Depression symptom profiles and long-term response to cognitive behavioral therapy plus contingency management for smoking cessation

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ABSTRACT

Background: Depression is heterogeneous in nature and using diagnostic categories limits insight into understanding psychopathology and its impact on treatment efficacy. This secondary analysis sought to: 1) identify distinct subpopulations of cigarette users with depression, and 2) examine their response to cognitive-behavioral treatment (CBT) + contingency management (CM) for smoking cessation at one year.
Method: The sample comprised 238 (74 % females) adults who smoke receiving CBT only or CBT + CM. A latent class analysis was conducted on baseline depressive symptoms measured using the Beck Depression Inventory-II. Generalized estimating equations assessed the main and interactive effects of class, time, treatment, and sex on smoking abstinence.
Results: Three distinct classes were identified: C1 ($n= 76/238$), characterized by mild depression, loss of energy, pessimism, and criticism, C2 ($n= 100/238$) presenting moderate severity and decreased appetite, and C3 ($n= 62/238$) showing severe depression, increased appetite, and feelings of punishment. There was a significant cluster × treatment interaction, which indicated additive effects of CM over CBT alone for Class 1 and 2. Persons in Class 1 and 2 were 3.60 [95 % CI: 1.62, 7.97] and 2.65 [95 % CI: 1.19, 5.91] times more likely to be abstinent if CBT + CM was delivered rather than CBT only. No differential sex effects were observed on treatment response according to cluster.
Conclusions: Profiling depression symptom subtypes of cigarette users may be more informative to improve CM treatment response than merely focusing on total scores.

1. Introduction

Smoking rates are now decreasing worldwide, but this reduction is not uniform across all segments of the population, such as among persons with depression (Drope et al., 2018; Parker et al., 2018). According to recent estimates, the percentage of people who smoke with comorbid depression still ranges between 10.6 % and 15.1 % (Li et al., 2017; Weinberger et al., 2020). In consequence, cigarette smoking and depression comorbidity represents a major public health priority for which new treatment interventions are needed.

Cumulative evidence has documented that depression is multidimensional in nature and that the symptoms differ from each other in their risk factors, and their impairment in individuals' life areas (Coid et al., 2021; Fried et al., 2014; Perlman et al., 2019; Rice et al., 2019;

Rosellini and Brown, 2014). A myriad of clinical presentations (ranging from 1030 to 14,528) have been identified (Fried and Nesse, 2015; Zimmerman et al., 2015). Also, in the psychopathology field, several efforts have been conducted to identify different, but not mutually exclusive, depression subtypes based on severity (e.g., high/low) (Choi et al., 2020; Ten Have et al., 2016), course (single/chronic) (Rush, 2007), and symptoms profile (atypical, cognitive, affective and somatic) (Manian et al., 2013).

Very few studies so far have investigated depression by adopting an individual-level perspective (Boschloo et al., 2019; van Loo et al., 2012) and even fewer in the tobacco field. Manley et al. (2009) identified four unique subtypes of people who smoke characterized by increasing levels of nicotine dependence severity and higher odds of major depression. However, the clinical utility of this categorization is unclear, as no

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examination of differential treatment response by class was performed. Most of the research has classified patients as depressed or not depressed based on depression total scores (Collado et al., 2014; Dahne et al., 2019; Hall et al., 1994; MacPherson et al., 2010). However, the use of sum-scores is increasingly being criticized because of their limited capacity to inform on prognosis and treatment specificity, since from this approach, it is assumed that patients scoring the same will necessarily inform of equally impaired psychosocial functioning and benefit from the same interventions (Eeden et al., 2019; Lee et al., 2012; McNeish and Wolf, 2020).

More recently, there has been an interest in determining moderators of treatment efficacy, as depression has been consistently associated with heavier daily smoking (Boateng-Poku et al., 2020) and poor cessation outcomes in the smoking literature (Cohn et al., 2019; Doran et al., 2019; Johnson et al., 2020; Levine et al., 2003). In particular, increased depressive symptoms while quitting are related to lower abstinence outcomes and increased risk of relapse at one year (Burgess et al., 2002). Similarly, different depression domains such as somatic features and negative affect predict short- and long-term smoking outcomes (Leventhal et al., 2008). This situation prompts clinicians to adopt their own criteria for tailoring the optimal psychotherapy to individual patients, but a more precise evidence-based characterization is needed.

Independent studies have compared the efficacy of different psychological and pharmacological therapies for smoking cessation in the depressed population (e.g., Brown et al., 2007; MacPherson et al., 2010; Martínez-Vispo et al., 2019). Contingency Management (CM) is now considered to be one of the most effective interventions for smoking cessation, including for those with depression (Baker et al., 2018; Forster et al., 2019; González-Roz et al., 2021; Petry et al., 2018). CM research has focused on the efficacy of voucher-based interventions for smokers with different levels of depression severity (Lopez et al., 2014; Secades-Villa et al., 2019, 2015), but no prior study has identified whether discrete latent subgroups exhibit differential responses.

Against this background, the primary aim of this study was to use a person-centered approach, latent profile analysis, to identify depression symptom classes in people who smoke. Secondary aims were: 1) to examine the differential treatment response (7-day point prevalence of abstinence) of latent subgroups to cognitive behavioral therapy (CBT) alone and CBT + CM, and 2) to examine the interactive effects of sex differences and classes in relation to abstinence outcomes. Given the multidimensional nature of depression, results are expected to inform on refinement methods to accurately identify poor treatment responders beyond those included in categorical (yes vs. no) diagnostic systems, to improve assessment practices, and to help clinicians develop tailored treatments.

2. Method

2.1. Participants and procedure

The study sample comprised a total of 238 treatment-seeking people who smoke from two randomized controlled trials (RCTs) (Secades-Villa et al., 2015; Secades-Villa et al., 2019) examining the efficacy of CBT only vs CBT + CM (Clinical Trials-gov Identifier: NCT03163056). Participants were mostly females (175/238; 73.5 %) and aged between 18–73 ($M = 50.20$; $SD = 11.15$). Baseline cigarettes per day were on average 21.72 ($SD = 8.43$). Mean nicotine dependence severity as per the Fagerström Test for Cigarette Dependence (FTCD; Fagerström, 2012; Heatherton et al., 1991) was 6.20 ($SD = 1.94$). Depression symptoms on the Beck Depression Inventory-II (BDI-II; Beck et al., 1996) were on average 26.16 ($SD = 10.26$).

Participants were recruited from the community using print, radio, and TV advertisements. Eligibility criteria for both studies were being aged 18 years or older, smoking at least 10 cigarettes per day, and being interested in quitting smoking. In addition to these criteria, participants

from one RCT were required to report at least mild depressive symptoms as per the BDI-II (i.e., ≥14). For the purpose of this study, participants from both RCTs with scores in the minimal to severe depression range were included. Self-reported diagnosis of severe mental disorders (i.e., active psychosis or bipolar disorder) precluded interested individuals from participating in this study.

Interested participants contacted the Clinical Research Unit directly to request a personal appointment. After giving informed consent, all patients completed baseline measures during a single assessment visit that took approximately 90 min and were given an appointment to start the treatment within the following week. The study procedures were assessed and approved by the local ethics committee from the main city hospital (ref: 124/15). The study conforms to The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans.

2.2. Treatment interventions

Treatment interventions have been described in detail elsewhere (see Secades-Villa et al., 2019). CM interventions were combined with cognitive-behavioral therapy (CBT) for smoking cessation in six/eight-week therapy sessions with a maximum of four-eight patients per group. In addition to the therapy sessions, patients were requested to attend the clinic for an additional mid-week session aimed at collecting CO and cotinine only. CBT strategies aimed to effectively train patients in dealing with withdrawal symptoms (i.e., negative mood, physical discomfort) through different psychological techniques (e.g., problem solving, diaphragmatic relaxation, action plans to prevent relapse back to smoking). Patients in both CBT only and CBT + CM conditions gradually decreased their nicotine intake by 30 % each week based on brands and numbers of cigarettes. The quit day was set at 48 h prior to the fifth session to facilitate nicotine-free samples which prompted the beginning of the awarding of incentives.

In both RCTs, incentives were intended to reinforce smoking abstinence with reinforcement magnitudes ranging from €175 (US$ 197) to €300 (US$ 337) at post-treatment. Incentives were delivered contingently at each session upon biochemical verification of smoking abstinence [i.e., CO levels ≤4ppm and cotinine (ng/mL) ≤80].

2.3. Measures

All participants completed an ad-hoc battery assessment including demographic information (i.e., sex, age, and monthly income) and smoking related measures (cigarettes per day, years of regular use, and number of lifetime 24-h quit attempts). In addition, nicotine dependence severity was assessed using the FTCD (Fagerström, 2012; Heatherton et al., 1991). This measure establishes a level of nicotine dependence. Based on total scores, five levels of nicotine dependence can be identified: very low (0–2), low (3–4), medium (5), high (6–7), and extremely high (8–10) (Fagerstrom and Kozlowski, 1990). Following the guidelines by the Society for Research on Nicotine and Tobacco (Benowitz et al., 2019), CO and cotinine were also collected to assess tobacco exposure at the baseline assessment and smoking status (i.e., smoker vs. abstinent) at each follow-up visit (at 1, 6, and 12 months post-treatment).

The Beck Depression Inventory-II (Beck et al., 1996) was used to characterize the sample in terms of depressive symptoms severity. The BDI-II captures past 14-day depressive symptomatology. Severity levels are interpreted as follows: minimal (0–13), mild (14–19), moderate (20–28), and severe (29–63).

The primary outcome measures were abstinence and smoking relapse at one year after treatment termination. All participants were required to attend three additional in-person follow-up visits that were scheduled to assess their tobacco use and depression symptomatology. Abstinence was informed using two measures: 1) point-prevalence (i.e., 24-h abstinence at the post-treatment, and 7 days prior to the visit at 1-,

6-, and 12-month follow-ups), and; 2) continuous abstinence (i.e., number of days without smoking, even a puff, since first quitting). Relapse was operationalized as 3 consecutive days with at least five cigarettes a day, in accordance with prior definitions in the smoking literature (Kirchner et al., 2012).

2.4. Statistical analyses

Descriptive analyses were carried out to characterize the sample in terms of sociodemographic, smoking, and depression characteristics. Student's *t*-tests and ANOVAs were used as appropriate for the continuous variables. Chi-squared tests were also performed to examine differences in categorical variables across groups. A latent class analysis (LCA) was conducted following recommended guidelines (Lanza and Rhoades, 2013). Firstly, a set of five baseline models (i.e., 2–5 classes) without any grouping or co-variable were conducted to identify an optimal baseline model for the entire sample size. All BDI-II items were entered in the LCAs as dichotomized (i.e., no endorsement vs. endorsement at any severity level). Items 15 (increased vs. decreased appetite) and 18 (insomnia vs. hypersomnia) were disaggregated as per prior recommendations (Ten Have et al., 2016). To ensure an orderly process, each model estimation was replicated using different random starting values for the ρ parameters, with 3000 sets of random starting values. The final number of depression latent classes was selected based on class sample size and theoretical interpretability of each latent class, the Log-likelihood test (LL), the incremental model fit via Akaike's Information Criteria (AIC), the sample-adjusted Bayesian Information Criterion (SABIC), the quality of classification via entropy, and stability of LCAs (i.e., percentage of seeds associated with best model fit). Smaller AIC and SABIC values and higher entropy values suggest a better model fit and parsimony.

Generalized estimating equation regression models (GEEs) were conducted on abstinence as implemented in SAS 9.4 to accommodate for the time-varying variable (i.e., time visit occurring at the end-of-treatment, 1-, 6-, and 12-month follow-up). The GEE models tested the main effects of sex, baseline nicotine dependence severity, time, treatment, and cluster membership. Interactive effects of cluster × sex, and cluster × treatment condition were examined, and simple effects comparisons of the modelled interactions were also provided. CBT only and Cluster 1 were entered as the reference categories in the tested models. Odds ratios were provided to inform on the significance and magnitude of the main and interactive effects.

3. Results

3.1. Depression symptom profiles

Fit statistics for each of the LCA models tested are presented in Table 1. Model fit statistics suggested that the five-class model had the best fit for the entire sample size [G^2 = -2479.86, SABIC = 2759.49, entropy = .92]. However, only 8.67 % of seeds associated with the best model were obtained, which suggests poor model stability. To enhance both interpretability and model quality, a 3-class solution [N_{C1} = 76/238; N_{C2} = 100/238; N_{C3} = 62/238] with 48.67 % of seeds was selected

Table 1
Model fit indices for 1-5 class models.

	LL	AIC	SABIC	Entropy	Seeds
Class = 2	−2656.55	2932.87	2947.09	0.82	93.67%
Class = 3	**−2572.43**	**2812.63**	**2834.11**	**0.89**	48.67 %
Class = 4	−2524.00	2763.77	2792.51	0.91	9.33%
Class = 5	−2479.86	2723.48	2759.49	0.92	8.67 %

Note. Fit indices pertaining to the selected model are highlighted in bold. LL = Log-likelihood; AIC = Akaike's Information Criteria; SABIC = The sample-adjusted Bayesian Information Criterion.

instead.

Table 2 shows the endorsement probability of each BDI-II item by class membership. The three classes differed in their total BDI-II scores [F (2) = 98.28, p < .001; C1: M = 16.42, SD = 6.22; C2: M = 29.03, SD = 8.44; C3: M = 33.48, SD = 7.71], suggesting different levels of severity. Class 1 showed a symptom pattern mainly characterized by loss of energy, pessimism, and criticism, in absence of sadness and a lack of interest in others and with a low probability of suicidal ideation. Class 2 endorsed very similar items as Class 3 with few exceptions. Whereas Class 2 was associated with an 84 % probability of endorsing decreased appetite, Class 3 presented a 90 % probability of increased appetite. This latter class reflected the most severe pattern of depression as evidenced by the highest item-response probabilities in the core depressive symptoms (sadness = 99 % and anhedonia = 99 %) and items related to self-criticism, blame, and punishment. Negligible endorsement of hypersomnia and decreased appetite also featured in Class 3.

3.2. Comparison of sociodemographic and smoking-related characteristics across depression symptom profiles

Table 3 informs on demographics and smoking characteristics by group. Classes did not differ in any sociodemographic characteristic, but they did differ significantly in CO and baseline nicotine dependence levels. Class 1 presented significantly lower nicotine dependence levels relative to Classes 2 and 3. As regards CO, Class 2 showed significantly higher levels compared to Class 1.

Table 2
Depression item response probabilities by class membership (N = 238).

BDI-II item	Class					
	I (n = 76)		II (n = 100)		III (n = 62)	
	Ip (%)	(SE)	Ip %	(SE)	Ip %	(SE)
Item 1 "Sadness"	49	(.74)	**79**	(.04)	**99**	(.01)
Item 2 "Pessimism"	**74**	(.05)	**94**	(.03)	**97**	(.02)
Item 3 "Sense of failure"	**53**	(.06)	**82**	(.04)	**93**	(.03)
Item 4 "Anhedonia"	**68**	(.05)	**99**	(.01)	**99**	(.003)
Item 5 "Feelings of guilt"	**64**	(.06)	**86**	(.04)	**99**	(.005)
Item 6 "Feelings of punishment"	24	(.05)	46	(.05)	52	(.07)
Item 7 "Disappointed in self"	**58**	(.06)	**94**	(.03)	**97**	(.02)
Item 8 "Critical of self"	**74**	(.05)	**90**	(.03)	**98**	(.02)
Item 9 "Suicidal ideation"	11	(.04)	35	(.05)	39	(.06)
Item 10 "Crying"	45	(.06)	**61**	(.05)	**86**	(.05)
Item 11 "Unrest"	**70**	(.05)	**89**	(.04)	**83**	(.05)
Item 12 "Loss of interest in others"	49	(.06)	**97**	(.02)	**92**	(.04)
Item 13 "Difficulty with decisions"	42	(.06)	**82**	(.04)	**93**	(.04)
Item 14 "Futility"	36	(.06)	**88**	(.04)	**91**	(.04)
Item 15 "Loss of energy"	**86**	(.04)	**99**	(.001)	**98**	(.02)
Item 16a "Insomnia"	**63**	(.06)	**56**	(.05)	**66**	(.06)
Item 16b "Hypersomnia"	33	(.05)	31	(.05)	25	(.06)
Item 17 "Irritability"	46	(.06)	**77**	(.05)	**93**	(.04)
Item 18a "Increased appetite"	35	(.06)	1	(.004)	**90**	(.08)
Item 18b "Decreased appetite"	29	(.06)	**84**	(.06)	2	(.007)
Item 19 "Difficulty concentrating"	**65**	(.06)	**92**	(.03)	**99**	(.004)
Item 20 "Fatigue"	**66**	(.05)	**97**	(.02)	**98**	(.02)
Item 21 "Libido"	**62**	(.06)	**80**	(.04)	**84**	(.05)

Note. Item-response probabilities higher than .50 are in bold to facilitate interpretation and indicate higher likelihood of item endorsement.

Table 3
Demographics and smoking characteristics (N = 238).

	Class			F/χ2	p
	I (n = 76)	II (n = 100)	III (n = 62)		
Demographics					
Female sex (%, n)	33.70$_a$ (59)	40$_a$ (70)	26.30$_a$ (46)	1.31	.52
Age: M (SD)	47.71$_a$ (12.63)	51.59$_a$ (10.60)	51.02$_a$ (9.65)	2.88	.06
Education level (%, n)				2.56	.87
No education	2.60$_a$ (2)	2$_a$ (2)	0$_a$ (0)		
Basic education	18.40$_a$ (14)	17$_a$ (17)	17.70$_a$ (11)		
High School	51.30$_a$ (39)	58$_a$ (58)	59.70$_a$ (37)		
≥University	27.60$_a$ (21)	23$_a$ (23)	22.60$_a$ (14)		
Smoking variables					
Cigarettes per day: M (SD)	20.53$_a$ (7.51)	21.81$_a$ (8.39)	23.03$_a$ (9.43)	1.53	.22
Years of regular smoking M (SD)	28.32$_a$ (12.27)	31.62$_a$ (10.93)	32.13$_a$ (12.03)	2.58	.08
FTCD: M (SD)	5.36$_a$ (1.99)	6.59$_b$ (1.79)	6.61$_{b,c}$ (1.77)	11.57	<.001
CO (ppm): M (SD)	17.53$_a$ (8.72)	25.94$_b$ (18.46)	23.13$_{a,b}$ (15.12)	6.71	.001
Cotinine (ng/mL): M (SD)	2,392.95$_a$ (1,456.51)	2,509.72$_a$ (1,347.19)	2590$_a$ (2,365.87)	.23	.80

Note. Subscripts inform on pairwise comparisons. Different subscripts indicate statistically significant differences across classes. FTCD = Fagerström Test for Cigarette Dependence; CO (ppm) = carbon monoxide in parts per million; ng/mL = nanograms/milliliter.

3.3. Relationship between depression symptom profile and CBT + CM treatment response

Smoking abstinence and relapse rates by time point and class membership are displayed in Table 4. GEE models testing main and interactive effects on smoking abstinence are presented in Table 5. Smoking outcomes at each time did not differ by class. However, the GEE analyses revealed statistically significant main effects for baseline

Table 4
Point prevalence abstinence and relapse rates by class membership and time point.

	Class 1 (n = 76)	Class 2 (n = 100)	Class 3 (n = 62)	p	Effect size
Smoking abstinence					
Point-prevalence abstinence (%, n)					
End of treatment	81.60 (62)	69 (69)	67.70 (42)	.11	.14
1-month follow-up	55.30 (42)	53 (53)	50 (31)	.83	.04
6-month follow-up	39.50 (30)	34 (34)	32.30 (20)	.64	.06
12-month follow-up	39.50 (30)	34 (34)	35.50 (22)	.75	.05
Continuous abstinence M (SD)					
End of treatment	13.25 (10.14)	15.03 (13.18)	14.81 (13.13)	.55	.004
1-month follow-up	24.05 (24.83)	27.65 (26.27)	25.71 (27.46)	.67	.002
6-month follow-up	65.04 (91.21)	58.09 (91.03)	59.34 (91.58)	.80	.001
12-month follow-up	129.58 (177.30)	105.06 (166.22)	109 (170.44)	.62	.004
Smoking relapse (%, n)					
1-month follow-up	27.60 (21)	16 (16)	17.70 (11)	.14	.13
6-month follow-up	15.80 (12)	21 (21)	19.40 (12)	.68	.06
12-month follow-up	2.60 (2)	4 (4)	1.60 (1)	.67	.06

Table 5
Generalized Estimation Equation (GEE) models on smoking abstinence.

	Model A (main effects model)			
	Estimate	SE	CI 95 %	Pr > |Z|
FTCD	−0.19	0.07	−0.33, −0.06	**.006**
Female Sex (reference category: male)	−0.18	0.29	−0.74, 0.39	0.54
Time	−0.92	0.12	−1.17, -0.68	**<.001**
CBT + CM (reference category: CBT)	.68	0.26	0.17, 1.20	**.009**
Cluster 2 (reference category: Cluster 1)	0.11	0.30	−0.49, 0.70	0.72
Cluster 3 (reference category: Cluster 1)	−0.02	0.34	−0.68, 0.64	0.95
	Model B (interactive effects of Cluster × Treatment)			
Cluster 1 × CBT + CM (reference category: Cluster 1 × CBT)	1.28	0.41	0.48, 2.08	**0.002**
Cluster 2 × CBT (reference category: Cluster 1 × CBT)	0.004	0.38	−0.73, 0.74	0.99
Cluster 2 × CBT + CM (reference category: Cluster 1 × CBT)	0.98	0.45	0.09, 1.86	**0.03**
Cluster 3 × CBT (reference category: Cluster 1 × CBT)	0.27	0.42	−0.54, 1.09	0.51
Cluster 3 × CBT + CM (reference category: Cluster 1 × CBT)	0.19	0.48	−0.76, 1.14	0.69
	Model C (interactive effects of Cluster × Sex)			
Cluster 1× Female Sex (reference category: Cluster 1 × Male sex)	−0.32	0.44	−1.19, 0.55	0.48
Cluster 2× Female Sex (reference category: Cluster 1 × Male sex)	−0.56	0.44	−1.41, 0.30	0.20
Cluster 2× Male Sex (reference category: Cluster 1 × Male sex)	−0.62	0.52	−1.64, 0.41	0.24
Cluster 3× Female Sex (reference category: Cluster 1 × Male sex)	−0.71	0.46	−1.62, 0.19	0.12

Simple effects comparisons of modelled interactions over smoking abstinence

Variable		OR [CI 95 %]	p
Cluster 1	Female vs. Male	0.73 [0.31, 1.74]	0.48
Cluster 2	Female vs. Male	1.06 [0.47, 2.42]	0.89
Cluster 3	Female vs. Male	0.82 [0.28, 2.40]	0.71
Cluster 1	CBT + CM vs. CBT	3.60 [1.62, 7.97]	**0.002**
Cluster 2	CBT + CM vs. CBT	2.65 [1.19, 5.91]	**0.02**
Cluster 3	CBT + CM vs. CBT	0.92 [0.36, 2.36]	0.86

Note. FTCD = Fagerström Test for Cigarette Dependence; CBT = Cognitive Behavioral Therapy; CBT + CM = Cognitive Behavioral Therapy plus Contingency Management.

nicotine dependence [B = -0.19, SE = .07, p = .006, 95 % CI: -0.33, -0.06], time [B = -0.92, SE = .12, p < .001, 95 % CI: -1.17, -0.68], and CBT+CM [B = 0.68, SE = .26, p = .009, 95 % CI: 0.17, 1.20] on smoking abstinence. This signified that higher baseline nicotine dependence severity was related to lower odds of point-prevalence abstinence across time. Of note, the odds of abstinence for persons in CBT+CM were estimated to be 3.92 times [95 % CI: 1.41, 10.94] the odds of those in CBT only.

The GEE models testing interaction effects yielded a significant cluster × treatment interaction, meaning more beneficial effects of CBT + CM for Classes 1 and 2. Persons in Classes 1 and 2 were 3.60 [95 % CI: 1.62, 7.97] and 2.65 [95 % CI: 1.19, 5.91] times more likely to be abstinent if CBT + CM was delivered rather than CBT only. There were no differential sex effects on cluster response to treatment as evidenced by non-statistically significant results in the sex × cluster tested interactions.

4. Discussion

This study identified subtypes of smokers based on depression symptomatology and examined their differential response to CBT + CM treatment for smoking cessation. Three main results are highlighted: 1) three depression symptoms profiles with unique patterns of symptoms endorsement emerged; 2) compared to CBT only, using CBT + CM facilitated more sustained abstinence outcomes for Class 1 and Class 2, and 3) there were no sex by class differential effects on abstinence.

Consistent with knowledge in the field of psychopathology (Holub et al., 2019; Li et al., 2014; Liao et al., 2019; Mathew et al., 2017; Pérez-Belmonte et al., 2020; Prisciandaro and Roberts, 2009), there were three distinct classes of depression patients with different levels of severity. In the first class, mild depression, loss of energy, pessimism, and criticism prevailed over other symptoms. Classes 2 and 3 presented similar patterns of depression symptoms but differed in their levels of severity (higher for Class 3) and endorsement of eating-related items (decreased appetite for Class 2 vs. increased appetite for Class 3). There is a vast amount of literature on data-driven depression subtypes, and no consistent pattern of latent classes has been identified so far (Ulbricht et al., 2018; van Loo et al., 2012). From a qualitative standpoint, classes in this study presented a symptom profile that does not exactly map onto the previously described classes, which further supports the enormous heterogeneity of depression (Fried and Nesse, 2015; Østergaard et al., 2011; Ten Have et al., 2016). Overall, patients receiving CBT + CM were nearly four times more likely to sustain abstinence at one-year follow-up. Even if CM is not focused on depression, vouchers may operate as 'nudges' that encourage engagement in healthy non-smoking behaviors, which resemble behavioral activation therapies (de Walque, 2020). As persons with depression experience difficulty in enjoying natural reinforcers, they may benefit from the artificially enhanced non-smoking rewards used in CM procedures (Petry et al., 2013).

It is of note that, unlike Classes 1 and 2, Class 3 was not more responsive if CBT + CM was delivered. Interestingly, feelings of punishment and increased appetite featured only in Class 3. Appetite changes seem the most informative to characterize subpopulations with severe depression (Li et al., 2014; Sullivan et al., 2002), and have also been linked to weight and body image concerns which are cited as the main reasons for tobacco use initiation and relapse (Chao et al., 2019; Dobmeyer et al., 2005; Salk et al., 2019). Recovery from addiction results from a decreased value or utility (i.e., benefit/cost ratio) of substance use combined with an increased value of competing substance-using alternatives (Field et al., 2019). In this vein, it is highly conceivable that persons in Class 3 may be using cigarettes as a coping mechanism to improve affect, to deal with feelings of punishment, and to control their weight (Garey et al., 2018), especially in the event of stressful situations (Tomko et al., 2020).

Several limitations need to be considered, as they may limit the generalizability. Firstly, the study sample comprised entirely white Spanish persons who smoke. Previous studies have revealed that ethnic minorities are less likely to quit (Weinberger et al., 2019), and the issue of whether depression class predicts treatment outcomes differently according to ethnic group warrants further attention. Also, the study sample consisted primarily of females (73.5 %), which precluded us from modelling sex invariance in the LCAs. Secondly, incorporating other dimensions, such as the impairment in psychosocial functioning, might have led to substantially different profiles and efficacy outcomes. Thirdly, this study was not designed to be a direct efficacy assessment of CBT vs. CBT + CM in the observed latent classes, and future attempts should be conducted to clarify this. SMART designs involving re-randomizations based on patients' response to other available treatments are increasingly being used in the addictions field (Fernandez et al., 2020; Fitzsimons et al., 2015). In this vein, an adaptive intervention where the intensity and treatment components are adjusted based on depression profiles is warranted. Lastly, information on weight was not registered, and examining post-cessation weight gain concerns

may be valuable to elucidate on their predictive role in smoking abstinence in future RCTs (Germeroth and Levine, 2018).

5. Conclusions

Empirically driven profiles of treatment-seeking smokers with depression offer increased validity over categorical diagnoses as they may assist in developing more targeted and effective interventions. Smoking cessation units should adopt a hybrid assessment approach (sum-scores and item-level analyses in depression questionnaires) and incorporate CBT + CM into standard smoking cessation protocols to facilitate sustained cessation outcomes. In addition, the presence of feelings of punishment and increased appetite, which featured in Class 3, should be assessed before considering CM for smoking cessation. In this event, using CBT alone initially may represent a less intensive and more cost-effective option. We hope this information will help guide clinicians and researchers to develop and implement interventions to continue reducing tobacco-related problems among individuals with depression.

Author statement contributors

AGR: participated in conceptualization, project administration, data collection, formal analyses, writing of the first draft. RSV: participated in conceptualization, funding acquisition, project administration, revised, and edited the final draft. GGF: participated in the writing of the first draft, revised and edited the final draft. VML: participated in data collection, the writing of the first draft, revised and edited the final draft. FAP: participated in conceptualization, data collection, revised the final draft. All authors have approved the final article.

Role of the founding source

Declaration of Competing Interest

The authors report no declarations of interest.

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