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Project Summary

Title: Two-stage Location Scale Mixed Modeling of EMA Data & Future Patterns of Dual Use of Cigs and E-Cigs in U.S. Adults

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Key Points

Question- Can ecological momentary assessment (EMA) data of subjective factors with respect to dual use of combustible cigarettes (CIGs) and electronic cigarettes (ECIGs) predict subsequent future trajectories of dual CIG and ECIG use in U.S. adults?

Findings- In this correlational study, intensive longitudinal data was sampled from a week-long natural history EMA study of U.S. adult dual users of CIGs and ECIGs (N=279) early in their ECIG uptake. EMA of subjective factors vis-à-vis urge to smoke a cigarette prior to a smoking event (URGE), positive affect change (PAC), and negative affect change (NAC) with respect to CIG and ECIG smoking events observed during a week were associated with subsequent future patterns of CIG and ECIG dual use in 279 U.S. adult smokers using a 2-stage location scale mixed modeling approach. While controlling for age and gender, a subject's mean URGE, PAC, and NAC during EMA CIG events and their intra-individual variability in URGE and PAC during EMA were found to be statistically significant predictors of their future mean ECIG use post EMA. While controlling for age, gender, and post-EMA time, a subject's mean URGE, PAC, and NAC during EMA CIG events and their intra-individual variability in URGE, PAC and NAC during EMA were found to be statistically significant predictors of yearly trends in their biweekly rate of ECIG use post EMA. A subject's intra-individual variability in NAC during EMA was found to be a statistically significant predictor of their yearly trends in biweekly rate of CIG use post EMA while similar associations with respect to future CIG use were not found to be statistically significant for URGE and PAC.

Meaning- These results provide a quantitative approach to understand and predict future trajectories of dual use of CIGs and ECIGs using location scale mixed modeling of EMA data collected during a limited period of time on certain subjective factors associated with dual CIG and ECIG use. This work aids in better understanding time-varying dynamics of early ECIG uptake in U.S. adult dual smokers and can potentially help design and assess effectiveness of intervention strategies aimed towards CIG-to-ECIG switching as a form of smoking cessation for adult U.S. CIG smokers.

Abstract

Importance- Combustible cigarette smoking is responsible for more than 480,000 deaths per year in the U.S., which accounts for 1 in every 5 annual U.S. death. By understanding if and how subjective factor EMA data collected during a limited period of time can be used to reliably predict future trajectories of dual use of CIGs and ECIGs at the subject level, we can help design and assess important intervention strategies for adult smoking cessation in U.S. adults through the use of ECIGs which research has shown to be a less harmful alternative to CIG smoking. This study has been inspired by previous work associating subjective outcome EMA data and future patterns of CIG use in adult smokers, however, it is novel in its treatment of dual use of CIGs and ECIGs in U.S. adults.

Objective- To understand the relationship between EMA of subjective factors associated with dual CIG and ECIG events observed during a week and subsequent future biweekly rates of CIG and ECIG use for up to a year at the subject-level using a 2-stage location scale mixed modeling approach.

Design, Setting, and Participants- In this observational study, subjects were instructed to report self-initiated smoking events and associated EMA ratings of subjective factors in real time via hand-held palmtop computers. Furthermore, subjects were randomly triggered multiple times a day throughout the week to inquire about potential smoking events and associated EMA of subjective factors. URGE was measured on a 1-10 point scale (mean=6.73, s.d.=2.76). PAC was calculated as the difference in Positive Affect pre and post each smoking event using the following items on a 1-10 scale and subsequently averaged: “I felt happy”, “I felt relaxed”, “I felt cheerful”, “I felt confident”, “I felt accepted by others” (mean=0.57, s.d.=1.39). NAC was measured similarly using the

following items: “I felt sad”, “I felt stressed”, “I felt angry”, “I felt frustrated”, “I felt irritable” (mean=-0.29, s.d.=1.25). Before the EMA week, subjects had also completed psychosocial and behavioral questionnaires at baseline to ensure reliability of EMA subjective ratings. Subsequently, post EMA week, longitudinal data on each subject’s future rate of CIG and ECIG use was collected for up to a year through biweekly survey reports. Only those subjects were included (N=279) in the final analysis of this study who had at least 1 entry each for CIG and ECIG EMA events and CIG and ECIG biweekly reports post EMA.

Exposures- Between-subject variability in mean levels and intra-individual variance in EMA ratings of subjective factors associated with dual CIG and ECIG events during EMA week and the time covariate post EMA.

Main Outcomes and Measures- In this correlational study, the relationship between subject-level random effects with respect to the mean and variance structures of 3 EMA subjective factors (stage 1 outcome variables) vis-à-vis URGE, PAC, and NAC and subject-level future biweekly rates of CIG and ECIG use (stage 2 outcome variables) was analyzed using a 2 stage joint modeling approach. In stage 1, a mixed-effects location scale (MELS) model proposed by Hedeker et al. (2008, 2012) was used to compute empirical baye’s estimates of normally and log-normally distributed subject-level random location and scale effects for the 3 EMA subjective factor outcomes associated with CIG and ECIG events, each outcome modeled separately. Here, random location and scale effects capture a subject’s influence on the mean levels and variance of their EMA subjective factor ratings respectively. In stage 2, a multi-level regression model was used with post EMA biweekly rates of CIG and ECIG use as outcome variables and stage 1 empirical baye’s estimates of subject random location and scale effects as regressors, while controlling for subject age and gender and post EMA time.

Results- While controlling for age and gender, higher levels of a subject’s mean URGE, PAC, and NAC during EMA CIG events and their intra-individual variability in URGE and PAC during EMA predicted lower average ECIG use post EMA. A higher level of a subject’s mean NAC predicted higher average ECIG use post EMA and a subject’s intra-individual variability in NAC was found to be a statistically insignificant predictor of average ECIG use post EMA. While controlling for age, gender, and post-EMA time, subjects with higher mean levels of URGE and PAC during EMA CIG events and higher

intra-individual variability in URGE and PAC during EMA were both found to have lower yearly trends in biweekly rate of ECIG use post EMA, while an inverse relationship was found to be true for NAC in both cases. Higher intra-individual variability in NAC was found to be associated with lower yearly trends in biweekly rate of CIG use post EMA at the subject-level. No statistically significant associations were found between a subject's means and intra-individual variances of URGE, PAC, and NAC and their future mean CIG use post EMA. Also, no statistically significant associations were found between a subject's means and intra-individual variances of URGE and PAC and their yearly trends in biweekly rate of CIG use post EMA. Some of these statistically insignificant results could be due to the fact that participants in this study were still early in their uptake of ECIGs relative to CIGs which means that it would have been harder for them to change their CIG use behavior relative to ECIGs. Indeed, stage 1 results show that subjects who smoked CIGs more often than ECIGs during EMA week also reported higher mean levels of URGE and NAC which are both factors typically associated with strong nicotine dependence. Age was found to be a universally statistically significant moderating factor in all the examined relationships between EMA subjective factors and future biweekly rates of dual CIG and ECIG use post EMA.

Conclusion and Relevance- This correlational study found statistically significant and theoretically plausible associations between subject-level variability in EMA of subjective factor outcomes of URGE, PAC, and NAC, and future average and yearly trends in biweekly rates of dual CIG and ECIG use post EMA. These results can aid us in developing and assessing intervention strategies for smoking cessation in U.S. adult dual users of CIGs and ECIGs.