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Perceived stress partially accounts for the association between Attention Deficit Hyperactivity Disorder (ADHD) symptoms and suicidal ideation among students

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ABSTRACT

The association between Attention Deficit Hyperactivity Disorder (ADHD) and suicidal ideation has been the focus of recent research interest among youths and young adults. However, the role perceived stress plays in this association is unclear. We investigated whether perceived stress accounts for the association between ADHD and subsequent suicidal ideation among French students enrolled in the i-Share cohort. The associations between ADHD symptoms, perceived stress at baseline, and suicidal ideation during follow-up were investigated using logistic regression models, and Structural Equation Modeling was used to estimate the indirect effect via perceived stress. In total 4333 participants (median age: 20.3 years; [interquartile range: 18.7-21.8]) were included in the main analyses. ADHD was associated with suicidal ideation (adjusted Odds Ratio = 1.15 [95% Confidence Interval: 1.04-1.26]). Perceived stress partially accounts for the association between ADHD and suicidal ideation (proportion explained 49%). Our study suggests that ADHD and perceived stress represent mental health targets for suicide prevention programs.

1. Introduction

Suicide is the second leading cause of death among youths aged 15-29, after road accidents (WHO, 2014). According to the World Health Organization (WHO), suicide accounts for 8.5% of all deaths in this age group (WHO, 2014). Suicidal ideation is often the starting point of a process leading to suicide, thus representing a relevant target for suicidality screening and prevention (Nicoli et al., 2012). Among young people, post-secondary students are particularly concerned by suicidal ideation (Mortier et al., 2017a,b; Wilcox et al., 2010). A meta-analysis estimated that the lifetime prevalence of suicidal ideation among students was 22.3%, and several studies have shown that more than 10% of students reported suicidal ideation at least once a year (Kirsch et al., 2015; Mortier et al., 2017a,b; Wilcox et al., 2010). The university years can be challenging for students due to academic stress, but also because students are becoming autonomous in a process of separation from the family network (Landry and Goupil, 2010; Wilcox et al., 2010). Thus, a significant proportion of students present psychological distress and adopt at-risk behaviors (e.g. psychoactive substance use) which in turn make suicidal behaviors more likely to occur (Arria et al., 2009; Assari, 2018; Wilcox et al., 2010).

Beyond known risk factors of suicidal behaviors (e.g. mental health problems including excessive or chronic stress) (Anastasiades et al., 2017); Attention Deficit Hyperactivity Disorder (ADHD) has recently been the focus of interest in scientific and clinical communities due to its high prevalence (5% of school-aged children and 2.5% of adults) and its association with suicidal behaviors (APA, 2013; Galéra et al., 2008; Stickley et al., 2016). The number of students with ADHD attending university has risen over the past years (AQICESH, 2017; Nugent and Smart, 2014; Sedgwick, 2018). The international situation regarding ADHD is variable. Whereas it is under-diagnosed in some countries (e.g. France), leaving ADHD students without specific support, ADHD is one of the major disabilities recorded at university in other countries (e.g. North America) (AQICESH, 2017; Nugent and Smart, 2014;

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Sedgwick, 2018). Various clinical dimensions associated with ADHD (i.e. inattention, hyperactivity/impulsivity, neuropsychological and emotional dysregulations) are likely to jeopardize individual functioning in the academic context (Landry and Goupil, 2010; Mortier et al., 2015). Several recent studies have reported associations between ADHD and suicidal ideation in students (Cheng et al., 2016; Mortier et al., 2017b, 2015; Stickley et al., 2016; Van Eck et al., 2015). Among mental health risk factors potentially involved in the association between ADHD and suicidal behaviors, perceived stress may play a significant role (Yeguez et al., 2018). However, the interrelationships between ADHD, perceived stress and suicidal ideation are poorly understood. There are known associations in the student population between ADHD symptoms and levels of perceived stress (Harrison et al., 2013; Salla et al., 2017; Vogel et al., 2017) and perceived stress is likely to increase suicidal ideation (Anastasiades et al., 2017). These results suggest that perceived stress could partially accounts for the association, as shown by Yeguez et al. who reported that stress was a mediator of the association between ADHD and suicidal ideation among young adults (Yeguez et al., 2018). This pathway remains underexplored in students. Therefore, exploring ADHD and perceived stress simultaneously will allow us to clarify the role of perceived stress on the association between ADHD and occurrence of suicidal ideation in students. It is important to understand the mechanism between ADHD, stress and suicidal ideation as this will help/promote the screening and identification of those at risk for suicidal ideation/attempts.

The main objective of this study was to investigate whether perceived stress accounts for the association between ADHD symptoms and suicidal ideation among university students in France.

2. Methods

2.1. Study population

This study was based on data from the internet-based Students HeAlth Research Enterprise (i-Share). This prospective cohort with annual online follow-up questionnaires was launched in 2013 throughout France. The objectives of i-Share are to evaluate the health status and well-being of university students over the years, including information on mental health, risk behaviors, addictions, accidents, infections and migraine. Students are informed about the objectives of the study through promotion campaigns (e.g. information stands at registration, lectures, flyers, social media and newsletters). Specifically, student ambassadors are trained to inform their peers about the study and collect contact information to initiate the online recruitment process.

To be eligible, students had to be aged 18 years or older, officially registered in a university or higher education institution in France, and able to read and understand French. Inclusion in the study was performed in two steps. First, volunteer students who wished to participate in the study were registered on the website (www.i-share.fr). Second, students completed and validated the baseline questionnaire, collecting information on socio-demographic characteristics, personal and family medical history, student lifestyle and mental health issues. Each participant received an online follow-up questionnaire on each anniversary of the date of the completion of the baseline questionnaire. Our study used the data from the first two follow-ups available on July 9, 2018. For this study, we used the data from participants who had completed at least one of the two follow-up questionnaires. This study was approved by the National Commission for Information Technology and Liberties (CNIL) [DR-2013-019].

2.2. Measures

2.2.1. Assessment of suicidal ideation

The study outcome was self-reported suicidal ideation in the last 12 months. During follow-up 1 and/or follow-up 2 (corresponding to first-year and second-year follow-up respectively), participants answered the question: "In the past 12 months, have you ever thought about committing suicide (or have you ever had suicidal thoughts)?". Answer options were: "Never", "Yes, it has happened to me", "Yes, several times" or "Do not want to answer". The variable was dichotomized into Yes or No. The "Yes" category applied if participants had chosen option "Yes, it has happened to me" or "Yes, several times" at least once during the two during the two follow-up times. The "No" category applied if participants had chosen the option "Never" for the two follow-up times. The "Do not want to answer" option in both follow-up questionnaires was considered as missing data.

2.2.2. Assessment of ADHD symptoms and perceived stress at baseline

ADHD symptoms: ADHD symptoms were assessed using the 6-item version of the World Health Organization (WHO) standardized screening tool ASRS-v1.1 (Adult Self Report Scale) (Kessler et al., 2005). Students were asked to answer questions about their behavior during the past 6 months before completing the questionnaire. The first four items assessed inattention symptoms and the last two items assessed hyperactivity/impulsivity symptoms. The questions were answered using a 5-point Likert scale ranging from never (0) to very often (4) and a total ADHD score was computed by summing the score obtained for each item (total score range 0-24). The higher the score, the greater the risk of presenting an ADHD diagnosis. Clinically relevant ADHD cutoff scores were based on ASRS screening strata: [0-14[, [14-17], [18-24] (Kessler et al., 2007). The ASRS has demonstrated good reliability, good validity and is an easy-to-use tool for assessing ADHD symptoms in students and in the general population (Gray et al., 2014; Kessler et al., 2005). ADHD information was collected at baseline.

Perceived stress: Perceived stress was assessed using the short version of the Perceived Stress Scale (PSS-4) (Cohen et al., 1983). This self-reported questionnaire measures the degree to which situations of daily life during the last month are perceived as stressful (i.e. unpredictable, out of control and painful) through four questions. Responses range from never (0) to very often (4). An overall score (score range 0-16) is calculated by summing the four items (two are reverse-coded). The higher the score, the higher the levels of perceived stress. The PSS-4 has demonstrated good reliability and validity in student samples (Cohen et al., 1983). Perceived stress information was collected at baseline.

2.2.3. Co-variables at baseline

The co-variables included were the potential confounders of the relationship between ADHD, perceived stress and suicidal ideation.

Student characteristics included: age, gender, study level at baseline (first year, second year, third year, fourth year or more); current tobacco consumption (non-smoker, <10 cigarettes/day, ≥ 10 cigarettes/day); frequency of alcohol consumption (no, occasionally, frequently); cannabis consumption at least once in lifetime (yes, no), previous history of depression/anxiety disorders diagnosed by a physician (yes, no); economic resources (family/scholarships, job activity, other); student living conditions (living alone, not living alone); overall life satisfaction score (ranging from 5 to 25) (Salla et al., 2017; Stickley et al., 2016).

Family characteristics included: parents' educational level ($\leq$ postgraduate, $>$ postgraduate); parents' marital status (not divorced, divorced); family economic conditions during childhood (not very/moderately comfortable, very comfortable); parents' previous history depression or anxiety problem (yes, no); family support during childhood and adolescence (not very/moderately satisfactory, very satisfactory) (Salla et al., 2017; Stickley et al., 2016). All co-variables were collected at baseline.

2.3. Statistical analysis

We first described the study sample and compared baseline characteristics between participants and non-participants. Then, we

compared the characteristics of students reporting suicidal ideation and those not reporting it during follow-up (t-tests/Wilcoxon test/chi-square tests). Our modeling strategy followed the following steps. First, we investigated the crude association between ADHD symptoms, perceived stress, and subsequent suicidal ideation by using a logistic regression model. Second, in order to rule out any moderation effect we tested the interaction term ADHD symptoms*perceived stress regarding suicidal ideation. When the interaction term was not significant, the interaction term was removed from the models and only adjusted effects were presented. Third, the existence of the potential effect of perceived stress was tested by simultaneously entering ADHD and perceived stress into the same model. Fourth, we estimated a fully adjusted model considering ADHD symptoms, perceived stress and all the co-variables identified as potential confounders. We then compared the strength of the association between ADHD and suicidal ideation from the models. When all conditions for mediation were met: association between ADHD and perceived stress; association between perceived stress and suicidal ideation (step 1) and difference between the strength of ADHD effect on suicidal ideation (step 1 and 3)), we then performed a Structural Equation Modeling (SEM) to test the mediation pathway (using Lavaan package in R). The total and direct effects of ADHD on suicidal ideation were estimated. Then, the indirect effect of ADHD on suicidal ideation through perceived stress was estimated by the product of the effect of ADHD on stress and the effect of stress on suicidal ideation. We estimated the proportion of the total effect explained by perceived stress (proportion mediated = indirect effect/total effect). Since gender is related to ADHD (males are overrepresented) (Green and Rabiner, 2012; Weyandt and DuPaul, 2006; Weyandt and Dupaul, 2008) and suicidal ideation (females are overrepresented) (Mortier et al., 2017b), the contribution of ADHD to suicidal ideation via perceived stress could vary according to the gender. We then have conducted separate exploratory analyses for females and males.

The R statistical software (R version 3.6.2) was used to conduct the analyses.

3. Results

The flow chart is shown in Fig. 1. A total of 4374 students (among the 14,912 students recruited at baseline) had completed at least one of the two follow-up questionnaires, which made them eligible for the present study. Among them, 4333 had no missing data on suicidal ideation at follow-up and were then included in the main analyses. Table S1 (supplemental material) shows the comparison between participants (N = 4333) versus non-participants (N = 10,579) at follow-up. Participants were more often females ($p < 0.001$), smoked less tobacco ($p < 0.001$), consumed less cannabis ($p < 0.001$) and alcohol ($p < 0.001$), lived more often alone ($p < 0.001$), reported a higher overall life satisfaction ($p < 0.001$), had slightly lower scores of ADHD symptoms ($p < 0.001$) and perceived stress ($p < 0.001$). They came less often from divorced families ($p < 0.001$), had parents with a higher level of education ($p < 0.001$), came from families with a better economic situation ($p < 0.001$) and had more family support during childhood ($p < 0.001$). Participants had a median age of 20.3 years [IQR: 18.7-21.9], and 79% were females. The median participation time was 24 months [IQR: 13.4-29.1]. The percentage of the sample with clinically significant symptoms of ADHD (score ≥ 18) was 4.6%. A total of 863 participants (19.9%) reported suicidal ideation at least once during the follow-up.

Table 1 shows the baseline characteristics of the sample according to subsequent suicidal ideation. Students reporting suicidal ideation were younger than those not reporting it. Students consuming alcohol, tobacco and cannabis were significantly more likely to report suicidal ideation than their peers who did not use these substances. Students who were freshmen, living alone, presenting a low overall life satisfaction score, a history of diagnosed depression/anxiety disorders, and having parents with a history of depression/anxiety were significantly more likely to report suicidal ideation than their counterparts. The proportion of students reporting suicidal ideation was not significantly different according to economic resources. Participants who declared very good family support during childhood and adolescence reported suicidal ideation significantly less frequently than other participants. Mean ADHD symptoms and perceived stress scores were significantly higher among students who reported suicidal ideation compared to those who did not report it.

Table 2 shows the associations between ADHD symptoms, perceived stress, and subsequent suicidal ideation. ADHD symptoms and perceived stress did not interact ($p = 0.099$). When ADHD and perceived stress were entered simultaneously, the effect of ADHD symptoms on suicidal ideation decreased by 16% (relative difference between Odds Ratio = 1.46 and OR = 1.22) but it remained significant. (Table 2).

The perceived stress score increased significantly on average by ß = 0.268 [95% CI: 0.244 – 0.292] ($p < 0.001$) for an increase of one point of the ADHD score. ADHD (ß = 0.028; [95% CI: 0.015 – 0.041]; $p < 0.001$; effect for increase of one point of the score) and perceived stress (ß = 0.096; [95% CI: 0.082 – 0.110]; $p < 0.001$; effect for increase of one point of the score) were associated with suicidal ideation. The path analysis showed that the direct (beta = 0.028) and indirect (0.268 *0.096 = 0.026) effects of ADHD on suicidal ideation were statistically significant ($p < 0.001$) (Fig. 2). The proportion of ADHD total effect on suicidal ideation explained by perceived stress was 49% (Table 3). When separate analyses were performed among females and males, the proportion of ADHD total effect explained by perceived stress was 51% in females and 37.5% in males (Table 3).

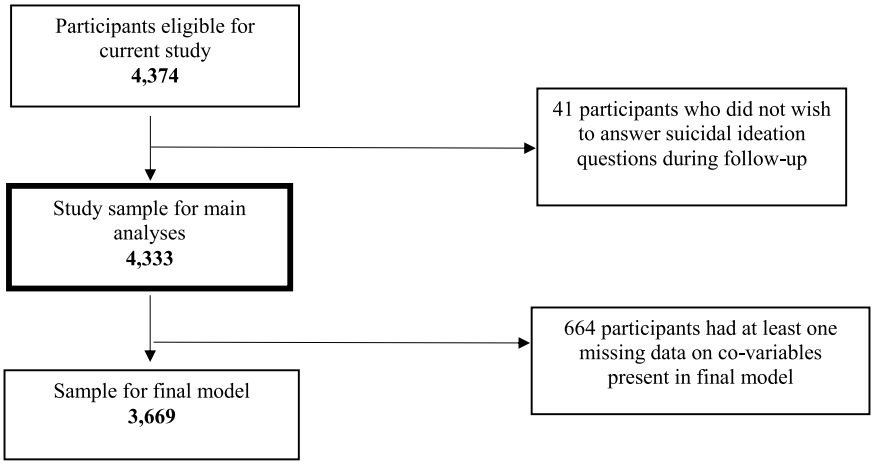

Fig. 1. Participants flow chart.

Table 1
Sample baseline characteristics according to suicidal ideation (i-Share study, France, N = 4333).

Characteristics	Mean (SD) / Median [IQR]	N (%)	Suicidal Ideation Yes (n = 863)	No (n = 3,470)	p-value
Age (years)*	20.3 [18.7-21.9]		19.9 [18.7-21.8]	20.4 [18.8-22.0]	0.015
Gender					0.189
Male		909 (21.0)	167 (18.4)	742 (81.6)	
Female		3424(79.0)	696 (20.3)	2728 (79.7)	
Tobacco consumption (cigarettes/day)+					< 0.001
No		3214 (74.2)	601 (18.7)	2613 (81.3)	
≤ 10		991 (22.9)	225 (22.7)	766 (77.3)	
≥ 10		126 (2.9)	37 (29.4)	89 (70.6)	
Cannabis consumption at least once in lifetime+					0.004
Yes		1390 (32.1)	311 (22.4)	1079 (77.6)	
No		2936 (67.9)	549 (18.7)	2387 (81.3)	
Alcohol consumption					0.013
No		303 (7.0)	80 (9.3)	223 (6.4)	
Occasionally		3164 (73.0)	614 (71.1)	2550 (73.5)	
Frequently		866 (20.0)	169 (19.6)	697 (20.1)	
Economic resources					0.152
Family/scholarships		2361 (54.5)	474 (20.1)	1887 (79.9)	
Job activity		1641 (37.9)	311 (19.0)	1330 (81.0)	
Other		331 (7.6)	78 (23.6)	253 (76.4)	
Student living conditions					0.013
Living alone		1847 (42.6)	400 (21.7)	1447 (78.3)	
Not living alone		2486 (57.4)	463 (18.6)	2023 (81.4)	
Previous history of depression/anxiety					< 0.001
Yes		850 (19.6)	308 (36.2)	542 (63.8)	
No		3483 (80.4)	555 (15.9)	2928 (84.1)	
Study level at baseline					< 0.001
1st		1641 (37.9)	366 (22.3)	1275 (77.7)	
2nd		925 (21.3)	197 (21.3)	728 (78.7)	
3rd		619 (14.3)	120 (19.4)	499 (80.6)	
4th or more		1148 (26.5)	180 (15.7)	968 (84.3)	
Overall life satisfaction score*,+	18 [15-20]		16 [13-19]	18 [15-20]	< 0.001
ADHD (score)	10.7 (3.9)		11.9 (4.0)	10.4 (3.9)	< 0.001
ADHD (strata)					< 0.001
< 14		3302 (76.2)	572 (17.3)	2730 (82.7)	
[14-17]		831 (19.2)	215 (25.9)	616 (74.1)	
≥ 18		200 (4.6)	76 (38.0)	124 (62.0)	
Perceived stress (score)	6.9 (3.1)		8.5 (3.2)	6.5 (2.9)	< 0.001
Perceived stress (in tertiles)					< 0.001
≤ 5		1567 (36.2)	177 (11.3)	1390 (88.7)	
6-8		1495 (34.5)	257 (17.2)	1238 (82.8)	
> 8		1271 (29.3)	429 (33.8)	842 (66.2)	
Parents' marital status+					< 0.001
Not divorced		2955 (70.1)	533 (18.0)	2422 (82.0)	
Divorced		1260 (29.9)	291 (23.1)	969 (76.9)	
Parents' educational level+					0.727
≤ Postgraduate		1164 (29.0)	222 (19.1)	942 (80.9)	
> Postgraduate		2854 (71.0)	558 (19.6)	2296 (80.4)	
Parents' previous history depression or anxiety problem+					< 0.001
Yes		576 (14.2)	192 (33.3)	384 (66.7)	
No		3476 (85.8)	586 (16.9)	2890 (83.1)	
Family economic situation during childhood					0.001
Very comfortable		2452 (56.6)	446 (18,2)	2006 (81.8)	
Not very/Moderately comfortable		1881 (43.4)	417 (22.2) 1464 (77.8)		
Family support during childhood and adolescence+					< 0.001
Very satisfactory		3213 (75.1)	516 (16.1)	2697 (83.9)	
Not very/Moderately satisfactory		1068 (24.9)	328 (30.7)	740 (69.3)	

*For quantitative variables with non-normal distributions: median [IQR:interquartile range]; SD: standard deviation; N: number of participants included in the main analyses; ADHD: Attention Deficit Hyperactivity Disorder.
+Variables with missing data: Tobacco consumption (n = 2); Cannabis consumption at least once in lifetime (n = 7); Overall life satisfaction score (n = 1); Parents' marital status (n = 118); Parents' educational level (n = 315); Parents' previous history depression or anxiety problem (n = 281); Family support during childhood and adolescence (n = 52).

4. Discussion

Previous investigations have shown a significant contribution of ADHD symptoms and perceived stress to suicidal ideation in post-secondary students (Assari, 2018; Cheng et al., 2016; Mortier et al., 2017b, 2015; Stickley et al., 2016; Van Eck et al., 2015). In addition to confirming the existence of these individual associations, the present study extends the literature by taking ADHD and perceived stress into account at the same time.

We found that ADHD symptoms are associated with high levels of perceived stress and that this increases the risk of suicidal ideation, which supports that association between ADHD symptoms and suicidal ideation could be explained by perceived stress. We found that perceived stress accounts around half of the total effect of ADHD on suicidal ideation. Our findings are consistent with those of Yeguez et al who reported that stress accounts for the association between ADHD

Table 2
Associations between ADHD symptoms, perceived stress and subsequent suicidal ideation (i-Share study, France).

	Suicidal Ideation Unadjusted (n = 4,333)		ADHD and perceived stress entered simultaneously (n = 4,333)		Fully adjusted* (n = 3,669)	
	OR (95% CI)	p-value#	OR (95% CI)	p-value#	OR (95% CI)	p-value#
ADHD and perceived stress scores						
ADHD (SD = 3.9)	1.46 (1.35-1.58)	< 0.001	1.22 (1.12-1.32)	< 0.001	1.15 (1.04–1.26)	0.005
Perceived stress (SD = 3.1)	1.90 (1.75-2.05)	< 0.001	1.78 (1.64-1.94)	< 0.001	1.35 (1.21–1.51)	< 0.001

#p-value of Wald's test; OR: odds ratio; CI: confidence interval; SD: standard deviation;
*ADHD and perceived stress were simultaneously present in model and were adjusted on: age; gender; study level at baseline; tobacco consumption; alcohol consumption; cannabis consumption at least once in lifetime; previous history of depression/anxiety disorders diagnosed by a physician; economic resources; student living conditions; overall life satisfaction; parents' educational level; parents' marital status; family economic condition during childhood; parents' previous history depression or anxiety problem; family support during childhood and adolescence; cohort participation time.
The full-adjusted model ran on 3,669 participants due to missing data on some co-variables.

and suicidal ideation in young adults aged 18 to 30 years (Yeguez et al., 2018). Our study expands the knowledge on the association by providing insights into the results by gender subgroup. Separate analyses by gender did not suggest variations by gender. However, their exploratory nature calls for cautious interpretation and further analyses.

Although the effect of perceived stress on suicidal ideation was higher than the effect of ADHD, its presence did not remove the association between ADHD and suicidal ideation. Several mechanisms may explain the association between ADHD symptoms and suicidal ideation. First, university may be a particularly challenging environment for individuals with ADHD. Many studies have shown that students with ADHD show several academic and social difficulties that may in turn influence the onset of mental health problems and suicidal behaviors (Fleming and McMahon, 2012; Kleiman and Riskind, 2013; Landry and Goupil, 2010; Mortier et al., 2015; Orozco et al., 2018). Indeed, students with ADHD, compared with peers without ADHD, have a greater risk of presenting difficulties at the academic and/or social level, poorer efficiency in preparing the exams, and greater adoption of inadequate

Table 3
Path analysis: estimation of total, direct and indirect ADHD effect on suicidal ideation via perceived stress (i-Share study, France, N = 3,669).

	Estimate - Beta	95% CI	p-value
Direct effect	0.028	0.015 - 0.041	< 0.001
Indirect effect	0.026	0.021 - 0.030	< 0.001
Total effect	0.053	0.041 – 0.066	< 0.001
Gender separate analyses			
Males (n = 776)			
Direct effect	0.034	0.005 – 0.064	0.022
Indirect effect	0.021	0.012 – 0.031	< 0.001
Total effect	0.056	0.028 – 0.084	< 0.001
Females (n = 2893)			
Direct effect	0.026	0.012 – 0.040	< 0.001
Indirect effect	0.027	0.022 – 0.032	< 0.001
Total effect	0.053	0.039 – 0.067	< 0.001

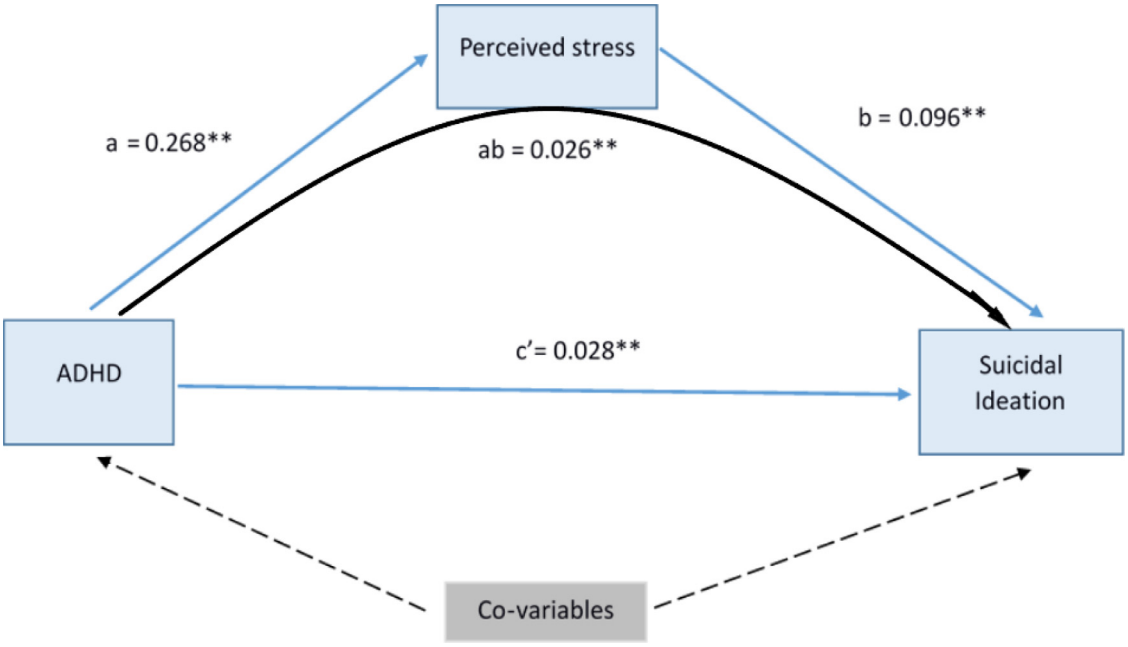

Fig. 2. Estimation of direct and indirect ADHD effect on suicidal ideation among college students (the i-Share cohort) using Structural Equation Modeling, n = 3669. a = Unadjusted effect of ADHD symptoms on perceived stress; b = effect of perceived stress adjusted on ADHD and co-variables; c' = effect of ADHD symptoms adjusted on perceived stress and co-variables; ab = indirect effect through perceived stress. **p-value < 0.001.
co-variables were: age; gender; study level at baseline; tobacco consumption; alcohol consumption; cannabis consumption at least once in lifetime; previous history of depression/anxiety disorders diagnosed by a physician; economic resources; student living conditions; overall life satisfaction; parents' educational level; parents' marital status; family economic condition during childhood; parents' previous history depression or anxiety problem; family support during childhood and adolescence; cohort participation time.

behaviors during schoolwork (e.g. higher rates of scribbling, chatting on social networks, playing video games, watching movies) (Fleming and McMahon, 2012; Landry and Goupil, 2010; Mortier et al., 2015; Weyandt and DuPaul, 2006). Second, independently from the academic context, clinical variables related with ADHD could also be at play in the association with suicidal ideation. ADHD is frequently comorbid with depression (Blase et al., 2009), disruptive behavioral disorders and substance use disorders (Blase et al., 2009; Breyer et al., 2014), which increase the risk of suicidal ideation and suicide attempts (Assari, 2018; Van Eck et al., 2015). In addition, characteristics such as impaired working memory have been shown to mediate the link between increased negative affect and suicidal ideation (Bauer et al., 2018). Furthermore, impulsivity is an important factor that could influence the association between ADHD and suicidality (ideation, plan, attempt), but we think that its impact would be observed more in the transition from suicidal ideation to suicide attempts and therefore in the ADHD-suicide attempt relationship (Wang et al., 2014). Third, there may be commonalities between ADHD and suicidal behaviors, including family and genetic factors (Ljung et al., 2014). Although ADHD symptoms and perceived stress provide independent contributions to suicidal ideation, we speculate that any underlying risk of the association ADHD-suicidal ideation may not manifest without some emotional component such as stress, depression or self-esteem, as shown Arsandaux et al. (2020), Yeguez et al. (2018) and the current study.

This study has several strengths, including its cohort design that provided temporal precedence of the exposure (ADHD) and the mediator (perceived stress) in relation to the event (suicidal ideation), the sample size that provided more precision in the estimates, and the adjustment on a wide range of potential confounding factors. Nevertheless, some limitations should be taken into consideration when interpreting the results. First, given the possibility of waning symptoms at age 18, the current study may have focused on persistent ADHD symptoms in participants aged 18 years or older, i.e. the most severely affected individuals. In addition, because participants were volunteers, and because there was a high proportion of females, the generalizability of our findings is somewhat limited. The i-Share cohort is not representative of the general student population of France, although it is the largest existing student cohort. Second, our sample was underrepresented in terms of key risk factors for ADHD (e.g. male gender, low socioeconomic status, and substance use problems) and not fully representative of the ADHD population, so the associations were possibly underestimated. Future research will have to replicate these findings in other general and clinical populations to consolidate our conclusions. Third, our study design may represent a weakness for path analysis. However, the results of the current study extend knowledge on the ADHD-suicidal ideation relationship in students and provide a large overview of the role of perceived stress in it. Further studies using an adequate design (i.e. Time 1: ADHD, Time 2: perceived stress, Time 3: suicidal ideation) and including an equal female-male ratio are required to consolidate / further explain our observations. It would also be relevant to use stress biomarkers over time, which could provide more accurate stress measures. Fourth, suicidal ideation was assessed with only one question. Indeed, an evaluation with psychometric instruments would have provided a much better degree of suicidal ideation. Fifth, the associations may have been affected by a social desirability bias due to the self-reported nature of the measures. However, the impact of this bias is potentially minimal because previous literature has shown that the use of an online self-questionnaire versus face-to-face interviews greatly reduces desirability in the responses (Tourangeau and Yan, 2007).

In a future research perspective, others emotional factors have been reported as mediators of the ADHD-suicidal ideation association (Arsandaux et al., 2020). Even if perceived stress and these other emotional factors (e.g. depression, self-esteem) are not direct or absolute consequences of ADHD in all instances, they may occur subsequently to the presence of ADHD and could influence the ADHD-suicidal ideation relationship (Anastasiades et al., 2017; Arsandaux et al., 2020; Salla et al., 2017; Van Eck et al., 2015). Therefore, a path analysis taking all these factors into account could provide additional knowledge about the relationship between ADHD and suicidal ideation in students.

In conclusion, the present study shows that perceived stress partially accounts for the association between ADHD symptoms and suicidal ideation among students. In addition, ADHD symptoms provide an independent contribution (beyond perceived stress) to suicidal ideation. It is relevant to consider both dimensions when addressing the prevention of suicidal ideation. Identification of ADHD, which is known to be under-diagnosed in countries like France, high levels of perceived stress, and suicidal ideation should be facilitated at university through screening measures and greater accessibility to mental health services. When necessary, the implementation of both appropriate non-pharmacological and pharmacological interventions should be proposed. For instance, targeted psychological interventions implemented by public authorities in student health services (e.g. individual psychotherapies or cognitive behavioral and emotional therapy groups) could help students to cope better with the onset of ADHD and manage their stress. More generally, the promotion of mental health literacy and healthy lifestyles (e.g. physical activity, adequate nutrition and sleep) may also be of interest in this population. ADHD medication should also be considered in the most severe cases of ADHD, since it has been proven to reduce the risk of suicidal behaviors in treated versus non-treated people (Liang et al., 2018). Overall, it is important to screen for the risk of suicide among young people with ADHD. Future studies are needed to corroborate our results in students from other countries in order to inform the most appropriate interventions.

Data statement

Database for the i-Share cohort can be made available upon reasoned request to Cedric Galera.

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Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent was obtained from all participants included in the study.

CRediT authorship contribution statement

Antoine Gbessemehlan: Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing, Visualization. **Julie Arsandaux:** Conceptualization, Methodology, Formal analysis, Writing - review & editing, Visualization. **Massimiliano Orri:** Writing - review & editing. **Ilaria Montagni:** Writing - review & editing. **Melissa Macalli:** Writing - review & editing. **Marie Tournier:** Writing - review & editing. **Christophe Tzourio:** Writing - review & editing, Project administration, Funding acquisition. **Cédric Galéra:** Conceptualization, Methodology, Formal analysis, Writing - review & editing, Visualization, Supervision.

Declaration of Competing Interest

The authors declare that they have no conflict of interest.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.psychres.2020.113284.

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