Original investigation

Examination of the Wisconsin Inventory of Smoking Dependence Motives (WISDM-68) Factor Structure in a Sample of Pregnant Smokers

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Abstract

Introduction: Smoking during pregnancy poses known risks to fetal and infant development. Women who continue to smoke during pregnancy exhibit higher levels of nicotine dependence than women who quit. Increased understanding of the construct of nicotine dependence in pregnant smokers may aid in the development of effective treatments. Research has suggested that nicotine dependence is a multifaceted construct, driven not only by withdrawal and tolerance processes, but also by reinforcement, sensory, and contextual processes. The Wisconsin inventory of smoking dependence motives (WISDM-68) assesses 13 varied smoking motives in order to assess processes that may lead to nicotine dependence.

Methods: The factor structure of the WISDM-68 was explored using an ethnically diverse sample of 294 pregnant women who had been screened and/or enrolled in a smoking cessation treatment study. Confirmatory analyses were conducted with previously published models. An exploratory factor analysis and exploratory structural equation modeling (ESEM) were conducted to develop and validate a measurement model for the WISDM-68 in this sample.

Results: Previously established models were not a good fit for the present data. Using ESEM, a 9-factor model exhibiting both predictive and concurrent validity emerged. Two factors predicted abstinence 6 months posttreatment. Several factors were associated with smoking heaviness, the Fagerström test for cigarette dependence and time to first cigarette.

Conclusions: In contrast to previously published studies, a 9-factor model best characterizes the WISDM in the present sample. These findings may reflect smoking motivations unique to young, pregnant women who continue to smoke during pregnancy.

Introduction

Nicotine dependence has been identified as an important factor maintaining smoking behaviors in adults¹ and is assigned a heavy explanatory and clinical burden.²⁻⁴ Nicotine dependence, assumed to be a function of dependence-tolerance processes, is often measured by the degree to which withdrawal symptoms are experienced and by the number of cigarettes consumed per day.^{5,6} However, recent evidence suggests that nicotine dependence may be multidimensional in nature. Smokers report smoking for reasons beyond withdrawal and habit, often citing smoking for pleasure, relaxation, boredom, and other physical and emotional reasons.⁷⁻¹⁰

Piper and colleagues⁹ developed a multidimensional measure of nicotine dependence based on theoretically grounded motives for drug use intended to reflect underlying dependence mechanisms. The measure includes items reflecting non-tolerance based motives for smoking, in addition to motives impacted by the withdrawal-tolerance process. This theory-driven approach resulted in the development of the Wisconsin inventory of smoking dependence motives (WISDM-68), a 68-item measure comprised of 13 subscales assessing a wide variety of distinct motives that might drive tobacco use in smokers. Exploratory factor analyses have yielded a 2-factor solution comprised of primary dependence motives (PDM) and secondary dependence motives (SDM).¹¹ The PDM scale has been found to predict tobacco dependence measures of tobacco self-administration, including the Fagerström test of cigarette dependence (FTCD),^{5,6} cigarettes smoked per day, puff consumption, self-monitored endorsement of habitual or automatic motives for smoking individual cigarettes, and relapse.¹¹⁻¹⁵ Associations of the SDM scale to these tobacco consumption measures have been found to be nonsignificant or weaker than the PDM. However, the SDM is a stronger predictor of self-monitored endorsement of situational and instrumental motives for smoking individual cigarettes, and real-time endorsement of post-cessation craving and distress-related reactions to withdrawal.¹¹⁻¹⁴

Smoking during pregnancy is associated with increased rates of infant mortality and morbidity.¹⁶⁻¹⁸ Women who continue smoking during pregnancy have been found to be more nicotine dependent, to have lifetime histories of heavier smoking and more failed quit attempts than women who were regular cigarette smokers but did not smoke during pregnancy or only part of their pregnancy.^{19,20} However, among women who continue to smoke during pregnancy, nicotine dependence scores, as assessed by measures such as the FTCD, have been found to be lower during pregnancy than prepregnancy,^{21,22} falling in the low to moderate range of severity.²¹⁻²⁵ Lower scores are likely due to women's efforts to reduce smoking during pregnancy.^{26,27}

Data from a twin study indicate that 34% of variance in number of cigarettes smoked during pregnancy is due to heritable influences, with 66% variance related to nonshared environmental influences.¹⁹ Additional evidence for the importance of heritable influences come from a study that found continued smoking during pregnancy was associated with a SNP that lies within the nicotine acetylcholine receptor gene *CHRNA3*.²⁸ Among the potential environmental influences examined in the twin study noted above, low levels of educational attainment, problems with substance use, traumatic life events, social anxiety and conduct disorder were associated with cigarettes smoked during pregnancy.¹⁹ Other studies have also noted psychosocial and psychological differences between women who spontaneously quit during pregnancy and those who do not, although in some studies controlling for nicotine dependence, psychiatric factors and stress were no longer independent predictors (for

review see Massey and Compton²²; Gilman, Breslau, Subramanian, Hitsman, and Koenen²⁹).

There is preliminary evidence that the WISDM PDM subscales are related to genetic variants located on *CHRNA5-A3-B*, which have been previously found to be associated with susceptibility for nicotine dependence.^{7,30} Several studies have found mood and anxiety psychiatric diagnosis status to be related to the PDM composite scale and its subscales; and to theoretically relevant SDM subscales reflecting affective, cognitive enhancement, affiliative attachment, and lack of alternative reinforcer motives for smoking in pregnant and nonpregnant samples.³¹⁻³⁵ In a previous study that used the same sample as that of the current study, we found childhood trauma to be predictive of the PDM subscale of Tolerance and several SDM scales, with Negative Reinforcement having the greatest relative contribution to variance.³⁶

Altogether, these data suggest that motivations for continued smoking during pregnancy may be heterogeneous and represented by both PDM and SDM subscales. To the extent that the WISDM-68 provides information on primary and secondary motives that characterize groups of smokers who are at high risk for cessation failure, such as that of pregnant smokers,³⁷⁻³⁹ this measure may be of greater use than unidimensional measures in guiding effective and tailored smoking cessation treatments and in predicting relevant clinical outcomes following treatment. Thus, using structural equation modeling (SEM) the present study examines the measurement structure of WISDM-68 and its prediction of behavioral outcomes, in a sample of pregnant smokers participating in a smoking cessation treatment study.

Methods

Participants and Procedures

The present study utilized data from a study that examined the impact of a depression-focused smoking cessation treatment on both smoking abstinence and depressed mood in pregnant smokers. A more detailed description of study procedures, treatment, and outcomes is discussed in Cinciripini et al.³⁸ The study was approved by the institutional review board at The University of Texas MD Anderson Cancer Center.

A total of 294 participants were screened for the trial (Table 1). As detailed in the parent study,³⁸ 37 participants were not assessed for abstinence at the end of treatment because they were never exposed to treatment ($n = 28$) or had a miscarriage ($n = 9$). The remaining 257 participants constitute the intent-to-treat sample from that report.

Measures

Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) Mood Disorders

Mood disorders were assessed at screening using the mood module of the patient edition of the structured clinical interview for Axis I diagnostic and statistical manual of mental disorders, fourth edition (DSM-IV) disorders.⁴⁰ DSM-IV mood disorders have previously been found to be related to nicotine dependence and persistent tobacco use during pregnancy in several epidemiological studies.^{41,42}

WISDM-68

This 68-item measure assesses 13 theoretically-derived smoking motives, ranging from subjective, internally-experienced motives, to motives related to tolerance and withdrawal, as well as miscellaneous processes such as Taste and Sensory properties. The scale yields

Table 1. Demographic and Smoking-Related Characteristics at Baseline

Variable	N = 294
Age, M (SD)	25.3 (4.8)
Ethnicity	
White (%)	96 (32.65)
Black (%)	164 (55.78)
Other (%)	34 (11.57)
Education	
Less than high school (%)	102 (34.69)
High school/general equivalency diploma (%)	95 (32.31)
Vocational school, some college, or greater (%)	97 (32.99)
Marital status	
Married and living with partner (%)	52 (17.75)
Not married and living with partner (%)	68 (23.21)
Widowed, divorced, or separated (%)	31 (10.58)
Never married, in committed relationship (%)	63 (21.50)
Never married, not in relationship (%)	79 (26.96)
FTCD score, M (SD)	3.4 (2.1)
HIS, M (SD)	1.9 (1.4)
TTFC	
After 60 min (%)	65 (22.26)
31–60 min (%)	61 (20.89)
6–30 min (%)	102 (34.93)
Within 5 min (%)	64 (21.92)
Mood disorder	
No history of mood disorder (%)	49 (19.76)
Mood disorder, current or partial remission (%)	95 (38.31)
Mood disorder, history positive (%)	104 (41.94)
Age of onset, M (SD)	15.7 (3.8)
Cigarettes/day before discovering pregnancy, M (SD)	16.6 (9.2)
Cigarettes/day at baseline, M (SD)	10.4 (9.4)

FTCD = Fagerstrom test for cigarette dependence; HIS = heaviness of smoking index; M = mean; SD = standard deviation; TTFC = time to first cigarette.

both a composite score and individual subscale scores. Both overall and individual subscale scores demonstrate high internal consistencies and predict abstinence in smokers.⁹ In the parent study, the WISDM-68 was administered at baseline.

Abstinence

Abstinence was assessed in the 257 women who were included in the intent-to-treat analyses,³⁸ using the timeline follow back interview⁴³ which was conducted at every clinic visit and telephone contact. Prolonged abstinence was defined as a self-report of not smoking following end of treatment (visit 10), and a CO value of less than 10 ppm at each follow-up. Beginning at EOT, relapse was defined by either seven consecutive days of smoking, or smoking at least one cigarette over two consecutive weeks from EOT to 6-months following treatment.⁴⁴

The Fagerström Test for Cigarette Dependence (FTCD)

The FTCD is a widely-used 6-item questionnaire designed to assess subjective nicotine dependence⁵ that was administered at baseline. In pregnant smokers, the FTCD has been found to be related to denial of smoking-related health risk during pregnancy.⁴⁵

The Heaviness of Smoking Index

The heaviness of smoking index (HSI)⁴⁶ is composed of two items from the FTCD: time to first cigarette (TTFC) and total number of

cigarettes smoked per day. These items are strongly predictive of quitting⁴⁷ and appear comparable to the FTCD.⁴⁸ Higher scores on the HSI have been found to be associated with other measures of high tobacco exposure during pregnancy.⁴⁹

TTFC

The FTCD–TTFC⁶ assesses time to first cigarette after waking. Smokers who report smoking within the first 5 min of waking have demonstrated differences from those who smoke later in their levels of expired carbon monoxide, difficulty abstaining for one day, and total number of cigarettes per day. This item is also a better predictor of abstinence at one week and six months than other measures of nicotine dependence.⁵⁰ In pregnant women, shorter TTFC has been found to be associated with other measures of high tobacco exposure during pregnancy.⁴⁹

It should be noted that the FTCD, HSI, and TTFC are interrelated measures and should not be interpreted as independent sources of validation. All three are presented here to provide comparison to publications that report only one of these indices.

Statistical Analysis

Estimator

When conducting factor analyses, assumptions of normality for Likert scale variables produce biased estimates.⁵¹ Accordingly, we treated the WISDM-68 items as ordinal data and conducted confirmatory factor analyses (CFA) using robust unweighted least squares for ordered probit data with Mplus, version 7.1.⁵² This approach has the advantage of providing widely used fit indices popularized in the analysis of continuous data.

Fit Criteria

We used the chi-square fit index (χ^2), the root mean square error of approximation (RMSEA), the comparative fit index (CFI) and the Tucker-Lewis index (TLI). The χ^2 and RMSEA are both indices of the discrepancy between the predicted model and the observed data, with higher values indicating poorer fit. Because the χ^2 is highly sensitive to sample size, it is often significant in large samples and is often considered an overly stringent criterion.⁵³ The CFI and TLI are indices of goodness-of-fit, with higher values indicating better fit. Criteria for adequacy of fit followed Hu and Bentler:⁵⁴ RMSEA $\leq$ 0.06, CFI $\geq$ 0.95, and TLI $\geq$ 0.95.

Missing Data

Three participants were missing one item value on the baseline FTCD. Although the unweighted least squares estimator in Mplus assumes data missing completely at random, only 1.016% of observations have a missing value, so the results are unlikely to be changed by nonignorable missingness.⁵⁵ Thirty-seven participants were missing the sustained abstinence measurement. Twenty-eight participants failed to return after completing baseline measures and were never exposed to either study treatment. Nine participants miscarried during the trial, and miscarriage was not differentially distributed across treatment conditions. These missing observations meet the assumptions of the unweighted least squares estimator.

Measurement Model

CFA fitted four previously published measurement models to the sample of 294 participants screened eligible for the trial. The first model was a 1-factor model.⁹ The second model tested the higher

order 2-factor oblique model detailed in Piper et al.¹¹ The third measurement model was an 11-factor model using only the 37 items that comprise the Brief WISDM.⁵⁶ The fourth was a 13-factor model where each item loads only on a factor corresponding with a specific motivation subscale.⁹ In addition to those models, the association between WISDM-68 subscales and lifetime exposure to nicotine⁹ inspired a 3-factor oblique model that posits an early-emergent factor, a late-emergent factor, and a mixed factor.

Since the strict requirement of zero cross-loadings in CFA often does not reflect the complexity in the data (e.g., nonzero cross-loadings), we also conducted exploratory factor analyses (EFA) using oblique Geomin rotation, which is recommended when factor indicators may have substantial loadings on more than one factor.⁵⁷ Evaluation of 1 through 13-factor, exploratory models for fit used the criteria recommended by Hu and Bentler.⁵⁴ The final EFA factor solution balanced adequate fit statistics with model parsimony.

Validation Model

Statistical fit only provides a preliminary index of goodness-of-fit, so we also investigated the concurrent and predictive validity of the five confirmatory models, as well as the selected exploratory model.⁵⁸ SEM simultaneously evaluated concurrent and predictive validity; concurrent validity estimation used the full sample ($n = 294$) and predictive validity estimation used the intent-to-treat sample ($n = 257$). Evaluation of predictive validity examined the regression of prolonged abstinence at six months on the factors in each of the WISDM-68 measurement models. SEM assessed model validity by regressing the TTFC, HSI, and the FTCD total score on each of the five confirmatory models. Similarly, exploratory structural equation modeling (ESEM) evaluated the concurrent and predictive validity of the selected EFA measurement model.⁵⁷

Results

Examination of the internal consistency of each of the WISDM-68's 13 subscales indicated acceptable alpha-coefficients for each subscale, ranging from 0.91–0.80. Table 2 presents intercorrelations of the WISDM subscales and the measures used in the study.

Brief assessment of the concurrent validity of the WISDM-68 using the original scoring approach indicated weak to moderate

correlations between this measure and other measures of nicotine dependence and use. Correlations with the FTCD total score and the subscales of the WISDM ranged from $r = 0.15$ ($p < .01$) for the Social and Environmental Goads subscale to $r = 0.62$ ($p < .01$) for the Tolerance subscale. The total WISDM score and the total FTCD score yielded a correlation of $r = 0.46$ ($p < .01$). The number of cigarettes smoked per day resulted in weak correlations, ranging from $r = 0.24$ ($p < .01$) for the Taste and Sensory Properties subscale to $r = 0.38$ ($p < .01$) for the Craving subscale.

Measurement Model

None of the confirmatory models achieved all three criteria for adequate fit (Table 3). In terms of relative fit, the 13-factor model performed best on all indices, but the CFI (0.934) and TLI (0.930) were both below the recommended cutoff (0.95). Only the RMSEA (0.046) fell within the recommended range (below 0.06). Next, examination of the exploratory models using the same thresholds identified the 9-factor EFA model as the most parsimonious exploratory solution that met all the criteria for adequate model fit (Supplementary Table 14).

Validation Model

Since the confirmatory measurement models did not achieve criteria for adequate fit, subsequent analyses regarding the validity of the factor solution focused on the 9-factor EFA model using ESEM. The 9-factor ESEM model demonstrated concurrent validity, predictive validity, and adequate fit ($CFI = 0.972$, $TLI = 0.963$, and $RMSEA = 0.031$ $\chi^2(df = 2,010) = 2577.111$, p value $< .001$). Specifically, increasing scores on factor 1 were associated with longer time to first cigarette (B-weight = -0.144 , $p = .038$) and lower FTCD total score (B-weight = -0.132 , $p = .019$), while increasing scores on factor 9 were associated with shorter time to first cigarette (B-weight = 0.690 , $p < .001$), higher HSI scores (B-weight = 0.625 , $p < .001$), and higher FTCD total scores (B-weight = 0.613 , $p < .001$). Increasing scores on factor 3 were associated with higher HSI scores (B-weight = 0.138 , $p = .037$). Increasing scores on factor 7 were associated with shorter time to first cigarette (B-weight = 0.191 , $p = .014$). Increasing scores on factor 8 were associated with higher HSI scores (B-weight = 0.156 , $p = .047$) and higher FTCD total scores (B-weight = 0.201 , $p = .015$). With regard to predictive validity, increasing scores on factors 2 and

Table 2. Correlations Between Wisconsin Inventory of Smoking Dependence Motives (WISDM-68) Subscales, Nicotine Dependence Measures, and Prolonged Abstinence

WISDM subscale	FTCD total	HSI	TTFC	Six months prolonged abstinence
Affiliative Attachment	0.29*	0.26*	0.21*	-0.08
Automaticity	0.37*	0.35*	0.26*	-0.13*
Loss of Control	0.44*	0.39*	0.29*	-0.11
Behavioral Choice Melioration	0.37*	0.32*	0.27*	-0.07
Cognitive Enhancement	0.29*	0.23*	0.17**	-0.03
Craving	0.49*	0.48*	0.39*	-0.11
Cue Exposure-Associative Processes	0.39*	0.37*	0.32*	-0.10
Negative Reinforcement	0.33*	0.30*	0.24*	-0.10
Positive Reinforcement	0.35*	0.32*	0.26*	-0.10
Social-Environmental Goads	0.16**	0.16**	0.18**	-0.04
Taste and Sensory Processes	0.30*	0.26*	0.22*	-0.11
Tolerance	0.62*	0.59*	0.52*	-0.07
Weight Control	0.21*	0.17**	0.10	0.02

FTCD = Fagerstrom test for cigarette dependence; HSI = heaviness of smoking index; TTFC = time to first cigarette.

* $p < .05$.

Table 3. Summary Statistics for Confirmatory Measurement Models (CFA)

Model	<i>df</i>	χ^2	CFI	TLI	RMSEA	χ^2/df
1-factor, Piper et. al. ⁹	2,210	5601.536*	0.833	0.828	0.072	2.535
2-factor, Piper et. al. ¹¹	2,196	3979.401*	0.912	0.909	0.052	1.812
3-factor, Piper et. al. ⁹	2,192	4111.279*	0.905	0.902	0.054	1.876
11-factor, Smith et. al. ⁵⁶	574	1183.568*	0.934	0.923	0.060	2.062
13-factor, Piper et. al. ⁹	2,132	3467.133*	0.934	0.930	0.046	1.626

CFI = comparative fit index; *df* = degrees of freedom; RMSEA = root mean square error of approximation; TLI = Tucker-Lewis index.

**p* < .001.

Table 4. Predictive Validity for 9-Factor Exploratory Structural Equation Modeling (ESEM) Model: Probit Regression Onto Prolonged Abstinence

Factor	Estimate	SE	Two-tailed <i>p</i> value
F1	0.105	0.119	.376
F2	-0.237	0.11	.031*
F3	-0.239	0.115	.037*
F4	0.001	0.11	.996
F5	0.070	0.092	.444
F6	-0.062	0.104	.551
F7	-0.108	0.118	.361
F8	0.155	0.111	.163
F9	0.041	0.116	.727

**p* < .05.

3 were associated with decreased probability of prolonged abstinence at six months (Table 4). An additional model, covarying for treatment group in the prediction of abstinence, did not alter these results. Finally, ESEM evaluated the fit of the more parsimonious 1–8 factor exploratory models, and they all failed to predict abstinence, leaving the 9-factor ESEM model as the most parsimonious model that demonstrates adequate fit, concurrent validity, and predictive validity (See Supplementary Tables 1–9 for factor loadings, Supplementary Table 10 for factor correlations and Supplementary Tables 11–13 for full concurrent validity results.)

Discussion

The purpose of this study was to examine the factor structure of the WISDM-68 in a population of pregnant smokers trying to quit. To do this, a variety of confirmatory models were tested; however these models did not demonstrate adequate indices of fit, likely due to the strong requirement of zero cross-loadings in CFAs.⁵⁷ ESEM was employed and a 9-factor model was most parsimonious. This model demonstrated both concurrent validity with other well-established measures of nicotine dependence as well as predictive validity with smoking abstinence at six months posttreatment. Although rejecting the previously reported models comes at the cost of reduced comparability, those models failed to demonstrate adequate statistical fit or predictive validity in this sample.

All subscales of the WISDM-68 exhibited sufficient internal consistency ($\alpha \geq 0.80$); however, this is slightly lower than reported by Piper, et al.⁹ who found alpha-coefficients exceeding 0.9 for all subscales. Results indicated weak to moderate correlations with the FTCD, which is lower than some previous studies,^{13,15} but similar to others.^{14,56} This finding may be impacted by the low level of dependence in this young sample of smokers. Mean FTCD scores in the sample ($M = 3.4$) fell in the low to moderate range of nicotine

dependence. This level of dependence is lower than that of smokers in many of the studies that have evaluated the WISDM in older samples,^{11,15,59} but is similar to that of a young adult sample of smokers⁶⁰ and samples of pregnant smokers participating in smoking cessation intervention trials.^{21,23,61} Few studies have evaluated the WISDM in young, less dependent samples of smokers. One study has evaluated the WISDM in two samples of college smokers. Correlations between individual WISDM scales and the FTCD in the current study were very similar to findings in one of the college samples that had a mean FTCD of 1.6.¹⁴ Thus, our findings on the relationship of WISDM-68 subscales and nicotine dependence concur with the limited research that has been done to date in less dependent samples of smokers, where nicotine dependence may be less likely to be driven solely by tolerance and withdrawal processes, relative to older groups of smokers.

The factor structure observed in this sample differs from previous research, which has identified two higher order factors: PDM and SDM. The PDM factor may index core features of tobacco dependence and contains the Loss of Control, Craving, Automaticity, and Tolerance subscales. This factor has been found to be associated with smoking heaviness and operant self-administration.^{11,14} These motives are major components of factor 9 in the present study. However, factor 9 motives explained the smallest amount of variance among the factors produced by the ESEM. The SDM factor contains the remaining nine WISDM-68 subscales and is more strongly related to operant self-administration and withdrawal from cigarettes.¹³ Piper et al.¹¹ hypothesizes that PDM are related to longer-term nicotine use, whereas SDM may be more important in the development of nicotine dependence. In this relatively young sample, it is possible that participants have not been smoking long enough for their smoking to be driven by PDM.

The 9-factor model exhibited predictive validity. The factors 2 and 3 from this model predicted smoking abstinence at six months posttreatment. Factor 2 is best characterized by items from the Taste and Sensory Processes, and factor 3 is best characterized by items from the Loss of Control and Cue Exposure-Associative Processes subscales. In this sample, participants were less likely to be abstinent at six months posttreatment if they reported finding pleasure in the act of smoking and its associated physical and sensory properties and/or who felt their smoking was out of their conscious control and were cued by external reminders to smoke. The significance of the Taste and Sensory Processes factor is somewhat unique in the literature. However, the WISDM Taste and Sensory properties subscale has been found to be associated with taste sensitivity genetic variants that predict smoking risk.⁶² These same genetic variants have been found to be related to the FTCD and HSI in Black female smokers.⁶³ These findings suggest that Taste and Sensory motives may be linked to genetic influences that contribute to core dependence motives; and

these motives, although considered secondary in the WISDM 2-factor model,⁹ may play a more significant role in early emergence of dependence, as would be the case in our young sample.

The model exhibited concurrent validity with several tolerance-based measures of nicotine dependence (HSI, TTFC, and FTCD total score) that are heavily weighted for assessment of time to first cigarette after waking. Factor 9, which is best characterized by two items from the Tolerance subscale assessing time to first cigarette, was unsurprisingly positively associated with all three of these measures. Interestingly, factor 1, which accounted for most of the variance of the measure in this sample, negatively predicted these measures, where higher scores on this factor predicted lower HSI and FTCD and greater time to smoke from waking. Factor 1 can be characterized as Instrumental Smoking and consists of items from the Cognitive Enhancement, Negative Reinforcement, Positive Reinforcement, and Behavioral Choice-Melioration subscales. If smokers cited cognitive enhancement or negative reinforcement as motivations to smoke, they were less likely to report tolerance-based symptoms of nicotine dependence. Similar findings have been noted in two samples of college smokers¹⁴ and in a laboratory study which found SDM to be negatively related to the amount of puffs smokers were willing to work for under differing fixed ratio reinforcement schedules.¹³ This suggests that treatments for pregnant smokers may require greater emphasis on these affective and instrumental smoking motives, in addition to strategies for addressing tolerance-based motives. Additionally, factor 7, which contains items highlighting a relationship or emotional bond with cigarettes, was predictive of shorter time to smoke in the morning. Factor 3 positively predicted heaviness of smoking and factor 8 positively predicted the total FTCD score; these factors were best represented by a variety of items assessing perceived smoking heaviness and out of control smoking, respectively.

The participants' relatively young age may play an important role in the current findings. Their primary motivations for smoking are instrumental as they endorse smoking to improve cognition and regulate affect, rather than smoking in response to physiological dependence or craving. Although the literature has indicated that time to first cigarette is an important measure of dependence, in this population instrumental smoking motivations were more salient and we might consider the nature of their smoking behavior to be fundamentally different than people who are older and smoke more heavily.

Differences in factor structure may be related to other unique aspects of the sample. The participants in the present study reported a high degree of emotional distress and extensive histories of depression and childhood trauma.^{36,38} Negative affective states have been assigned a central role in instigating and maintaining substance use⁶⁴ and the psychological symptoms reported by the participants may play an important part in the nature of their smoking behavior and motivations. Another difference may be that the participants in the present sample smoked relatively few cigarettes per day and had actively reduced their smoking since becoming pregnant. Given the specific demographics and life circumstances of the present sample, it is likely that their smoking behavior was not yet driven by automaticity and tolerance processes, as might be seen in an older, more heavily smoking sample, that the PDM identified by Piper and colleagues are not the principal motivations for smoking and that nicotine use and dependence may be contextually different than in other populations. However, we are not advocating a wholesale move to a 9-factor solution when the WISDM is administered to populations

of pregnant smokers. Rather, this finding underscores the importance of using a multidimensional measure in order to better capture the complex nature of dependence in different populations, and the need to evaluate the validity of published measurement models across different populations. Future research should investigate whether different motivations for tobacco use impact smoking cessation treatment considerations in pregnant smokers. The novel finding that baseline self-reported Taste and Sensory motives predict the clinically important endpoint of abstinence six months after the end of treatment bears further investigation.

Limitations of the present study include the specific demographic composition and treatment-seeking nature of the sample; subsequently, these findings may not generalize to other populations and may represent smoking motives in a subset of pregnant smokers. Although 21% of the sample smoked within the first 5 min of waking, the overall FTCD score was relatively low, which presents another limitation for examining relationships between variables and generalizing results. The administration of no other smoking dependence measure beyond the FTCD restricts our ability to assess concurrent validity. Due to the exploratory nature of the analyses and the unique subpopulation, replication is necessary to further validate these findings.

Supplementary Material

Supplementary Tables 1–14 can be found online at <http://www.ntr.oxfordjournals.org>

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Declaration of Interests

None declared.

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