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Stress, attention deficit hyperactivity disorder (ADHD) symptoms and tobacco smoking: The i-Share study

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ABSTRACT

Background: The contribution of mental health to the risk of smoking is increasingly acknowledged but still insufficiently studied during the key period of student life. In particular, the simultaneous action of stress and Attention Deficit Hyperactivity Disorder (ADHD) symptoms on the risk of smoking remains poorly understood.
Aims: To assess the effects of stress and ADHD symptoms on tobacco smoking.
Method: Multivariate modeling was conducted on the French i-Share study ($n = 8110$, median age 20.3 years, 74.8% females, 32.9% regular/occasional smokers) to evaluate the associations between stress, ADHD symptoms and tobacco smoking, adjusting for potential family/socio-demographic confounders.
Results: Students with high levels of stress were more likely to smoke > 10 cigarettes/day (adjusted odds ratio (aOR): 1.48, 95% CI: 1.12–1.96) than those with low levels of stress. Students with high levels of ADHD symptoms were more likely to smoke > 10 cigarettes/day (aOR: 2.08, 95% CI: 1.58–2.75) than those with low levels of ADHD symptoms.
Conclusions: Stress and ADHD contribute independently to the risk of smoking. Interventions targeting each condition are likely to reduce the burden of tobacco use in students.

1. Introduction

With more than 1 billion smokers worldwide and 6 million deaths per year, the tobacco epidemic is a major factor threatening human health and economic development [1]. Despite massive public health policies targeting its use, tobacco still remains unduly consumed, notably in western countries. France does not escape this pattern since 34.3% of adults are daily smokers [2]. While tobacco smoking is intrinsically a modifiable behavior, the highly addictive power of nicotine makes smoking cessation a daunting task. Tobacco initiation and addiction, like numerous health risk behaviors, settle down mostly during adolescence and young adulthood [3]. Student life is consequently a critical period when interventions may efficiently modify the onset of problematic behaviors and subsequently improve future outcomes. In this line, the Center for Disease Control has recently expended the age range for initiation prevention to college/university young adults [4]. Beyond the classical social risk factors for tobacco use (e.g. poverty, low education, cigarette availability, peer influences), individual mental health factors may play a crucial role [5]. In particular, stress and Attention Deficit Hyperactivity Disorder (ADHD) symptoms are two potentially important contributors that represent identifiable targets for interventions.

Stress has been shown to be associated with tobacco use (e.g. initiation, continuation and difficulties to quit) in both human and animal studies [6–8]. Epidemiological studies have shown that individuals exposed to high levels of stress report rates of cigarette smoking between two and three times higher than their non-stressed counterparts [8–10]. Engagement in smoking is often attributed to stress by individuals themselves. Indeed smoking is reported to be a means to alleviate stress and anxiety symptoms [11]. This is biologically plausible since acute nicotine modifies cerebrocortical neuroactive steroids and plasma corticosterone concentrations [12]. Stress and smoking may also have common genetic and environmental vulnerabilities. Interestingly, females

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may be more prone to smoking than men when exposed to stress [13,14]. Some authors even suggest that stress plays a key role in the emergence of tobacco use in women [14].

ADHD symptoms also represent significant independent risk factors for smoking. Epidemiological and clinical studies have repeatedly shown a consistent association between childhood/adult ADHD and tobacco use with a twofold risk of onset and dependence in ADHD individuals [15–17]. Although still to be elucidated, the underlying etiology of this association may be subsumed by several hypothesized mechanisms. In particular, shared genetic/environmental vulnerability and clinical/neurocognitive characteristics could make people with ADHD more likely to consume tobacco [18]. Of note, the gender effect in the relationship between ADHD and tobacco use remains unclear owing to scarce data and contradictory results [19,20].

Limitations in the literature regarding the links between tobacco smoking, stress and ADHD are manifold. First, stress and ADHD have hardly been studied simultaneously. Although these two psychopathological dimensions are likely related, there is scant data regarding their association, especially in university students [21,22]. Consequently, whether they confound each other, interact or represent different pathways leading to smoking is still unknown. Second, there may be gender differences with regard to the effect of both stress and ADHD symptoms on tobacco smoking. Although postulated, this potentially gender-specific vulnerability remains insufficiently studied in the available data. Third, the concurrent effects of stress and ADHD symptoms on tobacco smoking have hardly been investigated during late adolescence and young adulthood, yet this period is crucial in the crystallization of long-lasting risky behaviors. Clarifying the respective contributions of stress and ADHD symptoms to smoking in students is essential since it may yield levers for innovative interventions.

The i-Share cohort, which is one of the largest epidemiological studies conducted in European students, offers a unique possibility to test whether stress and ADHD symptoms contribute independently to the risk of smoking and if the association varies according to the sex. Addressing the key research question of the interplay between stress, ADHD and tobacco use could open new avenues for designing preventive and smoking cessation interventions early on. The aim of the present study was to assess the effects of stress and ADHD symptoms on tobacco smoking in the at-risk population of students.

2. Material and methods

2.1. Study population

Study subjects were participants in the Internet-based Students Health Research Enterprise (i-Share, www.i-share.fr) project, a prospective population-based cohort study of students in higher education institutions in France. The objectives of i-Share are to evaluate important health aspects among university students over the course of 10 years, including mental health, risk behaviors, addictions, accidents, infections and migraine. Eligible participants had to be officially registered at a university or higher education institute (within the Universities of Bordeaux, Versailles and Nice), be at least 18 years of age, able to read and understand French and provide informed consent for participation. Participants were invited to participate thanks to a recruitment campaign started in February 2013. Students were informed about the objectives of the study through promotion campaigns (via information stands at registration, lectures, flyers, social media and newsletters). Specifically, a group of trained students informed their peers about the study and collected information to initiate the online recruitment process. Registration was conducted in two steps: firstly, an online portal pre-registration was required; secondly, each student completed a self-administered online questionnaire. The baseline inquiry collected information on students' health, personal and family medical histories, socio-demographic characteristics, and lifestyle habits. The i-Share cohort is still ongoing. For this specific study, we used data available as of April 29th, 2016. Only students aged between 18 and 30 years old were included. The i-Share project on which this study was based was approved by the Commission nationale de l'informatique et des libertés (CNIL) [DR-2013-019].

2.2. Measures

2.2.1. Main variables of interest: stress and ADHD symptoms

Stress: perceived stress was assessed by using the short version of the Perceived Stress Scale (PSS-4) [23]. This self-reported questionnaire measures the degree to which situations in one's life over the past month are appraised as stressful (i.e. how overloaded, uncontrollable and unpredictable respondents find their lives). The PSS-4 consists of four items with possible responses rated on a 0 (never) to 4 (very often) scale. The global score was obtained by summing the items with reverse coding to score items 2 and 3. Higher scores corresponded to higher perceived stress. As the PSS-4 is not a diagnostic instrument, no cutoff was available to determine stressed individuals. Consequently, scores were divided into tertiles within each gender, the lowest tertile of the score distribution being the reference. The PSS has demonstrated good reliability and validity in university student samples [23].

2.2.2. ADHD symptoms

Students were asked to complete questions about their behavior during the past 6 months based on the 6-item version of the Adult ADHD Self-Report Scale (ASRS-v1.1, available in various languages at http://www.hcp.med.harvard.edu/ncs/asrs.php) [24]. The ASRS-v1.1 is a screening tool and not a diagnostic instrument. This scale lists the 6 questions found to be the most predictive of symptoms consistent with ADHD. Each of the six items was coded using a 5-point Likert scale ranging from never (0) to very often (4). We calculated three different scores by summing the items: 1: a global score (6 items); 2: an inattention symptoms score (4 items); 3: a hyperactivity symptoms score (2 items). Scores were then dichotomized according to the 90th centile of the score distribution within each gender. This cutoff was chosen in order to identify a subgroup with a high level of ADHD symptoms in the absence of a validated cutoff in French university students.

2.2.3. Covariates

Using the self-administered online questionnaire we built the following variables: age (continuous), sex (male/female), student variables (including current place of living [at parents' home/other place], job activity [yes/no], alcohol consumption [no/rare/occasional/regular/very regular]), and family variables (including family financial help [yes/no], parents' marital status [separated/not separated], parents' educational level [no postgraduate studies/postgraduate studies], family economic condition in childhood [comfortable/satisfactory/difficult], family support during childhood [high/moderate/low], parents' alcohol or depression problem [at least one parent has/had alcohol and/or depression problem: yes/no]).

2.2.4. Outcomes tobacco smoking variable

If students were smokers (i.e. answered yes to the question "do you smoke tobacco regularly or occasionally?"), the number of cigarettes smoked per day was quantified (i.e. students answered the question "how many cigarettes on average do you smoke per day/week/month?"). A count number of cigarettes smoked

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per day was generated which allowed a tobacco smoking categorical variable to be constructed (none, ≤ 10 cigarette/day, > 10 cigarette/day).

2.3. Statistical method

We first described the study sample. Then we compared the characteristics of students with respect to their level of cigarette smoking (i.e. none, ≤ 10 cigarette/day, > 10 cigarette/day). In order to ascertain whether students' behaviors were associated with smoking, we conducted multinomial regression model analyses. In the modeling process, variables were introduced sequentially. At step 1, we entered stress and ADHD symptoms. At step 2, we added all covariates linked to the categorical tobacco-smoking variable with a $P < 0.05$ (except student alcohol consumption which was not introduced into the main regression analyses but further considered in sensitivity analyses). We then estimated the following two-way interactions: stress × ADHD, sex × stress, sex × ADHD. Results were presented for the whole sample. In secondary analyses we decided to present the results stratified on gender, independently from the presence or absence of statistical interaction with sex. Indeed, owing to the assumptions about possible divergent outcomes in females and males and because the sample was gender-imbalanced (significantly more females than males), it seemed relevant to present the results separately by gender. Finally we conducted sensitivity analyses to test the robustness of the findings: (1) adjusting on youth alcohol consumption; (2) conducting the analyses according to the age at onset of tobacco smoking (i.e. age > 16 years and < 16 years); (3) conducting the analyses by considering separately the inattention and the hyperactivity dimensions of the ASRS-v1.1; (4) conducting Hurdle modeling. The latter approach is a multivariate model that estimates jointly a two-part model with two sets of coefficients for: (1) being or not a smoker (the estimates being equal to those resulting from a logistic model); (2) the cigarette count/day for those who smoke (this part of the model is fitted with a negative binomial link). Therefore, the Hurdle model can be used to verify whether the independent variables predict severity (as assessed by the cigarette count) beyond predicting the fact of being a smoker. All P-values were two-tailed and we considered $P < 0.05$ to be statistically significant. We performed all analyses using the SAS statistical software (SAS version 9.3; SAS Institute Inc, Cary, NC).

3. Results

The total sample comprised 8110 participants. Fig. 1 shows the flow chart of the study population. Of the 11,186 individuals who pre-registered on the i-Share study homepage, 9051 fully registered by changing their password and customizing their identification number. For this study, we included the 8110 participants who met the inclusion criteria and fully completed the baseline questionnaire. Table 1 summarizes the characteristics of the sample by levels of tobacco smoking. The mean age of the participants was 21.0 years (SD = 2.3) and 74.8% were females. In total, 32.8% of the students reported being smokers. Students with high levels of stress (high tertile) were more likely to smoke than students with low levels of stress (low tertile) ($P < 0.0001$). Students with high levels of ADHD symptoms were also more likely to smoke than those with low levels of ADHD symptoms ($P < 0.0001$). All the student and family variables were statistically significantly related to smoking (all $P < 0.05$). Table 2 shows the associations between stress, ADHD symptoms and levels of tobacco smoking in the total, female and male samples (multinomial regression models). All models were significant with Wald Chi-squares showing *P*-values < 0.001. Full models were adjusted on age, sex (only for the total sample), current place of living, job activity, family financial help, parents' marital status, parents' educational level, family economic condition in childhood, family support during childhood, parents' alcohol or depression problem. Students with high levels of stress were more likely to smoke more than 10 cigarettes/day (fully adjusted odds ratio (aOR): 1.48, 95% CI: 1.12–1.96) than those with low levels of stress. Students with high levels of ADHD symptoms were more likely to smoke more than 10 cigarettes/day (fully aOR: 2.08, 95% CI: 1.58–2.75) than

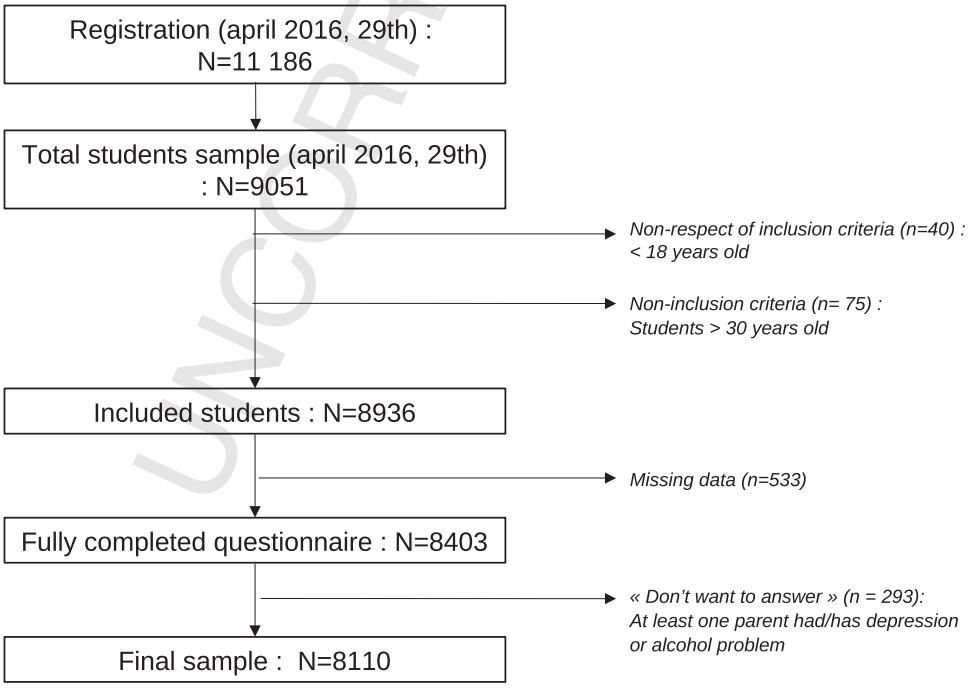

Fig. 1. Participants flow diagram.

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Table 1
Characteristics of i-Share total sample according to levels of tobacco consumption ($n = 8110$).

	% (n) or mean (SD)	Tobacco smoking			P-value
		No smoker ($n = 5446$)	≤ 10 cigarettes/day ($n = 2310$)	> 10 cigarettes/day ($n = 354$)	
Student variables					
Age (years)	21.0 (2.3)	20.7 (2.3)	20.7 (2.2)	21.6 (2.3)	< 0.0001
Female sex	74.8 (6067)	75.2 (4094)	75.6 (1746)	64.1 (227)	< 0.0001
Current place of living (parent's home)	31.9 (2589)	33.2 (1806)	30.1 (695)	24.9 (88)	0.0004
Job activity (yes)	41.0 (3324)	38.5 (2097)	45.4 (1049)	50.3 (178)	< 0.0001
Family financial help (yes)	81.9 (6642)	82.3 (4484)	81.8 (1889)	76.0 (269)	0.011
Alcohol consumption					< 0.0001
No, rare, occasional	27.4 (2220)	35.8 (1947)	10.2 (235)	10.7 (38)	
Regular	50.3 (4076)	50.2 (2735)	52.1 (1204)	38.7 (137)	
Very regular	22.4 (1814)	14.0 (764)	37.7 (871)	50.6 (179)	
Stress					< 0.0001
High tertile	30.9 (2502)	28.4 (1549)	34.7 (802)	42.7 (151)	
Medium tertile	34.6 (2809)	35.3 (1922)	34.2 (791)	27.1 (96)	
Low tertile	34.5 (2799)	36.3 (1975)	31.0 (717)	30.2 (107)	
ADHD symptoms					< 0.0001
High	12.2 (993)	10.3 (561)	15.3 (353)	22.3 (79)	
Low	87.8 (7117)	89.7 (4885)	84.7 (1957)	77.7 (275)	
Family variables					
Parents' marital status (separated)	31.2 (2531)	28.3 (1542)	35.8 (828)	45.5 (161)	< 0.001
Parents' educational level (postgraduate and more)	65.5 (5309)	64.5 (3513)	67.8 (1567)	64.7 (229)	0.018
Economic condition in childhood (difficult)	9.1 (736)	8.5 (465)	9.6 (222)	13.8 (49)	0.010
Support during childhood (moderate or little)	27.5 (2227)	25.6 (1395)	29.9 (691)	39.8 (141)	< 0.0001
Parents' alcohol or depression problem (yes)	45.0 (3646)	41.6 (2266)	49.7 (1149)	58.5 (207)	< 0.0001

P-values from one-way analysis of variance (non-parametric) and Chi-square tests.

those with low levels of ADHD symptoms. The same pattern of results was observed in both genders. There were no significant interactions with respect to tobacco smoking (high level of stress × ADHD, $P = 0.50$; sex × high level of stress, $P = 0.48$; sex × ADHD symptoms, $P = 0.60$). The Spearman test showed a significant correlation between continuous stress and ADHD variables (rho = 0.34, $P < 0.001$). Sensitivity analyses showed the same pattern of results: (1) adjusting on student alcohol consumption (high vs. low stress: > 10 cigarettes: aOR: 1.70 [1.28–2.26]; high vs. low ADHD: > 10 cigarettes/day: aOR: 1.84 [1.39–2.46]); (2) conducting the analyses on the earlier-onset tobacco smoking subsample (< 16 years of age) (high vs. low stress: > 10 cigarettes/day: aOR: 1.44 [1.04–2.03]; high vs. low ADHD: > 10 cigarettes/day: aOR: 2.20 [1.60–3.02]) and on the later-onset tobacco smoking subsample (> 16 years of age) (high vs. low stress: > 10 cigarettes/day: aOR: 1.56 [0.94–2.61]; high vs. low ADHD: > 10 cigarettes/day: aOR: 1.76 [1.05–2.95]); (3) conducting the analyses by considering separately the inattention (high vs. low inattention: > 10 cigarettes/day: aOR: 2.34 [1.78–3.08]) and the hyperactivity (high vs. low hyperactivity: > 10 cigarettes/day:

Table 2
Associations between stress, ADHD symptoms and tobacco smoking in university students (multinomial regression models): i-Share study ($n = 8110$).

	≤ 10 cigarettes/day			> 10 cigarettes/day		
	Unadjusted OR (95% CI)	Stress and ADHD adjusted OR (95% CI)	Fully adjusted OR (95% CI)	Unadjusted OR (95% CI)	Stress and ADHD adjusted OR (95% CI)	Fully adjusted OR (95% CI)
Total sample						
Stress						
High tertile	1.43 (1.26–1.61)	1.34 (1.19–1.52)	1.30 (1.14–1.48)	1.78 (1.39–2.33)	1.55 (1.19–2.02)	1.48 (1.12–1.96)
Medium tertile	1.13 (1.01–1.28)	1.11 (0.99–1.25)	1.11 (0.98–1.26)	0.92 (0.70–1.22)	0.87 (0.66–1.16)	0.91 (0.68–1.21)
Low tertile	Reference	Reference	Reference	Reference	Reference	Reference
ADHD symptoms						
High	1.57 (1.36–1.81)	1.46 (1.26–1.69)	1.43 (1.23–1.66)	2.50 (1.92–3.26)	2.21 (1.68–2.91)	2.08 (1.58–2.75)
Low	Reference	Reference	Reference	Reference	Reference	Reference
Female sample						
Stress						
High tertile	1.43 (1.24–1.65)	1.34 (1.16–1.55)	1.28 (1.10–1.48)	2.12 (1.51–2.97)	1.82 (1.29–2.58)	1.45 (1.01–2.07)
Medium tertile	1.18 (1.03–1.36)	1.16 (1.01–1.33)	1.14 (0.99–1.32)	1.14 (0.79–1.65)	1.08 (0.74–1.56)	1.01 (0.70–1.48)
Low tertile	Reference	Reference	Reference	Reference	Reference	Reference
ADHD symptoms						
High	1.62 (1.37–1.91)	1.51 (1.28–1.79)	1.49 (1.25–1.77)	2.63 (1.89–3.65)	2.24 (1.60–3.14)	2.26 (1.60–3.19)
Low	Reference	Reference	Reference	Reference	Reference	Reference
Male sample						
Stress						
High tertile	1.68 (1.31–2.15)	1.61 (1.25–2.07)	1.62 (1.25–2.10)	2.06 (1.30–3.26)	1.80 (1.13–2.89)	1.67 (1.02–2.72)
Medium tertile	1.10 (0.87–1.40)	1.09 (0.86–1.39)	1.08 (0.85–1.38)	1.25 (0.79–1.99)	1.20 (0.76–1.92)	1.19 (0.74–1.91)
Low tertile	Reference	Reference	Reference	Reference	Reference	Reference
ADHD symptoms						
High	1.44 (1.09–1.91)	1.27 (0.95–1.69)	1.21 (0.90–1.63)	2.20 (1.40–3.46)	1.89 (1.19–3.02)	1.80 (1.12–2.91)
Low	Reference	Reference	Reference	Reference	Reference	Reference

OR: odds ratio; CI: confidence interval. Full models adjusted on age, sex (only for total sample), current place of living, job activity, family financial help, parents' marital status, parents' educational level, family economic condition in childhood, family support during childhood, parents' alcohol or depression problem.

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Table 3
Associations between stress, ADHD symptoms and tobacco smoking in university students (Hurdle models): i-Share study ($n = 8110$).

	Liability to be a smoker: logit part			Smoking severity: positive part		
	Unadjusted OR (95% CI)	Stress and ADHD adjusted OR (95% CI)	Fully adjusted OR (95% CI)	Unadjusted RR (95% CI)	Stress and ADHD adjusted RR (95% CI)	Fully adjusted RR (95% CI)
Total sample						
Stress						
High tertile	1.48 (1.32–1.66)	1.37 (1.22–1.54)	1.31 (1.16–1.48)	1.17 (1.06–1.29)	1.13 (1.02–1.24)	1.11 (1.01–1.23)
Medium tertile	1.11 (0.99–1.24)	1.08 (0.96–1.21)	1.08 (0.96–1.21)	1.02 (0.92–1.12)	1.00 (0.91–1.11)	1.03 (0.93–1.13)
Low tertile	Reference	Reference	Reference	Reference	Reference	Reference
ADHD symptoms						
High	1.69 (1.47–1.93)	1.56 (1.36–1.79)	1.52 (1.32–1.75)	1.29 (1.16–1.44)	1.26 (1.13–1.40)	1.24 (1.12–1.38)
Low	Reference	Reference	Reference	Reference	Reference	Reference

OR: odds ratio; RR: rate ratio; CI: confidence interval. Full models adjusted on age, sex, current place of living, job activity, family financial help, parents' marital status, parents' educational level, family economic condition in childhood, family support during childhood, parents' alcohol or depression problem. The logit part of the Hurdle model explores the liability to be a smoker. The positive part of the Hurdle model explores smoking severity (modeling of number of cigarettes per day in smokers only).

aOR: 1.95 [1.48–2.57]) dimensions; (4) conducting Hurdle modeling (see Table 3). The fact that the associations were significant when considering tobacco smoking as a count number (positive part of the Hurdle model) reflected a linear increase in the risk of smoking.

4. Discussion

4.1. Principal findings of study

In this large sample of university students, high levels of stress and ADHD were independently associated with tobacco smoking. The pattern of associations was true in both genders. The relationships between stress, ADHD symptoms and the risk of smoking appear to reflect distinct pathways since: (1) stress and ADHD symptoms were independent contributors to tobacco smoking; (2) there was no significant interaction between high levels of stress and ADHD symptoms. All the associations described were adjusted for a range of potential confounders including student and family variables. This is a relevant result owing to the scarcity of data regarding the interplay between stress, ADHD and tobacco use.

4.2. Comparison with other studies and interpretation

Despite the relatedness of ADHD and stress, the current data do not support the hypothesis that they act in combination to heighten the risk of tobacco smoking. The presence of elevated ADHD symptoms does not create a specific vulnerability in highly stressed individuals and does not put them at greater risk of smoking, and reciprocally. The unique contributions of stress and ADHD towards tobacco smoking suggest that each relationship could rely on different underlying pathophysiological mechanisms.

Stress was linked to tobacco smoking, which is consistent with animal and human data. Self-medication may apply since nicotine is used to lessen stress and anxiety symptoms. The effects of nicotine on stress are mixed: acute nicotine administration mitigates stress by increasing plasma corticosterone levels whereas chronic nicotine administration alters the adaptive response to chronic stress [8]. In turn, chronic stress may reduce nicotine responsiveness through interactions between persistent elevated plasma corticosterone levels and the dopaminergic system. All these mechanisms are likely to promote nicotine addiction. Nevertheless, the mechanisms linking stress to smoking are complex and possibly bidirectional. Beyond the immediate stress reduction provided by smoking, stress itself may result from nicotine craving and withdrawal symptoms. Stress may also result from early exposure to tobacco [8]. However, when conducting the analyses in the subsamples of early and later tobacco users (under or over 16 years of age), we found the same pattern of associations, which is not in favor of a reverse causation mechanism in this sample. Even so, the interplay still needs to be disentangled so epidemiological longitudinal human data integrating biological variables are required.

In line with the large body of literature focusing on the ADHD-tobacco link, students with high levels of ADHD symptoms smoked at significantly higher rates and at heavier levels than those with low levels of ADHD symptoms. Here again the self-medication hypothesis may explain this pattern since individuals with ADHD smoke to improve their attention and executive functioning [25]. Alternatively this association may be due to common environmental/genetic vulnerabilities between ADHD and tobacco smoking [18]. Both the nicotinic-acetylcholinergic circuits and the dopamine reward processing mechanism possibly underlie the association mechanistically [18,26]. Of note, we found no specific gender effect in this sample.

4.3. Strengths and limitations

The strengths of the study are the large number of participants, the high rate of females, the standardized assessment tools, the concurrent evaluation of stress and ADHD, the detailed information on potential confounders and the age group considered (i.e. late adolescence, young adulthood). A set of limitations should however be considered to properly interpret the findings. First, the cross-sectional design makes temporal sequences not strictly evaluable, which limits causal inferences. Second, biases on measures are possible owing to the use of self-reports. Reassuringly, both perceived stress and current ADHD symptoms were shown to be reliable in college students [23,27]. Third, the Perceived Stress Scale is not a clinical instrument. Yet it remains relevant in the context of the present epidemiological study since it is one of the most widely used psychological tool for assessing nonspecific perceived stress. Fourth, The ASRS-v1.1 could show elevated scores in the presence of comorbid substance use or anxiety-depression. However the ASRS-v1.1 has shown a good validity with ADHD diagnostic [24] including for patients presenting with substance use disorders [28]. Fifth, a sampling bias could have arisen since participants were volunteers in the i-Share project and extrapolation to other student populations may be limited. Last, potential confounding factors were unmeasured (e.g. current psychiatric diagnosis, biological variables).

4.4. Implications, unanswered questions and future research

From the public health perspective of reducing the harm caused by tobacco, mental health contributors such as stress and ADHD symptoms are key targets to address in the student population in order to prevent enduring tobacco consumption and its related negative outcomes. Beyond universal programs directed towards the whole student population (e.g. educating students about

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tobacco risks), preventive interventions should include both specific selective and indicated programs. Selective interventions could be set up to target students presenting with high levels of stress and ADHD symptoms. This involves the following: screening stress and ADHD; being able to refer to mental health professionals those with high levels in order to diagnose and treat when appropriate (e.g. ideally through university health services, when available); providing information on tobacco risks to those with high levels of stress and ADHD symptoms. Finally, indicated programs targeting students already engaged in tobacco smoking should take into account stress and ADHD dimensions. After screening tobacco smoking and mental health problems, smoking cessation interventions should be run in parallel with treatment for stress and ADHD. Since weaning from chronic nicotine consumption is accompanied by higher levels of stress, effective stress management programs need to be developed to encourage students to quit smoking durably. Importantly, the constructs we tapped were not direct diagnoses. Rather they corresponded to the higher levels of psychological dimensions. Aside from suggesting a possible clinical diagnosis, taking into account subsyndromal levels of stress and attention difficulties in a non-clinical population may guide interventions. Instead of merely providing therapeutic interventions focusing on people displaying an already identified disorder, the current findings point to the need to promote positive psychological interventions.

From a mechanistic perspective, this study underlines the importance of individual cognitive and emotional dimensions in the genesis of the risk of smoking. Nevertheless, it is still unclear whether stress and ADHD symptoms trigger tobacco use, promote its maintenance and are consequences of a similar vulnerability or whether all these mechanisms function concomitantly to some extent. Further studies will likely unravel the complexity of the associations by exploring causality through understanding of the temporal sequences and integration of experimental variables (e.g. biological and neuro-imaging variables).

5. Conclusions

High levels of perceived stress and attention problems are two mental health features that may independently promote tobacco consumption in young adults. The student population, which is at high risk of adopting a long-term pattern of smoking but which is also potentially more reachable in terms of public health interventions, may benefit from specific actions focusing on stress and ADHD symptoms. Both pragmatic and mechanistic research including randomized controlled trials is needed to better understand these associations and determine which interventions are successful in getting individuals to reduce their smoking.

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Disclosure of interest

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The other authors have not supplied their declaration of competing interest. Q3

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