Impact of Cigarette Prices and Social Factors on Youth Smoking Initiation in Indonesia

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Executive summary

Background: Indonesia ranked first among Southeast Asian countries in 2021 with the youngest age of smoking initiation at an average of 16.8 years old. Early contact with harmful products such as tobacco may threaten adolescents with prolonged tobacco consumption and deleterious impacts on health. Despite the evidence discussing the roles of cigarette prices and social factors on youth smoking initiation is well-established worldwide, we found there is a limited number of studies that has been conducted to examine the determinants of smoking initiation among Indonesian adolescents.

Data and method: This study examines the impact of cigarette prices, parental smoking, and exposure to secondhand smoke on youth smoking initiation in Indonesia using survival analysis techniques. The information on smoking behaviour and socio-demographic of adolescents aged 10 to 18 years old are extracted from the 2023 Indonesian Health Survey (N = 117,983), while cigarette prices are constructed from the National Consumer Price for Selected Goods and Services from 2010 to 2023. Discrete-time hazard models with a complementary log-log (cloglog) are employed. All analyses use the sample weights that were provided with the data.

Results: Higher prices for cigarettes, particularly filtered kreteks (clove-mixed filtered cigarettes), significantly decreased the risk of smoking initiation, with a 1% price increase associated with a 2.2% reduction in the risk of smoking initiation (95% CI -3.8% to -0.46%). Meanwhile, having parents who smoke and daily exposure to cigarette smoke increased the hazard of adolescents starting smoking (HR=1.3, exp.(0.24) and HR=6.7, exp.(1.91), respectively).

Discussion and recommendation: Increasing cigarette prices could significantly reduce the probability of initiating smoking among Indonesian adolescents. On the other hand, social factors such as parental smoking and secondhand smoke are more likely to increase the risks of youth smoking initiation. To curb youth smoking, the government should raise cigarette prices significantly by setting higher excise taxes and minimum retail prices and simultaneously reducing the layers of tobacco excise tariff to diminish cheaper options of tobacco products. In addition, accessibility to smoking cessation services and enforcement of smoke-free laws should be prioritised. These measures will provide support for adults with high nicotine dependence to quit smoking and protect adolescents from secondhand smoke.

Background

Youth smoking persistently has become one of the major health problems in developing countries, particularly in Indonesia. A school-based national survey conducted in 2019, the Indonesia Global Youth Tobacco Survey (GYTS), conveyed that around 19% of students aged 13 to 15 years old consumed tobacco products in the past 30 days (1). This share was almost two-fold of smoking prevalence in adolescents globally from the same age group at 10 percent (2). Along with the alarming rate of youth smoking, smokers in Indonesia initiated smoking at an early age. More than half of Indonesian smokers started smoking at the age of 15-19 years old (3). In 2021, the nation ranked first among ASEAN countries with the youngest age of smoking initiation at an average of 16.8 years old (4).

Early exposure to tobacco products threaten adolescents whose growth is still developing with a wide range of adverse effects. Smoking in adolescence is significantly associated with quitting later, smoking relapse, and smoking continuation (5). Tobacco consumption during earlier life phases also has been widely acknowledged to cause and/or be associated with deleterious health effects that occur in the short run, as well as in the long-term. Youth smokers may experience immediate effects of tobacco smoking, such as coughing, wheezing, increased inflammation, and declining immune system (6). Concerning long-term health consequences, a study revealed that current smokers who started smoking at an earlier age have higher odds of experiencing smoking-related morbidities and all-cause mortality (7) and lung cancer (8).

Among tobacco control measures, increasing taxes and prices of tobacco products have been widely acknowledged to be the most effective strategies in decreasing cigarette consumption, particularly among youth (9). Some studies have suggested that increases in cigarette prices are significantly associated with lower hazards of smoking initiation among youth in several countries (10–13). One study explained that this is most likely because young people have limited financial resources and higher prices of cigarettes would make them reconsider the decision to buy and consume cigarettes (14). Despite the importance of tax and price increases to control smoking initiation among youth, Indonesia does not adjust its tobacco excise taxes annually. For instance, the government decided not to raise cigarette taxes in 2014 and 2019, which coincided with the presidential election. Whereas the World Health Organization (WHO) recommends a 25% annual increase, the Indonesian government raises tobacco excise tax at a fairly low rate of an average of 10% in the past years (9). The country adopts a complex and tiered specific excise tax structure, which reduces the effectiveness of cigarette tax policy in curbing consumption as it leads to greater price variation, thus enabling consumers to switch to cheaper cigarettes (15). In addition, the government

did not prohibit the sales of individual cigarette sticks before the year of 2024, enabling students to buy cigarette sticks at extremely affordable prices (16).

Increasing tobacco taxes and prices may hinder adolescents from purchasing the products, however, it is crucial to further examine other contributing factors such as smoking behaviour in the community where adolescents belong because it potentially contributes to facilitating smoking initiation among youth. A previous study revealed that adolescents gain access to tobacco products not solely through commercial means, which refers to the act of buying tobacco products directly from retailers, but also through social channels, which underline the alternative ways to acquire cigarettes from relatives or friends (17). Indonesian adolescents are vulnerable to nicotine addiction since one-third of parents smoke at home (18) and the same proportion of the general population are smokers (19). A recent publication from Indonesia revealed that adolescents with smoking parents have a higher probability of starting smoking earlier than their peers (20). Likewise, exposure to secondhand smoke increases the chance of adolescents being a smoker (21–23).

Regardless of the understanding that the effect of prices and social factors is well-established worldwide, there is a lack of evidence about the impact of prices, parental smoking, and exposure to secondhand smoke on tobacco use initiation among Indonesian adolescents. We found only one study that has examined the demand for cigarettes among the population aged 15 to 24 years old, but this study did not analyze the impact of prices on smoking initiation (24). Another study conducted in Indonesia investigated the association between parental smoking and smoking initiation, but the sample is not nationally representative as it only includes a sample from one city, thus it could not represent the general condition of the young population in the country (20).

This paper seeks to fill this knowledge gap by employing survival analysis on a national dataset to examine the effect of prices, parental smoking, and exposure to secondhand smoke on cigarette smoking initiation among Indonesian adolescents aged 10 to 18 years old. Findings from this study can be useful for the government to implement effective regulations that could prevent adolescents from initiating smoking.

Data

Smoking behavior and socio-demographic data

This research gathered information on tobacco consumption and sociodemographics from the 2023 Indonesian Health Survey (*Survei Kesehatan Indonesia*, SKI), carried out by the Ministry of Health (MoH). The SKI is a cross-sectional survey representing the

national level that utilizes a two-stage sampling method (3). It investigates various health-related factors in the Indonesian population, including awareness and behaviors related to tobacco use. In this survey, enumerators conducted face-to-face interviews during home visits. Questions related to tobacco use were asked to the household members aged 10 years old and older. Smoking behaviours refer to the consumption of any tobacco products unless the questions specifically mention a certain type of tobacco product. The focus of our study is adolescents, defined by MoH as individuals aged 10 to 18 years (25), thus we included 117,983 out of 877,531 SKI participants as the initial sample for this study.

We infer the year when smoking initiation first occurred from the following question: *"How old were you when you first tried a cigarette?"* and the data are treated as a continuous variable. We also take into account social factors including the smoking status of parents (whether at least one parent smokes or neither smokes) and frequency of exposure to secondhand smoke (daily, some days, or never). This study also considers sociodemographic conditions as control variables, such as age, sex (male/female), residence (urban/rural), and wealth group (lowest/lower-middle/middle/upper-middle/highest). The wealth group is constructed based on an index of a household's asset ownership, generated using principal component analysis of 19 commodities in the SKI (3).

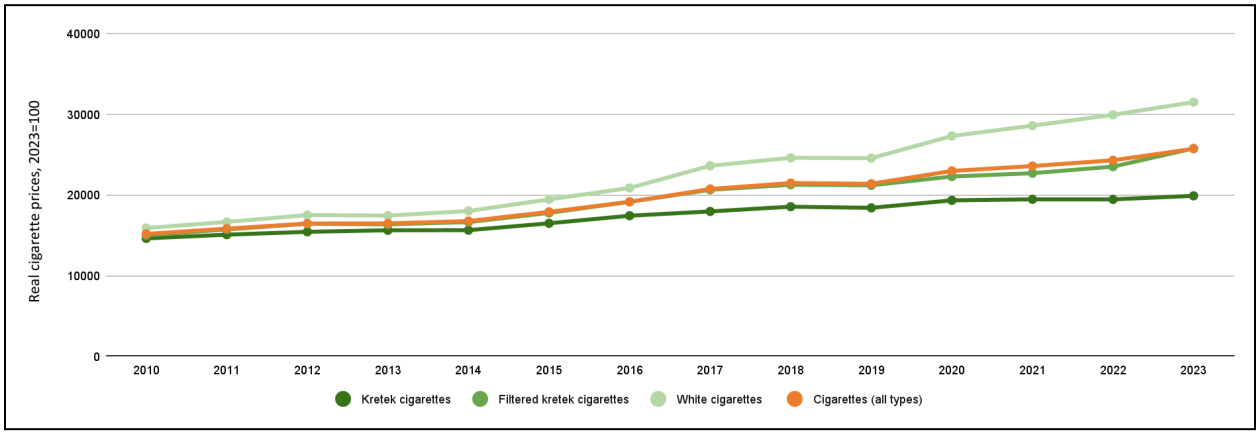
Cigarette price

We obtained annual data on cigarette prices from 2010 to 2023 from the National Consumer Price of Selected Goods and Services, published by the Bureau of Statistics (*Badan Pusat Statistik*, BPS). This dataset includes the retail prices of the most consumed cigarette packs across cities in Indonesia. It consists of three types of cigarettes—kretek (mixed-clove cigarette), filtered kretek (clove-mixed filtered cigarettes), and white cigarette. It is noteworthy to acknowledge that BPS does not provide clear guidance on cigarette brands and the number of sticks per pack (pack size) that are being surveyed. Furthermore, the price data is collected from a subset of surveyed cities, while SKI data encompasses all districts and cities across Indonesia, thus analysis at the city level was not feasible. Consequently, we utilized provincial-level average cigarette prices derived from city-specific price data. To adjust for inflation, nominal prices were converted into real prices using the provincial consumer price index (CPI), with 2023 serving as the base year.

The average price per pack of cigarettes in Indonesia has exhibited a general upward trend over the past decade (orange line), though the rate of increase has varied considerably across different periods as depicted in Figure 1. While price growth remained relatively stagnant from 2010 to 2016, a more pronounced increase was

observed between 2016 and 2023. Analysis of average price trends across different cigarette categories reveals notable variations in growth patterns. White cigarettes demonstrated the most substantial price appreciation over the study period, followed by filter cigarettes and kretek cigarettes which exhibited comparatively modest price increases and considerably less significant growth than other variants. This uneven pattern of price growth has led to widening price disparities among the three cigarette types, with white cigarettes becoming markedly more expensive compared to their kretek counterparts.

Figure 1. Inflation-adjusted cigarette prices in Indonesia between 2010 and 2023



Source: Authors' elaboration based on the National Consumer Price of Selected Goods and Services and Consumer Price Index (CPI) from the Central Bureau of Statistics *(Badan Pusat Statistik)*.

Estimation method

Construction of pseudo-panel dataset

This study uses survival analysis to estimate the effect of cigarette prices and social factors on youth smoking initiation. Since survival analysis requires longitudinal data (11,12) and SKI is not a panel dataset, we convert the data into a pseudo-longitudinal format to monitor participants' smoking status over time. We expand the SKI data into annual pseudo-panel data by generating annual records or ages when participants were at risk of initiation but had not yet started smoking. We assume that youth become at risk for smoking initiation at age eight, as fewer than 1% of adolescents in the sample began smoking between the ages of 5 and 7. This threshold is also consistent with studies conducted in Chile, Poland, Ghana, and Nigeria (11,13,26). Thus, age eight serves as the baseline for future yearly follow-ups, with smoking initiation observed from that age onward.

Then, we generate a binary variable for smoking initiation, coded as "0" for participants who have not yet started smoking and “1” for participants who started smoking in a

particular year for which subsequent data points are dropped. The variable remains "0" for those who never initiated smoking. After these transformations, we merge these pseudo-panel datasets with cigarette price data with province identifiers.

Estimation model

We employ a discrete-time hazard model with a complementary log-log (cloglog) specification due to its asymmetric response curve (11,27). This model is particularly suitable for cases where the probability of an event is low (28) and is commonly used to examine the effect of price on smoking initiation (11,13,27,28).

In this study, the hazard of smoking initiation ($Y_{i,p,t}$) of an adolescent i in the province p at the time of analysis t (given they have not previously smoked), is modeled as follows:

$$Y_{i,p,t} = P(T_i = t | T_i \geq t, Z_{i,p,t}) = F[\beta_0 + \beta_1 Log(Price_{p,t}) + \beta_2 S_i + \beta_3 X_i + \beta_4 P_p + \beta_5 R_p + \beta_6 t + \beta_7 t^2 + \beta_8 t^3] \quad (1)$$

Equation 1 represents the discrete-time hazard function, which forms the core of our analytical approach. Here $P(T_i = t | T_i \geq t, Z_{i,p,t})$ represents the conditional probability that smoking initiation occurs at exactly time t (where T_i indicates the time when the adolescent i starts smoking), given that the adolescent has remained a non-smoker until that point ($T_i \geq t$) and accounting for the set of covariates $Z_{i,p,t}$. F denotes the complementary log-log function that transforms our linear predictor into a probability measure.

The primary independent variables include cigarette prices ($Log(Price_{p,t})$) and social factors (S_i). $Log(Price_{p,t})$ represents the natural logarithm of the real average price of cigarettes, covering the average of all cigarette types, kreteks, filtered kreteks, and white cigarettes. Using market-level average price, rather than self-reported prices, helps mitigate endogeneity between price and consumption, a major concern that can bias estimates when isolating the effect of price (11,12).

S_i refers to social factors, including parents' smoking status and exposure to secondhand smoke. We include this variable in our model as it represents a crucial determinant of youth smoking initiation, consistently documented in previous literature (21,22). We conducted sensitivity analyses using various model specifications while maintaining identical covariates across all models. The first model included only parents' smoking status, another employed only exposure to secondhand smoke, and the last was our main model incorporating both parental smoking status and secondhand smoke exposure. The results demonstrated robust findings as the magnitude of cigarette price effects in the first two models remained within the confidence interval of our main model. In addition, omitting parents' smoking status may result in a significant omitted variable bias when estimating price effects. The concern regarding reverse causality is also minimized since it is unlikely that youth smoking could substantially alter their parents' smoking habits, which typically began long before the child's birth (12).

Among the variables included as socio-demographic controls (X_i), residence and wealth variables are treated as time-invariant due to the lack of sufficient information to reconstruct individual variability over time. We acknowledge this approach has limitations as it might not completely capture how changes in these variables relate to changes in smoking initiation patterns over time.

At the provincial level, we include real per capita gross domestic product (GDP) ($P_{p,t}$) to control for regional economic differences and province dummies (R_p) to account for province-specific fixed effects. By controlling for these fixed effects, we account for these unobserved, time-invariant variables and reduce potential bias. We expect that after adjusting for both observed and unobserved provincial characteristics, any remaining bias will be minimal. Finally, we account for duration dependence by applying a cubic polynomial functional form (t, t^2, t^3) to control for changes in the hazard rate over time from the initial exposure to risk.

To confirm the robustness of our results, we conducted two sets of sensitivity analyses based on our baseline model (Table A2 in Appendix). First, we incorporated a logarithmic form as the hazard function in addition to the cubic polynomial used in the baseline model. Second, we conducted the analysis using different risk ages, specifically at ages 5 and 10. We perform all models using STATA V.18 by incorporating sampling weights to enhance population representativeness with significance determined at $p<0.05$.

Results

There are 108,763 (or N=37,339,843 after applying weights) out of 117,983 adolescents aged 10 to 18 years old in the SKI dataset eligible for analysis. Table 1 summarizes descriptive statistics of key variables included in the model to analyse cigarette smoking initiation. Nearly 8% of adolescents aged 10 to 18 years old ever tried cigarette smoking, and most of them were male (99.8%). The median age of initiating tobacco use among adolescents is 15 years old and the majority of adolescents in this study live in the urban area (58%). Lastly, shares of parental smoking and daily exposure to secondhand smoke are higher among those who have initiated smoking relative to the teens who never smoked (69% vs 50% and 55% vs 21%, respectively).

Table 1. Weighted characteristics of adolescents aged 10 to 18 years old during the survey

	All	Ever smoke	Never smoke
Ever smokers	7.76	-	-
Age of initiation, median (SD)	-	15 (2.04)	-
Age group of initiation			
Age 6-12	-	18.53	-
Age 13-15	-	55.46	-
Age 16-18	-	26.00	-
Year of smoking duration, median (SD)	-	2 (1.83)	-
Socio-demographic			
Sex			
Male	51.46	99.79	47.55
Female	48.54	0.21	52.45
Age, median (SD)	14 (2.59)	17 (1.53)	14 (2.56)
Residence			
Urban	58.30	58.49	58.29
Rural	41.70	41.51	41.71
Wealth group			
Lowest	13.24	13.93	13.18
Lower-middle	13.14	21.88	17.83
Middle	21.79	26.01	21.43
Upper-middle	24.13	22.83	24.24
Highest	22.71	15.35	23.33
Social factors			
Having at least one parent smokes	51.52	68.65	50.01
Exposure to secondhand smoke			
Daily	31.22	54.71	20.92
Some days	23.54	39.07	45.76
Never	45.24	6.22	33.32
Number of individuals	37,339,843	2,899,273	34,440,570

N, weighted samples; weighted percentages.
In percentage unless otherwise stated

Figure 2 illustrates the risk of smoking initiation among adolescents. The Kaplan-Meier survival curve (left panel) estimates the probability of remaining a non-smoker

(surviving being a smoker) at each age, while the Nelson-Aalen cumulative hazard function (right panel) reflects the accumulated risk of smoking initiation over time. The probability of remaining a non-smoker declines sharply after age 13, with the biggest drop happening between ages 15 and 18. When comparing by sex, males are at a higher risk of starting to smoke with a faster decline in survival probability and a greater cumulative risk than females. The Nelson-Aalen model reveals that males have almost twice the cumulative risk of initiation compared to females by age 15. This gender gap grows as they get older indicating that males are more likely to start smoking during adolescence.

Figure 2. Hazard to initiate smoking by gender among adolescents aged 10 to 18 years old

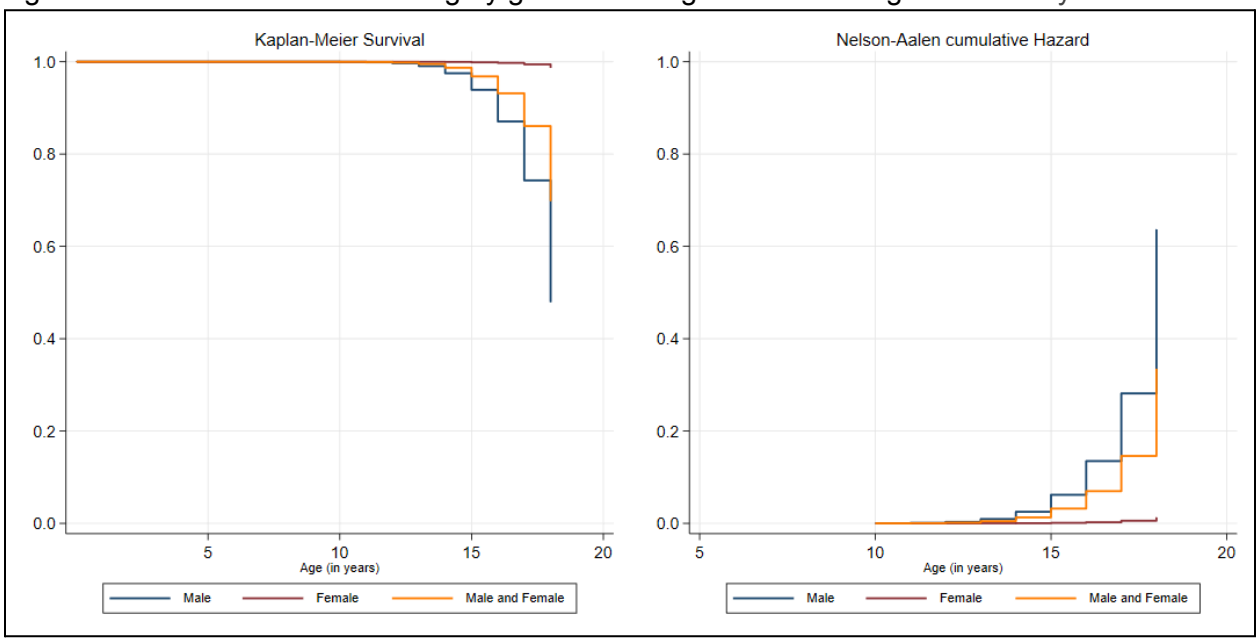


Table 2 presents the results from discrete-time complementary log-log (cloglog) duration models. For variables measured in natural logarithms within the cloglog model, coefficients represent the hazard elasticity relative to that variable (27,28). This allows us to interpret the price coefficient as directly showing how changes in real cigarette prices affect the risk of someone starting to smoke. Our results demonstrate that cigarette prices in general have a negative and significant effect on smoking initiation, with the price elasticity of initiation of around -2.2 (95% CI -3.8% to -0.46%). This implies that a 1% increase in cigarette prices lowers the chance to initiate smoking by 2.2%. Further analysis to examine the impact of prices among different cigarette types revealed that only prices of filtered kreteks are substantially associated with smoking uptake among Indonesian adolescents, with price elasticity for initiation hazard approximately -2.2 (95% CI -3.3% to -1.12%). The prices of white cigarettes and kreteks showed no significant effect on youth smoking initiation.

For dichotomous indicator variables, hazard ratios (i.e., the exponential of the reported coefficients) provide a more intuitive interpretation of variable effects (27). In our adjusted model, adolescents with smoking parents were more likely to initiate smoking (HR=1.3, exp.(0.24)). Our findings also indicated that both daily and some days exposure to secondhand smoke corresponded to higher risks of adolescent smoking initiation (HR=6.7, exp.(1.91) and HR=2.9, exp.(1.07), respectively). Conversely, our analysis demonstrated that being female and having upper-middle to highest income was associated with a lower risk of smoking initiation.

Our sensitivity analysis using age risk 5 and 10 years (compared to our baseline of 8 years) confirms the robustness of our findings on cigarette price impacts. Despite coefficient variations (-2.2 for age 5, -2.6 for age 10, compared to 2.2 for age 8), all estimates remain negative and statistically significant, with values within our main model's confidence interval. While the logarithmic time dependence specification yields somewhat different results than our cubic approach, this variation is expected when modeling duration dependence differently, and importantly, the negative relationship between price and smoking initiation persists across all specifications.

Table 2. Discrete-time complementary log-log (cloglog) duration models of smoking initiation among adolescents aged 10 to 18 years old (main model)

Explanatory variables	Dependent variable is 'starting smoking (1=yes, 0=no)'			
	All types of cigarettes	Kretek cigarettes	Filtered kretek cigarettes	White cigarettes
Prices (in *ln)*	-2.15303*	-1.00914	-2.23000**	0.18308
	(0.863)	(0.527)	(0.565)	(0.550)
Female	-3.91912**	-3.92000**	-3.91763**	-3.91942**
	(0.145)	(0.145)	(0.145)	(0.145)
Age at survey	-0.08269*	-0.00894	-0.08764**	0.01314
	(0.039)	(0.022)	(0.032)	(0.035)
Urban	-0.01075	-0.01103	-0.01004	-0.01093
	(0.052)	(0.052)	(0.052)	(0.052)
Wealth (ref, lowest)				
Lower-middle	0.00054	0.00064	-0.00046	0.00007
	(0.071)	(0.071)	(0.071)	(0.071)
Middle	-0.07056	-0.06930	-0.07174	-0.07035
	(0.071)	(0.072)	(0.071)	(0.072)
Upper-middle	-0.22723**	-0.22747**	-0.22787**	-0.22806**
	(0.074)	(0.074)	(0.074)	(0.074)
Highest	-0.51948**	-0.51938**	-0.51930**	-0.52000**
	(0.086)	(0.086)	(0.086)	(0.086)
Having at least one parent smokes	0.24005**	0.24056**	0.24003**	0.24032**
	(0.050)	(0.051)	(0.050)	(0.051)
Exposure to secondhand smoke (ref, never exposed)				
Yes, everyday	1.90802**	1.90856**	1.90641**	1.90810**
	(0.089)	(0.089)	(0.089)	(0.089)
Yes, not everyday	1.07304**	1.07326**	1.07249**	1.07311**
	(0.086)	(0.086)	(0.086)	(0.086)
Number of individuals	37,339,843	37,339,843	37,339,843	37,339,843

All models are adjusted for duration dependency (cubic polynomial functional form), province-level real GDP per capita, province-fixed effects, and include an intercept.
Robust standard errors (SE) are shown in parentheses.
SEs are clustered to control for inter-temporal correlations within the same individual.
Full results are available in Table A1 in the Appendix.
* and **, significant at 5% and 1%, respectively.

Discussions

We found that higher cigarette prices were significantly associated with a lower likelihood of smoking initiation among Indonesian adolescents aged 10 to 18 years old. The estimated price elasticity is around -2.2 which implies that a 10% increase in

cigarette price would reduce the odds of smoking initiation by 22%. Our findings are consistent with previous studies while the magnitude of price elasticity is relatively higher compared to the findings in the previous studies, such as Gambia (-0.7) (29), Zimbabwe (-0.9) (14), Nigeria (-1.04) (11), and Poland (-1.56) (26). This study serves as important evidence to support the notion that the younger population is sensitive to a price change in tobacco products. We argue that adolescents have limited financial capability, thus price increases can demotivate youth to try smoking. In addition, soaring prices of cigarettes may extend to the decline of tobacco consumption among peers and adults and afterwards trigger behavior change in adolescents themselves since they are highly susceptible to social cues (26).

Across different cigarette types, only prices of filtered kretek have a negative and significant relationship with youth smoking initiation in Indonesia. The plausible reason for this finding is due to the popularity and high availability of filtered kretek in Indonesia. A national survey in 2014 suggested that almost half of Indonesian adolescents aged 15 to 19 years old bought filtered kretek when trying cigarettes for the first time (30). Along with the high demand, kretek cigarettes exhibit a higher production volume in the country, with a total production of more than 300 million sticks, compared to white cigarettes, with a total production of only around 10 million sticks in 2023 (based on internal data of The Directorate General of Customs and Excise). In addition, filtered cigarettes have been deceptively marketed as safer options than unfiltered ones, despite evidence demonstrating that this notion is not true, resulting in youth perceiving filtered cigarettes as less harmful, having lower risks (31), and tasting smooth (32).

Other findings of this study are that family smoking and exposure to cigarette smoke appear to have a substantial impact on smoking initiation among Indonesian youth. These are in line with other studies (22,33) and add to the literature that parental smoking and secondhand smoking have a significant role in increasing the likelihood of youth smoking initiation. Having one or both parents who smoke increases the hazards of initiating smoking by 1.3 times. Previous studies suggested that young people tend to adopt beliefs and behaviours from their closest relatives, such as siblings and parents (14,34). Observing their parents as smokers may give social cues to adolescents that such behaviour is acceptable. In addition, parents who smoke may allow adolescents to access cigarettes more easily since the tobacco products are available within children's reach at home and it is possible for young people to consume cigarettes even when they lack the financial means to purchase by themselves (14).

Furthermore, being exposed to secondhand smoke raises the hazard of adolescents experimenting with cigarette smoking by 2.9 times, and this estimation is even higher when the exposure happens every day (6.7 times). Adolescents observe their

surroundings and repetitive encounters with cigarette smoking may give youth social cues and pressures to copy the behaviours. Besides that, nicotine exposure from cigarette smoke potentially increases brain sensitivity to nicotine through the activation and upregulation of nicotine-acetylcholine receptors in the brain, resulting in the urge to smoke (21,33). This finding underlines the importance of smoking-free environments for adolescents since exposure to secondhand smoke increases the risks of smoking initiation, even exceeding the risks associated with price and parental smoking. This provides a promising avenue for intervention, as establishing smoke-free spaces is a readily achievable policy goal for the government. Therefore, prioritizing and enforcing smoke-free policies should be a key strategy in efforts to prevent youth smoking.

Our study also demonstrated that boys are more likely to initiate smoking at an earlier age than girls. This is in line with previous research (14) and is depicted in the prevalence of tobacco consumption among the general population, 66% among males and 3% among females (19). Boys in our investigation started smoking uptake on average at 14 years, which is also known as puberty age: a period of life that is indicated by intense peer bonding, making them susceptible to social influence and more likely to initiate risky behaviours such as smoking and alcohol intake (35).

To sum up, cigarette prices, parental smoking, and exposure to cigarette smoke are significant predictors of smoking initiation among adolescents in Indonesia. The government that aims to curb youth smoking should raise cigarette prices significantly by setting higher excise taxes and minimum retail prices. Simultaneously, reducing the layers of tobacco excise tariff should be performed to diminish options for affordable cigarettes. With the current 8 layers of tobacco tax in Indonesia, a mere tax increase is not effective in making all cigarette types expensive and in reducing youth smoking prevalence. In addition, accessibility to smoking cessation services and enforcement of smoke-free laws should be prioritised. These measures will provide support for adults, including parents, with high nicotine dependence to quit smoking and protect adolescents from secondhand smoke.

Strengths and limitations

This study is the first to examine the impact of prices and social factors on smoking initiation among Indonesian adolescents using nationally representative data. We use the average cigarette retail price to rule out endogeneity between price and consumption.

There are several limitations in our study. First, SKI is a self-reporting survey which means that the responses are prone to recall bias and are conducted in the household where adolescents might be supervised by their parents and tend to give socially

acceptable answers. Second, several factors that are likely to be associated with youth smoking could not be considered in this study due to the limited information available. Those variables include peer smoking, exposure to tobacco advertising and promotion, and awareness of antismoking messages. Third, we acknowledge that there might be a miscalculation of cigarette prices due to the absence of information regarding the number of cigarette sticks per pack and the possibility of adolescents purchasing cigarette sticks. Lastly, we could not identify the type of cigarettes used by adolescents during smoking initiation nor provide the price of nonconventional tobacco products, such as electronic cigarettes, in our analysis. However, it is unlikely to greatly influence the results because e-cigarette use represents a small share of tobacco consumed by youth (around 8.5% in 2023).

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General

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Appendix

Table A1. Discrete-time complementary log-log (cloglog) duration models of smoking initiation among adolescents with all variables

Explanatory variables	Dependent variable is 'starting smoking (1=yes, 0=no)'			
	All types of cigarettes	**Kretek cigarettes**	**Filtered kretek cigarettes**	**White cigarettes**
Prices (in *ln)*	-2.15303*	-1.00914	-2.23000**	0.18308
	(0.863)	(0.527)	(0.565)	(0.550)
Female	-3.91912**	-3.92000**	-3.91763**	-3.91942**
	(0.145)	(0.145)	(0.145)	(0.145)
Age at survey	-0.08269*	-0.00894	-0.08764**	0.01314
	(0.039)	(0.022)	(0.032)	(0.035)
Urban	-0.01075	-0.01103	-0.01004	-0.01093
	(0.052)	(0.052)	(0.052)	(0.052)
Wealth (ref, lowest)				
Lower-middle	0.00054	0.00064	-0.00046	0.00007
	(0.071)	(0.071)	(0.071)	(0.071)
Middle	-0.07056	-0.06930	-0.07174	-0.07035
	(0.071)	(0.072)	(0.071)	(0.072)
Upper-middle	-0.22723**	-0.22747**	-0.22787**	-0.22806**
	(0.074)	(0.074)	(0.074)	(0.074)
Highest	-0.51948**	-0.51938**	-0.51930**	-0.52000**
	(0.086)	(0.086)	(0.086)	(0.086)
Having at least one parent smokes	0.24005**	0.24056**	0.24003**	0.24032**
	(0.050)	(0.051)	(0.050)	(0.051)
Exposure to secondhand smoke (ref, never exposed)				
Yes, everyday	1.90802**	1.90856**	1.90641**	1.90810**
	(0.089)	(0.089)	(0.089)	(0.089)
Yes, not everyday	1.07304**	1.07326**	1.07249**	1.07311**
	(0.086)	(0.086)	(0.086)	(0.086)
Real GDP per capita (in ln)	-2.11546**	-2.02889**	-2.02820**	-2.00678**
	(0.553)	(0.550)	(0.577)	(0.558)
Duration dependence				
t	0.45646**	0.35335*	0.46599**	0.27770
	(0.166)	(0.156)	(0.158)	(0.156)
t_sq	0.09086**	0.09664**	0.08578**	0.10307**
	(0.026)	(0.025)	(0.025)	(0.025)
t_cube	-0.00753**	-0.00785**	-0.00712**	-0.00808**
	(0.001)	(0.001)	(0.001)	(0.001)
Provincial fixed effects (ref, Aceh)				

Explanatory variables	Dependent variable is 'starting smoking (1=yes, 0=no)'			
	All types of cigarettes	Kretek cigarettes	Filtered kretek cigarettes	White cigarettes
North Sumatra	0.21351	0.59057*	-0.05998	0.47959
	(0.272)	(0.264)	(0.289)	(0.274)
West Sumatra	0.32769	0.60297**	0.25598	0.62687**
	(0.210)	(0.179)	(0.203)	(0.205)
Riau	1.71571**	1.77839**	1.55010*	1.63448*
	(0.643)	(0.640)	(0.668)	(0.647)
Jambi	0.57926	0.74241*	0.34493	0.45403
	(0.359)	(0.378)	(0.367)	(0.358)
South Sumatra	0.57604*	0.88074**	0.46869	0.78467**
	(0.277)	(0.272)	(0.284)	(0.287)
Bengkulu	-0.18163	0.06792	0.00153	0.00978
	(0.184)	(0.183)	(0.175)	(0.226)
Lampung	0.00093	0.31877	-0.22660	0.10299
	(0.166)	(0.211)	(0.183)	(0.177)
Bangka Belitung Islands	0.48509	0.58207*	0.64119*	0.71756*
	(0.288)	(0.284)	(0.284)	(0.293)
Riau Islands	2.79106**	2.95071**	2.12826**	2.59637**
	(0.717)	(0.723)	(0.748)	(0.722)
Jakarta Special Capital Region	3.98746**	4.52810**	3.78050**	4.34638**
	(1.091)	(1.080)	(1.132)	(1.122)
West Java	1.14997**	1.37944**	0.69778**	1.25168**
	(0.177)	(0.184)	(0.224)	(0.174)
Central Java	0.56051**	0.89062**	0.23605	0.82735**
	(0.165)	(0.142)	(0.198)	(0.148)
Special Region of Yogyakarta	1.03204**	1.44779**	0.70054**	1.37861**
	(0.209)	(0.179)	(0.236)	(0.196)
East Java	1.08365**	1.32772**	0.69671*	1.36814**
	(0.317)	(0.298)	(0.346)	(0.302)
Banten	1.46316**	1.54804**	1.27807**	1.45257**
	(0.265)	(0.268)	(0.273)	(0.267)
Bali	0.28800	0.74803**	-0.16377	0.50965
	(0.255)	(0.277)	(0.295)	(0.262)
West Nusa Tenggara	-0.66896*	-0.06503	-0.90229**	-0.12199
	(0.301)	(0.248)	(0.311)	(0.301)
East Nusa Tenggara	-1.30978**	-1.04866*	-1.62145**	-1.39557**
	(0.407)	(0.454)	(0.426)	(0.407)
West Kalimantan	-0.33021	-0.13129	-0.50613**	-0.22607
	(0.182)	(0.188)	(0.192)	(0.182)
Central Kalimantan	0.37608	0.54957	0.22912	0.31270
	(0.302)	(0.321)	(0.308)	(0.303)
South Kalimantan	0.31213	0.51105*	0.19652	0.34400
	(0.219)	(0.235)	(0.225)	(0.224)

Explanatory variables	Dependent variable is 'starting smoking (1=yes, 0=no)'			
	All types of cigarettes	Kretek cigarettes	Filtered kretek cigarettes	White cigarettes
East Kalimantan	3.74184**	3.81162**	3.66298**	3.67569**
	(0.917)	(0.912)	(0.956)	(0.925)
North Kalimantan	2.19384**	2.46129**	2.06795**	2.28215**
	(0.761)	(0.761)	(0.788)	(0.773)
North Sulawesi	0.41445	0.81596**	0.16958	0.59674*
	(0.267)	(0.286)	(0.284)	(0.283)
Central Sulawesi	1.52198**	1.83898**	1.25040**	1.56139**
	(0.399)	(0.417)	(0.434)	(0.406)
South Sulawesi	0.75065**	1.11071**	0.41471	1.04359**
	(0.279)	(0.258)	(0.303)	(0.270)
Southeast Sulawesi	-0.18496	0.07729	-0.24967	0.09624
	(0.281)	(0.263)	(0.279)	(0.283)
Gorontalo	-0.20296	0.01803	-0.78652**	-0.19337
	(0.186)	(0.216)	(0.245)	(0.191)
West Sulawesi	-0.78892**	-0.48514*	-0.85924**	-0.57236*
	(0.231)	(0.230)	(0.231)	(0.239)
Maluku	-1.04456**	-0.88930**	-1.06330**	-0.97568**
	(0.292)	(0.298)	(0.300)	(0.294)
North Maluku	-0.29437	-0.10682	-0.81897**	-0.31286
	(0.213)	(0.236)	(0.251)	(0.217)
West Papua	1.78649**	1.90253**	1.40381*	1.60951**
	(0.539)	(0.549)	(0.550)	(0.542)
Papua	0.65270*	0.95531**	0.42518	0.83441**
	(0.309)	(0.310)	(0.323)	(0.314)
Number of individuals	37,339,843	37,339,843	37,339,843	37,339,843

Notes: Robust standard errors (SE) shown in parentheses. SEs are clustered to control for inter-temporal correlations within the same individual. * and **, significant at 5% and 1%, respectively.

Table A2. Sensitivity analysis: Different time dependence variable and risk age using discrete-time cloglog duration models

Explanatory variables	Dependent variable is 'starting smoking (1=yes, 0=no)'					
	Baseline model (with risk age at 8)	Baseline model (with risk age at 8) - alternative time dependence	Baseline model (with risk age at 5)	Baseline model (with risk age at 5) - alternative time dependence	Baseline model (with risk age at 10)	Baseline model (with risk age at 10) - alternative time dependence
Prices (in ln)	-2.15303*	-1.67118*	-2.23993**	-3.22300**	-2.67324**	-0.79331
	(0.863)	(0.826)	(0.844)	(0.840)	(0.920)	(0.784)
Female	-3.91912**	-3.91904**	-3.92007**	-3.92776**	-3.90400**	-3.89948**
	(0.145)	(0.145)	(0.145)	(0.145)	(0.145)	(0.145)
Age at survey	-0.08269*	-0.06220	-0.09227*	-0.15792**	-0.10437*	-0.01824
	(0.039)	(0.037)	(0.038)	(0.038)	(0.041)	(0.035)
Urban	-0.01075	-0.01020	-0.00779	-0.00791	-0.01752	-0.01635
	(0.052)	(0.052)	(0.051)	(0.052)	(0.052)	(0.052)
Wealth (ref, lowest)						
Lower-middle	0.00054	-0.00570	0.00175	-0.00553	0.00848	0.00386
	(0.071)	(0.071)	(0.071)	(0.072)	(0.072)	(0.072)
Middle	-0.07056	-0.07383	-0.07087	-0.07554	-0.05988	-0.06200
	(0.071)	(0.072)	(0.071)	(0.072)	(0.073)	(0.072)
Upper-middle	-0.22723**	-0.22782**	-0.22158**	-0.22481**	-0.22536**	-0.22385**
	(0.074)	(0.073)	(0.073)	(0.074)	(0.074)	(0.074)
Highest	-0.51948**	-0.52193**	-0.51581**	-0.52203**	-0.51322**	-0.51244**
	(0.086)	(0.085)	(0.085)	(0.086)	(0.087)	(0.086)
Having at least one parent smokes	0.24005**	0.23882**	0.24198**	0.24130**	0.25082**	0.24897**
	(0.050)	(0.051)	(0.050)	(0.051)	(0.051)	(0.051)
Exposure to secondhand smoke (ref, never exposed)						
Yes, everyday	1.90802**	1.91069**	1.91147**	1.92182**	1.89484**	1.89336**
	(0.089)	(0.089)	(0.088)	(0.089)	(0.089)	(0.089)
Yes, not everyday	1.07304**	1.07351**	1.07623**	1.07814**	1.05594**	1.05581**
	(0.086)	(0.086)	(0.085)	(0.086)	(0.086)	(0.086)
Duration dependence						
t	0.45646**		0.24633		0.27621	
	(0.166)		(0.178)		(0.185)	
t_sq	0.09086**		0.10260**		0.14224**	
	(0.026)		(0.020)		(0.037)	
t_cube	-0.00753**		-0.00563**		-0.01348**	

Explanatory variables	Dependent variable is 'starting smoking (1=yes, 0=no)'					
	Baseline model (with risk age at 8)	**Baseline model (with risk age at 8) - alternative time dependence**	**Baseline model (with risk age at 5)**	**Baseline model (with risk age at 5) - alternative time dependence**	**Baseline model (with risk age at 10)**	**Baseline model (with risk age at 10) - alternative time dependence**
	(0.001)		(0.001)		(0.002)	
t_log		3.26010**		5.82469**		2.00775**
		(0.242)		(0.365)		(0.166)
Number of individuals	37,339,843	37,339,843	37,357,191	37,357,191	37,282,916	37,282,916

Notes:. Robust standard errors (SE) are shown in parentheses. SEs are clustered to control for inter-temporal correlations within the same individual. * and **, significant at 5% and 1%, respectively.