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The influence of sociodemographic, tobacco use, and mental health characteristics on treatment adherence among adults enrolled in a community-based tobacco cessation program

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ABSTRACT

Background: While counseling and pharmacological interventions are known to facilitate smoking cessation, poor adherence can impact their effectiveness. Therefore, this study aimed to identify personal and clinical factors that influenced adherence to smoking cessation treatment among socioeconomically disadvantaged adult Oklahomans enrolled in a publicly available tobacco treatment program and observational research study.

Methods: Adult participants ($N = 442$) were enrolled in a community-based tobacco treatment program. Logistic regression models identified sociodemographic, mental health, and substance use characteristics associated with treatment adherence. Adherence was measured by counseling session attendance and weeks of moderate/high medication adherence assessed via the Medication Adherence Questionnaire. Analyses were conducted using SAS 9.4 with $p < 0.05$.

Results: Participants (mean age of 53, 55 % female, and 42.3 % racially minoritized), smoked 16 (SD = 10) cigarettes/day for 30 years on average (SD = 15), and 44.8 % reported depression (Center for Epidemiological Studies Depression Scale [CESD] score $\geq$ 10). Self-efficacy, White race, increasing age, and years of smoking were positively associated with counseling adherence, while menthol use, being uninsured, and depression predicted lower counseling adherence. Medication adherence was lower among individuals who used menthol cigarettes, lived with someone who smoked, and had higher levels of expired carbon monoxide.

Conclusions: This study highlights key factors that influenced adherence to smoking cessation treatment in a socioeconomically disadvantaged population. Tailored interventions are needed to address social, behavioral, and environmental factors, such as living situations and mental health, in smoking cessation interventions to enhance treatment outcomes for underserved populations. Future tobacco cessation programs should consider these factors to improve adherence and, ultimately, success rates.

Abbreviations: CESD-10, Center for Epidemiological Studies Depression Scale-10; CI, Confidence Interval; CO, Carbon Monoxide; FDA, Food and Drug Administration; ICPSR, Inter-university Consortium for Political and Social Research; LGBTQ+, Lesbian, Gay, Bisexual, Transgender, Queer, and Others; MAQ, Medication Adherence Questionnaire; NCI, National Cancer Institute; NIMHD, National Institute on Minority Health and Health Disparities; NRT, Nicotine Replacement Therapy; OR, Odds Ratio; PHQ-9, Patient Health Questionnaire-9; RCT, Randomized Controlled Trial; SES, Socioeconomic Status; TSET, Tobacco Settlement Endowment Trust; TTRP, Tobacco Treatment Research Program; US, United States.

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1. Introduction

Smoking remains the most preventable cause of morbidity and mortality in the United States and is directly linked to cardiovascular disease, lung diseases, and cancer, particularly lung cancer (Center for Disease Control and Prevention, 2020; Centers for Disease Control and Prevention, 2020). While the prevalence of smoking among U.S. adults has declined to 11.6 %, many rural and socially vulnerable states continue to report high rates of adult cigarette smoking (e.g., 18.9 % in Oklahoma) (Center for Disease Control and Prevention, 2024) In addition, poverty, lower socioeconomic status (SES), and lack of insurance coverage have been strongly associated with higher smoking prevalence (Stanton et al., 2016). Factors such as poor mental health, substance use problems, and lack of healthcare access are also associated with smoking (Jawed & Jassal, 2021; Tan et al., 2023).

Currently recommended interventions for smoking cessation include counseling and pharmacotherapy (Giulietti et al., 2020; Krist et al., 2021). Telephone counseling and cessation medications, such as nicotine replacement therapy (NRT), have been reported to improve cessation efforts, especially among hard-to-reach populations such as rural dwellers (Jawed & Jassal, 2021). However, poor medication adherence poses a significant challenge to smoking cessation efforts (Cropsey et al., 2021; Walton & Herrmann, 2023). Adherence to prescribed tobacco cessation medications is essential for achieving optimal health outcomes (Krist et al., 2021; Rigotti et al., 2022). In some cases, individuals purchase these medications but use them at suboptimal doses, which limits their effectiveness (Rosen et al., 2021; Zawertailo et al., 2020). Poor medication adherence poses significant challenges in both clinical practice and research (Cropsey et al., 2021; Walton & Herrmann, 2023).

In addition to medication adherence, adherence to counseling sessions plays a crucial role in successful smoking cessation (Goldenhersch et al., 2020; Onwuzo et al., 2024). Strong evidence shows that individuals who adhere to counseling sessions are significantly more likely to quit smoking (Krist et al., 2021; Rigotti et al., 2022). Studies have consistently demonstrated a dose–response relationship, where completing more counseling sessions correlates with higher quit rates (Park et al., 2020; Scheuermann et al., 2019; Stead et al., 2016). Fiore et al. reported that attending at least four counseling sessions (10 min or more) was associated with a greater likelihood of quitting smoking (Fiore, 2009). This finding has been supported by other studies, including *meta*-analyses, which showed that intensive counseling, particularly when combined with pharmacotherapy, led to improved smoking cessation outcomes (Hartmann-Boyce et al., 2021; Hersi et al., 2024; Rojewski et al., 2017; Shields et al., 2023). In contrast, individuals who attend fewer or shorter sessions are less likely to quit successfully (Fan & Lee, 2021; Fucito et al., 2009; Rojewski et al., 2017; Shields et al., 2023).

Other factors associated with poor adherence to smoking cessation treatment include rurality, age, smoking, sexual orientation and gender identity, low SES, and limited health insurance coverage (Browning et al., 2016; Parker et al., 2022; Riley et al., 2023). To improve adherence to both counseling and pharmacotherapy, it is essential to understand the factors influencing treatment adherence, especially in populations experiencing disparities. Factors such as sociodemographic variables (e.g., age, gender, race/ethnicity, education, SES, marital status, health insurance, and geographical location) (Kushnir et al., 2017; Lopes de Oliveira et al., 2022), clinical variables (e.g., mental health and comorbidities), and smoking-related characteristics (e.g., history of quit attempts and substance use) (Crawford et al., 2019; Walton et al., 2019), are associated with smoking cessation outcomes, and may also be related to tobacco treatment adherence.

Despite the importance of treatment adherence for successful smoking cessation, there is limited research examining factors associated with adherence to counseling and pharmacotherapy, particularly among socioeconomically disadvantaged groups. Therefore, the current study aimed to characterize adherence to tobacco cessation counseling and pharmacotherapy among adults making a quit attempt and to identify socioeconomic, demographic, tobacco use, and mental health/substance use characteristics associated with treatment adherence.

2. Methods

2.1. Participants

Between October 2016 and August 2019, 649 adult smokers were enrolled in the Tobacco Treatment Research Program (TTRP). The TTRP is a publicly available program in Oklahoma City, Oklahoma, that offers free tobacco cessation counseling and pharmacotherapy and provides paid opportunities for individuals to participate in tobacco intervention studies (Boozary et al., 2021). Individuals enrolled in other treatment trials were excluded from the current study analyses, resulting in an analytic sample size of 442 participants. Eligible individuals were at least 18 years old and interested in quitting tobacco.

2.2. Procedures

During the enrollment visit, participants met with a Tobacco Treatment Specialist and were encouraged to set a quit date for one week later. Informed consent was obtained during the in-person enrollment visit. Participants were offered six weekly counseling sessions, either in person or by phone, from 1 week before the scheduled quit date (i.e., enrollment visit) through 4 weeks post-quit date. The counseling sessions covered the following topics: 1) the impact of tobacco on the health/benefits of quitting, 2) stress management techniques, 3) adopting healthy lifestyle changes, 4) developing coping strategies, and 5) preventing relapse.

Participants were provided with combination nicotine replacement therapy (NRT; patch + gum or lozenge) for up to 12 weeks. Varenicline or bupropion was prescribed for those who preferred not to use NRT or had contraindications (e.g., recent myocardial infarction or uncontrolled hypertension). Participants were followed for 26 weeks, with key assessments at 12 and 26 weeks post-quit date. Medication adherence was assessed weekly during the first four weeks following the quit date as a general indicator of early adherence. After this period, adherence was not closely monitored, as assessments were less frequent (i.e., at 12- and 26-week follow-ups). The institutional review board at the University of Oklahoma (IRB #6951) approved this study, and informed consent was obtained from all participants.

2.3. Measures

2.3.1. Outcome variables

Medication Adherence. Medication adherence was assessed weekly during post-quit weeks 1–4 with the Medication Adherence Questionnaire (MAQ) (Morisky et al., 1986), a four-item self-report instrument. Participants responded yes (0) or no (1) to individual items that inquired about their medication adherence over the past week. The items were summed to provide a total score, with higher scores indicating greater medication adherence. The number of weeks with moderate/high medication scores (2 or more) was summed to identify the number of weeks with moderate/high medication adherence. Responses were then categorized using the cutoff of 3 weeks of moderate/high adherence ($\geq$3 vs. $<$ 3). The 3-week cutoff was based on evidence that early adherence to smoking cessation pharmacotherapy is critical for long-term success, as it reduces withdrawal symptoms and cravings, increasing the chances of sustained abstinence (Patnode et al., 2021; Schnoll et al., 2016). Research also shows that lower adherence thresholds can still yield meaningful outcomes in disadvantaged groups, where partial adherence may lead to significant health improvements (Johnson et al., 2020; Sweitzer et al., 2013). This cutoff reflected real-world challenges and aimed to balance clinical efficacy with practical implementation in at-risk populations.

Counseling Adherence. Counseling adherence was operationalized as the number of counseling sessions completed over the 6-week counseling period, with a possible range of 1–6 completed sessions (all participants completed the enrollment session). High counseling adherence was categorized based on a cutoff of 4 counseling sessions (≥4 vs. < 4). This is consistent with clinical guidelines, which recommend completing 4 or more counseling sessions for optimal smoking cessation outcomes (Foulds, 2024; Kotsen et al., 2019; Tobacco, 2008).

2.3.2. Predictor variables

Sociodemographic Characteristics. Participants reported their age (in years), biological sex (female vs. male), race (distinguished between racially minoritized groups—Black/African, American Indian/Alaska Native, Latinx/Hispanic, Multirace—or White), minoritized sexual/gender identity (yes vs. no), marital status (married/living with significant other vs. not), years of education, annual income (<$21,000 vs. ≥$21,000), employment status (working full-/part-time vs. not employed), health insurance status (uninsured/Medicaid vs. other insurance), and rurality of residence (measured by mapping the distance between their address and the clinic; rural vs. not rural).

Depression. Depression was measured via the Patient Health Questionnaire-9 (PHQ-9) (Spitzer et al., 1999) and the Center for Epidemiological Studies Depression Scale-10 (CESD-10) (Andresen et al., 1994). The PHQ–9 contains nine items with scores ranging from 0 (not at all) to 3 (nearly every day). Probable major depression was indicated if ≥ 5 of the symptoms were present for at least "more than half the days." The CESD-10 is a 10-item self-report measure that rates the frequency of depressive symptoms over the past week on a 4-point scale (0 = rarely to 3 = most of the time). Total scores ranged from 0 to 30, with higher scores indicating greater distress. Total scores ≥ 10 indicated clinically significant depression (Andresen et al., 1994).

Alcohol Use. Past 7-day alcohol use was assessed via the Alcohol Quantity and Frequency Questionnaire (Room, 1990). Participants reported how many standard drinks they consumed on each of the previous seven days of the week. Daily drinks were summed to calculate the total consumed over the past seven days. Reports of > 7 drinks among women and > 14 drinks for men over the past week were considered heavy drinking. Standard drink conversion charts were provided to help participants accurately recall their alcohol consumption. Additional items assessed binge drinking episodes, defined as consuming ≥ 4 (females) or ≥ 5 (males) alcoholic drinks on a single occasion on any of the past seven days (Centers for Disease Control and Prevention, 2012). This variable was based on self-reported data regarding the number of drinks consumed in one day.

Tobacco Use Characteristics. Several variables characterized tobacco use: average number of cigarettes smoked per day, years of smoking, previous quit attempts for at least 24 h, menthol cigarette use (menthol/non-menthol/both), smoking among other household members (living with someone who smokes or not), heaviness of smoking (which assessed level of daily smoking and time to first cigarette upon waking in the morning [≤5 min vs. > 5 min]) (Kozlowski et al., 1994), and past 30-day use of other tobacco product use (e.g., e-cigarettes, chewing tobacco, cigars, hookah, snus). Expired carbon monoxide was measured in parts per million at baseline as an indicator of smoking level (Benowitz et al., 2020).

Psychological Variables. Confidence in coping with high-risk situations without relapsing was measured using nine items from the 18-item self-efficacy scale, with response options on a 5-point Likert scale from 1 (not at all confident) to 5 (extremely confident) (Velicer et al., 1990). The scale has three domains, each with three items: positive/social, negative/affective, and habit/addictive situations. Higher scores indicate greater confidence in coping without relapsing. The scale has demonstrated good reliability and validity (Velicer et al., 1990). The self-efficacy variables were categorized into quantiles to allow for a more detailed examination of their relationship with adherence outcomes.

2.4. Data analysis

Descriptive statistics were generated for all study variables. Logistic regression analysis was used to evaluate possible predictors (i.e., sociodemographic, mental health and alcohol use, smoking, and additional psychological variables) of treatment adherence using the dichotomized medication and counseling adherence variables. A significance level of $p < 0.05$ was used in the study, and all analyses were conducted using SAS 9.4.

3. Results

Participant Characteristics. Most participants were female (n = 243; 55.0 %) and racially minoritized (n = 187; 42.3 %), with 27.4 % identifying as Black. The average age was 53 years (SD = 12), and 41.9 % (n = 185) were married or living with a significant other. Seventy-four (n = 74; 16.7 %) participants resided in rural areas, and 10.6 % (n = 47) identified as sexual or gender minoritized. While 14.7 % (n = 65) participants were classified as having probable Major Depression Disorder (PHQ score ≥ 5), a higher proportion, 44.8 % (n = 198), scored ≥ 10 on the CESD scale. Four in ten participants (n = 179; 40.5 %) reported alcohol use in the past 30 days, with ~ 10 % (n = 41) reporting binge drinking and 11 % (n = 48) reporting heavy drinking in the past week. Participants smoked an average of 16 cigarettes per day (SD = 10) for an average of 30 years (SD = 15). More than half (n = 261; 59.0 %) had attempted to quit smoking at least once for 24 h or more. Table 1 provides a summary of these characteristics.

Medication and Counseling Adherence. Approximately 55 % (n = 242 out of 442) of participants attended four or more counseling sessions, while fewer (34.6 %, n = 148 out of 428) exhibited moderate-to-high medication adherence scores for at least 3 weeks. Table 2. contains a summary of these statistics.

Predictors of Counseling Adherence. Greater age (OR = 1.03, 95 % CI, 1.01–1.04; $p < 0.01$), White race (OR = 1.85, 95 % CI, 1.26–2.71; $p < 0.01$), more years of education (OR = 1.09, 95 % CI, 1.00–1.18; $p < 0.05$), past week alcohol use (OR = 1.58, 95 % CI, 1.08–2.33; $p < 0.05$), heavy drinking during the past seven days (OR = 1.95, 95 % CI, 1.03–3.70; $p < 0.05$), more years of smoking (OR = 1.02, 95 % CI, 1.00–1.03; $p < 0.05$), higher overall self-efficacy, Quantile 4 (≥3) vs 1 (<1.89) (OR = 2.09, 95 % CI, 1.25–3.48; $p < 0.01$) and positive self-efficacy, Quantile 4 (≥3) vs 1 (<2) (OR = 1.86, 95 % CI, 1.14–3.02; $p < 0.05$) were predictive of completing ≥ 4 counseling sessions. Conversely, being uninsured or having Medicaid insurance (OR = 0.63, 95 % CI, 0.43–0.93; $p < 0.05$), having high levels of distress (CESD score of ≥ 10) (OR = 0.60, 95 % CI, 0.41–0.88; $p < 0.01$), and reporting a menthol cigarette preference (OR = 0.52, 95 % CI, 0.34–0.79; $p < 0.01$) were associated with completing fewer counseling sessions.

Predictors of Medication Adherence. Smoking both menthol and non-menthol cigarettes (OR = 0.24, 95 % CI, 0.07–0.87, $p < 0.05$), living with someone who smokes (OR = 0.60, 95 % CI, 0.38–0.95, $p < 0.05$), and higher expired carbon monoxide levels (CO, ppm) (OR = 0.98, 95 % CI, 0.96–1.00, $p < 0.05$) were associated with lower odds of higher medication adherence. The full logistic regression results are displayed in Table 3.

4. Discussion

This study characterized adherence to smoking cessation counseling and pharmacotherapy and identified correlates of treatment adherence among adults receiving smoking cessation treatment in a community clinic. Overall, the majority of participants completed ≥ 4 counseling sessions in alignment with current treatment guidelines (Fiore, 2009; Shields et al., 2023). However, participants were considerably less adherent to their smoking cessation medication. Several key factors associated with adherence to behavioral counseling and medication were identified, including sociodemographic (age, race, and insurance

Table 1
Clinical and sociodemographic, mental health/substance use, and tobacco use characteristics of participants.

Participants in TTRP only (not in RCT), n = 442	n (%) or mean (SD)
Sociodemographics	
Age (years)	52.8 (12.3)
Female	243 (55.0 %)
Racially/ Minoritized*	187 (42.3 %)
Black±	123 (27.8 %)
Hispanic±	17 (3.9 %)
Minoritized sexual and/or gender identity±	47 (10.6 %)
Married/living with significant other	185 (41.9 %)
Education±	12.7 (2.3)
<$21,000 annual household income±	227 (51.4 %)
Working full/part time±	293 (66.3 %)
Uninsured/Medicaid±	187 (42.4 %)
Distance from clinic	15.5 (26.8)
Rural address	74 (16.7 %)
Mental Health and Alcohol Use	
Probable Major Depressive Disorder	65 (14.7 %)
CESD score ≥ 10±	198 (44.8 %)
Past week alcohol use	179 (40.5 %)
Binge drinking	41 (9.3 %)
Heavy drinking	48 (10.9 %)
Smoking Variables	
Cigarettes smoked per day (before quit date) ±	16.2 (10.2)
Years of smoking	30.3 (14.7)
Lifetime # of quit attempts lasting ≥ 24 h±	
0	43 (9.7 %)
1–5	261 (59.0 %)
6–10	58 (13.1 %)
11 or more	79 (17.9 %)
Menthol cigarette use±	
Non-Menthol	284 (64.3 %)
Menthol	131 (29.6 %)
Both	26 (5.9 %)
Lives with a person who smokes±	183 (41.4 %)
Smoke ≤ 5 min of waking	174 (39.4 %)
Heaviness of Smoking Index score	3.0 (1.6)
Any past 30-day other tobacco product use	199 (45.0 %)
Any past 30-day e-cigarette use	86 (19.5 %)
Number of other tobacco products used in the past 30 days	0.60 (0.82)
Baseline CO, ppm±	16.1 (12.1)
Additional Psychological Variables	
Self-efficacy	
Overall	2.4 (0.9)
Habit/addictive	2.6 (1.0)
Positive/social	2.5 (1.0)
Negative/affective	2.2 (1.0)

* Racially Minoritized participants were Black/African (64.7 %), American Latinx/Hispanic (7.5 %), American Indian/Alaska Native (10.7 %), Multirace/Other (17.1 %; 75 % of which identified one of their races as American Indian/Alaska Native). ±Some missing data.

Table 2
Descriptive statistics of treatment adherence variables.

Variable	n (%)
4 or more counseling sessions vs. < 4	242/442 (54.8 %)
3 or more moderate/high med scores vs. < 3	148/428 (34.6 %)

status), mental health and alcohol use (depression, alcohol use, and heavy drinking), smoking characteristics (years of smoking, menthol cigarette preference, living with someone who smokes, expired CO levels), and psychological (self-efficacy) variables. These findings highlight a variety of smoking-related vulnerabilities present within this population. Although many of the identified risk factors for poor counseling adherence are not directly modifiable, it is likely that

Table 3
Logistic regression models of correlates of adherence.

	Counseling Sessions	Moderate/high Medication Adherence
Characteristics	OR (95 % CI)	OR (95 % CI)
Sociodemographic Variables		
Age (years)	**1.03**	1.01
	(1.01–1.04)**	(0.99–1.02)
White (vs. racially minoritized)	**1.85**	1.19
	(1.26–2.71)**	(0.74–1.90)
Uninsured/Medicaid (vs. other insurance)	**0.63**	0.93
	(0.43–0.93)*	(0.59–1.49)
Mental Health and Alcohol Use Variables		
CESD score ≥ 10	**0.60**	0.79
	(0.41–0.88)**	(0.50–1.26)
Past week alcohol use	**1.58**	0.90
	(1.08–2.33)*	(0.57–1.42)
Past week heavy drinking (vs. no heavy drinking)	**1.95**	1.36
	(1.03–3.70)*	(0.68–2.73)
Smoking Variables		
Years of smoking cigarettes or cigarillos	**1.02**	1.00
	(1.00–1.03)*	(0.99–1.02)
Menthol cigarette preference		
Menthol (vs. non-menthol)	**0.52**	1.03
	(0.34–0.79)**	(0.61–1.74)
Both menthol and non-menthol (vs. non-menthol)	0.48	**0.24**
	(0.21–1.08)	**(0.07–0.87)***
Lives with a smoker	1.12	**0.60**
	(0.77–1.64)	**(0.38–0.95)***
CO, ppm	0.99	**0.98**
	(0.98–1.01)	**(0.96–1.00)***
Additional Psychological Variables		
Self-efficacy overall		
Quantile 2 (1.89 to < 2.44) vs 1 (<1.89)	1.08	0.81
	(0.63–1.86)	(0.42–1.58)
Quantile 3 (2.44 to < 3) vs 1 (<1.89)	1.28	0.97
	(0.77–2.15)	(0.51–1.83)
Quantile 4 (≥3) vs 1 (<1.89)	**2.09**	1.29
	(1.25–3.48)**	(0.71–2.35)
Self-efficacy positive		
Quantile 2 (2 to < 2.33) vs 1 (<2)	1.18	1.04
	(0.66–2.12)	(0.51–2.13)
Quantile 3 (2.33 to < 3) vs 1 (<2)	1.18	1.09
	(0.66–2.11)	(0.53–2.21)
Quantile 4 (≥3) vs 1 (<2)	**1.86**	1.65
	(1.14–3.02)*	(0.92–2.98)

OR = Odds Ratios; CI = Confidence Intervals; *$p < 0.05$; **$p < 0.01$.

participants in high-risk demographic groups, particularly socioeconomically disadvantaged and those with mental health challenges, may benefit from targeted adherence interventions.

Adherence to counseling sessions and proper use of NRT have been reported to be associated with improved tobacco abstinence outcomes (Stead et al., 2016). However, socioeconomically disadvantaged adults continue to experience higher smoking prevalence and poorer adherence to cessation treatments (Cropsey et al., 2021). This study, therefore, fills a critical gap in the literature and highlights the importance of medication and counseling adherence as a precursor to successful tobacco abstinence. Specifically, interventions can be best tailored to target populations by identifying factors linked to better adherence, ensuring that medication and counseling efforts—individually or in combination—are most effective.

4.1. Sociodemographic variables

Sociodemographic factors played a key role in adherence outcomes. Greater age, and non-Hispanic White race were positively associated with counseling adherence. These findings are consistent with previous

research showing that older individuals are more likely to engage with and complete counseling sessions (Pacek et al., 2014; Stead et al., 2016). In addition, White participants were more likely to attend counseling sessions, which may reflect broader trends in healthcare access disparities (Kulak et al., 2016; Pacek et al., 2014). Conversely, being uninsured or having Medicaid insurance was negatively associated with counseling adherence, highlighting the well-documented disparities in healthcare utilization among underserved populations (Meredith et al., 2023; Siemer et al., 2020). For example, individuals with low SES are less likely to engage in and are more prone to dropping out of tobacco cessation counseling sessions due to lower literacy levels, housing insecurity, and transportation challenges (Courtney et al., 2017; Cropsey et al., 2021; Walton & Herrmann, 2023). While the clinic offered free treatment, the relationship between healthcare access and insurance status remains unclear and warrants further exploration.

4.2. Mental health, alcohol Use, and smoking variables

Mental health comorbidity, specifically depression, was a significant predictor of lower adherence to counseling sessions. Similar to findings from other studies (Hahad et al., 2022; Weinberger et al., 2020), individuals with depression were less likely to complete counseling sessions. Addressing depressive symptoms at the outset of cessation treatment may yield incremental benefits in improving adherence in this population, given the high prevalence of depression among adult smokers (Weinberger et al., 2020). Interestingly, alcohol use and heavy alcohol use were associated with increased engagement in counseling sessions. Although heavy drinking and long smoking histories have been linked to poor medication adherence (Rojewski et al., 2017; Scheuermann et al., 2019), little is known about their relationship with counseling adherence. One potential explanation is that individuals with a history of substance abuse treatment may be more receptive to counseling services. Notably, high self-efficacy at baseline was associated with completing ≥ 4 counseling sessions. This finding is further supported by our model, which showed a positive association between self-efficacy and engagement in tobacco counseling. Although overall self-efficacy scores were low in our study, this may be due to our sample largely consisting of older individuals with long smoking histories, which may have affected their confidence in their ability to change their smoking behavior. Nonetheless, high self-efficacy is a key factor in driving behavioral change, and smokers with greater self-efficacy are more likely to engage in cessation efforts (Tseng et al., 2017; Wei et al., 2024). Therefore, enhancing self-efficacy could be an essential strategy for improving counseling adherence.

4.2.1. Menthol use

Menthol use was associated with lower odds of treatment adherence in both models. Research has shown that menthol smokers tend to have greater nicotine dependence due to menthol's cooling and anesthetizing effects, which can reinforce smoking behavior and make cessation more difficult (Cohn et al., 2020; Okuyemi et al., 2004). Menthol use is also more common among minoritized populations and individuals with low SES, contributing to disparities in smoking cessation outcomes (Ehlke et al., 2022).

Our post-hoc analysis further explored these findings and showed that menthol smokers in our study were more likely to be racially minoritized, identify as sexual/gender minorities, and they reported additional socioeconomic barriers, such as lower income and rural residence. These results align with existing literature that highlights the disproportionate impact of menthol smoking on at-risk populations (Cohn et al., 2020; Seaman et al., 2022). This underscores the need for culturally sensitive smoking cessation interventions tailored to the unique needs of menthol smokers to reduce morbidity and mortality rates.

Reducing access to menthol cigarettes could be an effective strategy to enhance the impact of cessation interventions for menthol users. Culturally tailored interventions that address the complex interplay of risk factors, including minoritized sexual/gender identity, race/ethnicity, and SES, are critical. For example, Canadian provinces that banned menthol cigarettes saw a significant increase in quit attempts and successes, alongside a reduced risk of relapse (Chung-Hall et al., 2022). The Food and Drug Administration (FDA) is also considering banning menthol in cigarettes and cigars to prevent tobacco initiation and reduce disparities (U.S Food and Drug Administration, 2022). Menthol is often a "starter" product for new smokers and is disproportionately used by Black/African American and Hispanic/Latino communities (Villanti et al., 2019). Our study findings highlight the significance of this ban in addressing disparities in smoking cessation, particularly among at-risk populations.

Smoking-related characteristics, such as living with a smoker and elevated CO levels, were associated with lower odds of medication adherence in our study. This aligns with findings from other studies showing that living in a household with smokers often presents significant barriers to successful cessation efforts (Nagawa et al., 2020; Nagawa et al., 2022). Research suggests that smokers in environments with other smokers face higher relapse rates due to social and environmental cues that trigger smoking urges, making it more challenging to maintain abstinence or adhere to treatment regimens (Nagawa et al., 2020; Nagawa et al., 2022).

Similarly, elevated CO levels, which indicate more frequent or recent smoking, have been associated with lower treatment adherence (Karelitz et al., 2021). This could reflect higher nicotine dependence or continued exposure to smoking environments, both of which make quitting more difficult. Individuals with higher CO levels are often less responsive to cessation interventions, as they may struggle with stronger withdrawal symptoms and cravings (Schnoll et al., 2016). Both factors underscore the importance of addressing social and environmental influences in smoking cessation programs.

This study has limitations. First, using a 3-week cutoff for medication adherence, while reflective of real-world challenges, may limit direct comparisons with studies that have used an 80 % adherence threshold (Siemer et al., 2018; Walton & Herrmann, 2023). This could make aligning our findings with broader literature more challenging. Future studies could explore varying adherence cutoffs to better capture meaningful behavior change across different populations. Additionally, the self-reported nature of medication adherence could introduce recall bias or misreporting, though the measures of adherence used have been used in similar settings (Boozary et al., 2021; Fucito et al., 2009). We were also unable to differentiate adherence by specific medications (NRT, bupropion, or varenicline), limiting our ability to explore potential differences in adherence patterns across treatments.

While this study was enriched with the participation of minoritized individuals often underrepresented in research, individuals with limited English proficiency (e.g., primarily Spanish speakers) may have been underrepresented. Furthermore, the attitudes of healthcare providers, educators, and tobacco treatment specialists towards medication adherence and counseling were not assessed, which could provide valuable insights for future research (Hall & Heath, 2021). Due to the observational design of this research, our study findings are susceptible to selection bias, and we cannot establish causal relationships between outcome and predictor variables. Moreover, we did not assess important personal and contextual variables linked to adherence, such as medication side effects (Hays et al., 2010), perceived severity of health risks, and cultural beliefs. Future studies could incorporate these factors to achieve a more comprehensive understanding. Despite these limitations, our study's focus on adherence to pharmacotherapy and counseling among socially disadvantaged adults, alongside the broad range of factors influencing adherence, is a notable strength.

5. Conclusion

This study characterized modifiable and non-modifiable correlates of

adherence to tobacco pharmacotherapy and behavioral counseling among adults in a tobacco cessation treatment. Our findings provide an essential framework for identifying specific subpopulations that may benefit the most from tailored interventions. Future longitudinal studies are needed to explore the potential effects of mediating variables not examined in this study, such as access to treatment and provider perceptions of treatment adherence.

Culturally specific interventions are also needed to improve adherence among individuals with lower SES, younger people, and racially minoritized groups who all had lower treatment adherence rates. Despite declining tobacco use in the U.S., these populations still experience high smoking rates and lower cessation success. Tailored interventions could help reduce these disparities.

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Contributors: Motolani Ogunsanya conceived the study, supervised the analyses, and led the writing. Summer Frank-Pearce conceived the study, led the analyses and interpretation of the findings, and assisted with writing. Darla Kendzor conceived the study, supervised the analyses, and assisted with the writing. Sixia Chen completed the analyses and interpretation of the findings. Munjireen Sifat, Amy Cohn, and Michael Businelle assisted with interpreting findings and writing. Motolani Ogunsanya wrote the first draft of the manuscript, and all authors commented on the manuscript. All authors contributed to the writing and editing of the manuscript and approved the final manuscript.

Conflict of Interest: Kendzor is a member of the Scientific Advisory Board of Qnovia. Inc., which is a drug development company focused on inhaled therapies including prescription inhaled nicotine replacement therapy for smoking cessation (not used or evaluated in the current study). Kendzor previously received medication (varenicline) at no cost from Pfizer to support a now completed pilot study. The other authors have no relevant financial or non-financial interests to disclose.

Author Agreement Statement.

All authors declare that this manuscript is original, has not been published before, and is not currently being considered for publication elsewhere. We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us. We understand that the Corresponding Author is the sole contact for the Editorial process. She is responsible for communicating with the other authors about progress, submissions of revisions, and final approval of proofs.

CRediT authorship contribution statement

Motolani E. Ogunsanya: Writing – original draft, Visualization, Validation, Supervision, Funding acquisition, Conceptualization. **Summer G. Frank-Pearce:** Writing – review & editing, Visualization, Validation, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Sixia Chen:** Writing – review & editing, Visualization, Formal analysis, Data curation, Conceptualization. **Munjireen Sifat:** Writing – review & editing, Visualization, Investigation. **Amy M. Cohn:** Writing – review & editing, Validation, Supervision, Investigation. **Michael S. Businelle:** Writing – review & editing, Supervision, Funding acquisition, Data curation. **Darla E. Kendzor:** Writing – review & editing, Visualization, Validation, Supervision, Methodology, Funding acquisition, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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