Original Research

Childhood Cigarette Smoking and Risk of COPD in Older United States Adults: A Nationally Representative Replication Study

Jenny E. Ozga, PhD[1] James D. Sargent, MD[2] Alexander W. Steinberg, MD[3] Zhiqun Tang, PhD[1] Cassandra A. Stanton, PhD[1] Laura M. Paulin, MD, MHS[3]

[1]Westat, Behavioral Health and Health Policy, Rockville, Maryland, United States

[2]Departments of Pediatrics and Biomedical Data Sciences, Geisel School of Medicine, Hanover, New Hampshire, United States

[3]Section of Pulmonary and Critical Care, Department of Medicine, Dartmouth-Hitchcock Medical Center, Lebanon, New Hampshire, United States

Address correspondence to:
Laura M. Paulin, MD, MHS
Dartmouth-Hitchcock Medical Center
Section of Pulmonary and Critical Care
One Medical Center Drive Suite 5C
Lebanon, NH 03756
Phone: (603) 650-5533
Email: Laura.M.Paulin@Hitchcock.org

Running Head: **Childhood Cigarette Smoking and Risk of COPD**

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Abbreviations**:** COPD=chronic obstructive pulmonary disease; U.S.=United States; NHIS=National Health Interview Survey; PATH=Population Assessment of Tobacco and Health; W=Wave; RR=risk ratio; aRR=adjusted risk ratio; CI=confidence interval

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ABSTRACT

A recent study found that the prevalence of COPD is significantly higher among adults who began smoking cigarettes before (vs after) 15 years of age, independent of current smoking, cigarette pack-years, and smoking duration. The current analysis went a step further to also account for second-hand smoke exposure, using data from U.S. adults aged 40+ years during Wave 5 (2018-2019) of the Population Assessment of Tobacco and Health (PATH) Study. Adults who had ever smoked cigarettes were asked at what age they began smoking fairly regularly. Multivariable Poisson regression assessed risk of self-reported COPD diagnosis due to childhood smoking (<15 years), adjusting for current smoking, cigarette pack-years or smoking duration, second-hand smoke exposure, and sociodemographic covariates. Overall, 13.4% reported that they had COPD. COPD prevalence was 7.5% for adults who never smoked compared to 29.0% and 21.1% for smoking onset at age <15 and 15+ years, respectively. Adults who initiated smoking at <15 (vs 15+) years had higher prevalence of current smoking (45.9% vs 33.3%), longer smoking duration (mean 34.2 vs 27.3 years), greater cigarette pack-years (mean 48.8 vs 30.8), and greater second-hand smoke exposure (p's<0.05). In multivariable analysis, the relative risk for COPD for smoking onset <15 (vs 15+) years of age was 1.27 (95% confidence interval [CI]=1.06, 1.51). The increased risk of COPD due to childhood smoking was independent of cigarette pack-years, smoking duration, second-hand smoke exposure, and current smoking. Findings give further evidence of increased COPD risk related to childhood smoking.

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INTRODUCTION

Although cigarette smoking prevalence in the United States (U.S.) has been declining since the 1960s [1,2], it remains the leading cause of preventable death and disease in the United States (U.S.), and it is the primary driver of chronic obstructive pulmonary disease (COPD) [2]. Today, most adults begin smoking cigarettes during adulthood (after age 25) [1] and adolescent smoking (before 18 years) is relatively uncommon [3]. However, in 2012, more than 80% of adults who smoked cigarettes reported smoking before 18 years of age, and 99% had initiated before age 26 [4]. Smoking initiation even earlier during adolescence (between 12-16 years of age) was highly prevalent before 1980, with current smoking among this age group reaching 25% at the time [5]. Today, adults who initiated cigarette smoking as adolescents before 1980 would be at least 55 years old.

Lung growth and development extends through adolescence, with the majority of lung function developing between 10 and 20 years of age [6]. Adolescent cigarette smoking has been associated with reduced FEV_1/FVC ratios and increased peripheral airway resistance among 16-year-olds [7]. Some studies have reported that earlier ages of cigarette smoking initiation significantly increases COPD risk in later adulthood [8-12]. However, these studies were all limited in that they were either restricted to samples of males only[9,12] or failed to adjust for important smoke-related factors that could have confounded their findings, such as lifetime smoking (e.g., cigarette pack-years or smoking duration)[10,11], current smoking status[8,11], and smoking intensity [11]. Indeed, adults who began smoking during childhood tend to have more pack-years of cigarette exposure than those who began smoking in adulthood due to a combination of smoking more cigarettes per day and having a longer duration of smoking [8]. In addition, none of the prior studies cited above accounted for second-hand smoke exposure [8-12], which has been associated

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with increased COPD risk independent of lifetime smoking for adults who currently smoke cigarettes [13].

A recently published study of U.S. adults aged 40+ in the 2020 National Health Interview Survey (NHIS) aimed to address the limitations of prior studies by assessing the relationship between age of cigarette smoking initiation and COPD risk independent of current smoking status, pack-years of smoking, smoking intensity, and smoking duration [14]. That study found increased COPD risk for cigarette smoking initiation during childhood (<15 years of age) after controlling for these potential confounders. Although those who began smoking <15 years of age were at greatest risk for COPD, adults who began smoking between ages 15-19 were also at significantly increased risk for COPD compared to those who began smoking at or after age 20[14]. That study also found that the higher risk of COPD for childhood smoking (<15 years of age) occurred at all smoking intensity levels for adults who currently smoked cigarettes. Together, findings are consistent with the window for known lung development, suggesting that early cigarette initiation may negatively influence this process and predispose individuals to future disease regardless of lifetime smoking, current smoking status, and smoking intensity. Still, a limitation of this recently published study is that NHIS does not include a measure for second-hand smoke exposure.

The current study aimed to expand upon results from the recently published NHIS study[14] by additionally accounting for second-hand smoke exposure in multivariable models. Further, recognizing the importance of replication in drawing conclusions from observational studies [15], we examined a separate nationally representative dataset of adults in the U.S., the Population Assessment of Tobacco and Health (PATH) Study. Using the PATH Study allowed us replicate the results of the NHIS study in another nationally representative sample of older (aged 40+)

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U.S. adults and test whether the COPD -- childhood smoking association is independent of lifetime smoking, current smoking status, smoking intensity, and second-hand smoke exposure. Similar to results from NHIS, we hypothesized that childhood cigarette smoking (i.e., <15 years of age) would be associated with increased COPD prevalence among older adults, independent of current cigarette smoking status, smoking intensity, pack-years of smoking, smoking duration, and second-hand smoke exposure.

METHOD

Study Design and Sample

Data were selected from Wave (W) 5 of the PATH Study, a national longitudinal cohort survey of U.S. youth and adults. Data were collected in respondents' households using computer-assisted self-interviews administered in English or Spanish as appropriate. Survey data were collected from adults (aged 18+) in 2013-2014 (W1), 2014-2015 (W2), 2015-2016 (W3), 2016-2017 (W4), and 2018-2019 (W5). The current secondary data analysis used the W1-W5 Adult Restricted Use Files [16] and was limited to adults aged 40+ years at W5 (N=10,126). This study qualified as exempt per guidelines of the Westat Institutional Review Board and the Dartmouth Health Human Research Protection Program.

Measures

COPD prevalence

At W1, participants were asked, "Has a doctor, nurse or other health professional EVER told you that you had any of the following lung or respiratory conditions? Choose all that apply: COPD, chronic bronchitis, emphysema, asthma, some other lung or respiratory condition, none of the above, don't know, refused." At W2-W5, participants who had not reported respiratory disease at prior waves were asked about new respiratory disease diagnoses from the past 12 months. Any

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COPD, chronic bronchitis, and emphysema diagnoses across W1-W5 were combined to create one COPD composite prevalence measure (yes/no) at W5 [17,18].

Childhood cigarette smoking

The primary exposure of interest was childhood cigarette smoking. Adult respondents who reported ever cigarette smoking, defined as smoking at least 100 cigarettes in their lifetime, were asked, "How old were you when you first started smoking cigarettes fairly regularly?" Responses were used to create two separate variables: one with three categories, which included adults who never smoked, those who began smoking before age 15 (childhood smoking), and those who began smoking after age 15; and one with four categories, which included adults who never smoked, those whole began smoking before age 15, those who began smoking between 15-19 years of age; and those who began smoking at or after age 20. For the NHIS paper [14], categories were created based on a lowess curve showing an inflection point between age of cigarette smoking initiation and COPD prevalence occurring between 15 and 20 years of age; the lowess curve for the current dataset (*Supplemental Figure 1*) is almost identical to the one derived from the NHIS data (Figure 1 from that paper).

Cigarette smoking covariates

W5 smoke-related covariates included cigarette smoking status, pack-years of cigarette smoking, second-hand smoke exposure, and number of cigarettes smoked per day. We used the PATH Study-derived variables for never, current established, and former established cigarette smoking to create a three-category smoking status variable capturing never, former, or current smoking. Pack-years were determined by first calculating the duration of cigarette smoking (in years) for respondents reporting current or former smoking and then multiplying duration of smoking by cigarette packs smoked per day (cigarettes smoked per day divided by 20) [19]. Pack-years were

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winsorized by reassigning values from the 99th percentile to the top and bottom 1% of values to reduce undue influence of outliers [20]. Second-hand smoke exposure was included as a continuous measure based on responses to the question, "In the past 7 days, number of hours that you were in close contact with others when they were smoking?" [21].

Cigarettes smoked per day were coded into three categories: <10 (light intensity), 11-19 (medium intensity), and 20+ (heavy intensity). Using the three-category variable for age of cigarette smoking initiation, smoking status, and smoking intensity, we created a 9-category variable that stratified childhood smoking by cigarette smoking status and smoking intensity: never smoking; former smoking <15; former smoking 15+; current light smoking <15; current medium smoking <15; current heavy smoking <15; current light smoking 15+; current medium smoking 15+; and current heavy smoking 15+.

Sociodemographic covariates

Sociodemographic covariates were categorized as shown in Table 1. From W5, these included age, sex, race, and total household income in the past 12 months. Missing data on age, sex, and race were imputed as described in the PATH Study Restricted Use Files User Guide [16]. Urbanicity, which was only available at W1, was also included as a covariate. Respondents' geographic locations were categorized as "urban" if the majority of the sampling area's total population resides in areas classified as urban according to the 2010 U.S. Census and "not urban" otherwise [16].

Statistical analysis

Weighted descriptives and multivariable Poisson regression were used to evaluate associations between sociodemographic characteristics and risk of childhood smoking. Then, weighted descriptive statistics and multivariable Poisson logistic regressions were used to evaluate

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associations between childhood smoking and COPD prevalence. Unadjusted models and models adjusted for age, sex, race, household income, cigarette pack-years, smoking status, and second-hand smoke exposure were examined to estimate risk ratios (RRs) and adjusted RRs (aRRs). The primary analysis included the 3-category age of initiation variable with 15+ as the reference category. A secondary analysis included the 4-category age of initiation variable with 20+ as the reference category. A third analysis included the 9-category variable that stratified 3-category age of cigarette smoking initiation by smoking status and intensity. Within each smoking status/intensity category, aRRs were compared across ages of cigarette smoking initiation (e.g., <15 was compared to 15+ among adults reporting current light smoking) to delineate how childhood smoking relates to COPD prevalence while accounting for differences in smoking status and current smoking intensity. All analyses were weighted using the W5 all-waves survey weights, which included full sample and 100 replicate weights, to produce nationally representative estimates. Variances were computed using the balanced repeated replication method with Fay's adjustment set to 0.3. All analyses were conducted using State/MP 17.0 (www.stata.com/statamp/).

Sensitivity analyses

Based on prior work suggesting that smoking duration alone may be a stronger predictor of COPD than pack-year exposure [22], we performed a sensitivity analysis that substituted smoking duration for pack-years. This was done first by including smoking duration as a continuous measure, replicating the NHIS study [14]. However, lowess curves (*Supplemental Figure 2*) showed a stronger relationship between smoking duration and COPD prevalence for adults smoking 25+ years (vs <25 years), so we created a dichotomous smoking duration variable (smoking <25 years_versus 25+ years) in a subsequent analysis.

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To explore the potential that adults who initiated smoking <15 years under-report their cigarette use, leading to biased pack-years estimates, we systematically increased cigarette pack-years in 5% increments for those who initiated smoking <15 years in a series of multivariable Poisson regression models.

RESULTS

Sample characteristics and childhood smoking

Table 1 shows sociodemographic characteristics overall and by childhood smoking status. Overall, participants were largely from urban areas (77.0%), female (53.4%), and of White race (80.2%). There was a relatively even distribution of respondents across total household income levels and age categories, though there were fewer adults aged 70+ compared to adults aged 40-69. We found that Black/African American (vs White) adults (aRR=0.69; 95% confidence interval (CI)=0.55, 0.87), females (aRR=0.71; 95% CI=0.60, 0.85), and older participants (aged 60+ vs 40-49) were at significantly lower risk for childhood smoking whereas participants reporting a household income of <$25,000 (vs $100,000+) were at significantly higher risk for childhood smoking (aRR=1.81; 95% CI=1.31, 2.48).

Associations between childhood smoking and COPD prevalence

Table 2 shows COPD and smoking-related characteristics overall and as a function of childhood smoking status. The overall weighted prevalence of COPD was 13.4%, with 7.5% of adults who never smoked, 29.0% of adults who initiated during childhood (<15 years), and 21.1% of adults who initiated 15+ years reporting a COPD diagnosis. Bivariate tests comparing respondents who initiated cigarette smoking at <15 years vs 15+ years showed higher prevalence of COPD, higher prevalence of current smoking, longer smoking duration, and greater cigarette pack-years for

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respondents who had initiated during childhood (p's<0.05). Those who initiated during childhood also had a lower prevalence of former smoking (p<0.05).

Table 3 shows results from bivariable and multivariable Poisson logistic regressions. In the primary analysis (Table 3a) where age of initiation was entered as a 3-category variable, initiating during childhood (vs 15+ years) of age was associated with an aRR of 1.27 (95% CI=1.06, 1.51). Current (vs never or former) cigarette smoking (aRR=1.37; 95% CI=1.19, 1.59), cigarette pack-years (per 10 pack-years; aRR=1.02; 95% CI=1.01, 1.03), and second-hand smoke exposure (per 5 hours in the past 7 days; aRR=1.06; 95% CI=1.02, 1.04) also significantly increased the risk of COPD. *Supplemental Table 1* shows results from the secondary analysis where age of initiation was entered as a 4-category variable. Results were similar to the 3-category model, with childhood smoking (vs 20+ years) significantly increasing risk of COPD (aRR=1.40; 95% CI=1.13, 1.75), though starting smoking between 15-19 years did not significantly increase risk.

Table 3b shows results from the third analysis where the 9-category variable combining age of cigarette smoking initiation, smoking status, and smoking intensity was included. Only one of the pairwise comparisons within smoking status/intensity category reached statistical significance: the aRR for adults currently smoking 10-19 cigarettes per day (medium intensity) was significantly higher for those who started smoking before the age of 15 as compared to 15+ years (p=0.027). aRRs did not significantly differ between <15 and 15+ years of age at cigarette smoking initiation within the other smoking status/intensity combinations.

Sensitivity results

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Supplemental Table 2 shows the distribution of cigarette pack years and cigarette smoking duration, highlighting the larger range for cigarette pack-years as compared to smoking duration that was entered into each respective model.

Supplemental Table 3 shows multivariable models when smoking duration was substituted for cigarette pack-years. When smoking duration was used as a continuous measure in place of cigarette pack-years in the 3-category age of initiation model (*Supplemental Table S3a)*, the association between childhood smoking and COPD was attenuated (aRR from 1.27 (95% CI=1.06, 1.51) to 1.16 (95% CI=0.99, 1.36). However, when smoking duration was used as a dichotomous measure (<25 years vs 25+ years smoking, approximating childhood smoking versus not; *Supplemental Table S3b)*, the association between childhood smoking and COPD remained significant (aRR 1.25; 95% CI=1.06, 1.46).

When we systematically added 5% to pack-years for respondents who initiated smoking <15 years, an additional 85% was needed to confound the childhood smoking finding reported in Table 3a.

DISCUSSION

In this large nationally representative study of childhood smoking and COPD risk, age of onset for cigarette smoking before 15 years of age was significantly associated with COPD risk, independent of cigarette pack-years, current smoking status, second-hand smoke exposure, and smoking duration. The current study replicated the results of a prior study that used NHIS data from 2020 using data from Wave 5 of the PATH Study, collected between 2018-2019. Lifetime COPD prevalence was higher in the current study as compared to NHIS overall (7.1% vs 13.4%), for each smoking status, and for each age of cigarette initiation category, reflecting differences in sampling strategies. At the time of the current data collection (W5, 2018-2019), adults in the

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PATH Study had already participated in four prior data collection waves, beginning in 2011, resulting in cumulative lifetime COPD diagnoses over the period of 5 waves. In contrast, NHIS provides a snapshot of COPD prevalence for one point in time in a cross-sectional cohort of U.S. adults and does not capture cumulative diagnoses over time.

Despite differences in COPD prevalence, lowess curves examining the association between childhood smoking and COPD prevalence were similar across NHIS and the PATH Study, both showing an inflection point at approximately 20 years of age. Also in both studies, it was clear that there was an increased risk for COPD based on age of cigarette initiation <15 (vs 15+ and 20+ years), and the aRRs for childhood smoking were similar to the aRRs for current smoking in both studies. However, the COPD risk associated with childhood smoking was somewhat lower in the PATH Study than in NHIS (aRRs of 1.27 vs 1.41) and the risk for adults who initiated smoking 15-19 years was not statistically significant in the PATH Study whereas it increased COPD risk in NHIS. Also in NHIS, childhood smoking increased COPD risk independent of current smoking status and intensity. In this study, the adjusted risk associated with childhood smoking was only apparent for adults who currently smoked at medium intensity (i.e., 15-19 cigarettes per day). Together, findings from both studies show that childhood smoking (<15 years of age) significantly increases risk of COPD independent of current smoking status and pack-years of cigarette smoking, though it is in unclear what role smoking intensity may play.

Another difference between studies occurred when continuous smoking duration was substituted for cigarette pack-years. In NHIS, substituting smoking duration as a continuous measure confounded the association between current smoking status and COPD, but did not significantly impact the association for childhood smoking. In this study, substituting continuous

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smoking duration confounded both associations. However, in this study, lowess curves showed a stronger relationship between smoking duration and COPD prevalence for adults smoking 25+ years (vs <25 years); when smoking duration was substituted for pack-years as a dichotomous measure that may approximate childhood smoking, the association between childhood smoking and COPD risk was no longer confounded. Results from both studies were consistent with findings from a recent report [22] showing that smoking duration was a stronger predictor of COPD risk than cigarette pack-years.

It's clear that active cigarette smoking is associated with worse lung function [23], including reduced lung growth and lower FEV_1 during adolescence [24]. By replicating and building on findings from the NHIS study [14], this work demonstrates that there is also an increased risk for long-term chronic disease due to childhood cigarette smoking. Importantly, the risk of COPD during adulthood associated with childhood smoking was found to be independent of current smoking status, second-hand smoke exposure, cigarette pack-years, and smoking duration across two separate nationally representative datasets of the U.S. population, suggesting that it may be a direct result of the effects of childhood cigarette smoking on lung development during a critical window of time [6,7].

In December 2019, the U.S. government passed a federal law that prohibits sales of nicotine and tobacco products, including cigarettes, to youth <21 years of age [25]. Findings from the current study support preventing, or at the very least delaying, cigarette smoking initiation until adulthood to allow for critical lung development to occur and to reduce the longer smoking durations that put people at heightened risk for lung diseases like COPD. Such findings could be used to inform public health campaigns that are aimed at preventing uptake of cigarettes among young people, highlighting the health effects of early cigarette smoking.

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This study is not without limitations. First, the primary outcome of COPD diagnosis relied on participants' self-report, not spirometry, which could lead to biased estimates. Similarly, respondents were asked at what age they began smoking regularly; "regularly" was left to respondent interpretation. Second, there could be unmeasured variables that account for the associations between early age of cigarette smoking initiation and COPD risk, such as prenatal smoke exposure [26] and unmeasured aspects of cigarette smoking not accounted for by pack-years, smoking duration, or current smoking status. In addition, second-hand smoke exposure during childhood without primary smoking has been associated with impaired lung development and the development of respiratory diseases like asthma during childhood [2]. The second-hand smoke exposure variable available in the PATH Study used in the current study asked respondents about their exposure to tobacco smoke only in the past 7 days, and did not capture second-hand smoke exposure during childhood. It is possible that alternative measures (e.g., years of living in a household where someone smokes)[13] would have influenced results differently. Still, a strength of this study is the inclusion of any measure of second-hand smoke exposure, which was not available for inclusion in the NHIS study and has not been examined as a potential confounder of the relationship between childhood smoking and COPD risk in prior work. Though greater second-hand smoke exposure significantly increased COPD risk, it did not appreciably impact the relationship between age of onset and COPD. Other strengths of the current study include the use of a large nationally representative dataset and sensitivity analyses showing the robustness of findings regarding childhood smoking and increased COPD risk.

In conclusion, findings from the current analysis using PATH Study data largely replicate those reported in a recent study using data from NHIS [14], after controlling for second-hand smoke exposure as an additional covariate. In both studies, smoking onset <15 years of age

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significantly increased COPD risk after controlling for sociodemographic covariates, current smoking status, cigarette pack-years, and smoking duration. This study builds on our understanding of how childhood smoking increases the risk of COPD independent of current smoking status and smoking history, which is consistent with prior work suggesting that injury during this phase of known lung development can have lifelong impacts. Physicians should consider talking to their young patients about childhood cigarette smoking, informing them about the potential long-term impacts regarding disease risk.

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DECLARATION OF INTEREST

All authors have no conflicts of interest to disclose.

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Table 1. Sociodemographic characteristics of the overall sample and by childhood smoking status.

	Overall (N=10,126)	Never smoking (N=2,752)	Cigarette initiation <15 years (N=935)	Cigarette initiation 15+ years (N=4,423)	
	Weighted %				ARR (95% CI)[1]
Urbanicity					
Urban	77.0	79.3	70.3	74.4	Ref
Non-urban	23.0	20.7	29.7	25.6	1.12 (0.92, 1.36)
Age					
40-49	24.6	28.1	26.8	21.5	Ref
50-59	26.5	27.3	32.3	24.6	1.03 (0.83, 1.28)
60-69	24.9	22.2	26.2	27.2	**0.76 (0.59, 0.98)**
70-79	16.7	15.8	12.3	18.6	**0.54 (0.37, 0.78)**
80+	7.2	6.6	2.4	8.2	**0.24 (0.12, 0.51)**
Sex					
Male	46.6	41.1	58.1	49.8	Ref
Female	53.4	58.9	41.9	50.2	**0.71 (0.60, 0.85)**
Race					
White	80.2	77.0	85.8	84.2	Ref
Black	11.7	12.8	8.7	10.1	**0.69 (0.55, 0.87)**
Other/Multiple	8.0	10.2	5.5	5.6	0.86 (0.64, 1.15)
Household income					
$100,000+	22.4	26.0	14.5	18.1	Ref
$50,000-$99,999	24.8	25.5	18.4	25.2	0.97 (0.69, 1.37)
$25,000-$49,999	20.0	18.6	21.3	22.6	1.32 (0.92, 1.89)
<$25,000	25.0	21.8	37.6	27.6	**1.81 (1.31, 2.48)**

[1]Adjusted risk ratios (ARRs) from a multivariable Poisson logistic regression assessing the risk of childhood smoking (<15 vs 15+ years) based on sociodemographic characteristics. Bolded values indicate statistical significance ($p<0.05$).

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Table 2. Smoking-related characteristics of the overall sample and by childhood smoking status.

	Overall (N=10,126)	Never smoking (N=2,752)	Cigarette initiation <15 years (N=935)	Cigarette initiation 15+ years (N=4,423)
	Weighted % (weighted mean)			
Lifetime COPD diagnosis*				
Yes	13.4	7.5	29.0	21.1
No	86.6	92.5	71.0	78.9
Smoking status*				
Never	47.2	100.0	-	-
Former	35.3	-	54.1	66.7
Current	17.5	-	45.9	33.3
Cigarette pack-years*	(14.6)	-	(48.8)[1]	(30.8)[1]
Cigarettes/day[2]	(26.1)	-	(21.5)	(23.4)
Smoking duration (years)*	(12.9)	-	(34.2)[1]	(27.3)[1]
Second-hand smoke exposure (hours in past 7 days)*	(3.4)	(1.2)	(10.1)	(5.7)

Asterisks denote a statistically significant difference from tests comparing adults who initiated cigarette smoking <15 years to 15+ years using chi-square tests for categorical variables and independent-samples t-tests for continuous variables ($p<0.05$); [1]Adults reporting current and former established cigarette smoking; [2]Only among adults reporting current smoking.

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Table 3. Bivariable and multivariable associations between childhood smoking and COPD risk.

3a. Entering age started smoking regularly separate from smoking status						
			Relative Risk (RR)		95% CI for Adjusted	p-value for Adjusted
		Weighted % with COPD	Unadjusted	Adjusted[1]		
Age of initiation	15+	21.1	Ref	Ref	Ref	Ref
	<15	29.0	**1.37**	**1.27**	**1.06, 1.51**	<0.01
	Never smoking	7.5	**0.35**	**0.51**	**0.41, 0.63**	<0.001
Smoking status	Never+former smoking	11.7	Ref	Ref	Ref	Ref
	Current smoking	27.7	**2.36**	**1.37**	**1.19, 1.59**	<0.001
Cigarette pack-years[2]			**1.05**	**1.02**	**1.01, 1.03**	<0.001
Second-hand smoke exposure[3]			**1.06**	**1.03**	**1.02, 1.04**	<0.001
3b. Combining age started smoking regularly with smoking status and smoking intensity						
			Relative risk (RR)		95% CI for Adjusted	p-value
Smoking status/intensity	Age of initiation	Weighted % with COPD	Unadjusted	Adjusted[1]		
Never smoking	-	7.5	Ref	Ref	Ref	Ref
Former smoking	<15	21.4	**2.86**	**2.57**	**1.78, 3.72**	0.212[4]
	15+	16.9	**2.27**	**2.01**	**1.60, 2.53**	
Current light smoking	<15	17.3	**2.31**	2.10	0.85, 5.16	0.551[4]
	15+	12.5	**1.68**	**1.56**	**1.11, 2.20**	
Current medium smoking	<15	32.4	**4.34**	**3.60**	**2.37, 5.48**	0.046[4]
	15+	20.0	**2.68**	**2.37**	**1.89, 2.98**	
Current heavy smoking	<15	40.8	**5.47**	**3.84**	**2.95, 4.99**	0.075[4]
	15+	33.4	**4.47**	**3.33**	**2.68, 4.12**	
Cigarette pack-years[2]			**1.05**	**1.02**	**1.01, 1.03**	<0.001
Second-hand smoke exposure[3]			**1.06**	**1.02**	**1.01, 1.03**	<0.001

[1]Adjusted also for age, sex, race, household income, and urbanicity; [2]Represents increased risk associated with each additional 10 pack-years (includes never-smoking respondents as having 0 pack-years); [3]Represents the increased risk associated with each additional 5 hours of second-

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hand smoke exposure in the past 7 days; [4]P-value compares the ARR for COPD by age of initiation within each smoking status/intensity category.

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Online Supplement

Supplemental Table 1. Multivariable associations between childhood smoking and COPD risk.

				95% CI	p-value
		Weighted % with COPD	ARR[1]		
Age of initiation	20+	20.3	Ref	Ref	Ref
	15-19	21.5	1.15	0.94, 1.40	>0.05
	<15	29.0	1.40	**1.13, 1.75**	**<0.01**
	Never smoking	7.5	0.56	**0.44, 0.72**	**<0.001**
Smoking status	Never+former smoking	11.7	Ref	Ref	Ref
	Current smoking	27.7	1.39	**1.21, 1.60**	**<0.001**
Cigarette pack-years[2]			1.02	**1.01, 1.03**	**<0.001**
Second-hand smoke exposure[3]			1.03	**1.02, 1.03**	**<0.001**

ARR=adjusted relative risk; [1]Adjusted also for age, sex, race, household income, and urbanicity; [2]Represents increased risk associated with each additional 10 pack-years (includes never-smoking respondents as having 0 pack-years); [3]Represents the increased risk associated with each additional 5 hours of second-hand smoke exposure in the past 7 days.

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Supplemental Table 2. Distributions for cigarette pack-years and cigarette smoking duration.

	Among full sample (including adults reporting never smoking)		**Among adults who ever smoked cigarettes**	
	Pack-years	Smoking duration	Pack-years	Smoking duration
1%	0.0	0.00	0.4	1.5
5%	0.0	0.00	1.5	3.0
10%	0.0	0.00	3.0	4.0
25%	0.0	0.00	10.5	19.0
50%	0.9	2.00	25.0	30.0
Mean (SD)	22.6 (45.8)	19.7 (18.5)	35.1 (53.0)	29.1 (15.2)
75%	31.5	35.7	42.0	40.4
90%	53.0	45.0	66.0	47.5
95%	74.0	49.2	88.0	52.0
99%	168.0	59.0	459.8	60.0

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Supplemental Table 3. Multivariable associations between childhood smoking and COPD, substituting cigarette smoking duration for cigarette pack-years.

S3a. Continuous smoking duration substituted for pack-years					
		Weighted % with COPD	ARR[1]	95% CI	p-value
Age of initiation	15+	21.1	Ref	Ref	Ref
	<15	29.0	1.16	0.99, 1.36	>0.05
	Never smoking	7.5	0.82	0.61, 1.09	>0.05
Smoking status	Never+former smoking	11.7	Ref	Ref	Ref
	Current smoking	27.7	0.94	0.81, 1.09	>0.05
Cigarette smoking duration[2]			1.26	1.17, 1.36	<0.001
Second-hand smoke exposure[3]			1.03	1.02, 1.04	<0.001
S3b. Dichotomous smoking duration substituted for pack-years					
		Weighted % with COPD	ARR[1]	95% CI	p-value
Age of initiation	15+	21.1	Ref	Ref	Ref
	<15	29.0	**1.25**	**1.06, 1.46**	**<0.01**
	Never smoking	7.5	**0.65**	**0.49, 0.86**	**<0.01**
Smoking status	Never+former	11.7	Ref	Ref	Ref
	Current	27.7	1.05	0.92, 1.21	>0.05
Cigarette smoking duration	25+ years	19.6	Ref	Ref	Ref
	<25 years[4]	9.0	**0.51**	**0.40, 0.66**	**<0.001**
Second-hand smoke exposure[3]			**1.03**	**1.02, 1.04**	**<0.001**

ARR=adjusted relative risk; Bolded values denote statistical significance; [1]Adjusted also for age, sex, race, household income, and urbanicity; [2]Represents increased risk associated with each additional 10 years of smoking (includes never-smoking respondents as having 0 years smoking duration); [3]Represents the increased risk associated with each additional 5 hours of second-hand smoke exposure in the past 7 days; [4]Includes never-smoking respondents

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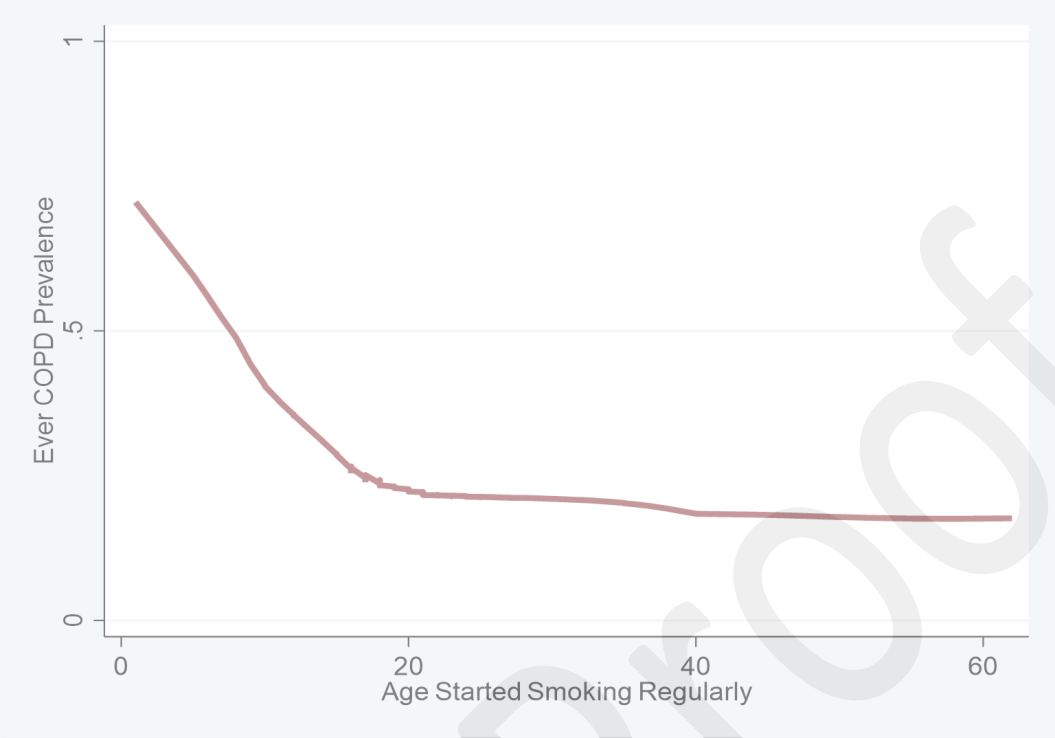
Supplemental Figure 1. Lowess curve showing COPD prevalence (%) as a function of age of cigarette smoking initiation (years).



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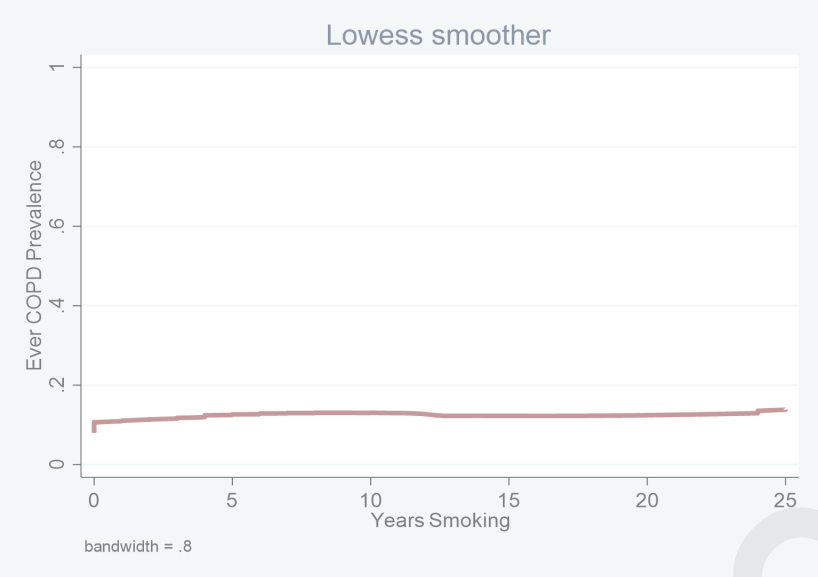
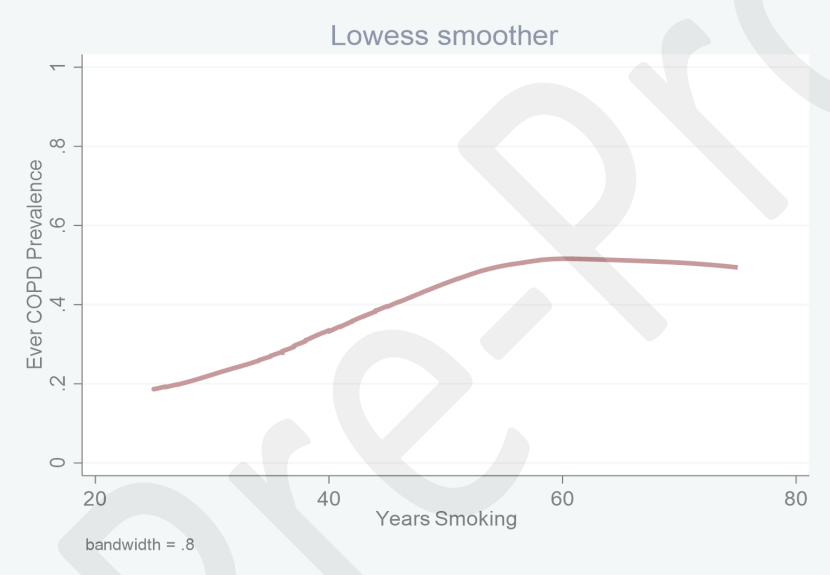
Supplemental Figure 2. Lowess curves showing the relationship between cigarette smoking duration and COPD prevalence (%) for adults who smoked for <25 years (left panel) versus 25+ years (right panel).





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