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The effect of smoking initiation in adolescence on the subsequent smoking trajectories of people who smoke, and the role of adverse childhood experiences: results from the 1958 British cohort study

Camille Joannès PhD, Post-doctoral researcher¹; Michelle Kelly-Irving PhD, Research Director¹; Sébastien Couarraze PhD, Senior Lecturer²; Raphaële Castagné PhD, Research Fellow¹

¹EQUITY Research Team, Center for Epidemiology & Research in POPulation Health (CERPOP), UMR 1295, University Toulouse III Paul Sabatier, Toulouse, France

²Department of Medicine, Maieutics and Paramedicine, Faculty of Health, Center for Epidemiology & Research in POPulation Health (CERPOP), UMR 1295, University Toulouse III Paul Sabatier, Toulouse, France

Correspondence: Camille Joannès, CERPOP, Faculty of medicine, 37 allées Jule Guesde 31000 Toulouse, France. Email: camille.joannes@univ-tlse3.fr

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Abstract

Objective: To examine the association between smoking initiation in adolescence and subsequent different smoking trajectories of people who smoke, and to examine the combined effect of adverse childhood experiences (ACEs) and smoking initiation in adolescence on smoking trajectories of people who smoke.

Design and sample: Data are from 8,757 individuals in Great Britain from the birth cohort National Child Development Study and who reported being smokers or former smokers by age 23.

Measurements: Smoking initiation in adolescence was measured at 16y and smoking trajectories were derived from smoking variables from ages 23 to 55. We modelled the relationship between smoking initiation in adolescence with or without ACEs and smoking trajectories.

Results: Individuals who initiated smoking in adolescence were more likely to quit later than quitting in twenties ($RRR_{\text{quitting in thirties}} = 3.43 [2.40; 4.89] p < 0.001$; $RRR_{\text{quitting in forties}} = 5.25 [3.38; 8.14] p < 0.001$; $RRR_{\text{quitting in fifties}} = 4.48 [2.95; 6.79] p < 0.001$), to relapse ($RRR_{\text{Relapse}} = 3.66 [2.82; 4.76] p < 0.001$) and to be persistent smokers ($RRR_{\text{persistent}} = 5.25 [3.81; 7.25] p < 0.001$) compared to those who had initiated smoking in young adulthood. These effects were particularly pronounced in case of ACEs.

Conclusion: Smoking prevention programs aimed at reducing smoking initiation should be promoted to adolescents to limit the burden of smoking, especially for people who have suffered adversity during childhood.

Keywords

Smoking; Psychosocial exposure; Health behaviours; Cohort study; Social inequalities in health; Life course epidemiology; Nursing ; Adolescence

Acknowledgments

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Introduction

Tobacco use is a leading preventable cause of morbidity and mortality worldwide, responsible for the world's leading causes of death: cancer, cardiovascular disease, chronic lung disease, and diabetes (World Health Organization, 2008). While smoking prevalence has declined worldwide, it has remained unchanged or even increased in some countries with a medium or high human development index such as USA, Australia, Qatar, Germany (Murray et al., 2020; The tobacco atlas, 2022), illustrating both the success and limitations of prevention and health promotion campaigns. Average smoking prevalence in the European Union remains high, with 25.3% of the population reporting smoking in 2020 (WHO Global Report on Trends in Prevalence of Tobacco Use 2000–2025 Fourth Edition, 2021) with around 13% of adult smoking cigarettes in the UK in 2022 (Office for National Statistics (Office for National Statistics (ONS), 2023), positioning tobacco consumption the biggest preventable behavioral risk factor. Most adult who smoke cigarette want to quit (Babb, 2017) but quitting is extremely difficult because of the highly addictive nature of nicotine. Nicotine dependence is closely related to the early period of smoking initiation: the earlier the initiation in adolescence, the higher the degree of dependence thereafter (Royal College of Physicians of London, 2007).

To date, smoking initiation rates remain high among European adolescents even if a downward trend has been observed over the last few decades in Northern Europe (Marcon et al., 2018). While adolescence is a sensitive age where brain areas associated with emotional, social, and cognitive

functions appear to remain more plastic, or malleable, than other brain areas (Sydnor et al., 2023), multiple levels of influence are involved in smoking initiation. Macro, societal levels of influence including disadvantaged socio-economic background (Gilman et al., 2003), advertising and tobacco-related policies (Turner et al., 2004) have been associated with the risk of adolescent smoking initiation, as well as intra-individual factors such as impulsive temperament, low self-esteem (O'Loughlin et al., 2009) or conscientiousness (Daly et al., 2016) and alcohol consumption (O'Loughlin et al., 2009). Social factors are also involved such as smoking among family and friends (Ridner, 2005), difficulties at school (O'Loughlin et al., 2009) or adverse childhood experiences (ACEs) (Anda et al., 1999; Afifi et al., 2020). ACEs, described as a set of psychological trauma, abuse, living conditions, out of the child's control, that can generate chronic stress responses in the child's immediate environment (Felitti et al., 1998), have been identified as an important upstream determinant of smoking initiation in adolescence and of persistent smoking (Joannès et al., 2022). The question then arises as to how ACEs and smoking initiation relate to the influence of subsequent smoking behaviour. The understanding of the long-term effects of early exposure on later smoking is in line with the conceptual framework of the life course approach, which allows to understand the mechanisms behind the observation that exposures or conditions experienced by people at a given point in their lives are associated with health consequences several years later (Bartley et al., 1997; Kuh et al., 2003).

Studies have found that the escalation from initial to regular use and dependence takes two to three years among adolescents (National Center for Chronic Disease Prevention and Health Promotion (US) Office on Smoking and Health, 2012) and smoking initiation in adolescence has been linked with later tobacco use in college students (Azagba et al., 2015; Everett et al., 1999). This transition to dependence then leads to a lifelong trajectory of smoking, which varies from one individual to another. Once dependence has occurred, smoking trajectories take on three main forms: a definitive smoking cessation trajectory at a given age; a trajectory of persistent smoking; a non-definitive cessation trajectory characterized by multiple attempts to quit followed by relapse. Individuals who initiated smoking in adolescents are most likely to continue smoking in young adulthood (Jefferis et al., 2003) and persistent smoking (Royal College of Physicians of London, 2007). Furthermore, the likelihood of smoking cessation was greater among people who smoke the later in life they had started (Breslau & Peterson, 1996). Definitive smoking cessation significantly reduces the risk of developing smoking-related diseases (U.S. Department of Health and Human Services, 2020) and the longer the duration of smoking, the more severe the adverse effects on health (Doll & Peto, 1978; Lubin et al., 2016).

Many studies have focused on the smoking trajectories of adolescents or young adults (Abroms et al., 2005; Ahun et al., 2020; Audrain-McGovern et al., 2004; Chassin et al., 2008; Chen & Jacques-Tiura, 2014; Colder et al., 2001; Dutra et al., 2017; Juon et al., 2002; Karp et al., 2005; Lessov-Schlaggar et al., 2008), and the association between age of smoking initiation and smoking trajectories has only been investigated up to early adulthood (Colder et al., 2001; Orlando et al., 2004; Riggs et al., 2007) without accounting for the effects of ACEs on the “smoking career” of people who smoke. Studying the effect of smoking initiation in adolescence on different detailed smoking trajectories over the life course will allow to better understand its extent. Examining this impact in the light of ACEs would provide a better understanding of the risks faced by this population of individuals. These results could then be used to set up prevention programs by prevention professionals, public health nurses, advanced practice nurses and school nurses, which aims to prevent smoking initiation, rather than smoking cessation.

In this study we aimed (i) to study the effect of smoking initiation in adolescence on the subsequent smoking trajectories of people who smoke, and (ii) to examine the combined effect of ACEs and smoking initiation in adolescence on smoking trajectories of people who smoke.

Method:

Study design

We used data from the 1958 National Child Development Study (NCDS 58), a prospective birth cohort study of 18,558 people born in 1958 in Great Britain. A full description of the study design and methods has been detailed elsewhere (Power & Elliott, 2006). Data collection from a variety of sources on multiple aspects of the cohort members' lives, such as economic, social, behavioural and health-related factors, have been collected at birth and at ages 7, 11, 16, 23, 33, 42, 44/45, 46, 50, 55, and 62. Detailed information on ethics approval and informed consent across the different data collection waves is available from the study website (Shepherd, 2012).

Sample

We selected participants who reported being smokers or former smokers at age 23. We excluded participants who reported at age 23 having never smoked, i.e. having never smoked before that age, leaving a sample of 8,757 participants who smoked or were former smokers at age 23. We used participants' information from birth to age 55, as data by age 62 were not yet available. The sample

selection strategy is described in Appendix Figure 1. See Appendix Table 1 for detailed information about missing data.

Measures

Exposure

The exposure assessed in this analysis was smoking initiation in adolescence. Smoking initiation was derived from information on smoking behavior, reported in questionnaires at age 16, where respondents answered the following question: "How many cigarettes do you usually smoke in a week?". Individuals who had an "Initiation by 16y" were those who reported smoking at least one cigarette per week at that age. Individuals who had an "Initiation in young adulthood" were those who reported not smoking at 16y, corresponding to individuals whose initiation occurred after the age of 16 and up to the age of 23.

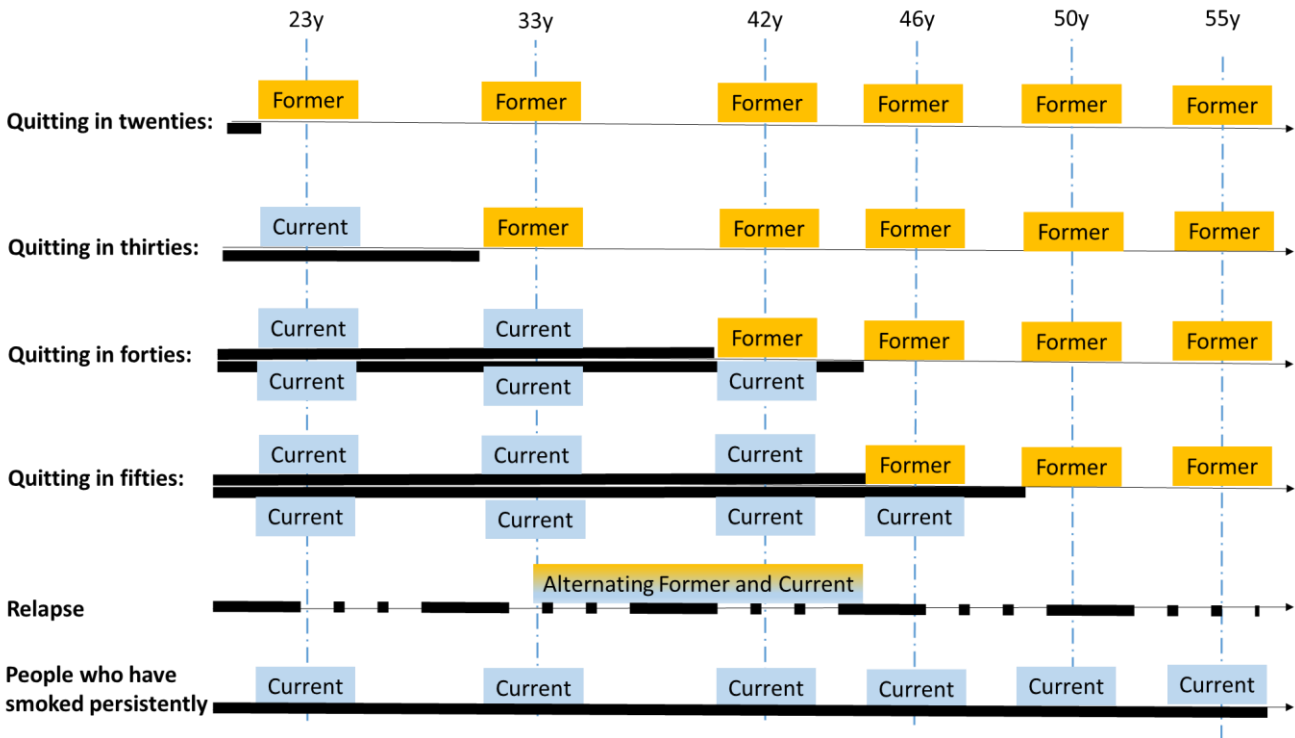
Outcome

The outcome measured in this analysis was smoking trajectories. The smoking trajectories variable was constructed in two steps. In the first step, smoking statuses were measured from information on smoking behavior reported in questionnaires between the ages of 23 and 55. At each age, "people who currently smoke" were defined as follows: at 23y as those who reported currently smoking cigarettes and those who reported smoking cigars or pipes; at 33y as those who reported currently smoking cigarettes and as those who reported smoking at least one cigarette per day; at 42y, 46y, 50 and 55y as those who reported smoking cigarettes occasionally or every day. From 23y to 55y, "People who formerly smoked" were defined as those who reported not currently smoking but had previously smoked cigarettes. See Appendix Table 2 for more detailed informations of the smoking status construction.

In the second step, from this set of smoking status variables from 23 to 55 years, we derived the smoking trajectories variable by combining these smoking statuses into six categories: "Quitting in twenties"; "Quitting in thirties"; "Quitting in forties"; "Quitting in fifties"; "Relapse"; "People who have smoked persistently". Individuals classified as "Quitting in twenties" were those identified as "People who currently smoke" at age 16 and "People who formerly smoked" at ages 23, 33, 42, 46, 50 and 55. Individuals classified as "Quitting in thirties" were those identified as "People who currently smoke" at ages 23 and "People who formerly smoked" at ages 33, 42, 46, 50 and 55. Individuals classified as "Quitting in forties" were those identified as "People who currently smoke" at ages 23, 33 and 42 or 46 and "People who formerly smoked" at ages 50 and 55. Individuals classified as "Quitting in fifties"

were those identified as "People who currently smoke" at the previous ages and "People who formerly smoked" at ages 50 or 55. Individuals assigned to the "Relapse" category were those who alternated between "People who currently smoke" or "People who formerly smoked" at different ages. "People who have smoked persistently" were defined as those identified as "People who currently smoke" at age 23, 33, 42, 46, 50 and 55y. Figure 1 illustrates the construct of the smoking trajectories variable.

Figure 1. Illustration of the smoking trajectories variable (the six categories as shown on the left hand side)



The six categories are illustrated in each line (black bold line). Each blue vertical dashed line represents the smoking status measured during the data collection wave, which are spaced according to the time lapsed. There are two black lines for "Quitting in forties" and "Quitting in fifties" due to the grouping of two trajectories close to each other in time.

Confounders

To examine the relationship between smoking initiation in adolescence and smoking trajectories, confounding variables were identified based on the literature, from questionnaires completed during childhood. Socioeconomic background was included (Jefferis et al., 2003) using parental socioeconomic classification of occupations (SEC) at birth (I-professional occupations & II-intermediate occupations/III-skilled occupations (non-manual)/III-partly skilled occupations (manual)/IV-partly skilled occupations & V-unskilled), as well as mother's and father's level of education (left school <14 years/ left school ≥15 years) and material living conditions at ages 7, 11 and 16

(advantaged/disadvantaged). Parental and family characteristics were also included (Joannès et al., 2022): mother's age at birth ($\leq 23y/24-27y/27-31y/>31y$), sibling order at 7y (Single child/Elder/2nd place or more), parental smoking at 16y (Smoker/Non-smoker), and parental involvement, derived from reading to the child, outdoor activities (Frequent/Occasionally, Hardly ever), and father's role in the management of the child (Equal parental investment/Father less invested/ Father not invested). We considered parents' interest in their child's education as perceived by teachers (Both interested/Low, no interest) (Mirowsky & Ross, 1998) using data collected at 7, 11, and 16y. Individual characteristics were also included, such as the respondent's sex (Wetter et al., 1999), their participation in festive activities at age 16 (ranked from 0 to 4, where 4 indicates a high participation in parties with friends) (Nichter et al., 2010) and their conscientiousness personality traits at age 16 (measured with a score in which higher values indicated higher conscientiousness) (Pluess & Bartley, 2015).

Sources of ACEs were considered into six categories using information collected in childhood at 7, 11 and 16 years of age from questions to the child's parent, their teacher, or the health visitor:

1. Child in care: cohort member has been in public/voluntary care or foster care at age 7, 11 or 16, according to the information given by the parent (or parental substitute) at these ages.
2. Physical neglect: cohort member appeared undernourished/dirty at age 7 or 11. Information was collected from the response from child's teacher.
3. Offenders: cohort member lived in a household where a family member was in prison or on probation or was in contact with a probation service at ages 7, 11 and 16. Cohort member has ever been to prison or been on probation at 16 years. Information was collected from the health visitor's response.
4. Parental separation: cohort member has been separated from their father or mother due to death, divorce, or separation at 7, 11 or 16 years according to the response of the child's parent (or parent substitute).
5. Mental illness: the household was in contact with mental health services at 7 or 11 years according to the response of the child's parent (or parent substitute).
6. Alcohol abuse: A family member had alcohol abuse problem at 7 years according to the health visitor.

ACEs were measured by counting the number of positive responses across the above categories (Felitti et al., 1998; Kelly-Irving et al., 2013). Based on the distribution of the cumulative ACEs score (1.69 %

of participants were defined as having three or more ACEs), a three-category variable was constructed (0 adversity/1 adversity/more than one adversity).

Statistical analysis

First, analyses were carried-out to describe the variables studied. Second, the relationship between smoking initiation in adolescence and smoking trajectories of people who smoke was investigated by using multinomial logistic regression model. Relative risk ratios (RRR) with 99% confidence intervals (CI) of smoking trajectories were estimated comparing participants who initiated smoking by age 16, to those initiated smoking in young adulthood ([16y-23y]), controlling for confounders variables (Model 1).

- Model 1: Multinomial logistic regression modeling the probability of each level j , namely $\{1, \dots, J\}$, of the smoking trajectory by:

$$\log\left(\frac{p_j(x)}{p_J(x)}\right) = \beta_0 + \beta_{\text{Smoking initiation in adolescence}} + \beta_{\text{ACEs}} + \beta_{\text{parental SEC}} + \beta_{\text{father education}} + \beta_{\text{mother education}} + \beta_{\text{material living conditions}} + \beta_{\text{mother's age}} + \beta_{\text{sibling order}} + \beta_{\text{parental smoking}} + \beta_{\text{parenting}} + \beta_{\text{outdoor activities}} + \beta_{\text{reading activities}} + \beta_{\text{parents' interest in their child's education}} + \beta_{\text{social activities}} + \beta_{\text{conscientiousness}}$$

To examine the combined effect of ACEs and smoking initiation in adolescence on smoking trajectories, we performed the same model than before with a variable constructed by combining smoking initiation with ACEs as exposure.

- Model 2: Multinomial logistic regression modeling the probability of each level j , namely $\{1, \dots, J\}$, of the smoking trajectory by:

$$\log\left(\frac{p_j(x)}{p_J(x)}\right) = \beta_0 + \beta_{\text{initiation-ACEs}} + \beta_{\text{parental SEC}} + \beta_{\text{father education}} + \beta_{\text{mother education}} + \beta_{\text{material living conditions}} + \beta_{\text{mother's age}} + \beta_{\text{sibling order}} + \beta_{\text{parental smoking}} + \beta_{\text{parenting}} + \beta_{\text{outdoor activities}} + \beta_{\text{reading activities}} + \beta_{\text{parents' interest in their child's education}} + \beta_{\text{social activities}} + \beta_{\text{conscientiousness}}$$

In order to limit bias due to missing data and gain in precision, we used multiple imputation methods to impute missing data. Multiple imputation replaces missing values by generating probable values based on the distributions and pre-existing relationships between variables in the database (Rubin,

1987). We ran 10 dataset imputations for exposure, outcome and covariate variables with missing data using the multiple imputation by chained equations method taking the missing at random assumption (Bousquet, 2012; Rubin, 1987). It is generally accepted that ten imputations is a sufficient number (Rubin, 1987). Comparisons were made between complete-case analyses and estimates obtained by imputation to ensure that our results were not biased by missing values (Appendix Table 3).

Statistical analyses were performed using STATA v18 (StataCorp, 2023, p. 18).

Results

Among participants who reported being smokers or former smokers by age 23, and for whom data were available, half had started smoking by age 16, a third had experienced ACEs and 18% had experienced both ACEs and smoking initiation by 16y. Around 43% of participants quit smoking in their twenties and 16% smoked persistently into their fifties. Regarding the early life social environment, over 70% of participants had parents with medium or low SEC and had a father and a mother who had left school before the age of 14. Additionally, around one-thirds have lived in unfavourable conditions. Regarding family constitution and characteristics, 27% of the individuals at birth had a mother aged 23 or over and 64% were the second sibling or more, 76% had a parent who smoked, 11% had father who were absent in its family investment. More than half of the participants had most weeks reading activities or outdoor activities and 53% had parents perceived by the teacher as uninterested. Regarding the cohort members' characteristics, around 48% were women, 15% attended no parties, and the majority had a high conscientiousness score (Table 1).

Table 1. Descriptive statistics in 8,757 participants from the 1958 National Child Development Study.

Variable	Category	N	%
<i>Exposures</i>			
Smoking initiation	In young adulthood ([16y-23y])	3,282	49.57
	In adolescence (by 16y)	3,339	50.43
	Missing	2,136	
Smoking initiation & ACEs	Initiation>16y & No ACEs	2,320	37.41
	Initiation>16y & ACEs	731	11.79
	Initiation by 16y and No ACEs	2,020	32.57
	Initiation by 16y and ACEs	1,131	18.24
	Missing	2,555	
<i>Outcome</i>			

Smoking trajectories	Quitting in twenties	2,021	42.94
	Quitting in thirties	572	12.15
	Quitting in forties	326	6.93
	Quitting in fifties	319	6.78
	Relapse	724	15.38
	People who have smoked persistently	745	15.83
	Missing	4,050	
<i>Counfounders</i>			
ACEs	None	5,642	69.27
	One	1,829	22.46
	Two or more	674	8.28
	Missing	612	
Parental SEC	I & II	1,453	17.71
	IIINM	819	9.98
	IIIM	4,119	50.20
	IV&V	1,814	22.11
	Missing	552	
Father's level of education	Left school \geq 15y	1,736	23.44
	Left school < 14y	5,669	76.56
	Missing	1,352	
Mother's level of education	Left school \geq 15y	2,096	25.37
	Left school < 14y	6,165	74.63
	Missing	496	
Housing deprivation	Advantaged	5,452	63.66
	Disadvantaged	3,112	36.34
	Missing	193	
Mother's age	\leq 23 y	2,266	27.30
	24-27 y	2,272	27.37
	27-31y	1,781	21.46
	> 31y	1,982	23.88
	Missing	456	
Sibling order	Single child	609	7.95
	Elder	2,125	27.73
	\geq 2	4,930	64.33
	Missing	1,093	
Parental smoking	Non smoker	1,531	24.26
	Smoker	4,780	75.74
	Missing	2,446	

Paternal involvement	Mother=Father	4,355	58.76
	Mother>Father	2,274	30.68
	Father not	783	10.56
	Missing	1,345	
Outdoor activities	Most weeks	6,635	86.79
	Occasionally/hardly ever	1,010	13.21
	Missing	1,112	
Reading activities	Most weeks	4,183	54.81
	Occasionally	2,540	33.28
	Hardly ever	909	11.91
	Missing	1,125	
Parents' interest in their child's education	Both interested	3,664	47.54
	Low/No interest	4,043	52.46
	Missing	1,050	
Sex	Men	4,527	51.70
	Women	4,230	48.30
Leisure : parties	0 : No parties	920	14.88
	1	1,108	17.92
	2	1,585	25.64
	3	1,600	25.88
	4 : Lots of parties	969	15.67
	Missing	2,575	
Conscientiousness	Score (med[p25-p75])	8	[6-9]
	Missing	2,480	28.32
Total		8,757	100.00

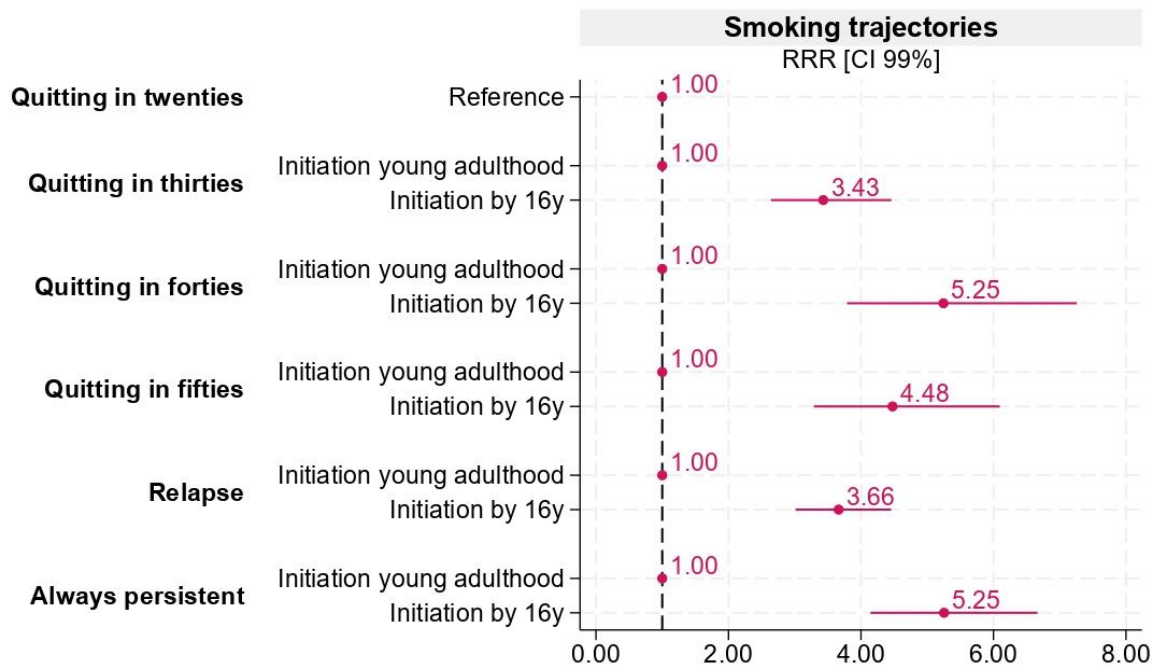
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269 Multivariable multinomial logistic regression results between smoking initiation in adolescence and
270 smoking trajectories on the imputed data are presented in Figure 2. Cohort members who had started
271 smoking by age 16 were more likely to quit later than quitting in their twenties ($RRR_{\text{quitting in thirties}} = 3.43$
272 $[2.40; 4.89]$ $p < 0.001$; $RRR_{\text{quitting in forties}} = 5.25 [3.38; 8.14]$ $p < 0.001$; $RRR_{\text{quitting in fifties}} = 4.48 [2.95; 6.79]$ p
273 < 0.001) compared to those who had initiated smoking between 16y to 23y. Cohort members who had
274 started smoking by the age of 16 also tended to relapse ($RRR_{\text{Relapse}} = 3.66 [2.82; 4.76]$ $p < 0.001$) and to
275 be persistent smokers ($RRR_{\text{persistent}} = 5.25 [3.81; 7.25]$ $p < 0.001$) compared to those who had initiated
276 smoking between 16y to 23y.

277

278 Figure 2: Relative risk ratios for smoking trajectories according to smoking initiation in
279 adolescence in 8,757 participants with imputed data from the NCDS 58.



280 *Estimates are from multinomial logistic regression model where the quitting in twenties group is the*
281 *reference category. Models are adjusted for sex, parental SEC, father education, mother education,*
282 *material living conditions, mother's age, sibling order, parental smoking, parenting, outdoor activities,*
283 *reading activities, ACEs, parents' interest in their child's education, social activities and*
284 *conscientiousness. Initiation in young adulthood correspond to a smoking initiation between]16y-23y].*

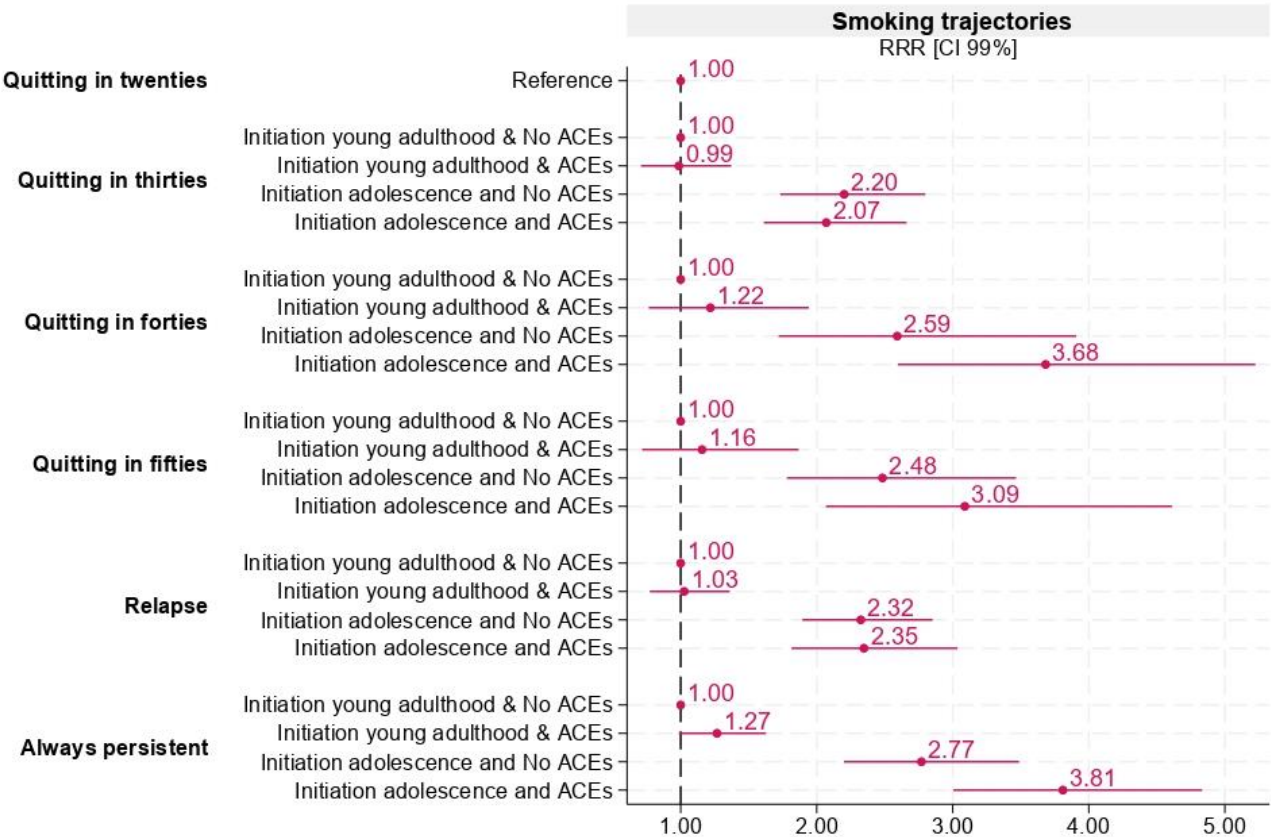
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286

287 Multivariable multinomial logistic regression results between ACEs and smoking initiation on smoking
288 trajectories on the imputed data are presented in Figure 3. Cohort members who experienced ACEs
289 and initiated smoking by 16y had an increased risk of quitting later (notably in their 40s and 50s) or
290 being persistent smokers thereafter than quitting in twenties, compared to those who initiated
291 smoking in young adulthood and did not experience ACEs. The estimates observed tended to be more
292 pronounced in cases of smoking initiation in adolescence and childhood adversity.

293

Figure 3: Relative risk ratios for smoking trajectories according to the composite variable of smoking initiation and ACEs in 8,757 participants with imputed data from the NCDS 58.



Estimates are from multinomial logistic regression model where the quitting in twenties group is the reference category. Models are adjusted for sex, ACEs, parental SEC, father education, mother education, material living conditions, mother's age, sibling order, parental smoking, parenting, outdoor activities, reading activities, parents' interest in their child's education, social activities and conscientiousness. Initiation in adolescence correspond to a smoking initiation by 16y and initiation in young adulthood correspond to a smoking initiation between]16y-23y].

Discussion

In this prospective UK cohort, in which half of the smokers at 23y for whom data were available initiated smoking by 16y, we found evidence that smoking initiation in adolescence was associated with a decreased risk of quitting in their twenties and an increasing risk of persistent smoking, of relapse consumption and a longer exposure to smoking. These results are consistent with those of previous studies in which smoking initiation in adolescence was associated with later smoking behavior (Breslau, 1993; Breslau & Peterson, 1996; Jefferis et al., 2003) and where early users of cigarettes during adolescence tend to have heavy use smoking trajectories several years later (Riggs et al., 2007). In addition, we found that cohort members who experienced both ACEs and smoking initiation by 16y had a higher risk of quitting later, and were more likely to be persistent smokers thereafter, compared to those who had not experience both exposures together. This result is in line with another study

where the impact of ACEs on smoking behavior tend to begins as early as adolescence and continues to exacerbate into emerging adulthood (Rogers et al., 2021).

Our results offer several insights with respect to previous studies. Early initiation to smoking during adolescence can lead to significant nicotine dependence, with lasting effects into adulthood with persistent smoking. Indeed, adolescence is a sensitive period when the brain is developing, and it has been shown that the physiological effects of nicotine can be exacerbated at this age (Leslie, 2020). Nicotine intake can lead to structural changes in the brain that are strongly implicated in addiction mechanisms. Nicotine target receptors usually interact with the neurotransmitter acetylcholine activating the reward circuit by releasing dopamine into the body. The more these nicotine receptors are stimulated, the less they react to nicotine. They can become desensitized, and the number of nicotine receptors can multiply in compensation (Royal College of Physicians of London, 2007). Furthermore, nicotine consumption can increase the onset of anxiety disorders (Nguyen et al., 2021), also related with withdrawal symptoms that increase cravings. This in turn reinforces the need for nicotine to reduce cravings, while worsening these anxiety disorders over time in a vicious circle of interdependence (Kutlu & Gould, 2015). The links between anxiety and smoking can be bidirectional. People suffering from anxiety or stress disorders related to nicotine dependence are less likely to overcome withdrawal and cessation symptoms, which contributes to the maintenance of tobacco dependence (Kassel et al., 2003). Our results contribute further to evidence of the effect of early smoking initiation on later cessation, difficulty in quitting or persistent smoking. Furthermore, the results of our study call for further research to determine whether people who started smoking early are more likely to report anxiety later than those who started smoking later to support this evidence. Behavioral interventions (Selph et al., 2020) are especially important in reducing the likelihood of smoking initiation in non-smoking children and adolescents. In particular, these interventions can use positive self-image, perceived confidence, approval from parents and friends, personal beliefs to influence adolescents' decision not to smoke (Kulbok et al., 2008) and caregiver smoking cessation support promoting smokefree homes and cars (Ball et al., 2023).

Our results emphasize that smoking initiation in adolescence influences subsequent smoker's career, but in different ways depending on whether or not adversity was experienced during childhood. Exposure to adversity in early life can lead to emotional and stress-response disorders in childhood, as well as negative affect (NA) (Shonkoff et al., 2012). NA has been closely correlated with behavioral regulation difficulties, which underlie externalizing disorders, i.e. maladaptive disruptive, impulsive,

delinquent, hyperactive, and aggressive behaviors (Werner-Seidler et al., 2022), that may play a role in smoking initiation (Kassel et al., 2003) and subsequent smoking. Smoking provides an immediate pharmacological and psychological benefit on affect regulation (Carmody, 1992) through the use of the reward circuit and the release of dopamine (Felitti et al., 1998; McKee et al., 2020). Smoking can then be an effective coping option due to its anxiolytic and sedative properties (Pomerleau & Pomerleau, 1984). In addition, early exposure to toxic stress can lead to alterations in biological systems and neural circuits (Committee on Psychosocial Aspects of Child and Family Health et al., 2012) which could increase sensitivity to nicotine (Duffy et al., 2018), leading to a differential susceptibility (Diderichsen et al., 2018) to smoking. Individuals who have experienced adversity during childhood are therefore a population at risk to be taken into account in interventions to prevent smoking initiation in adolescence. However, the results of this research, using the grouping of different adversity indicators at different ages, call for precautions in public health communication. As the measure of childhood adversity is a probabilistic tool at the population level, estimating average effects, it is important not to take a deterministic approach to the effects of childhood adversity on smoking. The individual approach can lead to stigmatization drifts that could ultimately exacerbate social health inequalities (Kelly-Irving & Delpierre, 2019). It is therefore necessary to consider the ACEs in their global and population context for their prevention.

Our research provides important insights that could be considered for smoking interventions based on the combination of different approaches such as the "high-risk" approach, supporting at the community levels families at high risk of experiencing childhood adversities, as well as the "population" approach aimed at reducing smoking initiation among adolescents in the general population, and the "vulnerable population" approach intervening on smoking initiation among adolescents who have experienced childhood adversities (Diderichsen et al., 2018; Frohlich & Potvin, 2008).

There are several limitations in this study. First, our sample may be biased in terms of representativeness. The main weaknesses of this study are due to the amount of missing data caused by attrition in the cohort study. For example, 24% of the initial sample had missing values for smoking initiation and 46% for smoking trajectories. These weaknesses has been partly addressed by using estimates obtained from multiple imputations to account for the missing data. We conducted comparative analyses by running the model using imputed datasets and using the complete case dataset without imputation. We found that the relationship between smoking initiation and smoking trajectory was stable. Furthermore, this study is based on a subsample of individuals according their

smoking status at age 23. It is therefore possible that selection biases are present due to attrition, and that the individuals studied who participated in the surveys at that age are relatively more advantaged in terms of socio-economic background (Wadsworth et al., 2003). Given that low socio-economic position has been associated with smoking behaviour (Jefferis et al., 2004), our sub-sample of individuals may have lower levels of smoking than the general population.

Second, regarding the construction of smoking variables. They are derived from self-reported data and it is possible that we have misclassified individuals due to reporting bias or due to the fact that questions about smoking differed between data collection waves. However, studies comparing self-reported smoking status with biochemical markers have concluded that self-reported data are reliable for population-based studies (Patrick et al., 1994; Rebagliato, 2002). In addition, the construction of the smoking variable at age 23 took into account those who smoked cigars, pipes, and resulted in a heterogeneous group of individuals in the current smoking category. However, comparative analyses showed similar results for this group, justifying their inclusion. Data collection waves at given ages were spaced several years apart, implying probable changes in smoking status that we were unable to measure. We therefore hypothesized that the variables measured at a given age were proxies for constant measurements of behavior over time. The exact age of smoking initiation was not available. However, two surveys of a large British population in 1975 indicated that smoking initiation was low before the age of 14/15 (Rawbone et al., 1978, 1979), which suggests that the measurements recorded at age 16 are reasonably robust estimates of teenage smoking. This study used data from teenagers in the 1970s, which meant that it was not possible to take into account the known effects of e-cigarettes and other associated modes of consumption as a "gateway" to smoking. In addition, this sample of people will have experienced by the time they were in their fifties the role of macro-economic policies and major public health intervention, such as the Europe-wide ban on smoking in indoor public places around 2007-2008. This implies that we have not been able to measure the effect of these public health interventions at the individual level on smoking opportunities for adolescents in certain places, such as pubs, bars or concerts, where peer pressure can play an important role.

Third, the measurement of ACEs may be limited as it remains a proxy for severe circumstances that we hypothesized as being chronically stressful, considering only the child's circumstances at ages 7, 11, and 16. Misclassification bias, linked to a social desirability bias, may have occurred in relation to adversity categories, namely when considering the sensitive nature of the questions. For this reason, we constructed the ACEs variable conservatively. The "no adversity" category therefore represents a heterogeneous group of individuals, possibly made up of a few misclassified individuals. Given the fact that we were conducting a secondary analysis of the data, we were unable to measure other circumstances, such as sexual abuse or physical maltreatment. However, the strength of this measure

lies in its prospective collection method, which limits memory bias. We focused on ACEs in our study, as they have been identified as an important determinant of smoking, independently of socio-economic background. We controlled for socio-economic background in our analyses by adjusting for parental social class at birth, mother's and father's level of education and housing deprivation during childhood. However, further research is needed to analyze the impact of individuals' socio-economic position over the course on the association between smoking initiation and smoking trajectories. An interesting perspective would be to deconstruct smoking trajectories and examine the effect of ACEs on each smoking status age by age or to use other approaches using time-variant covariates.

Finally, we may have overlooked variables or assumptions contributing to the relationship between smoking initiation and smoking trajectories such as the family's ethnic origin, the parents' level of health literacy, the neighbourhood or the urban or rural living environment. Therefore, it is probable that residual confounding factors are present, and that our estimates of the impact of ACEs on smoking are overestimated. Furthermore, we have not accounted for intermediate confounding factors in our modelling. The estimation of associations cannot therefore be concluded as causal estimates.

Conclusion

Using longitudinal prospective data covering 55 years of the life course, in a large sample from a representative cohort study, we provide evidence that the contribution of adolescent smoking initiation to adult smoking burden is high suggesting a need to formulate and implement effective actions to reduce smoking initiation in adolescents. People who have suffered adversities during childhood can also be considered as a population at risk by nurses and other medical and non-medical professionals responsible for prevention programs in schools, social services and other structures aimed at adolescents, in order to reduce initiation during adolescence and limit the burden of smoking. Further studies are also needed to assess the influence of early e-cigarettes use on subsequent smoking trajectories and the role of ACEs.

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