	<.001
31. Latex condoms are better than natural skin or lambskin condoms in preventing the spread of HIV. (T)	44%	88%	0.003
36. A person who has had a sexually transmitted disease is at increased risk for HIV. (T)	24%	76%	<.001
41. Condoms that are not long enough to cover the whole penis may not be able to prevent the transmission of HIV. (T)	52%	84%	0.022
42. Using oil-based lubricants, such as hand lotion, cold cream, food products or baby oil, with a condom will weaken the condom and increase the likelihood that it may break during sex. (T)	44%	96%	<.001
Drug Risk Knowledge	70%	83%	<.001
18. Rubbing injection sites with alcohol can lower the risk of getting AIDS. (T)	20%	80%	<.001
27. Needles bought on the street in a sterile wrapper cannot transmit HIV. (F)	44%	76%	0.022
43. Boiling “drug works” for 15 minutes before each use will reduce the likelihood of becoming infected with the AIDS virus. (T)	24%	68%	0.003

Only items in which changes in accuracy from Pre- to Post-Test were significant ($p<.05$) are presented; correct answers are denoted in parentheses (T=True, F=False)

Table 7.
Significant HCV Pre- to Post-Test Improvements

Item	Pre-Test %	Post-Test %	P-value
3. There is a vaccine available for Hepatitis C. (F)	32%	64%	0.022
5. There is only one test that can be used to diagnose the Hepatitis C infection. (F)	8%	80%	<.001
12. There are 6 different types of Hepatitis C; the main difference between them is that some are easier to cure than others. (T)	44%	84%	0.021
16. Hepatitis C can be cured in 100 percent of people who begin treatment. (F)	44%	92%	<.001

Only items in which changes in accuracy from Pre- to Post-Test were significant ($p < .05$) are presented; correct answers are denoted in parentheses (T=True, F=False)

Figure Legend

Figure 1. Mean percent of correct items on the HIV and HCV Knowledge questionnaires in a prior study of an in-person HIV+HCV educational intervention with opioid-dependent adults (Dunn et al., 2013). Asterisks denote significant differences ($p < .01$) between scores on knowledge assessments administered Pre-Test (black bar) and Post-Test (grey bar).

Figure 2. Mean percent of correct items on the HIV and HCV knowledge assessments in the present study. Data bars sharing a common letter are not significantly different (Fisher's LSD, $p < .05$).

Figure 1.

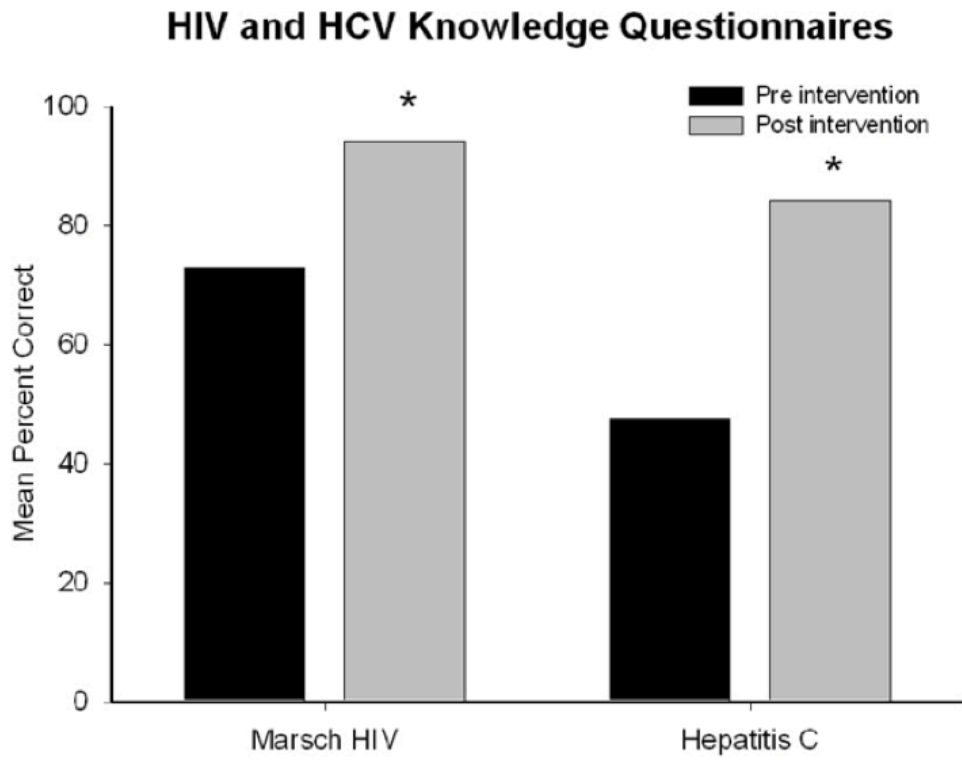
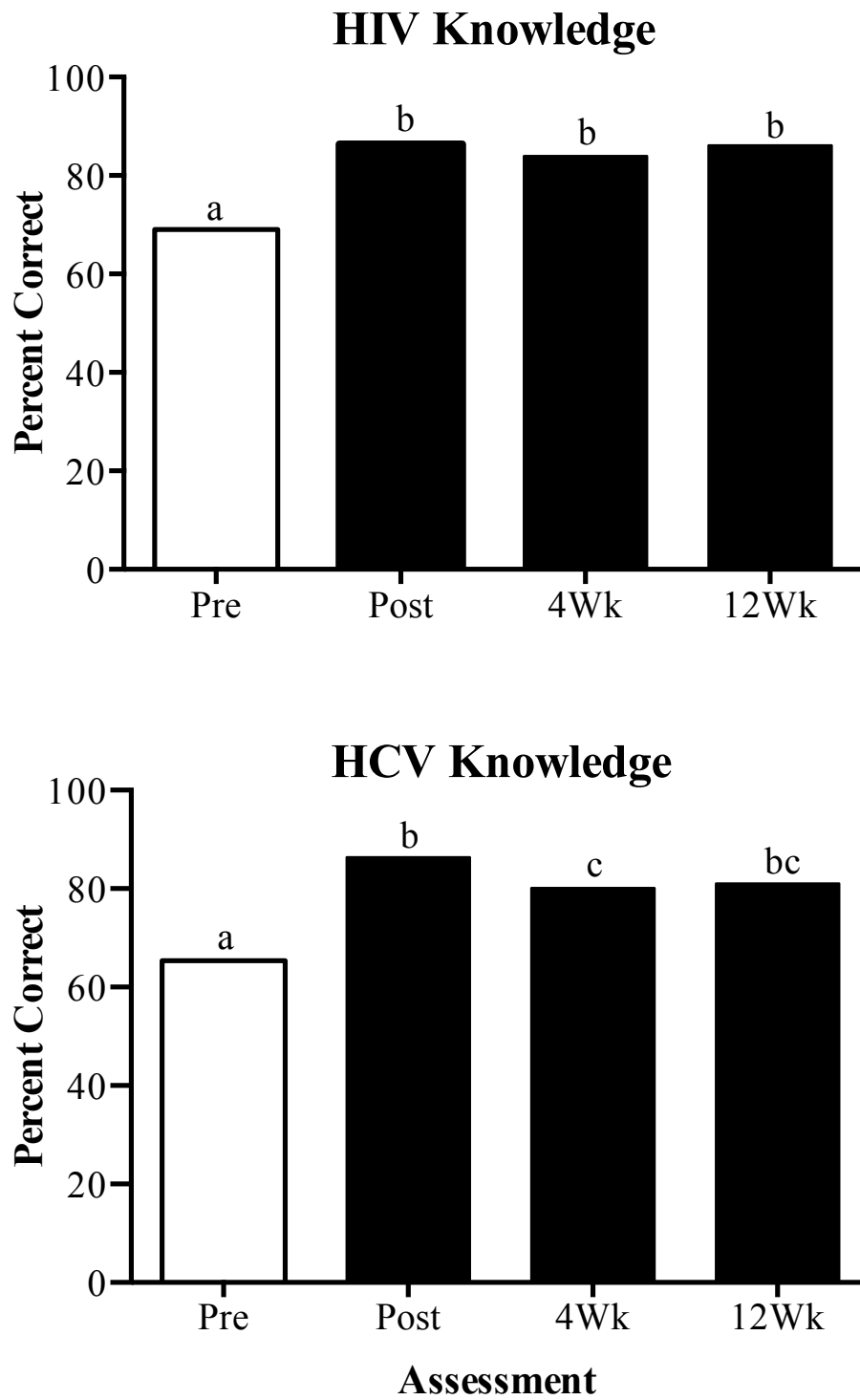


Figure 2.



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