# Research manuscripts bibliography

## THE COMPLETE COLLECTION OF WOEBOT HEALTH RESEARCH PUBLICATIONS

July 2020

For questions regarding research posters, publications and presentations, please contact research@woebothealth.com

# Peer Reviewed Manuscripts

## 2017

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Delivering Cognitive Behavior Therapy to Young Adults With Symptoms of Depression and Anxiety Using a Fully Automated Conversational Agent (Woebot): A Randomized Controlled Trial

- **Theme:** RCT, Depression, Anxiety
- **Collaborator:** Stanford University School of Medicine
- **Synopsis:** The feasibility, acceptability, and preliminary efficacy of a fully automated conversational agent was examined among 70 adults in a College-based (graduate and undergraduate) sample. Participants had statistically significant (F=6.47; P=.01) and clinically meaningful reductions in symptoms of depression (22%) as measured by the Patient Health Questionnaire (PHQ-9) compared to an Information only control group who were directed to the National Institute of Mental Health ebook. This represented a moderate between groups effect size (Cohen's d=.44). Conversational agents appear to be a feasible, engaging, and effective way to deliver CBT.
- **Citation:** Fitzpatrick KK, Darcy A, Vierhile M. Delivering Cognitive Behavior Therapy to Young Adults With Symptoms of Depression and Anxiety Using a Fully Automated Conversational Agent (Woebot): A Randomized Controlled Trial. JMIR Mental Health 4(2). doi: 10.2196/mental.7785

# Abstracts

## 2020

- **Theme:** RCT, Postpartum Depression, Feasibility, Acceptability
- **Collaborator:** Lucille Packard's Children's Hospital, Stanford University Hospital & Clinics
- **Synopsis:** This randomized clinical trial evaluated acceptability and satisfaction with a CBT-based automated conversational agent as a postpartum mood management tool. Women (N=192) were recruited and randomized to the chatbot intervention or treatment as usual during their delivery hospitalization. Participants reported high satisfaction with and acceptability of the 6-week program. Such programs should be further examined as a postpartum mental health resource.
- **Citation: Ramachandran MK,** Suharwardy S, Leonard SA, Gunaseelan A, Robinson A, Darcy A, Lyell D, Judy A (2020). Acceptability of postpartum mood management through a smartphone-based automated conversational agent. Abstract presented at the annual meeting of the Society of Maternal and Fetal Medicine.

# Posters

## 2020

- **Theme:** RCT, Postpartum Depression
- **Collaborator:** Lucille Packard's Children's Hospital, Stanford University Hospital & Clinics
- **Synopsis:** Barriers to postpartum mental health resources include limited availability and cost. Automated conversational agents can deliver CBT content through text-based conversations, reducing depression and anxiety symptoms in select populations. This randomized clinical trial sought to examine the effect of a mental health chatbot on mood in a general postpartum population. The self-selected sample of 192 women yielded sub-clinical baseline scores, assessed within 72 hours of giving birth, on both the Patient Health Questionnaire and Edinburgh Postnatal Depression Scale. However, among the women with elevated baseline depression scores, trends indicated greater drops in the intervention as compared to treatment-as-usual group.
- **Citation:** Suharwardy S, Ramachandran MK, Leonard SA, Gunaseelan A, Robinson A, Darcy A, Lyell D, Judy A (2020). Effect of an automated conversational agent on postpartum mental health: A randomized, controlled trial. Poster presented at the annual meeting of the Society of Maternal and Fetal Medicine.

# Manuscripts in progress

## 2020

- **Theme:** RCT, Postpartum Depression, Feasibility
- **Collaborator:** Stanford University School of Medicine
- **Synopsis:** Childbirth and the perinatal period is perhaps the most significant event and transition a woman may undergo in her lifetime; it organically brings significant lifestyle, occupational, relational and physical health changes that may result in exhaustion, pain, anxiety, frustration, and guilt, as well as happiness and excitement. Postpartum depression (PPD) is the occurrence of a major depressive episode with onset during the third trimester of pregnancy or within the first four weeks following childbirth. The syndrome of PPD impacts approximately 10-20% of women worldwide, although more than 50% have some anxiety and depression symptoms (‘baby blues’) in the first year following childbirth14. The PPD literature indicates that CBT and IPT are preferred psychotherapeutic approaches for women with mild to moderate PPD, yet significant barriers to such treatments limit access for women in need. This manuscript designed the protocol implementation of a randomized clinical trial investigating the feasibility and acceptability of digital therapeutic for PPD, delivered through a fully automated conversational agent, among N=192 women who had recently (within 72 hours) given birth. Participants reported high satisfaction with and acceptability of the 6-week program. Barriers and augments to participant recruitment within a Labor and Delivery Unit will be discussed. Such programs should be further examined as a postpartum mental health resource.
- **Status:** Study completed in June 2019. Manuscript in progress.

# Clinical research informing Woebot

## Partial list

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Machine Learning and the Profession of Medicine

Must a physician be human? A new computer, “Ellie,” developed at the Institute for Creative Technologies, asks questions as a clinician might, such as “How easy is it for you to get a good night’s sleep?” Ellie then analyzes the patient’s verbal responses, facial expressions, and vocal intonations, possibly detecting signs of posttraumatic stress disorder, depression, or other medical conditions. In a randomized study, 239 probands were told that Ellie was “controlled by a human” or “a computer program.” Those believing the latter revealed more personal material to Ellie, based on blind ratings and self-reports. In China, millions of people turn to Microsoft’s chatbot, “Xiaoice,” when they need a “sympathetic ear,” despite knowing that Xiaoice is not human. Xiaoice develops a specially attuned personality and sense of humor by methodically mining the Internet for real text conversations. Xiaoice also learns about users from their reactions over time and becomes sensitive to their emotions, modifying responses accordingly, all without human instruction. Ellie and Xiaoice are the result of machine learning technology.

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Conversational Agents and Mental Health: Theory-Informed Assessment of Language and Affect

A study deployed the mental health Relational Frame Theory as grounding for an analysis of sentiment dynamics in human-language dialogs. The work takes a step towards enabling use of conversational agents in mental health settings. Sentiment tendencies and mirroring behaviors in 11k human-human dialogs were compared with behaviors when humans interacted with conversational agents in a similar-sized collection. The study finds that human sentiment-related interaction norms persist in human-agent dialogs, but that humans are twice as likely to respond negatively when faced with a negative utterance by a robot than in a comparable situation with humans. Similarly, inhibition towards use of obscenity is greatly reduced. We introduce a new Affective Neural Net implementation that specializes in analyzing sentiment in real time.

# Research awards

## 2020

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- **Theme:** Substance use disorders, quality of life, evidence-based psychotherapeutics, digital therapeutics
- **Collaborator:** Stanford University School of Medicine
- **Synopsis:** Substance use disorder (SUD) manifests in continuous substance use in the face of significant substance related problems, including cognitive, behavioral as well as physiological symptoms. SUD prevalence is at public health epidemic levels and climbing, yet treatment seeking has plateaued given significant access barriers. Effective, accessible, and engaging intervention modalities for SUD are desperately needed. Woebot for Substance Use Disorders (W-SUDs) is a two-phase NIDA-funded SBIR. W-SUDs, a novel digital therapeutic, was developed and is presently being evaluated for feasibility and acceptability in the Phase I (N=104) non-controlled pilot. Phase II will investigate W-SUDs's efficacy compared to an active control condition in a fully powered randomized clinical trial (N=206). The noteworthy ecological validity of such mobile health initiatives makes the proposed research both warranted and timely with great potential to reach a traditionally underserved population in need of prompt attention.
- **Status:** Phase I pilot will be completed by July 2020. Anticipated Phase II start date is September 2020.

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- **Theme:** Substance use disorders, Covid-19, randomized controlled trial, digital therapeutics
- **Collaborator:** Stanford University School of Medicine
- **Funding Agency:** National Institutes of Drug Abuse, Covid-19 Administrative Supplement to the Parent Grant Small Business Innovation Research Award
- **Synopsis:** Since the initial parent grant award of W-SUDs, and across mere months, Covid-19 became a global pandemic, and users worldwide came to Woebot to discuss it and seek help. The company responded by building and deploying Covid-19 specific programming (W-C19) in March 2020. W-C19 elements have been integrated into W-SUDs; we felt it was timely and appropriate to address users' concerns about the pandemic and demonstrate that Woebot was 'intelligent' to the crisis. Experts expect Covid-19's direct and indirect impact upon individuals with SUDs to be particularly heavy. These individuals often have physical vulnerabilities, which increase the relative risk of death from Covid-19 and face limited health care access -- fundamentally challenging given often comorbid mental illness. Moreover, high rates of housing insecurity hinder compliance with shelter-in- place and social distancing recommendations, thereby increasing contagion risk. This supplemental proposal to the parent grant award, with the timely addition of a randomized controlled trial comparing W-SUDs to a waitlist control (WL), expands understanding of W-SUDs' efficacy whilst investigating Covid-19's impact upon the SUD population. Secular trends of increased substance use are anticipated given Covid-19 stressors (e.g., shelter-in- place, disease concerns, economic strife, under-/unemployment). Hence, the WL condition is essential for

testing W-SUDs' efficacy in mitigating these Covid-19 related downstream effects. W-SUDs offers immediate access to a digital therapeutic in a resource constrained, socially distanced healthcare ecosystem for an already vulnerable and underserved population, likely faced with readily growing psychological challenges.

- **Status:** Supplement awarded in June 2020. Anticipated completion October 2020.

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- **Theme:** Depression, adolescents, randomized controlled trial, evidence-based psychotherapeutics, digital therapeutics
- **Collaborator:** Washington University Department of Medicine and Pediatrics
- **Funding agency:** Washington University Institute of Clinical and Translational Sciences
- **Synopsis:** Adolescent depression is common and often debilitating. Many teens may be prescribed antidepressant medications, although families may express hesitancy around medication as a first line of treatment for their child. Research indicates that the optimal treatment typically includes a combination of antidepressant therapy (specifically selective serotonin reuptake inhibitors; SSRIs) plus psychotherapy. Woebot is a promising digital therapeutic intervention to deliver CBT to adolescents with depression in the context of primary care management. In collaboration with Washington University, Woebot Labs Inc. will be launching a RCT of Woebot for mild-moderate depression among adolescents in the summer of 2020, within approximately 11-13 participating pediatric clinics. This RCT will not only assess the preliminary feasibility and efficacy of the intervention itself but will also gather valuable feedback qualitative from parents and pediatricians about the use of the digital therapeutic in this population. The goals of the feasibility and acceptability study are to establish the program's utility and feasibility within the primary care ecosystem, as well as to test measurement strategies to inform a more rigorous, fully powered subsequent RCT to evaluate the effectiveness of the program in the primary care management of adolescent depression.
- **Status:** Study protocol under review by Washington University IRB June 2020. Anticipated start date August 2020.