**Title: Resense - Detecting Relapse Before It Happens: Integrating Wearable Biosensors into Outpatient Cocaine Use Disorder (CUD) Care**

**Significance:** Cocaine use disorder (CUD) is associated with high relapse rates in outpatient care, partly due to the reliance on self-reported symptoms and infrequent clinical visits, which fail to capture real-time physiological changes that often precede relapse [8, 12]. Wearable biosensors, such as the Empatica E4, can passively monitor stress- and craving-related biomarkers, including electrodermal activity (EDA), heart rate variability (HRV), and skin temperature. These technologies may enable earlier detection of relapse risk [3, 4, 19]. However, they are rarely validated or deployed in real-world outpatient addiction care, and their usability across diverse patient populations remains understudied [6, 11, 12, 17]. To address this gap, this project evaluates the feasibility and predictive value of ReSense, a wearable biosensor patch, for relapse detection in outpatient CUD treatment. It also assesses usability and user experience to inform scalable, just-in-time interventions [5, 14, 15].

**Innovation:** ReSense will be the first biosensor system systematically validated for real-time relapse prediction in outpatient CUD care, moving beyond lab-based studies [3, 19]. The project integrates biosensor data, ecological momentary assessments (EMA), and machine learning to generate individualized risk profiles and enable proactive interventions [14, 15]. Usability will be assessed across demographics, generating evidence-based recommendations for inclusive device design [11, 17]. Successful implementation could transform clinical protocols and inspire future digital health solutions for substance use disorders [10, 16].

**Proposed Study Design**: This project evaluates the feasibility, predictive utility, and usability of ReSense for individuals undergoing outpatient treatment for CUD. A mixed-methods design includes observational predictive modelling study and cross-sectional usability assessment [3, 18].

**Study 1. Prospective Observational Predictive Study:** Hypothesis: Physiological signals collected via the ReSense wearable biosensor can predict relapse risk in adults undergoing outpatient treatment for cocaine use disorder (CUD). Method: A six-week prospective observational study will be conducted with 30 adults (aged 18–60) diagnosed with CUD. Participants will continuously wear the Empatica E4 biosensor and report cravings via ecological momentary assessments (EMA). Weekly urinalysis will confirm relapse events. Data Collection & Inclusion Criteria: Participants must have a confirmed CUD diagnosis; exclusion criteria include pregnancy, comorbid opioid use, or dermatological conditions affecting sensor use [16]. Analysis: Supervised machine learning models (e.g. logistic regression, random forest) will be trained using the labeled physiological data. Outcome Measures: Model performance will be assessed using ROC curves, AUC, precision, recall, and confusion matrix analysis [19]. Evaluation: Predictive accuracy will determine the biosensor’s ability to detect early relapse risk, establishing its clinical utility in outpatient addiction care.

**Study 2. Cross-sectional Usability Study:** Hypothesis: Usability perceptions of the ReSense biosensor vary by user demographics such as age, gender, and prior digital health experience. Method: A cross-sectional usability study will be conducted with 30 participants from Study 1 after four weeks of continuous ReSense use [1]. Data Collection: Participants will complete the System Usability Scale (SUS) and a validated acceptability questionnaire [11]. Outcome Measures: Between-group differences in SUS scores and satisfaction ratings will be analyzed using the Kruskal–Wallis H test. Evaluation: Semi-structured interviews will explore usability perceptions and barriers, with themes analyzed using a grounded theory approach to inform inclusive biosensor design and future deployment strategies [17]. N   
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