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Feasibility of a remotely monitored blood alcohol concentration device to facilitate treatment motivation

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HIGHLIGHTS

- Technological interventions can facilitate treatment motivation.
- The breathalyzer was easy to use and provided facilitation of treatment.
- No lasting difference across groups were noted between self-efficacy ratings.

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ABSTRACT

Background: Consistent monitoring of blood alcohol concentration through breathalyzers is critical for identifying reoccurrence. Little research has effectively utilized convenient wireless enabled breathalyzers that can measure blood alcohol concentration while enhancing treatment motivation for outpatient care. The current study attempted to understand the impact of wireless breathalyzers on treatment motivation and self-efficacy in remaining sober for individuals diagnosed with alcohol use disorder in an outpatient treatment facility.

Methods: Participants were assigned to one of two conditions: the experimental breathalyzer and the treatment as usual group. The groups were assessed by the University of Rhode Island Change Assessment (URICA), and on self-efficacy, measured by the Alcohol Abstinence Self-Efficacy Scale (AASE). The evaluation period took place over three months with a six-week follow-up evaluation. During the entirety of the evaluation period and post-study follow up, interviews occurred.

Results: As a secondary analysis, the URICA's motivational scores were higher for participants receiving the experimental intervention at a two-month evaluation and at the six-week follow-up. The AASE's temptation to reoccurrence scores significantly reduced over time for both groups. The confidence to resist temptation was not significant. Three major themes emerged from the interviews, including the benefit of the breathalyzer facilitating their treatment, ease of device use, and technical issues.

Conclusions: The insights gained from this study will be important to develop cost-effective ancillary interventions for comprehensive alcohol dependence treatment. On-going monitoring enabled by new technology allows treatment providers to take an individualized disease-management approach as well as facilitating timely interventions by the treatment provider.

1. Introduction

Alcohol Use Disorder (AUD) is a chronic disorder with a predisposition to reoccurrence and is in the top five leading causes of disability-adjusted life years (WHO, 2019). Reoccurrence rates for AUD are relatively high, ranging between 30% to 70% three months after treatment (Mekonen et al., 2021; Moos & Moos, 2006). While in treatment, patients can easily get discouraged (e.g., self-stigma, lack of support, triggers), potentially causing relapse or lapse along with reductions in treatment motivation for care (Ball et al., 2006; Carvalho et al., 2019).

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Self-reporting is the predominantly utilized method to monitor the recovery of patients with AUD (Del Boca & Darkes, 2003; Grüner Nielsen et al., 2021); however, it has questionable treatment integrity, reliability, as well as false positives and negatives (Jung & Namkoong, 2014; Le Berre et al., 2017). Due to exceedingly high (74%) client dropout in treatment (Hamalainen et al., 2018), it would be instrumental for recovery methods to embed technological features which facilitate continuous notifications that identify reoccurrence or misuse.

The use of technology, such as mobile phones, biometric monitoring, and digital interventions, can greatly expand access to care while enabling detection and prevention of lapse or reoccurrence in treatment modalities (Gustafson et al., 2014; Mellentin et al., 2019; Mellentin et al., 2017). A wireless breathalyzer is a small handheld device that measures blood alcohol concentration and sends the results to a portal in absence of being wired into a secondary device. Breathalyzer technologies in particular assist in providing real-time information to the patient and the care provider enabling efficient and proactive measurement of treatment (Davis-Martin et al., 2021). Previous research has incorporated breathalyzers to ensure other treatment strategies (e.g., contingency management) have been utilized correctly (Koffarnus et al., 2021). The benefits of using remote breathalyzers lie in their ability to provide real-time feedback, establish accountability, and offer convenient self-regulation mechanism that can reinforce one's commitment to recovery (Baig et al., 2017).

To date, there is little research that sufficiently assesses the utilization of a wireless or WIFI enabled breathalyzer, more specifically one that can accurately, securely, and reliably measure blood alcohol concentration (BAC), and the potential emerging benefits (Payne et al., 2015). Therefore, we utilized Soberlink, a wireless breathalyzer, that detects alcohol levels at an accuracy of +/-.005 BAC. Soberlink was chosen due to its ability to ensure accuracy of the recording, the device has an embedded camera and uses facial recognition software to automatically identify the patient during the test. The device will only recognize patient's facial identification and the device will maintain monitoring for facial identification throughout the test. Research on the effectiveness of commitment devices is mixed (Rogers et al., 2014), and sustainability of a behavioral change remains a key challenge (Staats et al., 2017). We assessed the impact of a wireless breathalyzer on treatment motivation and self-efficacy to maintain sobriety for individuals diagnosed with AUD over the course of an addiction recovery treatment and six weeks after. To guide our analyses, we hypothesized that use of a wireless breathalyzer would improve treatment motivation as assessed by University of Rhode Island Change Assessment Scale.

2. Methods

2.1. Participants

Patients enrolled at an outpatient substance-abuse treatment facility located in Connecticut, USA were recruited and screened for participation in the current study between July 2020 and December 2022. Participation inclusion criteria included the following: 1) were at least 21 years old, 2) currently enrolled with Aware Recovery Care in-home addition treatment, and 3) primary or secondary DSM-5 diagnosis of AUD. Exclusion criteria included: 1) current suicide or homicide risk as defined by the SCID-5, 2) met criteria for DSM-5 current psychotic disorder, or bipolar disorder (currently or previously diagnosed by mental health provider reviewed mental health records), 3) did not have phone access with text message capabilities, 4) unable to read or understand English, 5) unable to complete the study because of anticipated incarceration or residence relocation, 6) life-threatening or unstable medical problems, 7) current or pending legal action.

2.2. Assessments

The **Alcohol Abstinence Self-Efficacy Scale (AASE)** is a 40-item self-report scale with 4 subscales (Negative Affect, Social/Positive, Physical and Other Concerns, and Cravings and Urges) used to determine ability to avoid drinking in different situations based on temptation and confidence (DiClemente et al., 1994). **University of Rhode Island Change Assessment Scale (URICA)** is a 32-item self-report scale with 4 subscales (Precontemplation, Contemplation, Action and Maintenance) used to assess stages of change relating to alcohol use.

2.3. Procedure

The study utilized a parallel randomized control trial (RCT) (1:1 ratio) design including two groups: treatment as usual (TAU) and experimental (EP). We implemented a block randomization sequence to allow for equal representation between two groups without bias on gender, age, or ethnicity given all individuals were categorized as a single variable. A more detailed description of the procedure can be found in the primary feasibility manuscript (under review). The intervention for both groups lasted for three months with a six week-follow up. Data collection occurred at several intervals throughout the study, including 30 days (T1), 60 days (T2), 90 days (T3), and post study follow-up - 45 days (T4). The current study was approved by the first author's institutional review board (IRB #2000027787) and was registered at ClinicalTrials.gov (NCT04380116). All surveys were completed online by participants through a secure link sent directly to them, due to COVID protocols put in place.

All individuals had access to the Aware Recovery Care (ARC) In-home addiction treatment model which is a four-phase step down model that provides access to continual care through an integrated team of medical, nursing, counselors, and home health advisors coming to the patient's home (Buono et al., 2021; McDonnell et al., 2021). Their approach implements principles of evidence-based practices including Motivational Interviewing, Cognitive Behavioral Therapy, and Dialectical Behavioral Therapy. Patient's care team is overseen by a master's level alcohol and drug counselor, an advanced practicing nurse, and an addiction psychiatrist. The licensed professional is responsible for leading the team, collaborating with external providers, communicating with family members, and providing referrals to external providers as needed. In this condition, the clinical team tested the patients based on self-report of alcohol usage and during monthly visit with the lead clinician.

Individuals randomized into the EP group were required to use a breathalyzer device. The breathalyzer device consists of a wireless breathalyzer that uses a professional grade fuel cell sensor to detect alcohol levels at an accuracy of +/-.005 BAC. To ensure accuracy of the recording, each device has an embedded camera which uses facial recognition software to automatically identify the patient during the assessment. Retesting was automatically scheduled for 30 minutes after a positive test was received or if a patient's identity cannot be verified. If a positive test occurred, an email was sent to the research coordinator along with the lead clinician on the team, which provided the time of test, and the test's value. The participant had a set testing schedule that consisted of 2 tests per day, and the test window of 2 hours with a late window of 1 hour. Individuals could provide the BAC at any time within the testing window; all tests performed outside the window were recorded but counted as unscheduled tests.

After program completion, both groups participated in a semi-structured qualitative interview that captured participant's general thoughts of the research study, what needed to be added or improved, and likes and dislikes. All interviews lasted between 15 to 30 minutes and were conducted online through Zoom, with the audio file being stored for transcription.

2.4. Data analysis

For the current study, as a secondary analysis, we used a General Linear Model (GLM) procedure in IBM SPSS v.28 to perform a two-way

repeated measures ANOVA with group as a between-subjects factor and repeated outcome measures (URICA, AASE temptation and AASE confidence) as within-subjects factors. We used missing values analysis (MVA) to deal with missing datum prior to proceeding with substantial analyses. The MVA is the most conservative measure, as opposed to the mean substation or completion a regression to answer for the missing data (Tabachnick & Fidell, 2019). In alignment with Enders (2010) if more than 5% of the data was missing for a specific assessment, the data was eliminated from the data set to reduce potential errors and bias. Intention to treat (ITT) analysis can only be carried out if there is a complete and full set of data, with the control group dropouts tracked and followed on.

In the current study, the data loss in the control group after randomization but before the assessment was due to Aware recovery trying to retain individuals who were deemed unsuitable for treatment, primarily characterized by their lack of psychological stability or placement in the program through court mandate. Consequently, there was a number of prospective participants initially targeted for inclusion in the study, but a substantial portion either did not commence their participation or commenced but did not complete the study requirements. The TAU group was affected disproportionally, because they lacked access to the Soberlink breathalyzer device.

Following a grounded theory approach, we used standard, qualitative procedures to code the data (Strauss & Corbin, 1998). Two coders, working independently, read discharge interviews from the clients and identified phenomena in the text that were deemed responsive to the question and thus, in the opinion of the coder, should be regarded as relevant data for inclusion in the analysis. All phrases or statements conveying meaningful ideas, events, objects, and actions were collected. If both coders selected the same phrase or statement in the answer to a given question, then it was counted as an agreement. Overall, percent agreement between coders averaged 86% and disagreements were resolved through discussion and consensus.

3. Results

A total of 117 participants were initially recruited for the current study of which 96 qualified for the study. The EP group had a total of 43 complete the study while the TAU had 32. The mean age for each group was 48.6 (SD=10.5) for the EP, and 44.1 (SD=11.8) for TAU, of which 70% and 84% were male respectively. Several subjects in both groups had treatment without sustained recovery at other alcohol facilities (EP= 3.1; TAU= 2.9), and most individuals had mild to moderate depression and/or anxiety. The remaining demographics can be seen in Table 1. As seen on Table 2, we reported the feasibility of the Soberlink device within the experimental group and it was noted, that no patients consistently missed both tests.

We performed a series of t-tests and chi-square tests for demographic variables. Groups did not differ in education level, nor in employment, and had a similar male/female composition, with males being 73% for the EP and 77% for the TAU group. The TAU group had a higher percentage of single individuals, with 25% reporting being single in the TAU and 15% in the EP group. Finally, there was a significant age difference, with the EP participants being on average 6 years older, $p = 0.14$.

A two-way repeated measures ANOVA with the composite URICA (Cronbach's $\alpha = .836$) as a within-subjects factor and group (EP vs TAU) as a between-subjects factor, using a Greenhouse-Geisser correction, produced a significant interaction of URICA composite scores over time and group ($F(2.145, 145.89) = 3.719$, $p = .024$, $\eta^2 = .052$). Post hoc analysis with a Bonferroni adjustment revealed that the patients in the EP group had significantly higher scores than the TAU group patients at the 2-month evaluation (EP mean = 7.126, SD = 1.29 vs TAU mean = 6.323, SD = 1.86, $p < .05$) and at a follow-up (EP mean = 7.116, SD = 1.32 vs TAU mean = 6.121, SD = 2.29, $p < .05$). Although there was no significant difference between the two groups at the time of discharge, the difference between the EP and TAU groups had significantly and notably increased by the end of the study period as seen in Fig. 1.

Table 1
Demographics across Experimental and Treatment as Usual Group.

	Experimental Group (N=43)	Treatment As Usual (N=32)
Age Mean (SD)	48.6 (10.5)	44.1 (11.8)
Gender Identification		
Male	30 (70%)	27 (84%)
Female	13 (30%)	5 (16%)
Transgender	0	0
Other	0	0
Marital Status		
Single	5 (12%)	9 (28%)
Married	26 (61%)	19 (59%)
Divorced	10 (23%)	1 (3%)
Separated	2 (5%)	2 (6%)
Widowed	0	1 (3%)
Other	0	0
Highest Education		
High School	11 (28%)	9 (28%)
Some of College	5 (12%)	6 (19%)
Associates	1 (2%)	1 (3%)
Bachelors	12 (29%)	10 (31%)
Advanced Degree	14 (33%)	6 (19%)
Work Status		
Employed	33 (77%)	27 (84%)
Student	1 (2%)	0
Retired	3 (7%)	2 (6%)
Unemployed	4 (9%)	3 (9%)
Worker's Compensation	1 (2%)	0
Generalized Anxiety Disorder M (SD)	14.8 (4.3)	15.3 (6.1)
Patient Health Questionnaire M (SD)	13.3 (5.5)	12.6 (4.8)
Treatment without Sustained Recovery M (SD)	3.1 (2.2)	2.9 (1.8)

Note. N= Number of participants; SD =standard deviation; M = Mean.

Table 2
Experimental Group's results of breathalyzers usage.

	Experimental Group (N=43)		
	Number of Tests	Mean (SD)	Percent
Clients that used the intervention as intended	3	0.02 (14.9)	1.67%
Clients that had missed one of the daily tests	43	0.24 (8.5)	23.89%
Number of tests completed by clients	6,561	150 (34.5)	–

Note. N= Number of Subjects; SD= Standard Deviation

The AASE subscale scores were combined into two composite variables to measure overall *temptation* (Cronbach's $\alpha = .913$) and *confidence* (Cronbach's $\alpha = .972$). A repeated measures ANOVA with temptation over time as a within-subjects and group as a between-subjects variable revealed a main effect for temptation ($F(1,68) = 15.397$, $p < .01$, $\eta^2 = .185$), indicating that temptation significantly faded over time for both groups. Lastly, contrary to the hypothesized difference in confidence scores, there were no main effects nor interaction in the scores for these two groups over time. It is worthy to point out that although the EP group was higher in value relative to the TAU in confidence score at a follow-up (13.78 vs 11.92), the difference was not significant ($p = .142$).

3.1. Qualitative feedback

Patients who were assigned to the breathalyzer indicated multiple benefits of having the breathalyzer in which three main themes were derived from the qualitative interviews, all which were were

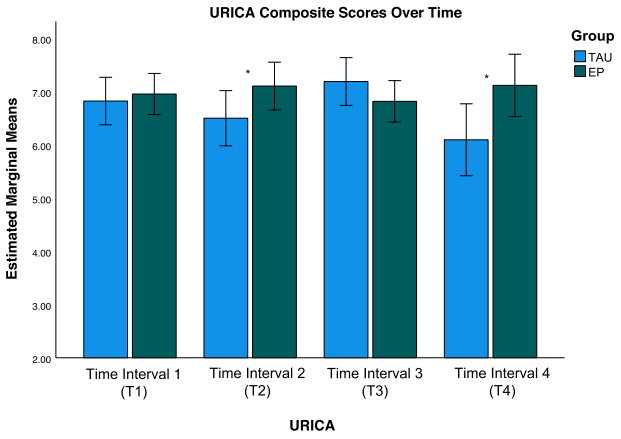

Fig. 1. * Indicates significant difference at $p < .05$; Error bars: 95% CI; Time Intervals correspond to data collection time periods. T1=30 days, T2=60 days, T3 =90 days, T4= Follow-up.

unprompted. Of the three themes, 55% of those who had access discussed using the breathalyzer as helping or facilitating their treatment. In doing so, comments were mentioned about 'proving their sobriety' and 'reminding themselves of their struggle with alcohol use disorder'. Specifically, one client stated, "having the device provided proof to me and my family of my sobriety". Additionally, patients discussed having the device provided them motivation for not drinking, "Seeing the device, reminded me that my was test coming up soon." In doing so, that individual did not partake in the alcohol. The second major theme was perceived ease of the device. Investigators noted that 38% of participants reflected largely on the little time it took for the BAU to be captured. Moreover, 23% of participants did not mind completing the BAU twice a day for the protocol. One client, who was in their third treatment program for alcohol use disorder explained, "Turning the device on and blowing into it from my home was easy. It is way better than driving somewhere to take this test." The third major theme was technical issues. Participants were asked if there were issues with the device during the trial and several participants did report having technical issues with the device with most of the issues being mild, interviewers noticed 22% of patients having issues with the battery not being charged or not having service due to the patient's location. Two patients reported about defective devices towards the end of the study. In both cases, participants reported receiving new devices and there were no proceeding issues.

4. Discussion

The study evaluated potential for increased motivation towards treatment and reoccurrence prevention by embedding a wireless breathalyzer for individuals suffering from AUD. As seen in the results the URICA scores changed over time and were higher for the EP group thus supporting the hypothesis. As noted in Fig. 1, when the device was removed between month 3 and the follow-up the URICA scores increased for the EP group and decreased for TAU, indicating a difference for treatment after the device was in place than the TAU condition; thus, providing an initial justification for the utilization of this device or similar devices as additional augmentative technology to facilitate continued treatment. Our hypothesis of no differences in temptation was supported, as the temptation scores decreased over time in both groups. As for confidence, we hypothesized that the EP group would score higher relative to the TAU group; however, this was not supported by the results, as there were no significant differences. Utilizing the wireless breathalyzer did provide confidence of the accuracy of the BAU, and it was convenient for the participants. However, the cost of the device can be prohibitive.

Embedding this technology in treatment can serve as a useful tool for treatment engagement with health care providers and for case management during treatment and beyond discharge. In the context of this study, breathalyzers served as a commitment device, thereby aiding the habit formation in inducing sustained behavior change (Staats et al., 2017; Volpp & Loewenstein, 2020). Staats et al. (1998) demonstrated the effectiveness of electronic monitoring on motivating process compliance in the setting of hand hygiene but found the decrease in compliance after individual monitoring was interrupted. Our pilot results demonstrate significant and sustained effects of a breathalyzer device on motivation at the follow-up after the device is removed. Remote breathalyzers offer a convenient and non-invasive means of self-assessment and regulation, as the ease of use reduces barriers to monitoring and makes it more likely for individuals to incorporate regular BAC testing into their daily routine. Furthermore, such devices are promising sobriety commitment devices that are likely to support the existing and contribute to the new treatment programs.

The self-reported qualitative findings demonstrated the positive impact on improving relationships, and family interactions, with previous studies showing that family involvement improves assessment of symptom severity and impairment to better utilize treatment interventions (Lander et al., 2013), improved health outcomes for all family members (Ventura & Bagley, 2017), and higher treatment entry and treatment completion (Hogue et al., 2021; McCrady & Flanagan, 2021; Ventura & Bagley, 2017). As demonstrated in the current study, embedding technology into treatment programs can provide clinical implications, while benefitting the patient's quality of life and support from family members.

There were several limitations in the study. First, the groups were not equally balanced at the completion of the study, with 43 individuals in the EP group and 32 individuals in the TAU group. This was largely due to attrition of participants within the outpatient treatment program site. One explanation could be found in recent research on the COVID pandemic resulting in higher likelihood of attrition rates in treatment facilities due to isolation and increased mental health issues (Irizar et al., 2021). Second, the current study only recruited from a state in Northeastern United States. The recruitment efforts were consistent with percentages of the current state, but future studies should attempt to extend the current findings by increasing the percentages of minority ethnicities and races. Third, this study only evaluated the progress of participants over a shortened period of time (e.g., 3 months), which is a limitation as alcohol treatment is a continuous process with high reoccurrence rate (Callaghan et al., 2008).

5. Conclusions

The current pilot study demonstrates that a wireless breathalyzer can potentially provide added benefits to motivate individuals in treatment for alcohol use disorder.

Author contributions

Frank D. Buono: Conceived and designed the analysis, Collected the data, Contributed data or analysis tools, Wrote the paper. **Maxim Polonsky:** Contributed data or analysis tools, Performed the analysis, Wrote the paper. **Matthew E. Sprong:** Contributed data or analysis tools, Wrote the paper, Other contribution, Provided supervision of the project. **Allison Aviles:** Collected the data, Contributed data or analysis tools. **Christopher J. Cutter:** Conceived and designed the analysis, Wrote the paper, Other contribution, Provided mentorship for the project.

Declaration of Competing Interest

No conflict declared.

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