



HAL
open science

Association between Sleep Disturbances During Childhood and Smoking Trajectories During Adulthood: The Longitudinal TEMPO Cohort Study

Thibaut Sabatier, Isabelle Kousignian, Ramchandar Gomajee, Katharine Barry, Maria Melchior, Murielle Mary-Krause

► **To cite this version:**

Thibaut Sabatier, Isabelle Kousignian, Ramchandar Gomajee, Katharine Barry, Maria Melchior, et al.. Association between Sleep Disturbances During Childhood and Smoking Trajectories During Adulthood: The Longitudinal TEMPO Cohort Study. Behavioral Sleep Medicine, 2022, pp.1-14. 10.1080/15402002.2022.2137511 . hal-03840558

HAL Id: hal-03840558

<https://hal.science/hal-03840558v1>

Submitted on 30 Jan 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Association between sleep disturbances during childhood and smoking trajectories during adulthood: the longitudinal TEMPO cohort study

Thibaut Sabatier^{a*}, Isabelle Kousignian^b, Ramchandar Gomajee^a, Katharine Barry^a, Maria Melchior^a, Murielle Mary-Krause^a

^a Sorbonne Université, INSERM, Institut Pierre Louis d'Épidémiologie et de Santé Publique (IPLESP), Equipe de Recherche en Epidémiologie Sociale (ERES), F75012, Paris, France

^b Université Paris Cité, Unité de Recherche « Biostatistique, Traitement et Modélisation des données biologiques » BioSTM - UR 7537, F-75006 Paris, France

*Corresponding author:

Thibaut SABATIER

INSERM UMRS_1136

Faculté de Médecine Saint-Antoine

27 rue de Chaligny

75012 Paris, France

Telephone: + 33 (0)1 85 56 03 02

Email: thibaut.sabatier1@gmail.com

Author's Email:

Thibaut Sabatier : thibaut.sabatier1@gmail.com

Isabelle Kousignian : isabelle.kousignian@u-paris.fr

Ramchandar Gomajee: ramchandar.gomajee@inserm.fr

Katharine Barry: katharine.barry@iplesp.upmc.fr

Maria Melchior: maria.melchior@inserm.fr

Murielle Mary-Krause: murielle.mary-krause@iplesp.upmc.fr

Association between sleep disturbances during childhood and smoking trajectories during adulthood: the longitudinal TEMPO cohort study

Abstract

Objective: This study examined the longitudinal association between child sleep disturbances from ages 3 to 16 and smoking in adulthood among subjects from a French cohort study.

Methods: Data from 2,134 subjects who participated in the French TEMPO cohort from 1991 to 2018 were used. Sleep disturbances observed from ages 3 to 16 years defined our exposure. Tobacco consumption trajectories constitute our outcomes and were ascertained by using Group-Based Trajectory Modelling, a semiparametric probabilistic method that hypothesizes the existence of distinct developmental trajectories over time within one population. The impact of SDs in childhood on adulthood's Tobacco consumption were studied using multinomial logistic regression.

Results: Sleep disturbances at 16 years or under were observed in 26.5% of participants. Five smoking trajectories were defined: “non-smokers”, “decrease in consumption at age 20 years”, “low-level tobacco use”, “smoking followed by cessation at age 30 years” and “high-level tobacco use”. No statistically significant association between sleep disturbances and smoking trajectories was found. Compared with non-smokers, adjusted odds-ratios and 95% Confidence Intervals for each trajectory were respectively: 0.81 [0.52-1.26], 1.28 [0.74-2.22], 1.37 [0.88-2.15] and 1.01 [0.60-1.69].

Conclusion: These results suggest that smoking in adulthood may not be related to sleep disturbances in childhood.

1. Introduction

In France, as in many high-income countries, rates of tobacco smoking have declined in recent years, but France remains one of the European countries with the highest levels of tobacco consumption (WHO, 2017). Indeed, in 2020, 31.8% of individuals between 18 and 75 years of age reported smoking and 25.5% were daily smokers (Pasquereau et al., 2021). Thus, research on factors associated with smoking is important to better target vulnerable populations in prevention campaigns.

Sleep disturbances, particularly in childhood and adolescence, are a major public health problem (Dépinoy et al., 2007). Sleep homeostasis is an important factor to maintain optimal health and well-being in children and adolescents (Dahl & Lewin, 2002; Logan et al., 2018). Sleep loss can be particularly problematic in the process of brain development and maturation taking place during this period of life. Indeed, childhood and adolescence are marked by a dramatic development in the frontostriatal reward circuit (Forbes et al., 2010; Padmanabhan et al., 2011) and an increase in the availability of dopamine (Luciana & Collins, 2012; Padmanabhan & Luna, 2014). Sleep disturbances can have multiple consequences for this vulnerable population, such as an alteration in reward-related brain function and a negative impact on executive functions and inhibitory processes (Harrison et al., 2000; Killgore, 2010). This may increase the likelihood of engaging in risky behaviors such as psychoactive substance use (Nigg et al., 2006; McKnight-Eily et al., 2011; Hasler et al., 2012; Shochat et al., 2014; Logan et al., 2018). Thus, reward-related brain circuitry may underlie a link between sleep and substance use disorders. In addition, poor health behaviors tend to group in clusters (Rabel et al., 2019) and certain categories of the population, especially according to their socio-economic status, show common patterns of multiple risk behaviors (Meader et al., 2016). These social determinants of health behaviors could also explain this link (Grandner et al., 2015). SDs and tobacco use are multifactorial, and both share several vulnerability factors, such as gender (Lee

et al., 1999; Eaton et al., 2008), externalizing and internalizing problems (Gregory & O'Connor, 2002; Shochat et al., 2014; Pederson et al., 2018; Cioffredi et al., 2021), academic difficulties (Wolfson & Carskadon, 1998; Fakier & Wild, 2011), age of puberty (Dahl & Lewin, 2002; Patton & Viner, 2007) and marital instability (Doherty & Needle, 1991; Mannering et al., 2011).

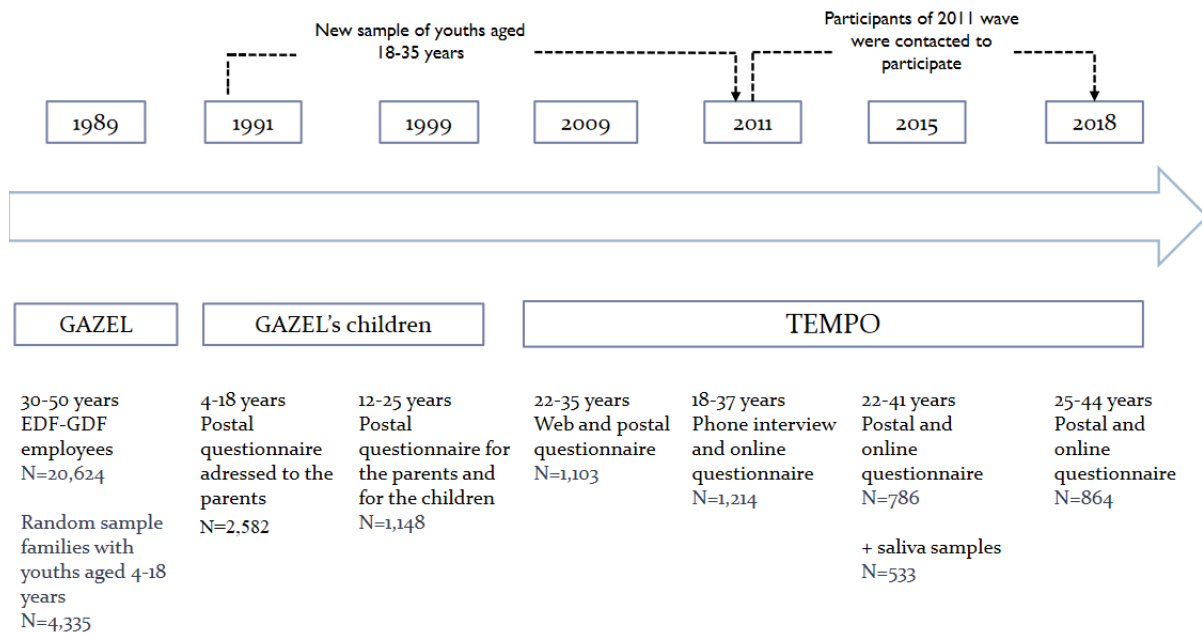
It was long thought that sleep disturbances were a consequence of addiction (Khurshid, 2018). It seems that the relation is more complex and may go both ways. While several studies have investigated the effect of psychoactive products on sleep (Babson et al., 2017; Kwon et al., 2019; Cohen et al., 2020;), few studies have studied the reverse relation, mainly being cross-sectional studies (Pasch et al., 2010; McKnight-Eily et al., 2011; Paiva et al., 2016). All these studies report a simultaneous psychotropic drugs consumption with SDs in high school students. A systematic review (Shochat et al., 2014) that examined the functional consequences of inadequate sleep in adolescents showed that sleep loss and sleep problems seem to increase future engagement in certain health related risk behaviors, such as alcohol consumption. However, among the 23 studies on the relationship between sleep and risk behaviors reviewed, only 3 studied tobacco and were longitudinal. Among these studies, two showed no longitudinal effect of sleep disturbances on smoking, and one showed that reduced weekday sleep duration predicted greater cigarette smoking. These studies examined the short-term (one to two years) effect of sleep disturbance on smoking initiation. However, an important aspect of tobacco addiction is the heterogeneity of addiction levels and motive over time. To date it is not known whether sleep disturbance predict long-term smoking trajectories. In this context, the aim of our study, based on data from 2,134 subjects who participated in the French longitudinal TEMPO cohort between 1991 and 2018, is to investigate whether SDs between ages 3 to 16 years can predict later tobacco use trajectories through adulthood. France, which is a country with high level of psychoactive use (Pasquereau et al., 2018) provides an appropriate setting to evaluate this association.

2. Methods

2.1. Participants

Our data come from the French TEMPO cohort (Mary-Krause et al., 2021), whose objectives are to improve the knowledge of mental health and addictive behaviors between childhood and adulthood. This cohort was established in 2009 to follow-up young adults aged 22-35 years who had taken part in a study on children's psychological problems in 1991 and 1999, whose parents participated in the GAZEL cohort study (**Figure 1**). The 1991 sample of children ($n = 2,582$) was randomly selected from children aged 4 to 18 years whose parents had participated in the GAZEL cohort. The GAZEL cohort, which is a closed cohort, was launched in 1989 among employees of a large public sector utility company in France in order to study long-term adult health (Goldberg et al., 2007).

In 1991, parents were asked to complete questionnaires about the development and mental health of one of their children. In 1999, these children (aged 12-25 years) completed a questionnaire regarding their living conditions, mental health, and addictive behaviors ($n = 1,148$). In 2011, recruitment was extended ($n = 1,214$) in order to make up for attrition in the study. Participants were contacted again in 2015 and in 2018 ($n = 786$, and $n = 864$ respectively), yielding up to 5 waves of tobacco use measures (1999, 2009, 2011, 2015 and 2018).



The TEMPO cohort is managed by INSERM (French National Institute of Health and Medical Research) and received approval from the French National Committee for Data Protection (CNIL: Commission Nationale de l'Informatique et des Libertés).

Overall, 3,401 subjects responded to at least 1 wave, among these, 2,316 were eligible for tobacco consumption trajectories (*i.e.*, be over 16 years old since 1999) and after exclusion of the subjects with missing data regarding tobacco consumption ($n = 182$), our analytical sample includes 2,134 TEMPO participants with at least one measure of tobacco use. Compared to our analytical sample, TEMPO participants with missing data on tobacco consumption were more likely to be male ($p < .001$), have SDs at 16 years or under ($p < .001$), have externalizing disorders ($p < .001$), have had a puberty at an early age ($p < .001$), have parents who divorced at 16 years ($p < .001$) and less likely to have grade retention at 16 years or under ($p < .001$), have parents who were current or former smokers ($p < .001$), and have parents with history of alcohol use ($p < .001$).

2.2. Measures

2.2.1. Sleep disturbances (SDs)

SDs in childhood (≤ 16 years) were measured by parent's ratings done on the Child Behavior Checklist-Parent Version (CBCL) (Achenbach, 1991) in 1991 and on the Child Behavior Checklist -Youth Version fulfilled by participants themselves in 1999. The CBCL is a widely used instrument that measures common behavioral and emotional problems among children. It measures 8 syndrome scales and scales of externalizing and internalizing disorders. The reliability and validity of these scales have previously been demonstrated (Ivanova et al., 2007; Achenbach & Rescorla, 2011). One item on the CBCL's DSM-oriented affective disorder scale is used to indicate sleep disturbances: "having trouble sleeping". Responses to this item were scored on a three-point rating scale (0: not true; 1: somewhat or sometimes true; 2: often or very true). Due to the small number of scores equal to 2 (5.6%), this item was recoded into a dichotomous variable (0: not true; 1: sometimes or often true). When two measures have been collected, the notion of SDs is equal to "sometimes or often true" if it appears in a least one of the 2 measurements.

2.2.2. *Tobacco smoking trajectories*

To study tobacco use, we defined tobacco smoking trajectories among subjects above 16 years old with at least one measure of number of cigarettes smoked per day between 1999 and 2018. Because tobacco use is an evolving phenomenon over time, we used the Group-Based Trajectory Modeling (Nagin, 1999; Nagin, 2009; Jones, 2021) and the Bayesian Information Criterion to select the number of trajectories with the best fit for our data. All possible combinations of polynomial orders for trajectory shapes were tested. Each participant was assigned to a specific smoking trajectory group based on the posterior probability to belong to that group. The posterior validity criteria (Nagin, 2009) included average posterior probability of assignment to each trajectory group, odds of correct classification, and the difference between the estimated group probabilities and proportion of the sample assigned to each group.

Following the recommendation established by Nagin (2009), a sensitivity analysis was performed on participants with at least two measures of tobacco use ($n = 1,274$), in order to validate the trajectories estimated with at least one measure of tobacco use.

2.2.3. *Covariates*

Several children and parental characteristics have been identified to be associated with children's sleeping problems and tobacco use in adulthood (Doherty & Needle, 1991; Wolfson & Carskadon, 1998; Lee et al., 1999; Dahl & Lewin, 2002; Gregory & O'Connor, 2002; Patton & Viner, 2007; Eaton et al., 2008; Fakier & Wild, 2011; Mannering et al., 2011; Shochat et al., 2014; Pedersen et al., 2018; Cioffredi et al., 2021) and were therefore controlled in the analyses.

Gender: Women vs. Men.

Externalizing disorders at 16 years or under: Children's juvenile behavioral problems at 16 years or under (No vs. Yes) were ascertained using the externalizing symptom scale of the CBCL reported by parents in 1991 or by participants themselves in 1999. Following the CBCL coding rules, we considered that a score above or equal to the 85th percentile was indicative of clinically significant behavioral problems (Achenbach & Ruffle, 2000).

Internalizing disorders at 16 years or under: Anxiety or depression symptoms at 16 years or under (No vs. Yes) were ascertained using the internalizing symptom scale of the CBCL reported by parents in 1991 or by participants themselves in 1999. A score greater than or equal to the 85th percentile was indicative of clinically significant internalizing problems (Achenbach & Ruffle, 2000).

Grade retention at 16 years or under: Presence of academic difficulties was defined by the proxy variable "grade retention at 16 years or under" (No vs. "At least one grade retention").

Age of puberty: measured via parent-report in 1999 ("Precocious", "Normal" and "Delay").

Parental divorce at 16 years or under: reported by parents in the GAZEL study (No vs. Yes).

Parental occupational grade: reported by participant's parents in the 1989 GAZEL study questionnaire, ascertained by the highest parental occupational grade, and categorized as "Manager"; "Technician or administrative associate" and "Manual worker or clerk".

Parental tobacco smoking: defined by the highest level of either parent as "Persistent smoker", "Former smoker", and "Non-smoker". This information was obtained directly from one of the parents in the yearly GAZEL study questionnaire until TEMPO participant was ≤ 16 years of age.

Parental history of alcohol abuse: reported in the GAZEL cohort study (No vs. Yes).

2.3. Statistical Analysis

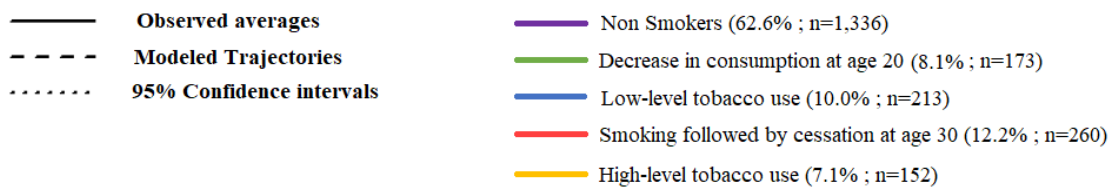
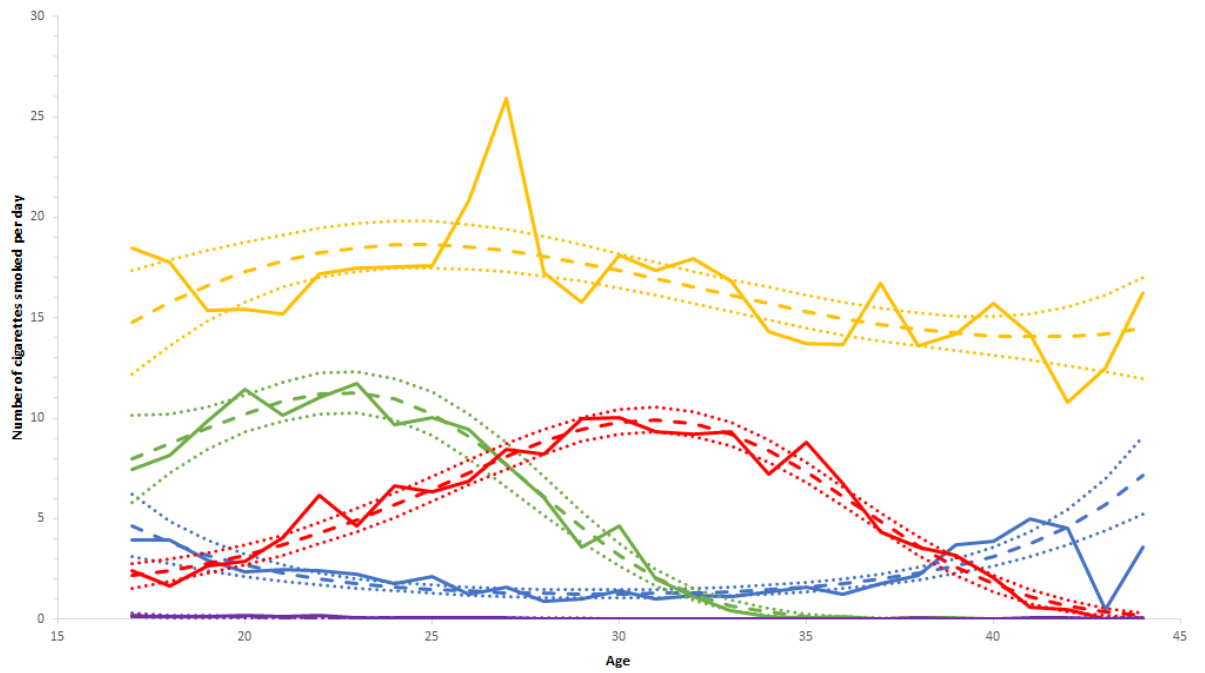
Percentages of missing values across covariates varied from 0% to 11%, with a majority around 2%, and only the age of puberty was missing for 11% of participants. Nevertheless, our exposure variable was missing for 51.8 % of participants (n=1,105). All missing data on covariates and on exposure were imputed using multiple imputations by Fully Conditional Specification (Van Buuren et al., 2006). Ten number of imputations were performed. If the chance of being a complete case does not depend on the outcome after conditioning on the main covariates and exposure, a complete-case approach gives unbiased results (Hughes et al., 2019). We therefore first investigated whether the chance of being a complete case depends on the outcome after conditioning on the covariates and exposure, and then performed two additional sensitivity analyses. First with subjects with complete exposure data with at least one measure of tobacco use (n= 1,029) and second, with subjects with complete exposure data with at least two measure of tobacco use (n=603).

The association between SDs and tobacco smoking trajectories was studied using a multinomial logistic regression model, with “non-smokers” trajectory as the reference group. The multivariate regression model included all covariates that were associated, with a $p < .20$, with at least one smoking tobacco trajectory in bivariate regression models (Supplementary Table 1). Results will be expressed in terms of adjusted odds-ratios (ORa) and their associated 95% confidence intervals (95% CI). Results were deemed statistically significant at $p < .05$. All analyses were carried out using SAS® 9.4.

3. Results

3.1. Tobacco Smoking Trajectories

We identified 5 trajectories of tobacco use (**Figure 2**): “non-smokers” (62.6%), 2 trajectories of persistent smoking, a “Low-level tobacco use” (10.0%) with about 3 cigarettes smoked per day, and a “High-level tobacco use” (7.1%) with about 15 cigarettes smoked per day, and 2 trajectories of reduction in consumption, “Decrease in consumption at age 20” (8.1%) and “Smoking followed by cessation at age 30” (12.2%).



3.2. Studied population characteristics

Table 1 describes the characteristics of our study population ($n = 2,134$) after imputations of missing data on covariates and exposure. SDs at 16 years or under were observed in 26.5% of participants. SDs were more frequent among women. Participants with externalizing and internalizing disorders at 16 years or under and those whose parents have low socioeconomic position have more SDs at 16 years or under.

[Table 1 near here]

3.3. Multinomial logistic regression

From the bivariate regression models, gender, externalizing disorders at 16 years or under, grade retention at 16 years or under, puberty, parental divorce at 16 years or under,

parental occupational grade, parental tobacco smoking and parental history of alcohol abuse were included in the multivariate regression model.

After adjustment, no statistically significant relationship between SDs at 16 years or under and tobacco smoking trajectories has been highlighted (**Table 2**).

[Table 2 near here]

3.4. Sensitivity analysis for smoking trajectory

After identifying trajectories among subjects over 16 years old with at least two measures of tobacco ($n = 1,274$), the number and shape of smoking trajectories did not change with a similar distribution in each group than those obtained with at least one measure.

After multiple imputation of subjects with missing exposure data, the association between SDs and tobacco smoking trajectories was studied among 1,274 participants. We found a similar proportion of SDs below 16 years old (26.3%). Moreover, the subjects included in this analysis were more likely to be women ($p < .001$) (62.7% vs. 53.8%) and to have parents who were former smokers ($p = .002$) compared to those with only one measure of tobacco use.

In the adjusted multinomial logistic regression model (**Table 3**), SDs at 16 years or under was associated with “Smoking followed by cessation at 30 years” (ORa: 1.84; 95% CI = [1.02-3.32]).

[Table 3 near here]

3.5. Sensitivity analyses for missing data.

Among subjects with at least one measure of tobacco, subjects with missing data on exposure, were more likely female ($p = .047$), non-smokers ($p < .001$), with parents who divorced at 16 years or under ($p = .027$), and with parents current or former smokers ($p < .001$).

After adjustment on the main covariates, the probability of being a complete case did not depend on the outcomes (ORa=0.82; 95% CI= [0.42-1.63], ORa=1.03; 95% CI= [0.54-1.98], ORa=1.43; 95% CI= [0.82-2.50], ORa=0.94; 95% CI= [0.43-2.10]; Respectively for the trajectories: “decrease consumption at age 20 years”, “low-level tobacco use”, “smoking followed by cessation at age 30 years” and “high-level tobacco use”) and was only associated with the exposure (ORa= 5.81; 95% CI= [3.92-8.62]).

We then performed two other sensitivity analyses, which consisted of an adjusted multinomial logistic regression, first among subjects with at least one measure of tobacco and complete exposure data (n=1,029) and then among subjects with at least two measures of tobacco and complete exposure data (n=603).

These two sensitivity analyses (Supplementary tables 2 and 3) yielded close ORa and similar results with: (i) no statistically significant relationship between SDs at 16 years or under and tobacco smoking trajectories in subject with at least one measure of tobacco, and (ii) an association between SDs at 16 years or under with “Smoking followed by cessation at age 30 years” in subject with at least two measures of tobacco (ORa: 1.79; 95% IC = [1,01-3,20]).

4. Discussion

In this study performed in a community-based cohort of adolescents followed up to adulthood, we found no significant association between sleep disturbances during childhood and the different trajectories of tobacco consumption in adulthood. These results are consistent with two other longitudinal studies that showed no association between SDs in adolescents and subsequent tobacco use (Catrett & Gaultney, 2009; Umlauf et al., 2011), but not with the longitudinal study conducted by Pasch et al. (Pasch et al., 2012). Indeed, in this study, sleep duration (weekday, weekend, and total) was associated with tobacco use, which was not the case in the other investigations that evaluated the consequences of “possible insomnia” (Catrett & Gaultney, 2009) or “sleep disturbance” (Umlauf et al., 2011). Thus, this difference in sleep measurement may explain the inconsistent results. Some studies have shown an association between sleep and tobacco use in adolescents (Pasch et al., 2010; McKnight-Eily et al., 2011, Paiva et al., 2016), but they focused on sleep duration and the difference between weekdays and weekends. Moreover, all these studies were cross-sectional studies with no temporality between SDs and smoking. Some longitudinal studies have shown an association between SDs in childhood and substance use disorders in adulthood (Roane & Taylor, 2008; Wong et al., 2010; Hasler et al., 2016). However, they only focused on alcohol and cannabis consumption.

An association between SDs in childhood and the trajectory “smoking followed by cessation at 30 years” was found in sensitivity analyses in subjects with at least two measures of tobacco use. This result may be partly explained by a selection bias. Indeed, some past studies have shown that women have better health literacy than men (Van der Heide et al., 2013; Lee et al., 2015; Christy et al., 2017), which can lead to a better follow-up rate when participating in longitudinal studies (Leak et al., 2015; Kripalani et al., 2019). Similarly, in this analysis with two measures of tobacco use, there were more women than in the main analysis and prior meta-analysis have confirmed that women were more at risk of SDs, particularly insomnia, than men

(Zhang & Wing, 2006). Moreover, since 2011 in France, the mean age to have a first child is approximately 30 years for women (Insee, 2022), and pregnancy is often a motivation to quit smoking cigarettes, as some women spontaneously stop cigarettes when they find out they are pregnant. Data from the Health Promotion and Disease Prevention supplement to the National Health Interview Survey (LeClere & Wilson, 1997) have demonstrated that up to 40% of smoking women spontaneously quit during their pregnancy. Nevertheless 43% of women who stop smoking during pregnancy re-start by 6 months postpartum, however for some women the cessation of smoking is sustainable (Jones et al., 2016). That could explain the result obtained in the sensitivity analysis.

We have considered SDs at 16 years or before. It is known that causes of environmental and psychological SDs' vary with age (Collège des enseignants de neurologie, 2019), and treatments may also vary depending on the cause. Nevertheless, consequences of SDs, particularly on behavior, remain the same in children and adolescents because the brain is in development at these ages (Dahl & Lewin, 2002; Petit et al., 2007; Logan et al., 2018)

We chose to take only participants' responses to define our exposure in 1999 rather than their parents' responses as in 1991, because parents seem to underestimate their children's SDs. Indeed, in our study, parents reported less sleep disturbances than their children (3.5 % vs. 6.7% respectively). In addition, some studies have shown that adolescents' self-reports regarding to their problems, particularly for internalizing and externalizing problems, were more reliable than parents' reports (Hope et al., 1999; Begovac et al., 2004).

Smoking rates have decreased in France in recent years, with the implementation of national anti-smoking strategy since 2014 (French ministry of Health, 2014, 2018), including tax increases, smoking ban in public places, plain tobacco packaging, reimbursement of nicotine replacement treatment by the national health insurance system. Nevertheless, despite a high taxation level leading to one of the highest prices of cigarettes in Europe, France remains

one of the European countries with the highest smoking prevalence levels (Lermenier-Jeannet, 2018). This French paradox could be partly explained by lack of implementation of the ban on tobacco sales to minors (Dautzenber & Birkui, 2017; Le Nézet et al., 2018), cross-border tobacco purchases in countries where the price is lower (Lermenier-Jeannet, 2018), and the limited increases in the price of tobacco (Hill & Legoupil, 2018; Lermenier-Jeannet, 2018). Indeed, smoking was banned in indoor public places in 1992, and this legislation was extended to all public places and workplaces, public transport, and indoor and outdoor places with minors in 2007, while reimbursement of nicotine replacement therapy started in 2016, with a more significant decline in smoking in France since then. (OFDT, 2019).

Our study has several limitations. First, we used self-reported data on a single item to define our exposure that has been further dichotomized in the analysis. Some studies (Wong et al., 2004; Wong et al., 2010) combined two items of the CBCL (“having trouble sleeping” and “overtiredness”) to create a composite indicator of sleep problems. Although children who were rated as having SDs were also more likely to be rated as being overtired in our study ($p < .001$), we chose to only consider the item “having trouble sleeping” as an indicator of SDs, because overtiredness in childhood may be caused by factors other than sleep problems, such as anemia (Janus & Moerschel, 2010) or inadequate nutrition (Roulet et al., 2005) and the inclusion of this item could therefore be a source of classification bias. It would have been more reliable to use a diagnostic of sleep problems via a medical assessment or a polysomnogram, but this is difficult, to achieve in a cohort. Secondly, TEMPO cohort participants had at least one parent working for a single, large national energy company who accepted to be part of a longitudinal follow-up. Thus, our study may not be fully representative of the French population, as it is less likely to include participants who come from very disadvantaged socio-economic backgrounds, where smoking is more prevalent compared to socioeconomically advantaged groups (Pasquereau et al., 2021). Moreover, there is a social gradient in SDs, with more sleep

complaints in subjects with lower income or educational attainment (Grandner et al., 2010). Therefore, our study might have underestimated the effect of SDs on tobacco consumption. Nevertheless, TEMPO study participants are characterized by a diversity of profiles, ensuring sufficient heterogeneity to make comparisons across different groups. Thirdly, age of puberty was determined retrospectively, which can induce a recall bias. However, this question was asked at an age very close to puberty thus minimizing this recall bias. Fourthly, we did not study some factors associated both to SDs and tobacco use, such as screen exposure. Indeed, the risk of insomnia is higher in young people who wake up during the night to connect to their screens. Even for a connection of one to thirty minutes, the risk of insomnia is doubled (OR = 2.3; 95%CI = [1.7-3.2]) (Zayoud & Matulonga Diakiese, 2020). Some studies have also found an association between the time spent with video games, and an increase in psychoactive substances use (Carson et al., 2011; Hull et al., 2014; Rucker et al., 2015). Considering these factors might decrease the association between SDs and tobacco use which is already not significant.

Our study also has some strengths that offset the previously cited limitations. This study is the first longitudinal analysis on SDs in childhood and the impact on tobacco use in adulthood that we know of. This study was based on a large cohort of observational data beginning during childhood, which allowed us to include information about sleep disturbances and participants' externalizing and internalizing symptoms in childhood and adolescence, as well as parents' psychoactive substance use, which can predict later substance use (Biederman et al., 2000).

The study also benefited from including several sensitivity analyses that first showed the robustness of our model in describing smoking trajectories and then showed that the results of our model after multiple imputation of missing exposure data were less likely to be biased because the chance of being a complete case did not depend on the outcome and the results were similar in the complete cases analysis on exposure.

Given the importance of sleep in human physiology and the need for public health to find early markers of risk of psychoactive substance use, it is important to investigate further the potential impact of SDs on consumption of tobacco products other than cigarettes. Future research could, for example, use a more objective measures of sleep disturbance such as the use of a medical diagnostic test, or a specific questionnaire, including a sleep diary (e.g. the Sleep Disorders Questionnaire (SDQ) (Douglass et al., 1994)). Regarding tobacco use trajectories, it would be interesting to include vaping and use of other tobacco products in addition to cigarette smoking. Polydrug use could be interesting to study as well, as some studies suggested a relationship between SDs in childhood and later alcohol use (Roane & Taylor, 2008; Wong et al., 2015; Hasler et al., 2016).

Acknowledgments

We thank TEMPO and GAZEL study participants who provided data for this project.

Funding

The TEMPO cohort received funding from the French National Research Agency (ANR); the French Institute for Public Health Research-IReSP (TGIR Cohorts); the French Inter-departmental Mission for the Fight against Drugs and Drug Addiction (MILDeCA); the French Institute of Cancer (INCa); and the Pfizer Foundation.

Disclosure Statement

None of the study authors have conflicts of interest to declare

Data Availability Statement

Research participants were guaranteed that the raw data they provided will remain confidential. To request access to the data, please send an email to cohortes.tempo@inserm.fr. Anonymized data can only be shared after explicit approval of the French national committee for data protection (Commission Nationale de l'Informatique et des Libertés, CNIL).

References:

- Achenbach, T.M. (1991). *Manual for the Child Behavior Checklist/ 4-18 and 1991 profile*. Burlington, VT: University of Vermont. Department of psychiatry.
- Achenbach, T. M., & Ruffle, T. M. (2000). The Child Behavior Checklist and related forms for assessing behavioral/emotional problems and competencies. *Pediatrics in review*, 21(8), 265–271.
- Achenbach, T. M., & Rescorla, L. A. (2001). *Manual for the ASEBA School-Age Forms and Profiles*. Burlington, VT: University of Vermont Research Center for Children, Youth, & Families.
- Babson, K. A., Sottile, J., & Morabito, D. (2017). Cannabis, Cannabinoids, and Sleep: a Review of the Literature. *Current psychiatry reports*, 19(4), 23.
- Begovac, I., Rudan, V., Skocić, M., Filipović, O., & Szirovicza, L. (2004). Comparison of self-reported and parent-reported emotional and behavioral problems in adolescents from Croatia. *Collegium Antropologicum*, 28(1), 393–401.
- Biederman, J., Faraone, S. V., Monuteaux, M. C., & Feighner, J. A. (2000). Patterns of alcohol and drug use in adolescents can be predicted by parental substance use disorders. *Pediatrics*, 106(4), 792–797.
- Carson, V., Pickett, W., & Janssen, I. (2011). Screen time and risk behaviors in 10- to 16-year-old Canadian youth. *Preventive medicine*, 52(2), 99–103.
- Catrett, C. D., & Gaultney, J. F. (2009). Possible insomnia predicts some risky behaviors among adolescents when controlling for depressive symptoms. *The Journal of genetic psychology*, 170(4), 287–309.

- Christy, S. M., Gwede, C. K., Sutton, S. K., Chavarria, E., Davis, S. N., Abdulla, R., Ravindra, C., Schultz, I., Roetzheim, R., & Meade, C. D. (2017). Health Literacy among Medically Underserved: The Role of Demographic Factors, Social Influence, and Religious Beliefs. *Journal of health communication, 22*(11), 923–931.
- Cioffredi, L. A., Kamon, J., & Turner, W. (2021). Effects of depression, anxiety and screen use on adolescent substance use. *Preventive medicine reports, 22*, 101362.
- Cohen, A., Ben Abu, N., & Haimov, I. (2020). The Interplay Between Tobacco Dependence and Sleep Quality Among Young Adults. *Behavioral sleep medicine, 18*(2), 163–176.
- Collège des enseignants de neurologie (2019). *Trouble du sommeil chez l'enfant et l'adulte [Sleep disorders in children and adults]*. (5th ed.). Elsevier-Masson; Retrieved August 26, 2021 from: <https://www.cen-neurologie.fr/deuxieme-cycle/troubles-du-sommeil-lenfant-ladulte>
- Dahl, R. E., & Lewin, D. S. (2002). Pathways to adolescent health sleep regulation and behavior. *The Journal of adolescent health : official publication of the Society for Adolescent Medicine, 31*(6 Suppl), 175–184.
- Dautzenberg, B., & Birkui, P. (2017). Quels adolescents achètent leurs cigarettes chez le buraliste à Paris ? [Where do Parisian teenagers buy their cigarettes?]. *Revue des maladies respiratoires, 34*(3), 223–231.
- Dépinoy, M., Delormas, F., & Broussouloux, S. (2007, March-April). Le sommeil : une nouvelle priorité de santé publique ? [Sleep: a new public health priority?]. *La santé de l'Homme, 388*, 14-15.
- Doherty, W., & Needle, R. (1991). Psychological Adjustment and Substance Use among Adolescents before and after a Parental Divorce. *Child Development, 62*(2), 328-337.

- Douglass, A. B., Bornstein, R., Nino-Murcia, G., Keenan, S., Miles, L., Zarcone, V. P., Jr, Guilleminault, C., & Dement, W. C. (1994). The Sleep Disorders Questionnaire. I: Creation and multivariate structure of SDQ. *Sleep, 17*(2), 160–167.
- Eaton, D. K., Kann, L., Kinchen, S., Shanklin, S., Ross, J., Hawkins, J., Harris, W. A., Lowry, R., McManus, T., Chyen, D., Lim, C., Brener, N. D., Wechsler, H., & Centers for Disease Control and Prevention (CDC) (2008). Youth risk behavior surveillance--United States, 2007. *Morbidity and Mortality Weekly Report. Surveillance Summaries (Washington, D.C.: 2002), 57*(4), 1–131.
- Fakier, N., & Wild, L. G. (2011). Associations among sleep problems, learning difficulties and substance use in adolescence. *Journal of Adolescence, 34*(4), 717–726.
- Forbes, E. E., Ryan, N. D., Phillips, M. L., Manuck, S. B., Worthman, C. M., Moyles, D. L., Tarr, J. A., Sciarrillo, S. R., & Dahl, R. E. (2010). Healthy adolescents' neural response to reward: associations with puberty, positive affect, and depressive symptoms. *Journal of the American Academy of Child and Adolescent Psychiatry, 49*(2), 162–72.e725.
- Goldberg, M., Leclerc, A., Bonenfant, S., Chastang, J. F., Schmaus, A., Kaniewski, N., & Zins, M. (2007). Cohort profile: the GAZEL Cohort Study. *International journal of epidemiology, 36*(1), 32–39.
- Grandner, M. A., Patel, N. P., Gehrman, P. R., Xie, D., Sha, D., Weaver, T., & Gooneratne, N. (2010). Who gets the best sleep? Ethnic and socioeconomic factors related to sleep complaints. *Sleep medicine, 11*(5), 470–478.
- Grandner, M. A., Jackson, N. J., Izci-Balserak, B., Gallagher, R. A., Murray-Bachmann, R., Williams, N. J., Patel, N. P., & Jean-Louis, G. (2015). Social and Behavioral Determinants of Perceived Insufficient Sleep. *Frontiers in neurology, 6*, 112

- Gregory, A. M., & O'Connor, T. G. (2002). Sleep problems in childhood: a longitudinal study of developmental change and association with behavioral problems. *Journal of the American Academy of Child and Adolescent Psychiatry, 41*(8), 964–971.
- Harrison, Y., Horne, J. A., & Rothwell, A. (2000). Prefrontal neuropsychological effects of sleep deprivation in young adults--a model for healthy aging?. *Sleep, 23*(8), 1067–1073.
- Hasler, B. P., Dahl, R. E., Holm, S. M., Jakubcak, J. L., Ryan, N. D., Silk, J. S., Phillips, M. L., & Forbes, E. E. (2012). Weekend-weekday advances in sleep timing are associated with altered reward-related brain function in healthy adolescents. *Biological psychology, 91*(3), 334–341.
- Hasler, B. P., Kirisci, L., & Clark, D. B. (2016). Restless Sleep and Variable Sleep Timing During Late Childhood Accelerate the Onset of Alcohol and Other Drug Involvement. *Journal of studies on alcohol and drugs, 77*(4), 649–655.
- Hill, C., & Legoupil, C. (2018). Taxation et prix du tabac en France et conséquences sur la consommation [Taxation and price of tobacco in France and consequences on consumption]. *Bulletin Epidémiologique Hebdomadaire, (14-15)*, 309 -316. Available at https://www.santepubliquefrance.fr/content/download/186658/document_file/41734_spf0000203.pdf
- Hope, T. L., Adams, C., Reynolds, L., Powers, D., Perez, R. A., & Kelley, M. L. (1999). Parent vs. self-report: Contributions toward diagnosis of adolescent psychopathology. *Journal of Psychopathology and Behavioral Assessment, 21*(4), 349–363.
- Hughes, R. A., Heron, J., Sterne, J., & Tilling, K. (2019). Accounting for missing data in statistical analyses: multiple imputation is not always the answer. *International journal of epidemiology, 48*(4), 1294–1304.

- Hull, J. G., Brunelle, T. J., Prescott, A. T., & Sargent, J. D. (2014). A longitudinal study of risk-glorifying video games and behavioral deviance. *Journal of Personality and Social Psychology, 107*(2), 300–325.
- Insee (2022). *Age moyen de la mère à l'accouchement [average age of mother at delivery]*. Retrieved January 3, 2022, from: <https://www.insee.fr/fr/statistiques/2381390>.
- Ivanova, M. Y., Dobrean, A., Dopfner, M., Erol, N., Fombonne, E., Fonseca, A. C., Frigerio, A., Grietens, H., Hannesdottir, H., Kanbayashi, Y., Lambert, M., Achenbach, T. M., Larsson, B., Leung, P., Liu, X., Minaei, A., Mulatu, M. S., Novik, T. S., Oh, K. J., Roussos, A., ... Chen, W. J. (2007). Testing the 8-syndrome structure of the child behavior checklist in 30 societies. *Journal of clinical child and adolescent psychology : the official journal for the Society of Clinical Child and Adolescent Psychology, American Psychological Association, Division 53, 36*(3), 405–417.
- Janus, J., & Moerschel, S. K. (2010). Evaluation of anemia in children. *American family physician, 81*(12), 1462–1471.
- Jones, B. L. (2021). *Traj: group-based modeling of longitudinal data*. Retrieved August 3, 2021, from: <https://www.andrew.cmu.edu/user/bjones/index.htm>.
- Jones, M., Lewis, S., Parrott, S., Wormall, S., & Coleman, T. (2016). Re-starting smoking in the postpartum period after receiving a smoking cessation intervention: a systematic review. *Addiction, 111*(6), 981–990.
- Khurshid, K. A. (2018) Relationship between sleep disturbances and addiction. *Mental Health and Addiction Research, 3*(3), 1-4.
- Killgore, W. D. (2010). Effects of sleep deprivation on cognition. *Progress in brain research, 185*, 105–129.

- Kripalani, S., Heerman, W. J., Patel, N. J., Jackson, N., Goggins, K., Rothman, R. L., Yeh, V. M., Wallston, K. A., Smoot, D. T., & Wilkins, C. H. (2019). Association of Health Literacy and Numeracy with Interest in Research Participation. *Journal of general internal medicine, 34*(4), 544–551.
- Kwon, M., Park, E., & Dickerson, S. S. (2019). Adolescent substance use and its association to sleep disturbances: A systematic review. *Sleep health, 5*(4), 382–394.
- Leak, C., Goggins, K., Schildcrout, J. S., Theobald, C., Donato, K. M., Bell, S. P., Schnelle, J., Kripalani, S., & Vanderbilt Inpatient Cohort Study (2015). Effect of Health Literacy on Research Follow-Up. *Journal of health communication, 20 Suppl 2*(0), 83–91.
- Le Nézet, O., Janssen, E., Brissot, A., Philippon, A., Shah, J., Chydériotis, S., Spilka, S. (2018) . Les comportements tabagiques à la fin de l’adolescence. Enquête Escapad 2017 [Smoking behaviors in late adolescence. Escapad survey 2017]. *Bulletin Epidémiologique Hebdomadaire, (14-15)*, 274-282. From: http://beh.santepubliquefrance.fr/beh/2018/14-15/pdf/2018_14-15_2.pdf
- LeClere, F. B., & Wilson, J. B. (1997). Smoking behavior of recent mothers, 18-44 years of age, before and after pregnancy: United States, 1990. *Advance data, (288)*, 1–11.
- Lee, H. Y., Lee, J., & Kim, N. K. (2015). Gender Differences in Health Literacy Among Korean Adults: Do Women Have a Higher Level of Health Literacy Than Men? *American journal of men's health, 9*(5), 370–379.
- Lee, K. A., McEnany, G., & Weekes, D. (1999). Gender differences in sleep patterns for early adolescents. *The Journal of adolescent health: official publication of the Society for Adolescent Medicine, 24*(1), 16–20.

- Lermenier-Jeannet A. (2018) Consommations, ventes et prix du tabac : une perspective européenne. [Tobacco consumption, sales, and prices: a European perspective]. *OFDT, Tendances*, 126, 1-6. From <https://www.ofdt.fr/BDD/publications/docs/eftxaly7.pdf>
- Logan, R. W., Hasler, B. P., Forbes, E. E., Franzen, P. L., Torregrossa, M. M., Huang, Y. H., Buysse, D. J., Clark, D. B., & McClung, C. A. (2018). Impact of Sleep and Circadian Rhythms on Addiction Vulnerability in Adolescents. *Biological psychiatry*, 83(12), 987–996.
- Luciana, M., & Collins, P. F. (2012). Incentive Motivation, Cognitive Control, and the Adolescent Brain: Is It Time for a Paradigm Shift?. *Child development perspectives*, 6(4), 392–399.
- Meader, N., King, K., Moe-Byrne, T., Wright, K., Graham, H., Petticrew, M., Power, C., White, M., & Sowden, A. J. (2016). A systematic review on the clustering and co-occurrence of multiple risk behaviours. *BMC public health*, 16, 657.
- Mannering, A. M., Harold, G. T., Leve, L. D., Shelton, K. H., Shaw, D. S., Conger, R. D., Neiderhiser, J. M., Scaramella, L. V., & Reiss, D. (2011). Longitudinal associations between marital instability and child sleep problems across infancy and toddlerhood in adoptive families. *Child development*, 82(4), 1252–1266.
- Mary-Krause, M., Herranz Bustamante, J. J., Bolze, C., Galéra, C., Fombonne, E. J., & Melchior, M. (2021). Cohort Profile: The TEMPO Cohort Study. *International journal of epidemiology*, 50(4), 1067–1068k.
- McKnight-Eily, L. R., Eaton, D. K., Lowry, R., Croft, J. B., Presley-Cantrell, L., & Perry, G. S. (2011). Relationships between hours of sleep and health-risk behaviors in US adolescent students. *Preventive medicine*, 53(4-5), 271–273.

- Ministry of Health (2014). *Programme national de réduction du tabagisme 2014-2019. Plan cancer 2014-2019 - Objectif 10 [National tobacco reduction program 2014-2019. Cancer plan 2014-2019 - Goal 10]*. From: <https://solidarites-sante.gouv.fr/prevention-en-sante/addictions/article/lutte-contre-le-tabagisme>
- Ministry of Health (2018). *Programme national de lutte contre le tabac (2018-2022) [National tobacco control program (2018-2022)]*. From: <https://solidarites-sante.gouv.fr/prevention-en-sante/addictions/article/lutte-contre-le-tabagisme>
- Nagin, D. S. (1999). Analyzing developmental trajectories: A semiparametric, group-based approach. *Psychological Methods*, 4(2), 139–157.
- Nagin, D. S. (2009). *Group-Based Modeling of Development*. Cambridge, MA and London, England: Harvard University Press.
- Nigg, J. T., Wong, M. M., Martel, M. M., Jester, J. M., Puttler, L. I., Glass, J. M., Adams, K. M., Fitzgerald, H. E., & Zucker, R. A. (2006). Poor response inhibition as a predictor of problem drinking and illicit drug use in adolescents at risk for alcoholism and other substance use disorders. *Journal of the American Academy of Child and Adolescent Psychiatry*, 45(4), 468–475.
- Organisation de coopération et de développement économiques (OCDE) (2019). *Tabagisme chez les adultes [Smoking among adults]*. From: <https://www.oecd-ilibrary.org/sites/fac453d-fr/index.html?itemId=/content/component/fac453d-fr>
- Padmanabhan, A., Geier, C. F., Ordaz, S. J., Teslovich, T., & Luna, B. (2011). Developmental changes in brain function underlying the influence of reward processing on inhibitory control. *Developmental cognitive neuroscience*, 1(4), 517–529.

- Padmanabhan, A., & Luna, B. (2014). Developmental imaging genetics: linking dopamine function to adolescent behavior. *Brain and cognition*, *89*, 27–38.
- Paiva, T., Gaspar, T., & Matos, M. G. (2016). Mutual relations between sleep deprivation, sleep stealers and risk behaviours in adolescents. *Sleep science (Sao Paulo, Brazil)*, *9*(1), 7–13.
- Pasch, K. E., Laska, M. N., Lytle, L. A., & Moe, S. G. (2010). Adolescent sleep, risk behaviors, and depressive symptoms: are they linked?. *American journal of health behavior*, *34*(2), 237–248.
- Pasch, K. E., Latimer, L. A., Cance, J. D., Moe, S. G., & Lytle, L. A. (2012). Longitudinal bi-directional relationships between sleep and youth substance use. *Journal of youth and adolescence*, *41*(9), 1184–1196.
- Pasquereau A., Andler R., Guignard R., Richard JB., Arwidson P., & Nguyen-Thanh VL. (2018). La consommation de tabac en France: premiers résultats du Baromètre santé 2017 [Tobacco consumption in France: preliminary results from the 2017 Health Barometer]. *Bulletin Epidémiologique Hebdomadaire*, (14-15), 265-273.
- Pasquereau A., Andler R., Guignard R., Soullier N., Gautier A., Richard JB., Nguyen-Thanh V.(2021). Consommation de tabac parmi les adultes en 2020 : résultats du Baromètre de Santé publique France [Tobacco consumption among adults in 2020 : results of the Health Barometer]. *Bulletin Epidémiologique Hebdomadaire*. (8), 132-139.
- Patton, G. C., & Viner, R. (2007). Pubertal transitions in health. *Lancet (London, England)*, *369*(9567), 1130–1139.
- Pedersen, M. U., Thomsen, K. R., Heradstveit, O., Skogen, J. C., Hesse, M., & Jones, S. (2018). Externalizing behavior problems are related to substance use in adolescents across six

- samples from Nordic countries. *European child & adolescent psychiatry*, 27(12), 1551–1561.
- Petit, D., Touchette, E., Tremblay, R. E., Boivin, M., & Montplaisir, J. (2007). Dyssomnias and parasomnias in early childhood. *Pediatrics*, 119(5), e1016–e1025.
- Rabel, M., Laxy, M., Thorand, B., Peters, A., Schwettmann, L., & Mess, F. (2019). Clustering of Health-Related Behavior Patterns and Demographics. Results From the Population-Based KORA S4/F4 Cohort Study. *Frontiers in public health*, 6, 387.
- Roane, B. M., & Taylor, D. J. (2008). Adolescent insomnia as a risk factor for early adult depression and substance abuse. *Sleep*, 31(10), 1351–1356.
- Roulet, M., Cheseaux, M., & Coti, P. (2005). Conséquences de la dénutrition chez l'enfant et l'adolescent. Mortalité, morbidité, conséquences médicoéconomiques. [Consequences of disease-related malnutrition in children and adolescents. Mortality, morbidity, and costs]. *Nutrition Clinique et Métabolisme*, 19(4), 207-213.
- Rücker, J., Akre, C., Berchtold, A., & Suris, J. C. (2015). Problematic Internet use is associated with substance use in young adolescents. *Acta paediatrica (Oslo, Norway : 1992)*, 104(5), 504–507.
- Shochat, T., Cohen-Zion, M., & Tzischinsky, O. (2014). Functional consequences of inadequate sleep in adolescents: a systematic review. *Sleep medicine reviews*, 18(1), 75–87.
- Umlauf, M. G., Bolland, J. M., & Lian, B. E. (2011). Sleep disturbance and risk behaviors among inner-city African-American adolescents. *Journal of urban health : bulletin of the New York Academy of Medicine*, 88(6), 1130–1142.

- Van Buuren, S., Brand, J.P.L., Groothuis-Oudshoorn, C. G.M., & Rubin D. B. (2006) Fully conditional specification in multivariate imputation, *Journal of Statistical Computation and Simulation*, 76(12), 1049-1064.
- Van der Heide, I., Rademakers, J., Schipper, M., Droomers, M., Sørensen, K., & Uiters, E. (2013). Health literacy of Dutch adults: a cross sectional survey. *BMC public health*, 13, 179.
- World Health Organization. (2017). WHO report on the global tobacco epidemic, 2017: monitoring tobacco use and prevention policies. World Health Organization. <https://apps.who.int/iris/handle/10665/255874>. Licence: CC BY-NC-SA 3.0 IGO.
- Wolfson, A. R., & Carskadon, M. A. (1998). Sleep schedules and daytime functioning in adolescents. *Child development*, 69(4), 875–887.
- Wong, M. M., Brower, K. J., Fitzgerald, H. E., & Zucker, R. A. (2004). Sleep problems in early childhood and early onset of alcohol and other drug use in adolescence. *Alcoholism, clinical and experimental research*, 28(4), 578–587.
- Wong, M. M., Brower, K. J., Nigg, J. T., & Zucker, R. A. (2010). Childhood sleep problems, response inhibition, and alcohol and drug outcomes in adolescence and young adulthood. *Alcoholism, clinical and experimental research*, 34(6), 1033–1044.
- Wong, M. M., Robertson, G. C., & Dyson, R. B. (2015). Prospective relationship between poor sleep and substance-related problems in a national sample of adolescents. *Alcoholism, clinical and experimental research*, 39(2), 355–362.
- Zhang, B., & Wing, Y. K. (2006). Sex differences in insomnia: a meta-analysis. *Sleep*, 29(1), 85–93.

Zayoud A., & Matulonga Diakiese B. (2020). Effets des écrans sur le sommeil des adolescents – Résultat de l'enquête du réseau morphée auprès des collégiens et lycéens franciliens.[Effects of screens on teenagers' sleep - Results of the « morphée » network's survey of middle and high school students in the Paris region]. *ORS - Focus santé en Île-de-France*, 1-15

Tables and Figures

Table 1. Characteristics of the study sample according to the presence of sleep disturbances (SDs) at 16 years or under, after imputations on missing data (TEMPO Cohort study, 1991-1999, $n = 2,134$)

Table 2. Multivariate multinomial logistic regression model (ORa, 95%CI) in subject with at least one measure of tobacco use after multiple imputation on missing data (TEMPO cohort study, 1991-2018, $n = 2,134$).

Table 3. Multivariate multinomial regression model (ORa, 95% CI) in subjects with at least two measures of tobacco use after multiple imputation on missing data (TEMPO cohort study, 1991-2018, $n = 1,274$).

Figure 1. Timeline of TEMPO cohort.

Figure 2. Estimation of the mean smoking tobacco trajectories and associated 95% confidence intervals among TEMPO subjects ($n = 2,134$).

Supplementary materials

Supplementary Table 1. Bivariate multinomial logistic regression model (OR, 95% CI) in subjects with at least one measure of tobacco use (TEMPO Cohort study, 1991-2018, $n = 2,134$).

Supplementary Table 2. Multivariate multinomial logistic regression model (ORa, 95%CI) in subjects with at least one measure of tobacco use and complete exposure data (TEMPO cohort study, 1991-2018, $n = 1,029$).

Supplementary Table 3. Multivariate multinomial regression model (ORa, 95% CI) in subjects with at least two measures of tobacco use and complete exposure data (TEMPO cohort study, 1991-2018, $n = 603$)

Table 1. Characteristics of the study sample according to the presence of sleep disturbances (SDs) at 16 years or under, after imputations on missing data (TEMPO Cohort study, 1991-1999, $n = 2,134$)

	SDs \leq 16 years old (26.5%)	No SDs \leq 16 years old (73.5%)	<i>P</i> *
Gender			
Women	64.2 %	57.3 %	.028
Men	35.8 %	42.7 %	
Externalized disorders at 16 years or under			< .001
Yes	26.8 %	8.8 %	
No	73.2 %	91.2 %	
Internalized disorders at 16 years or under			< .001
Yes	36.3 %	10.0 %	
No	63.7 %	90.0 %	
Grade retention at 16 years or under			
Yes	11.5 %	11.4 %	.496
No	88.5 %	88.6 %	
Puberty			
Precocious	20.5 %	13.3 %	.073
Normal	69.8 %	80.0 %	
Delay	9.7 %	6.7 %	
Parental divorce at 16 years or under			
Yes	7.0 %	5.0 %	.329
No	93.0 %	95.0 %	
Parental occupational grade			
Manager	59.2 %	55.4 %	
Technician/administrative associate	31.6 %	39.8 %	.009
Manual worker/clerk	9.2 %	4.8 %	
Parental tobacco smoking			
Non-smoker	34.6 %	35.9 %	.292
Former smoker	27.6 %	30.8 %	
Persistent smoker	37.8 %	33.3%	
Parental history of alcohol abuse			.468
Yes	32.3 %	33.2 %	
No	67.7 %	66.8 %	

*P = P-value: with chi-square test

Table 2. Multivariate multinomial logistic regression model (ORa, 95%CI) in subject with at least one measure of tobacco use after multiple imputation on missing data (TEMPO cohort study, 1991-2018, n = 2,134).

	Tobacco smoking trajectories ^a				
	“Non-Smokers” n = 1,336	“Decrease in consumption at 20 years” n = 173	“Low-level tobacco use” n = 213	“Smoking followed by cessation at 30 years” n = 260	“High-level tobacco use” n = 152
SDs at 16 years or under					
No	ref.	1	1	1	1
Yes		0.81 (0.52-1.26)	1.28 (0.74-2.22)	1.37 (0.88-2.15)	1.01 (0.60-1.69)

^a: After conditioning on gender, externalized disorders at 16 years or under, grade retention at 16 years or under, Puberty, Parental divorce at 16 years or under, Parental occupational grade, parental tobacco smoking and parental history of alcohol abuse.

Table 3. Multivariate multinomial regression model (ORa, 95% CI) in subjects with at least two measures of tobacco use after multiple imputation on missing data (TEMPO cohort study, 1991-2018, n = 1,274).

	Tobacco smoking trajectories ^a				
	“Non-Smokers” n = 808	“Decrease in consumption at 20 years” n = 77	“Low-level tobacco use” n = 152	“Smoking followed by cessation at 30 years” n = 145	“High-level tobacco use” n = 92
SDs at 16 years or under					
No	ref.	1	1	1	1
Yes		0.77 (0.39-1.51)	0.96 (0.45-2.02)	1.84 (1.02-3.32)	0.60 (0.31-1.18)

^a: After conditioning adjustment on: gender, externalized disorders at 16 years or under, grade retention at 16 years or under, Puberty, Parental divorce at 16 years or under, Parental occupational grade, parental tobacco smoking and parental history of alcohol abuse.

Supplementary Table 1: Bivariate multinomial logistic regression model (OR, 95% CI) in subjects with at least one measure of tobacco use (TEMPO Cohort study, 1991-2018, $n = 2,134$).

	“Non-Smokers” $n = 1336$	“Decrease in consumption at 20 years” $n = 173$	“Low-level tobacco use” $n = 213$	“Smoking followed by cessation at 30 years” $n = 260$	“High-level tobacco use” $n = 152$	P
SDs at 16 years or under Yes vs. No		1.11 (0.74-1.66)	1.38 (0.82-2.34)	1.50 (1.00-2.25)	1.30 (0.78-2.14)	.425
Gender Men vs. Women		1.41 (1.03-1.95)	0.76 (0.56-1.04)	1.30 (0.99-1.70)	1.39 (0.99-1.96)	.005
SDs at 16 years or under Yes vs. No		0.83 (0.55-1.28)	1.27 (0.74-2.18)	1.34 (0.89-2.02)	0.99 (0.59-1.65)	.333
Externalized disorders at 16 years or under Yes vs. No		3.43 (2.11-5.57)	1.81 (1.11-2.96)	1.74 (1.10-2.74)	3.28 (1.98-5.41)	<.001
SDs at 16 years or under Yes vs. No		1.07 (0.69-1.65)	1.32 (0.76-2.32)	1.48 (0.96-2.28)	1.27 (0.74-2.18)	.540
Internalized disorders at 16 years or under Yes vs. No		1.06 (0.64-1.77)	1.24 (0.76-2.02)	0.96 (0.60-1.55)	0.98 (0.57-1.67)	.700
SDs at 16 years or under Yes vs. No		1.08 (0.72-1.62)	1.41 (0.83-2.40)	1.47 (0.98-2.21)	1.27 (0.77-2.08)	.475
Grade retention at 16 years or under Yes vs. No		1.22 (0.71-2.11)	1.20 (0.66-2.18)	1.60 (0.99-2.59)	1.94 (1.10-3.43)	.134
SDs at 16 years or under Yes vs. No		1.02 (0.67-1.56)	1.41 (0.84-2.36)	1.41 (0.91-2.19)	1.21 (0.73-2.00)	.520
Puberty Precocious vs. Normal		1.84 (1.05-3.24)	1.44 (0.79-2.62)	1.86 (1.16-3.00)	1.74 (0.62-4.90)	.215
		1.42 (0.63-3.19)	0.37 (0.10-1.38)	0.73 (0.39-1.38)	1.16 (0.44-3.02)	
SDs at 16 years or under Yes vs. No		1.06 (0.71-1.59)	1.40 (0.82-2.37)	1.47 (0.97-2.22)	1.25 (0.76-2.04)	.483
Parental divorce at 16 years or under Yes vs. No		2.15 (1.20-3.82)	1.60 (0.89-2.89)	0.99 (0.52-1.88)	2.12 (1.15-3.93)	.018
SDs at 16 years or under Yes vs. No		1.09 (0.72-1.63)	1.45 (0.84-2.47)	1.52 (1.00-2.31)	1.30 (0.78-2.17)	.397
Parental occupational grade Technician vs. Manager		1.03 (0.73-1.43)	0.99 (0.73-1.35)	1.22 (0.92-1.61)	1.37 (0.96-1.95)	.265
		0.94 (0.49-1.83)	0.51 (0.24-1.08)	0.62 (0.32-1.20)	0.96 (0.46-1.99)	
SDs at 16 years or under Yes vs. No		1.06 (0.70-1.60)	1.43 (0.84-2.41)	1.45 (0.95-2.20)	1.25 (0.76-2.09)	.505
Parental tobacco smoking Former smoker vs. Non-smoker		1.00 (0.65-1.52)	1.70 (1.20-2.43)	1.06 (0.75-1.50)	1.60 (1.03-2.49)	<.001
		1.66 (1.15-2.41)	1.21 (0.83-1.75)	1.52 (1.11-2.09)	1.82 (1.20-2.78)	
SDs at 16 years or under Yes vs. No		1.08 (0.72-1.62)	1.41 (0.84-2.39)	1.48 (0.97-2.24)	1.27 (0.78-2.09)	.471
Parental history of alcohol abuse Yes vs. No		0.88 (0.62-1.25)	1.20 (0.88-1.62)	1.43 (1.09-1.89)	1.58 (1.12-2.23)	.009

SDs: Sleep Disturbances; word in bold = reference; P: P-value

Supplementary Table 2. Multivariate multinomial logistic regression model (ORa, 95% CI) in subjects with at least one measure of tobacco use and complete exposure data (TEMPO cohort study, 1991-2018, $n = 1,029$)

Tobacco smoking trajectories^a					
	“Non-Smokers”	“Decrease in consumption at 20 years”	“Low-level tobacco use”	“Smoking followed by cessation at 30 years”	“High-level tobacco use”
	<i>n</i> = 617	<i>n</i> = 116	<i>n</i> = 99	<i>n</i> = 125	<i>n</i> = 72
SDs at 16 years or under					
No	ref.	1	1	1	1
Yes		0.78 (0.48-1.27)	1.30 (0.80-2.11)	1.30 (0.84-2.01)	1.18 (0.67-2.07)

^a: After conditioning on gender, externalized disorders at 16 years or under, grade retention at 16 years or under, Puberty, Parental divorce at 16 years or under, Parental occupational grade, parental tobacco smoking and parental history of alcohol abuse.

Supplementary Table 3. Multivariate multinomial regression model (ORa, 95% CI) in subjects with at least two measures of tobacco use and complete exposure data (TEMPO cohort study, 1991-2018, $n = 603$)

Tobacco smoking trajectories^a					
	“Non-Smokers”	“Decrease in consumption at 20 years”	“Low-level tobacco use”	“Smoking followed by cessation at 30 years”	“High-level tobacco use”
	<i>n</i> = 354	<i>n</i> = 50	<i>n</i> = 80	<i>n</i> = 70	<i>n</i> = 49
SDs at 16 years or under					
No	ref.	1	1	1	1
Yes		0.80 (0.39-1.66)	1.01 (0.56-1.81)	1.79 (1.01-3.20)	0.72 (0.34-1.55)

^a: After conditioning on gender, externalized disorders at 16 years or under, grade retention at 16 years or under, Puberty, Parental divorce at 16 years or under, Parental occupational grade, parental tobacco smoking and parental history of alcohol abuse.