Published in final edited form as:

Prev Med. 2020 November ; 140: 106190. doi:10.1016/j.ypmed.2020.106190.

Biopsychosocial Mechanisms Associated with Tobacco Use in Smokers with and without Serious Mental Illness

Teresa DeAtley, MPH^a, Rachel L. Denlinger-Apte, PhD^b, Patricia A. Cioe, PhD^a, Suzanne M. Colby, PhD^c, Rachel N. Cassidy, PhD^a, Melissa A. Clark, PhD^d, Eric C. Donny, PhD^e, Jennifer W. Tidey, PhD^{a,c}

^aDepartment of Behavioral and Social Sciences, Brown University School of Public Health, Providence RI, USA, 02912

^bDepartment of Social Sciences and Health Policy, Wake Forest School of Medicine, Winston-Salem, NC, USA, 27127

^cDepartment of Psychiatry and Human Behavior, Brown University Alpert Medical School, Providence RI, USA, 02912

^dDepartment of Health Services, Policy and Practice, Brown University School of Public Health, Providence RI, USA, 02912

^eDepartment of Physiology and Pharmacology, Wake Forest School of Medicine, Winston-Salem, NC, USA, 27109

Abstract

Smokers with serious mental illness (SMI) are less responsive to cessation treatments than those without SMI. In this study, we compared smokers with and without SMI on validated measures of biological and psychosocial factors associated with tobacco use. Smokers with (n=58) and without SMI (n=83) who were enrolled in parallel clinical trials were compared on measures of carbon monoxide (CO) exposure, nicotine exposure, tobacco-specific nitrosamine exposure, craving, smoking motives, affect, perceived stress, environmental exposure to smoke/smokers, respiratory symptoms, tobacco-related health risk perceptions, and whether they had received recent advice to quit smoking from a health care provider. Data were collected between 2013–2017 in Providence, Rhode Island, USA. Samples were compared using independent-sample t-tests and chi-squared tests. Smokers with SMI had higher CO, nicotine, and tobacco-specific nitrosamine exposure levels, greater cigarette dependence, higher craving, and higher scores on eight out of eleven smoking motives (p 's<0.05). Smokers with SMI reported more severe respiratory symptoms but lower perceived health risks of tobacco (p 's<0.05). These smokers were more likely to report having received advice to quit from a medical provider in the past 6 weeks (p <0.05). Affect, stress,

Corresponding author: Jennifer W. Tidey, Ph.D., Center for Alcohol & Addiction Studies, Brown University, Box S121-5, Providence, RI, 02912, USA. Tel.: +1 401 863 6418; fax: +1 401 863 6697; Jennifer_Tidey@brown.edu.

Conflicts of Interest: The authors declare that they have no conflicts of interest with this research.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

and exposure to smoke/smokers did not differ across samples. Our findings advance the understanding of the elevated smoking rates of people with SMI by comparing smokers with and without SMI on validated biopsychosocial measures. There is a need for interventions that reduce craving, reduce smoking motives, and increase risk awareness among smokers with SMI.

Keywords

nicotine; tobacco use disorder; smoking; craving; comorbidity; schizophrenia

Rates of tobacco use among individuals with serious mental illness (SMI, i.e., people with schizophrenia or bipolar disorder) are 2–4 times higher than those of the general population.^{1,2} Despite downward trends in the prevalence of smoking among the general population, smoking among people with SMI has not declined over the past 20 years, indicating that current tobacco control efforts are not effective for these smokers.³ Consequently, individuals with SMI die at 3.5 times the rate of the general population, largely due to smoking-related diseases.^{4–6} Combined pharmacological and behavioral cessation treatments are effective for smokers with SMI,⁷ but access to such treatments is poor.⁸ Therefore, it is critical to understand factors that may be related to the high smoking and low cessation rates among smokers with SMI.

Two recent reviews of qualitative and quantitative studies have described smoking experiences and beliefs that are reported most frequently among people with SMI.^{9,10} A narrative review of qualitative studies⁹ found that the perceived mental health benefits of smoking was the most frequently-cited barrier to cessation among people with SMI, followed by low self-efficacy for quitting, the perception that smoking is pleasurable and makes one feel in control, and systemic barriers such as lack of support from healthcare providers. The most frequently-cited reason for wanting to quit was health concerns, followed by the financial costs of smoking. A systematic review of qualitative, quantitative, and mixed-method studies¹⁰ found that high levels of craving and addictive smoking (as measured by the Reasons for Smoking Questionnaire¹¹) were the most frequently-identified barriers to cessation among smokers with SMI, followed by concerns that quitting would increase negative affect, stress, or boredom, impair social relationships, and lead to weight gain. The most commonly-reported reasons for quitting were health concerns, physician advice to quit, and feeling social pressure to quit¹⁰. However, none of these factors were unique to, or more prominent among, smokers with SMI. Moreover, the authors of these reviews noted several limitations of the existing literature that may have affected the validity of their findings, particularly that studies often lacked a control group, had small sample sizes, or used non-validated questionnaires.^{9,10} For these reasons, it was difficult to determine whether levels of these facilitators and barriers differ for smokers with and without SMI.

In the current study, we address this gap in the literature by comparing several validated measures of biological and psychosocial factors associated with tobacco use in smokers with and without SMI. Data were collected at baseline in two randomized controlled trials using parallel methods conducted 2 years apart.^{12,13} We hypothesized that we would confirm the

barriers and facilitators of quitting identified in recent systematic reviews,^{9,10} and that levels of the identified barriers would be higher among those with SMI. Specifically, we hypothesized that smokers with SMI would have higher levels of nicotine and smoke exposure, and would report higher levels of cigarette dependence, craving, withdrawal symptoms, negative affect, and stress, stronger motives for smoking across numerous domains, more environmental exposure to smoke and smokers, more respiratory symptoms, and lower perceived risks of tobacco-related disease. We compared the likelihood of provision of quit advice from a health provider across groups, but did not hypothesize a difference across groups.

Methods

Participants

Measures were collected in two parallel projects conducted sequentially: a single-site study of smokers with SMI, conducted in Providence, RI¹² and a multi-site study of smokers without SMI, conducted at 10 sites.¹³ To control for factors related to geographic region, we limited participants in the multi-site study to those enrolled at the Providence, RI site. Eligibility criteria for both studies were identical, with the exception of mental health criteria and minimum number of cigarettes smoked per day (CPD), which was 5 or more CPD for the non-SMI sample and 10 or more CPD for the SMI sample. Both studies enrolled male and female adult daily smokers ages 18–70 who were not seeking cessation treatment and were willing to use research cigarettes varying in nicotine content for 6 weeks. Participants in the SMI sample met diagnostic criteria for schizophrenia, schizoaffective disorder or bipolar disorder based on the Structured Clinical Interview for DSM-IV (SCID) as assessed by trained and experienced research staff. In both projects, the measures reported here were collected prior to randomization and when participants were not abstinent from smoking. Other details about the studies are provided in the primary outcome reports.^{12,13}

Measures

Cigarette use and biomarkers—Cigarettes per day (CPD) was collected using a Timeline Follow-Back interview.¹⁴ Breath carbon monoxide (CO) level, a validated measure of smoke exposure,¹⁵ was assessed using a Bedfont Micro+ breath monitor (Bedfont Scientific, Ltd). Total nicotine equivalents (TNE), a validated measure of nicotine exposure,¹⁶ and 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanol (NNAL), a validated measure of exposure to the tobacco-specific nitrosamine 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanone (NNK), were assessed from first-void urine samples or a spot urine sample if the participant had forgotten to bring in a first-void sample. These samples were analyzed using liquid chromatography with tandem mass spectrometry.

Cigarette Dependence—The Fagerström Test of Cigarette Dependence (FTCD), which has been validated in SMI and non-SMI samples,¹⁷ was used to assess cigarette dependence.^{18,19} Scores range from 0 to 10, with higher values indicating greater dependence.

Craving—Craving was measured using the Brief Questionnaire on Smoking Urges,²⁰ consisting of 10 items rated on 1–7 scales (strongly disagree to strongly agree). The QSU

yields two factors: Factor 1, representing desire and intention to smoke for positive reinforcement, and Factor 2, representing anticipation of relief from negative affect and nicotine withdrawal, along with urgent desire to smoke.²¹

Affect—Affect was measured using the Positive and Negative Affect Schedule²² (PANAS), which contains 20 adjectives (e.g., excited, distressed) rated from 1–5 (very slightly/not at all to extremely). This measure yields two factors, one representing positive affect and the other representing negative affect.

Nicotine Withdrawal—Self-reported withdrawal symptoms were measured using the Minnesota Nicotine Withdrawal Scale (MNWS).²³ This scale consisted of 15 items. Participants were asked to report symptoms of withdrawal in the last they felt or noticed in the last week. Response options were on a scale of 0–4 (none/severe).

Perceived Stress—Perceived stress was assessed using the Perceived Stress Scale - 4 item version²⁴ (PSS-4). Items on this scale relate to how unpredictable or uncontrollable respondents find events in their lives (e.g., “In the past week, how often have you felt that you were unable to control the important things in your life?”). Participants rated how often they had experienced the stressor in the past week on 1–5 scales (never to very often).

Smoking Motives—Smoking dependence motives were assessed using the Brief Wisconsin Inventory of Smoking Dependence Motives (WISDM) scale,²⁵ adapted from the original WISDM scale.²⁶ The Brief WISDM has 37 items rated on 1–7 scales (not true of me at all to extremely true of me), which load onto 11 subscales: Tolerance (need to smoke increasing amounts to get desired effect; ability to smoke heavily without toxicity), Craving (intense frequent urges to smoke), Loss of Control (loss of volitional control over smoking), Automaticity (smoking without awareness or intention), Affective Enhancement (smoking to improve mood), Cognitive Enhancement (smoking to improve cognitive functioning), Affiliative Attachment (strong emotional attachment to smoking), Cue Exposure/Associate Processes (associate strength of cues to elicit smoking motivation), Social/Environmental Goads (potential of social stimuli or contexts in increasing smoking motivation), Taste/Sensory Properties (smoking for orosensory or gustatory effects), and Weight Control. The Tolerance, Craving, Loss of Control and Automaticity subscales combine to create a Primary Dependence Motives scale and the remaining items combine to create a Secondary Dependence Motives Scale.²⁶

Social and Workplace Exposure—Exposure to tobacco smoke/smokers was measured using a modified version of the Environmental Tobacco Smoke Questionnaire²⁷ (ETSQ). The modified version (ETSQ-10) is a 10-item self-report measure of exposure to tobacco smoke in the home, workplace and in social settings. Based on a recent factor analysis/validation of the ETSQ-10,²⁸ we used the Social and Workplace factors to characterize exposure to smoke/smokers in social and workplace environments.

Respiratory Health—Respiratory health was measured using a Respiratory Health Questionnaire.²⁹ Participants reported self-assessed severity of cough, shortness of breath

and other respiratory symptoms since their last study visit on 0–10 scales (none to severe). Item scores were summed to create a single score.

Perceived Health Risks—Perceived health risks of smoking were assessed using the Perceived Health Risks Scale³⁰ (PHRS). Participants rated their risk of developing lung cancer, other cancers, emphysema, bronchitis, heart disease, stroke, and addiction using 1–10 scales (very low risk for disease to very high risk). Item scores were averaged to create a single score.

Advice to Quit from a Health Provider—Receipt of recent advice to quit smoking was assessed using a single item: “Over the past 6 weeks, have any health providers told you to quit smoking cigarettes?” with response options consisting of doctor, dentist, some other medical provider, or none. Receipt of advice from any health care provider was counted as a yes response.

Statistical Analyses

Data were examined for systematic missing data, marked skewness, and outliers. Two-sample t-tests with equal variances were used to compare the SMI and non-SMI samples on the continuous measures and chi-square tests were used to compare the number of participants in each group who reported having received recent advice to quit from a health provider. Mean and standard deviation values were provided for baseline characteristics and scale scores. Geometric means and 95% confidence intervals were used for the biomarkers creatinine-corrected TNE and NNAL, to account for non-normal distributions.

Results

Characteristics of participants in the SMI and non-SMI groups are shown in Table 1. Overall, participants were 42.4 ± 12 ($M \pm SD$) years old, 44% female, 74.5% White, and 7% Hispanic, with no significant differences in these characteristics across samples. Clinical characteristics of the SMI sample have been reported.¹² Briefly, 73% of the sample had a diagnosis of schizophrenia or schizoaffective disorder and 27% had a diagnosis of bipolar disorder; participants were clinically stable with low-to-moderate psychiatric symptom levels.

As shown in Table 1, daily smoking rate (CPD) and proportion of menthol use did not significantly differ across samples, although there was a non-significant trend toward a higher proportion of menthol cigarette use in the SMI sample ($p = 0.09$). Participants in the SMI sample had significantly higher breath CO and urinary TNE and NNAL levels than those in the non-SMI sample. The smokers with SMI had higher FTCD scores, indicating that they were more dependent on cigarettes ($p < 0.05$).

Internal consistency of the QSU, MNWS, PANAS and WISDM scales were high in both samples. For QSU Factor 1, Cronbach’s alphas were 0.94 in both samples. For QSU Factor 2, Cronbach’s alpha was 0.89 in the non-SMI group and 0.88 in the SMI group. For the MNWS, Cronbach’s alphas were 0.86 in the non-SMI sample and 0.89 in the SMI sample. For the PANAS positive affect scale, the Cronbach’s alphas were 0.89 for the non-SMI

group and 0.87 for the SMI group. For the PANAS negative affect scale, the alphas were 0.88 for the non-SMI group and 0.93 for the SMI group. For the WISDM Primary Dependence Motives scale, Cronbach's alphas were 0.93 for the non-SMI group 0.94 for the SMI group. For the WISDM Secondary Dependence Motives scale, the alphas were 0.92 for the non-SMI group and 0.93 for the SMI group.

Internal consistencies of the PSS, ETSQ and Respiratory Health Questionnaire were fair to moderate compared to the aforementioned measures. For the PSS, Cronbach's alpha was 0.67 for both the non-SMI and SMI groups. For the ETSQ Social subscale, Cronbach's alphas were 0.74 for the non-SMI group and 0.72 in the SMI group. For the ETSQ Workplace subscale, the Cronbach's alphas were 0.61 for the non-SMI group and 0.64 for the SMI group. For the Respiratory Health Questionnaire, Cronbach's alphas were 0.80 for the non-SMI group and 0.81 for the SMI group. Finally, for the PHRS, Cronbach's alphas were quite high: 0.95 for the non-SMI group and 0.96 for the SMI group.

Scores on these measures for the SMI and non-SMI groups are shown in Table 1. Smokers with SMI reported higher levels of cigarette craving on both QSU Factor 1 and Factor 2 ($p < 0.05$ and $p < 0.01$, respectively). The SMI group also reported higher withdrawal symptoms on the MNWS than the non-SMI group ($p < 0.001$). The samples did not significantly differ on PANAS positive or negative affect scores, although there was a non-significant trend toward higher negative affect in the SMI group ($p = 0.06$). The SMI sample had significantly higher WISDM total and Primary Dependence Motives scores than the non-SMI sample ($p < 0.05$ and $p < 0.01$, respectively). Scores on the WISDM Secondary Dependence Motives scale tended to be higher in the SMI sample but this did not reach significance ($p = 0.053$). As shown in Figure 1, the smokers with SMI reported higher scores on most WISDM subscales, including Tolerance, Craving, Automaticity, Loss of Control, Cue exposure/Associative Processes, Cognitive Enhancement, Affective Enhancement, and Affiliative Attachment (p 's < 0.05). There were no differences between samples on WISDM Social/Environmental Goads, Taste, or Weight Control subscale scores, PSS-4 scores, or ETSQ Social or Work scores (Table 1).

The smokers with SMI reported more severe respiratory symptoms, but lower perceived risks of tobacco-related disease, than those without SMI (p 's < 0.05). Finally, smokers with SMI were more likely to report having received advice to quit from a health provider than those without SMI (83% and 64%, respectively; $p = 0.01$).

Discussion

The results of the current study extend the conclusions of a recent systematic review that reported that smokers with SMI cite cigarette craving, addiction, negative affect or boredom reduction, and social facilitation as smoking beliefs that may impair cessation,¹⁰ by finding that scores on measures of cigarette craving, dependence, withdrawal symptoms, and addiction motives were significantly higher in smokers with SMI compared to equally-heavy smokers without SMI. Although we did not find significant differences in affect or perceived stress across samples, smokers with SMI reported higher motivation to smoke to improve mood (i.e., scores on the Brief WISDM Affective Enhancement subscale), which is

consistent with the findings of the systematic review.¹⁰ The current results are also consistent with our previous reports indicating that smokers with schizophrenia have elevated QSU Factor 1 and 2 craving scores compared to controls³¹, higher withdrawal symptom scores compared to controls³¹, and that reduction of negative affect was the most highly-rated smoking expectancy by smokers with and without schizophrenia.³² Elevated WISDM scores have been reported in smokers with lifetime mood, anxiety, and substance use disorders,³³ but to our knowledge no study has compared WISDM scale scores in smokers with and without SMI. Therefore, the finding of higher scores on most of the Brief WISDM subscales in the sample of smokers with SMI is a novel contribution of this study.

Our results also indicate that levels of breath CO intake, TNE and NNAL were higher among the smokers with SMI than the smokers without SMI. These findings are consistent with previous studies that reported that smokers with SMI have higher CO and nicotine levels than equally-heavy smokers without SMI, which have been attributed to differences in smoking topography.^{34–36} It is possible that the higher nicotine intake obtained by smokers with SMI may contribute to the lower efficacy of nicotine replacement in smokers with SMI compared to smokers without SMI who smoke a similar number of cigarettes per day.^{37,38}

Some differences between our findings and those of a recent systematic review¹⁰ should also be noted. While that review found that social facilitation was often reported to be a reason for smoking in people with schizophrenia¹⁰, smokers with SMI in the current study did not report higher scores on the ETSQ Social factor or Brief WISDM Social/Environmental Goads subscale than smokers without SMI. Both samples reported high scores on these scales, indicating that all participants were frequently around other smokers and that this often cued smoking. Interestingly, the SMI sample reported higher scores on the Brief WISDM Affiliative Attachment scale, which indicates strong emotional attachment to smoking. Smokers with mood and anxiety disorders also report higher scores on this scale,³³ as do adolescent menthol smokers compared to non-menthol smokers,³⁹ suggesting that this may be a transdiagnostic risk factor for continued smoking. The samples did not differ on the ETSQ Workplace factor. However, given the low rates of employment in the current samples, (21% of participants with SMI and 39% of those without SMI), this may not be a reliable finding and this scale may not be well-suited for populations with low employment rates in general.

One cessation barrier addressed in a narrative review of qualitative studies⁹ was smoking for cognitive enhancement, i.e., the degree to which cigarettes are viewed as helpful for cognitive function. The putative cognitive-enhancing effects of nicotine have long been suspected to underlie the high rates of smoking in people with schizophrenia, though controlled comparisons have found that effects of smoking and nicotine manipulations on cognitive performance are similar in smokers with and without schizophrenia.^{40,41} Nevertheless, the current finding of higher WISDM Cognitive Enhancement motives in smokers with SMI compared to controls suggests that smokers with SMI may be more likely to perceive smoking as a cognition-enhancing behavior than those without SMI, which may contribute to persistent smoking in this population.

The most commonly-cited reason to quit among smokers with SMI that was identified in recent reviews^{9,10} was concern about the health risks of smoking. In the current study, smokers with SMI reported experiencing more severe respiratory symptoms associated with tobacco use (e.g., cough, shortness of breath), but lower perceived risks of smoking on the PHRS. This finding, which supports previous research,⁴² suggests that psychosocial treatments that highlight the discrepancy between current respiratory symptoms and risk perceptions could increase motivation to quit among people with SMI. Recent studies have reported promising effects of pictorial warnings and media campaigns on risk perceptions and smoking behavior in smokers with psychotic disorders and other mental health conditions,^{43,44} suggesting that there are multiple methods of increasing smoking risk perceptions in people with SMI.

Another important variable associated with quitting, cited by both reviews,^{9,10} was advice to quit from a healthcare provider. In the current study, more smokers with SMI reported having received advice to quit from a health care provider than those without SMI (83% vs. 64%). Similarly, one review¹⁰ reported that the median rates of receipt of advice to quit from a health provider were similar across groups (80–83%), although the range was wider in the SMI group. While the high rate of receipt of advice to quit in this and other studies⁴⁵ is cause for considerable optimism, providing advice alone is clearly insufficient for reducing smoking rates in this population. Methods of enhancing the delivery of cessation treatments by healthcare providers are needed.⁴⁶

Results of this study should be considered in light of several limitations. First, smokers in these samples were not seeking treatment for smoking; rather, they were enrolled in studies designed to test whether reducing the nicotine content of cigarettes would reduce smoking in ongoing smokers.^{12,13} Because participants were not seeking treatment, our analyses were restricted to tests of association rather than regression analysis that model factors associated with cessation or motivation to quit. In addition, the study was cross-sectional, which precludes causal attributions. An important next step of this research is to investigate whether the mechanisms identified in this work predict treatment entry, retention and changes in smoking behavior, including smoking reductions and quitting success. Second, the SMI and non-SMI samples were assessed in two separate studies conducted by the same investigators and staff in the same environment, but were conducted consecutively rather than concurrently. However, given the concordance between our findings and those reported in a recent systematic review,¹⁰ we believe it is unlikely that the brief period between these studies (1–2 years) had significant confounding effects on outcomes.

This study also has several strengths that address gaps identified in the current literature, such as the inclusion of an equally-heavy-smoking control group and the use of validated measures of biological and psychosocial factors associated with tobacco use. Furthermore, as noted above, to our knowledge this is the first study to compare Brief WISDM subscale scores in smokers with and without SMI. The biopsychosocial factors associated with tobacco use that were identified in this work have clear implications for intervention development and may stimulate greater focus in the field on this important population.

Acknowledgements

Funding: This research was supported by grant U54DA031659 from the National Institute on Drug Abuse (NIDA) and the Food and Drug Administration Center for Tobacco Products (FDA). Additional author support during the preparation of this paper was provided by National Institute of Health (NIH) grants F31DA049460, K01CA189300, P20GM130414, R36DA045183 and U54DA036114. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH or FDA. The funding sources had no involvement with this work other than financial support.

We thank Mollie Miller, PhD; Netesha Reid, MSN, FNP-C; Emily Xavier, MS; Ashley Marzullo, MA, LMHC; Kimberly Duguay, AS; Tonya Lane, MEd; the Center for Evaluation of Nicotine in Tobacco (CENIC) Administrative, Biomarkers and Biostatistics Cores, and the study participants for their essential contributions to this research.

References

1. Smith PH, Mazure CM, & McKee SA (2014). Smoking and mental illness in the U.S. population. *Tobacco Control*, 23(e2), e147–53. doi: 10.1136/tobaccocontrol-2013-051466. [PubMed: 24727731]
2. Smith PH, Chhipa M, Bystrick J, Roy J, Goodwin RD, & McKee SA (2020). Cigarette smoking among those with mental disorders in the US population: 2012–2013 update. *Tobacco Control*, 29(1), 29–35. doi:10.1136/tobaccocontrol-2018-054268. [PubMed: 30377242]
3. Prochaska JJ, Das S, & Young-Wolff KC (2017). Smoking, mental illness, and public health. *Annual Review of Public Health*, 38, 165–185. doi: 10.1146/annurev-publhealth-031816-044618.
4. Callaghan RC, Veldhuizen S, Jeysingh T, Orlan C, Graham C, Kakouris G, Remington G, & Gatley J (2014). Patterns of tobacco-related mortality among individuals diagnosed with schizophrenia, bipolar disorder, or depression. *Journal of Psychiatric Research*, 48(1), 102–110. doi: 10.1016/j.jpsychires.2013.09.014. [PubMed: 24139811]
5. Olfson M, Gerhard T, Huang C, Crystal S, & Stroup TS (2015). Premature mortality among adults with schizophrenia in the United States. *JAMA Psychiatry*, 72(12), 1172–1181. doi: 10.1001/jamapsychiatry.2015.1737. [PubMed: 26509694]
6. Scott KM, Lim C, Al-Hamzawi A, Alonso J, Bruffaerts R, Caldas-de-Almeida JM, Florescu S, de Girolamo G, Hu C, de Jonge P, Kawakami N, Medina-Mora ME, Moskalewicz J, Navarro-Mateu F, O'Neill S, Piazza M, Posada-Villa J, Torres Y, & Kessler RC (2016). Association of mental disorders with subsequent chronic physical conditions: World Mental Health Surveys from 17 countries. *JAMA Psychiatry*, 73(2), 150–158. doi: 10.1001/jamapsychiatry.2015.2688. [PubMed: 26719969]
7. Evins AE & Cather C (2015). Effective cessation strategies for smokers with schizophrenia. *International Review of Neurobiology*, 124, 133–47. doi:10.1016/bs.irn.2015.08.001. [PubMed: 26472528]
8. Marynak K, VanFrank B, Tetlow S, Mahoney M, Phillips E, Jamal Mbbs A, Schecter A, Tipperman D, & Babb S (2018). Tobacco cessation interventions and smoke-free policies in mental health and substance abuse treatment facilities - United States, 2016. *MMWR Morbidity and Mortality Weekly Report*, 67(18), 519–523. doi:10.15585/mmwr.mm6718a3. [PubMed: 29746451]
9. Trainor K & Leavey G (2017). Barriers and facilitators to smoking cessation among people with severe mental illness: A critical appraisal of qualitative studies, *Nicotine & Tobacco Research*, 19 (1), 14–23. doi.org/10.1093/ntr/ntw183. [PubMed: 27613905]
10. Lum A, Skelton E, Wynne O, & Bonevski B (2018). A systematic review of psychosocial barriers and facilitators to smoking cessation in people living with schizophrenia. *Frontiers in Psychiatry*, 9, 565–565. doi:10.3389/fpsy.2018.00565. [PubMed: 30459658]
11. Russell M, Peto J, & Patel U (1974). The classification of smoking by factorial structure of motives. *Journal of the Royal Statistical Society. Series A (General)*, 137(3), 313–346. doi:10.2307/2344953
12. Tidey JW, Colby SM, Denlinger-Apte RL, Goodwin C, Cioe PA, Cassidy RN, Swift RM, Lindgren BR, Rubin N, Murphy SE, Hecht SS, Hatsukami DK, & Donny EC (2019). Effects of 6-week use

- of very low nicotine content cigarettes in smokers with serious mental illness. *Nicotine & Tobacco Research*, 2019 Dec 23;21(Supplement 1), S38–S45. doi:10.1093/ntr/ntz133. [PubMed: 31867650]
13. Donny EC, Denlinger RL, Tidey JW, Koopmeiners JS, Benowitz NL, Vandrey RG, al' Absi M, Carmella SG, Cinciripini PM, Dermody SS, Drobes DJ, Hecht SS, Jensen J, Lane T, Le CT, McClermon FJ, Montoya ID, Murphy SE, Robinson JD, Stitzer ML, Strasser AA, Tindle H, & Hatsukami DK (2015). Randomized trial of reduced-nicotine standards for cigarettes. *New England Journal of Medicine*, 373(14), 1340–1349. doi:10.1056/NEJMsa1502403. [PubMed: 26422724]
  14. Brown RA, Burgess ES, Sales SD, Whiteley JA, Evans DM, & Miller IW (1998). Reliability and validity of a smoking timeline follow-back interview. *Psychology of Addictive Behaviors*, 12, 101–112.
  15. Benowitz NL, Bernert JT, Foulds J, Hecht SS, Jacob P, Jarvis MJ, Joseph A, Oncken C, & Piper ME (2019). Biochemical verification of tobacco use and abstinence: 2019 Update. *Nicotine & Tobacco Research*, 2019 Oct 1. pii: ntz132. doi: 10.1093/ntr/ntz132. [Epub ahead of print].
  16. Scherer G, Engl J, Urban M, Gilch G, Janket D, & Riedel K (2007). Relationship between machine-derived smoke yields and biomarkers in cigarette smokers in Germany. *Regul Toxicol Pharmacol*, 47(2), 171–183. doi: 10.1016/j.yrtph.2006.09.001. [PubMed: 17034917]
  17. Weinberger AH, Reutenauer EL, Allen TM, Termine A, Vessicchio JC, Sacco KA, Easton CJ, McKee SA, & George TP (2007). Reliability of the Fagerström Test for Nicotine Dependence, Minnesota Nicotine Withdrawal Scale, and Tiffany Questionnaire for Smoking Urges in smokers with and without schizophrenia. *Drug and Alcohol Dependence*, 86(2–3), 278–82. doi: 10.1016/j.drugalcdep.2006.06.005. [PubMed: 16876968]
  18. Fagerström K (2012). Determinants of tobacco use and renaming the FTND to the Fagerström Test for Cigarette Dependence. *Nicotine & Tobacco Research*, 14(1), 75–78. doi: 10.1093/ntr/ntz137. [PubMed: 22025545]
  19. Heatherton TF, Kozlowski LT, Frecker RC, & Fagerström KO (1991). The Fagerström Test for Nicotine Dependence: A revision of the Fagerström Tolerance Questionnaire. *British Journal of Addiction*, 86, 1119–1127. doi: 10.1111/j.1360-0443.1991.tb01879.x [PubMed: 1932883]
  20. Cox LS, Tiffany ST, & Christen AG (2001). Evaluation of the brief questionnaire of smoking urges (QSU-brief) in laboratory and clinical settings. *Nicotine & Tobacco Research*, 3, 7–16. doi:10.1080/14622200020032051. [PubMed: 11260806]
  21. Tiffany ST & Drobes DJ (1991). The development and initial validation of a questionnaire on smoking urges. *British Journal of Addiction*, 86(11), 1467–1476. doi: 10.1111/j.1360-0443.1991.tb01732.x [PubMed: 1777741]
  22. Watson D, Clark LA, & Tellegen A (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. *Journal of Personality and Social Psychology*, 54(6), 1063–1070. doi: 10.1037/0022-3514.54.6.1063. [PubMed: 3397865]
  23. Hughes JR & Hatsukami D (1986). Signs and symptoms of tobacco withdrawal. *Archives of General Psychiatry*. 43(3), 289–294. doi:10.1001/archpsyc.1986.01800030107013 [PubMed: 3954551]
  24. Cohen S, Kamarack T, & Mermelstein R (1983). A global measure of perceived stress. *Journal of Health and Social Behavior*, 24, 385–396. doi: 10.2307/2136404. [PubMed: 6668417]
  25. Smith SS, Piper ME, Bolt DM, Fiore MC, Wetter DW, Cinciripini PM, & Baker TB (2010). Development of the Brief Wisconsin Inventory of Smoking Dependence Motives. *Nicotine & Tobacco Research*, 12(5), 489–499. doi:10.1093/ntr/ntq032. [PubMed: 20231242]
  26. Piper ME, McCarthy DE, Bolt DM, Smith SS, Lerman C, Benowitz N, Fiore MC, & Baker TB (2008). Assessing dimensions of nicotine dependence: an evaluation of the Nicotine Dependence Syndrome Scale (NDSS) and the Wisconsin Inventory of Smoking Dependence Motives (WISDM). *Nicotine & Tobacco Research*, 10(6), 1009–1020. Erratum in: *Nicotine & Tobacco Research*, 2008 Sep;10(9), 1517. doi:10.1080/14622200802097563. [PubMed: 18584464]
  27. Nondahl DM, Cruickshanks KJ, & Schubert CR (2005). A questionnaire for assessing environmental tobacco smoke exposure. *Environmental Research*, 97, 76–82. doi: 10.1016/j.envres.2004.02.005. [PubMed: 15476736]

28. DeAtley T, Clark MA, Colby SM, Denlinger-Apte RL, Cioe PA, Cassidy RN, Donny EC, & Tidey JW Psychometric analysis of an environmental tobacco smoke questionnaire. Under review.
29. Hatsukami DK, Kotlyar M, Allen S, Jensen J, Li S, Le C, & Murphy S (2005). Effects of cigarette reduction on cardiovascular risk factors and subjective measures. *Chest*, 128(4), 2528–2537. doi: 10.1378/chest.128.4.2528 [PubMed: 16236919]
30. Hatsukami DK, Vogel RI, Severson HH, Jensen JA, & O'Connor RJ (2016). Perceived health risks of snus and medicinal nicotine products. *Nicotine & Tobacco Research*, 18(5), 794–800. doi: 10.1093/ntr/ntv200. [PubMed: 26386473]
31. Tidey JW, Colby SM, & Xavier EM (2014). Effects of smoking abstinence on cigarette craving, nicotine withdrawal, and nicotine reinforcement in smokers with and without schizophrenia. *Nicotine & Tobacco Research*, 16(3), 326–334. doi: 10.1093/ntr/ntt152.
32. Tidey JW & Rohsenow DJ (2009). Smoking expectancies and intention to quit in smokers with schizophrenia, schizoaffective disorder and non-psychiatric controls. *Schizophr Res.* 115(2–3), 310–306. doi: 10.1016/j.schres.2009.09.032. [PubMed: 19836210]
33. Piper ME, Smith SS, Schlam TR, Fleming MF, Bittrich AA, Brown JL, Leitzke CJ, Zehner ME, Fiore MC, & Baker TB (2010). Psychiatric disorders in smokers seeking treatment for tobacco dependence: Relations with tobacco dependence and cessation. *Journal of Consulting and Clinical Psychology*, 78, 13–23. doi:10.1037/a0018065 [PubMed: 20099946]
34. Olincy A, Young DA, & Freedman R (1997). Increased levels of the nicotine metabolite cotinine in schizophrenic smokers compared to other smokers. *Biological Psychiatry*, 42(1), 1–5. doi.org/10.1016/S0006-3223(96)00302-2 [PubMed: 9193735]
35. Tidey JW, Rohsenow DJ, Kaplan GB, Swift RM (2005). Cigarette smoking topography in smokers with schizophrenia and matched non-psychiatric controls. *Drug and Alcohol Dependence*, 80(2), 259–265. doi:10.1016/j.drugalcdep.2005.04.002 [PubMed: 15869844]
36. Williams JM, Gandhi KK, Lu SE, Kumar S, Steinberg ML, Cottler B, & Benowitz NL (2011). Shorter interpuff interval is associated with higher nicotine intake in smokers with schizophrenia. *Drug and Alcohol Dependence*, 118(2–3), 313–319. doi:10.1016/j.drugalcdep.2011.04.009 [PubMed: 21596491]
37. Anthenelli RM, Benowitz NL, West R, St Aubin L, McRae T, Lawrence D, Ascher J, Russ C, Krishen A, & Evins AE (2016). Neuropsychiatric safety and efficacy of varenicline, bupropion, and nicotine patch in smokers with and without psychiatric disorders (EAGLES): a double-blind, randomised, placebo-controlled clinical trial. *Lancet*, 387(10037), 2507–20. doi: 10.1016/S0140-6736(16)30272-0. [PubMed: 27116918]
38. Evins AE, Benowitz NL, West R, Russ C, McRae T, Lawrence D, Krishen A, St Aubin L, Maravic MC, Anthenelli RM (2019). Neuropsychiatric safety and efficacy of varenicline, bupropion, and nicotine patch in smokers with psychotic, anxiety, and mood disorders in the EAGLES trial. *Journal of Clinical Psychopharmacology*, 39(2), 108–116. doi: 10.1097/JCP.0000000000001015. [PubMed: 30811371]
39. Cwalina SN, Majmundar A, Unger JB, Barrington-Trimis JL, & Pentz MA (2019). Adolescent menthol cigarette use and risk of nicotine dependence: Findings from the national Population Assessment on Tobacco and Health (PATH) study. *Drug and Alcohol Dependence*. 206, 107715. doi: 10.1016/j.drugalcdep.2019.107715. [Epub ahead of print]. [PubMed: 31760252]
40. AhnAllen CG, Bidwell LC, & Tidey JW (2015). Cognitive effects of very low nicotine content cigarettes, with and without nicotine replacement, in smokers with schizophrenia and controls. *Nicotine & Tobacco Research*, 17(5), 510–514. doi:10.1093/ntr/ntu163. [PubMed: 25143294]
41. Hahn B, Harvey AN, Concheiro-Guisan M, Huestis MA, Holcomb HH, & Gold JM (2013). A test of the cognitive self-medication hypothesis of tobacco smoking in schizophrenia. *Biological Psychiatry*, 74 (6), 436–443. doi: 10.1016/j.biopsych.2013.03.017. [PubMed: 23660272]
42. Kowalczyk WJ, Wehring HJ, Burton G, Raley H, Feldman S, Heishman SJ, & Kelly DL (2017). Predictors of the perception of smoking health risks in smokers with or without schizophrenia. *Journal of Dual Diagnosis*, 13(1), 29–35. doi:10.1080/15504263.2016.1260190. [PubMed: 27858591]
43. Coletti DJ, Brunette M, John M, Kane JM, Malhotra AK, & Robinson DG (2015). Responses to tobacco smoking-related health messages in young people with recent-onset schizophrenia. *Schizophrenia Bulletin*, 41(6), 1256–1265. doi:10.1093/schbul/sbv122. [PubMed: 26316595]

44. Prochaska JJ, Gates EF, Davis KC, Gutierrez K, Prutzman Y, & Rodes R (2019). The 2016 Tips From Former Smokers® Campaign: Associations with quit intentions and quit attempts among smokers with and without mental health conditions. *Nicotine & Tobacco Research*, 21(5), 576–583. doi: 10.1093/ntr/nty241. [PubMed: 30496491]
45. Kalkhoran S, Thorndike AN, Rigotti NA, Fung V, & Baggett TP (2019). Cigarette smoking and quitting-related factors among US adult health center patients with serious mental illness. *Journal of General Internal Medicine*, 34(6), 986–991. doi:10.1007/s11606-019-04857-3. [PubMed: 30783880]
46. Rojewski AM, Bailey SR, Bernstein SL, Cooperman NA, Gritz ER, Karam-Hage MA, Piper ME, Rigotti NA, & Warren GW (2019). Considering systemic barriers to treating tobacco use in clinical settings in the United States. *Nicotine & Tobacco Research*, 21(11), 1453–1461. doi: 10.1093/ntr/nty123. [PubMed: 29917118]

Highlights

- We compared factors associated with tobacco use in smokers with and without SMI
- Smokers with SMI had higher craving and more severe smoking motives
- Smokers with SMI had more severe respiratory symptoms but lower perceived risks
- Interventions to address these risk factors are needed for smokers with SMI

Figure 1.

Mean scores on the Brief Wisconsin Inventory of Smoking Dependence Motives (WISDM) scale in smokers with serious mental illness (solid bars) and control smokers without serious mental illness (open bars). Error bars represent SEM. Asterisks indicate significant differences between samples (* $p < .05$, ** $p < .01$). Data were collected in 2013–2017 in Providence, Rhode Island, USA.

Table 1. Biopsychosocial characteristics of smokers with and without serious mental illness (SMI).^a

	Smokers with SMI (<i>n</i> = 58)	Smokers without SMI (<i>n</i> = 83)	<i>p</i> -value
Age (years)	43.2 (10.2)	41.7 (13.2)	0.46
Gender (female) no. (%)	24 (41)	38 (46)	0.73
Race no. (%)			
White	34 (58) [‡]	66 (79)	
Black	15 (25)	12 (14)	
Multiracial or Other	10(17)	6(7)	0.10
Hispanic ethnicity no. (%)	3 (5)	7 (8)	0.68
Cigarettes per day	19.2 (8.3)	17.8 (8.0)	0.33
Menthol use no. (%)	41 (70.7)	46 (55)	0.09
Breath CO level (ppm)	20.7 (17.5, 24.0)	14.8 (13.2, 16.5)	.002
TNE (nmol/mg creatinine)	79.1 (67.1, 93.3) ^{‡‡}	38.0 (29.9, 48.2)	<0.001
NNAL (nmol/mg creatinine)	1.66 (1.33, 2.07) ^{‡‡}	1.17 (0.92, 1.48)	0.03
FTCD	6.7 (1.5)	5.8 (2.1)	0.02
QSU Factor 1	24.4 (9.7)	20.3 (10.1)	0.02
QSU Factor 2	16.3 (8.9)	12.5 (7.6)	0.01
PANAS Positive Affect	32.0 (7.4)	33.5 (7.5)	0.24
PANAS Negative Affect	19.3 (7.9)	17.1 (6.1)	0.06
PSS-4	5.7 (2.9)	5.0 (2.9)	0.19
MNWS	1.29 (0.71)	0.68 (0.50)	<0.001
Total Brief WISDM Scale	4.5 (1.3)	4.0 (1.2)	0.02
WISDM Primary Motives	5.2 (1.4)	4.6 (1.4)	0.009
WISDM Secondary Motives	4.1 (1.3)	3.7 (1.2)	0.05
ETSQ Social subscale	2.4 (0.9)	2.5 (0.9)	0.23
ETSQ Work subscale ^b	1.2 (0.2)	1.4 (0.1)	0.5
Respiratory Health symptoms	15.0 (7.7)	11.9 (6.7)	0.01
PHRS	6.6 (3.0)	7.4 (2.2)	0.046
Advice to Quit no. (%)	48 (83)	53 (64)	0.01

^aUnless otherwise indicated, values represent mean (standard deviation) or geometric mean (95% confidence interval) for creatinine-corrected TNE and NNAL.

^b values are based on 12 participants with SMI (21%) and 32 without SMI (39%) who reported any work.

[‡] Three participants did not report race.

^{‡‡} One participant was missing creatinine at baseline.

TNE, total nicotine equivalents; NNAL, 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanol; FTCD, Fagerström Test of Cigarette Dependence; QSU, Brief Questionnaire on Smoking Urges; PANAS, Positive and Negative Affect Schedule; PSS-4, Perceived Stress Scale – 4 item version; WISDM, Brief Wisconsin Inventory of Smoking Dependence Motives; ETSQ, Environmental Tobacco Smoke Questionnaire; PHRS, Perceived Health Risks Scale.