Letter

Impact of the Law on the Protection of Minors on the Denial of Tobacco Sales to Minors in China

Qingqing Xu[1,&], Xinying Zeng[2,&], Yongfu Yan[2], Xinbo Di[2], Huiyu Xie[2], Zida Meng[2], Mingxin Qi[2], Jidong Huang[3], Lin Xiao[2], and Shiwei Liu[2,#]

Adolescents who abuse tobacco are more vulnerable to long-term nicotine dependence, and more than 75% of current smokers started smoking during puberty[1]. This early initiation is particularly concerning because the prefrontal cortex, which governs executive functions and complex behavior, is not fully mature until age 25, making it especially susceptible to the neurotoxic effects of smoking[2]. The smoking rate among Chinese secondary school students decreased from 5.9% in 2019 to 4.2% in 2023[3]. However, easy access to cigarettes remains a critical obstacle to further reducing the smoking rate[4]. China's tobacco control strategy goes beyond general population measures to include specific policies protecting minors, such as the Tobacco Monopoly Law (1991) and the Law on the Protection of Minors (2006), which explicitly prohibit tobacco sales to minors. A 2020 revision of the Law on the Protection of Minors, which came into effect in June 2021, introduced specific penalties for non-compliance and significantly enhanced the enforceability of the legislation[5].

Recent studies have primarily focused on the availability of tobacco products near schools in highly developed cities. For example, an average of 3 tobacco stores were found within 100 m of each school in Changsha[6]. In addition, the China National Youth Tobacco Survey (NYTS) revealed that the percentage of secondary school smokers who succeeded in purchasing tobacco decreased from 83.3% in 2019 to 71.7% in 2023[5,7]. Despite these indications, there is still limited evidence regarding whether policies banning tobacco sales to minors are effectively enforced. To address this gap, we used data from the 2019, 2021, and 2023 China NYTS and a logistic difference-in-differences (DID) regression analysis[8] to examine the impact of the revised tobacco laws implemented in June 2021. Our findings provide key evidence regarding the effectiveness of bans on tobacco sales to minors and may inform strategies to prevent underage smoking in China.

The China NYTS was a nationally representative survey that covered 31 provinces of mainland China and used a multi-stage stratified cluster random sampling design. Additional details of this survey have been published elsewhere[4]. The 2019, 2021, and 2023 waves were conducted in the same schools between September and December of each respective year. All three surveys were approved by the Institutional Review Board of the Chinese Center for Disease Control and Prevention (2019: No. 202008, 2021: No. 202110, 2023: No.202301).

The main point of interest for our DID analysis was a revised tobacco policy implemented in June 2021. A two-category variable was created for the time period: the pre-policy revision group (2019–2021) and the post-policy revision group (2023), with the policy change period beginning in the calendar year of implementation. We selected 17- and 18-year-olds based on their similar physical characteristics and differing legal eligibility for tobacco purchase. The 17-year-olds were assigned to the intervention group and the 18-year-olds to the control group.

The primary outcome, denial of cigarette purchase due to age, was assessed by asking students who had bought cigarettes in the past 30 days, "During the past 30 days, did anyone refuse to sell you cigarettes because of your age?" Binary (yes/no) responses were recorded. Covariates included weekly pocket money, categorized into ≤ 10, 11–30, 31–50, or > 51 RMB; smoking behavior, where respondents who had not smoked in the past

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1. Zaozhuang Center for Disease Control and Prevention, Zaozhuang 277100, Shandong, China; 2. Tobacco Control Office, Chinese Center for Disease Control and Prevention, Beijing 100050, China; 3. School of Public Health, Georgia State University, Atlanta, GA 30303, USA

30 days were defined as nonsmokers, with further categories for frequency (1–9, 10–19, and 20–30 days) and intensity (≤ 5, 6–10, 11–20, > 20 cigarettes per day) for smokers; and the unit of cigarette purchase (pack, individual sticks, or carton) among current smokers.

All analyses accounted for the complex sampling design by using a three-step weighting scheme. The point estimate and 95% confidence interval (*CI*) for each parameter was calculated using the final weights. Differences in denial rates across demographic and smoking-related subgroups (including gender, residence, geographic region, school type, pocket money, cigarette use, smoking frequency, smoking intensity, and unit of purchased cigarettes) were assessed using the Rao-Scott test. These same variables were included as covariates in the adjusted regression models. Linear regression models were applied to identify the change in the denial rate from 2019 to 2023. The Jackknife replication method was used to calculate the relative percentage change.

The effect of the policy revision was estimated using a DID approach that compared pre-post (2019–2021 *vs.* 2023) changes in denial rates between 17-year-olds (the intervention group, protected by the law) and 18-year-olds (the control group, not protected). The DID estimate was derived from the interaction term between group and time variables in the logistic regression models. This design relied on the critical identifying assumption that, in the absence of the policy, outcome trends for both groups would have followed parallel paths[9]. We developed two types of models for each relationship, running both unadjusted and adjusted versions. Model 1 included all students who reported purchasing cigarettes in the past 30 days. Model 2 restricted the sample to those who had both purchased and smoked cigarettes in the same period. Analogous models in the sensitivity analysis compared individuals aged 16–17 to those aged 18–19. All analyses were conducted using SAS 9.4. The threshold of significance was $P < 0.05$ and all tests were two-sided.

The China NYTS surveyed 288,192 secondary school students in 2019 (response rate: 94.8%), 269,250 in 2021 (response rate: 95.9%), and 261,454 in 2023 (response rate: 95.7%). Across all three waves, the mean age of participants was 15 years (range: 13–16). In 2023, among all secondary school students who purchased cigarettes during the previous 30 days, 29.6% reported being denied purchase due to age, which is lower than previously reported in Thailand and Brazil. The denial rates were lowest in Zhejiang and Shanghai for secondary and middle school students and lowest in Hubei, Jilin, and Henan for high school students (Figure 1).

Between 2019 and 2023, the denial rate increased by 13.9% (95% *CI*: 11.4%, 16.3%), with a 7.4% (95% *CI*: 4.6%, 10.1%) increase occurring between 2021 and 2023. The absolute increase in the denial rate was greater for middle school students (8.4%, 95% *CI*: 4.7%, 12.0%) than for high school students (5.6%, 95% *CI*: 2.1%, 9.0%) (Table 1, Supplementary Table S1), despite the latter having a significantly higher baseline smoking prevalence[10]. This discrepancy may indicate that enforcement has been either stricter for middle school students or that retailers are more likely to comply when facing younger adolescents. Given that rigorous age verification is a cornerstone of effective enforcement—as demonstrated by Japan's successful proof-of-age system for tobacco vending machines—the development and adoption of an electronic verification system in China could be a pivotal next step to sustain and amplify these gains. The development of such a system in China would likely enhance the accuracy of age verification processes.

While denial rates for 17- and 18-year-olds did not differ significantly in 2019 and 2021, a significant gap emerged by 2023 (23.1% *vs.* 19.1%). The increase in the denial rate for 17-year-olds from 2021 to 2023 was significant (5.3%, 95% *CI*: 1.2%, 9.3%), whereas the change for 18-year-olds was not statistically significant (3.4%, 95% *CI*: –2.5%, 9.2%) (Table 2). Although several policies banning tobacco sales to minors have been implemented since 1999 in China, more than 75% of 17-year-olds still successfully purchased cigarettes in 2023. Internationally, raising the legal purchasing age is an increasingly adopted strategy to protect youth, as seen in New Zealand's landmark generational ban. We suggest that China promptly raise the legal age for purchasing tobacco.

The event studies showed that pre-policy trends in denial rates between 17- and 18-year-olds were relatively parallel (Supplementary Figure S1), validating the DID design. Following the implementation of the revised law, the DID analysis found no statistically significant effect on cigarette purchase denials among the targeted minors. After

Table 1. Characteristics of Chinese secondary school students who were denied purchase of cigarettes due to age during 2019 and 2023

Characteristics	2019			2021			2023			2019–2023 Absolute change-% (95% *CI*)	2021–2023 Absolute change-% (95% *CI*)
	Sample size	Tobacco-buyers	Weighted % (95% *CI*)	Sample size	Tobacco-buyers	Weighted % (95% *CI*)	Sample size	Tobacco-buyers	Weighted % (95% *CI*)		
Total	288,192	12,790	15.7 (14.4, 17.0)	269,250	9,277	22.2 (20.4, 24.1)	261,454	13,082	29.6 (27.6, 31.5)	13.9 (11.4, 16.3)	7.4 (4.6, 10.1)
Sex											
Boys	145,245	10,746	15.9 (14.6, 17.2)	138,007	7,730	22.6 (20.5, 24.7)	136,859	9,887	30.6 (28.3, 33.0)	14.8 (12.0, 17.5)	8.0 (4.8, 11.3)
Girls	142,947	2,044	14.6 (11.9, 17.3)	131,243	1,547	20.3 (17.4, 23.2)	124,595	3,195	26.4 (24.1, 28.8)	11.8 (8.2, 15.4)	6.1 (2.5, 9.8)
Residence											
Urban	153,054	5,899	14.9 (13.3, 16.6)	149,047	4,119	22.6 (20.8, 24.4)	141,280	6,633	30.2 (28.0, 32.3)	15.2 (12.5, 18.0)	7.6 (4.8, 10.4)
Rural	135,138	6,891	16.1 (14.4, 17.8)	120,203	5,158	21.9 (19.1, 24.8)	120,174	6,449	29.1 (25.9, 32.2)	13.0 (9.2, 16.7)	7.1 (2.8, 11.5)
Geographic region*											
Eastern	98,234	3,342	15.9 (13.8, 17.9)	98,142	2,707	20.3 (18.6, 22.0)	93,516	3,477	27.3 (24.3, 30.3)	11.5 (7.9, 15.0)	7.0 (3.5, 10.6)
Central	93,374	3,842	12.6 (10.6, 14.7)	72,848	2,224	18.8 (16.4, 21.2)	69,965	3,038	26.0 (22.4, 29.5)	13.3 (9.0, 17.6)	7.2 (3.4, 11.0)
Western	96,584	5,606	17.6 (15.5, 19.7)	98,260	4,346	26.4 (22.6, 30.3)	97973	6,567	34.1 (31.1, 37.1)	16.5 (12.8, 20.2)	7.7 (2.5, 12.8)
Pocket money (RMB)											
≤ 10	40,941	155	21.0 (16.1, 25.9)	35,277	151	32.5 (26.1, 39.0)	16,878	231	38.4 (32.9, 43.8)	17.4 (10.1, 24.7)	5.9 (–2.1, 13.8)
11–30	79,928	533	20.0 (17.6, 22.5)	74,122	547	26.7 (23.7, 29.8)	28,745	456	33.4 (29.5, 37.4)	13.4 (8.7, 18.1)	6.7 (1.6, 11.8)
31–50	42,973	373	15.3 (12.8, 17.7)	62,333	610	22.4 (19.2, 25.5)	25,696	466	31.1 (26.7, 35.6)	15.9 (10.8, 21.0)	8.8 (3.5, 14.1)
≥ 51	85,747	809	13.0 (11.6, 14.4)	51,546	609	18.0 (15.6, 20.4)	61,211	1,365	25.1 (22.2, 27.9)	12.1 (8.9, 15.3)	7.1 (3.3, 10.9)
Cigarette use											
No	271,198	1,262	17.6 (13.5, 21.8)	254,787	819	21.0 (17.2, 24.9)	247,900	4,430	33.1 (30.6, 35.5)	15.5 (10.6, 20.3)	12.1 (7.3, 16.8)
Yes	15,257	11,024	15.3 (14.1, 16.6)	12,934	8,088	22.0 (20.0, 24.1)	11,733	8,024	27.1 (24.5, 29.6)	11.7 (8.7, 14.7)	5.0 (1.7, 8.3)
Smoking frequency (days)											
0	271,198	1,262	17.6 (13.5, 21.8)	254,787	819	21.0 (17.2, 24.9)	247,900	4,430	33.1 (30.6, 35.5)	15.5 (10.6, 20.3)	12.1 (7.3, 16.8)
1–9	8,341	4,804	18.3 (16.3, 20.2)	7,489	3,700	25.3 (22.6, 28.0)	6,434	3,677	31.9 (28.6, 35.1)	13.6 (9.6, 17.6)	6.6 (2.3, 10.9)
10–19	2,185	1,909	14.5 (11.8, 17.2)	1,663	1,323	19.8 (16.3, 23.2)	1,591	1,305	25.2 (21.4, 29.0)	10.7 (5.9, 15.6)	5.4 (0.4, 10.5)
20–30	4,731	4,311	12.4 (10.8, 14.0)	3,782	3,065	18.6 (15.9, 21.3)	3,708	3,042	21.3 (19.0, 23.7)	9.0 (6.0, 11.9)	2.7 (–1.0, 6.4)
Smoking intensity											
≤ 5 cigs	283,455	9,626	16.1 (14.7, 17.5)	264,313	6,784	21.6 (19.4, 23.9)	256,225	10,125	31.0 (29.0, 33.0)	14.7 (12.2, 17.2)	9.5 (6.7, 12.2)
6–10 cigs	1,643	1,527	12.9 (10.1, 15.7)	1,271	1,120	23.0 (18.6, 27.5)	1,447	1,300	20.9 (15.7, 26.1)	8.0 (2.3, 13.7)	–2.1 (–8.8, 4.6)
11–20 cigs	677	624	12.6 (8.6, 16.6)	622	539	20.3 (13.5, 27.1)	658	589	20.1 (14.9, 25.4)	7.6 (1.0, 14.1)	–0.15 (–8.7, 8.4)
> 20 cigs	580	493	12.9 (8.5, 17.3)	476	348	23.0 (14.9, 31.1)	416	307	23.3 (15.9, 30.7)	10.5 (1.6, 19.3)	0.3 (,10.9, 11.5)

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Characteristics	2019			2021			2023			2019–2023 Absolute change-% (95% *CI*)	2021–2023 Absolute change-% (95% *CI*)
	Sample size	Tobacco-buyers	Weighted % (95% *CI*)	Sample size	Tobacco-buyers	Weighted % (95% *CI*)	Sample size	Tobacco-buyers	Weighted % (95% *CI*)		
Purchasing pattern											
No	261,664	–	–	245,240	–	–	243,495			0	0
Pack	10,617	10,554	13.7 (12.5, 14.8)	7,491	7,488	20.6 (19.1, 22.1)	7,715	7,531	27.3 (25.0, 29.5)	13.6 (10.9, 16.2)	6.7 (3.9, 9.5)
Individual sticks	1,152	1,143	30.3 (25.8, 34.8)	737	735	39.7 (31.6, 47.7)	608	562	45.0 (37.1, 53.0)	14.7 (5.7, 23.7)	5.4 (2.3, 8.5)
Carton	877	867	16.9 (13.0, 20.7)	876	876	20.4 (16.1, 24.7)	861	780	22.8 (17.4, 28.3)	6.0 (–0.5, 12.5)	2.4 (–4.6, 9.4)

Note. *CI* = confidence interval; RMB = renminbi. Eastern region: Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Hainan; Central region: Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan; Western region: Sichuan, Chongqing, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang, Inner Mongolia, Guangxi.

Table 2. Characteristics of 17- and 18-year-olds who were denied purchase of cigarettes due to age in 2021 and 2023

Characteristic	2019		2021		2023		2019–2023 Absolute change, % (95% *CI*)	2021–2023 Absolute change, % (95% *CI*)
	Sample size	Weighted % (95% *CI*)	Sample size	Weighted % (95% *CI*)	Sample size	Weighted % (95% *CI*)		
17-year-olds								
Total	3,278	11.7 (9.9, 13.5)	2,326	17.9 (15.3, 20.5)	2,873	23.1 (20.2, 26.1)	11.4 (7.9, 14.9)	5.3 (1.2, 9.3)
Sex								
Boys	2,891	11.9 (10, 13.7)	2,056	18.2 (15.2, 21.1)	2,341	22.5 (19.5, 25.5)	10.6 (7.1, 14.2)	4.3 (0.1, 8.6)
Girls	387	10.3 (5.8, 14.7)	270	15.5 (9.4, 21.5)	532	25.9 (19.3, 32.4)	15.6 (7.6, 23.5)	10.4 (1.7, 19.1)
Residence								
Urban	1,622	9.4 (7.1, 11.7)	1,128	15.9 (13.0, 18.8)	1,519	26.4 (21.9, 31.0)	17.1 (12, 22.1)	10.6 (5.4, 15.8)
Rural	1,656	13.1 (10.6, 15.5)	1,198	19.5 (15.5, 23.6)	1,354	19.7 (16.4, 23.0)	6.6 (2.2, 10.9)	0.1 (–5.6, 5.8)
School type								
Middle school	84	18.2 (10.7, 25.8)	29	4.1 (0.0, 9.3)	25	25.2 (3.2, 47.3)	7.0 (–18.4, 32.5)	21.2 (–4.0, 46.4)
High school	3,194	11.5 (9.7, 13.3)	2,297	18.1 (15.5, 20.8)	2,848	23.1 (20.2, 26.1)	11.6 (8.1, 15.1)	5.0 (0.9, 9.1)
Geographic region								
Central	1,013	9.9 (6.6, 13.3)	564	14.2 (10.4, 18.1)	594	19.8 (15.4, 24.2)	10.6 (5.3, 15.8)	5.3 (0.2, 10.5)
Eastern	864	11.5 (8.3, 14.8)	679	17.1 (12.4, 21.8)	772	19.6 (15.8, 23.3)	8.0 (3.1, 13.0)	2.4 (–4.0, 8.8)
Western	1,401	13.1 (10.4, 15.8)	1,083	20.7 (16.3, 25.1)	1,507	28.1 (22.8, 33.4)	15.1 (9.0, 21.1)	7.5 (0.3, 14.6)
Pocket money (RMB)								
≤ 10	347	14.1 (8.2, 19.9)	263	11.9 (6.9, 16.9)	32	25.9 (6.5, 45.2)	12.1 (–16.5, 40.7)	13.8 (–6.0, 33.7)
11–30	497	15.5 (11.6, 19.4)	362	20.8 (15.2, 26.3)	147	17.7 (9.2, 26.2)	2.1 (–7.3, 11.5)	–2.9 (–13.3, 7.5)
31–50	528	12.8 (8.3, 17.3)	644	20.9 (16.0, 25.7)	222	25.9 (16.9, 35.0)	13.1 (3.0, 23.2)	4.9 (–5.5, 15.3)
≥ 51	1,899	9.8 (7.7, 11.9)	1,055	16.6 (12.7, 20.4)	1,478	21.3 (17.2, 25.4)	11.5 (6.9, 16.1)	4.6 (–1.1, 10.3)

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Characteristic	2019		2021		2023		2019–2023 Absolute change, % (95% *CI*)	2021–2023 Absolute change, % (95% *CI*)
	Sample size	Weighted % (95% *CI*)	Sample size	Weighted % (95% *CI*)	Sample size	Weighted % (95% *CI*)		
Cigarette use								
No	261	6.8 (3.5, 10.1)	158	17.3 (9.8, 24.9)	701	29.6 (23.9, 35.3)	22.8 (16.1, 29.4)	12.2 (2.9, 21.6)
Yes	2,902	12.3 (10.4, 14.1)	2,083	17.8 (15.2, 20.4)	2,018	20.9 (17.4, 24.4)	8.6 (4.6, 12.7)	3.1 (–1.4, 7.6)
Smoking frequency (days)								
0	261	6.8 (3.5, 10.1)	158	17.3 (9.8, 24.9)	701	29.6 (23.9, 35.3)	22.8 (16.1, 29.4)	12.2 (2.9, 21.6)
1–9	1,089	11.9 (9.1, 14.7)	801	20.0 (16.3, 23.7)	754	24.7 (19.2, 30.1)	12.8 (6.4, 19.1)	4.7 (–2.1, 11.5)
10–19	507	16.0 (11, 20.9)	341	21.6 (14.5, 28.8)	311	21.8 (14.6, 29.0)	5.9 (–3.1, 15.0)	0.2 (–10.1, 10.4)
20–30	1,306	11.1 (8.3, 13.8)	941	14.5 (10.7, 18.4)	953	17.4 (14.0, 20.8)	6.3 (1.9, 10.7)	2.8 (–2.5, 8.1)
Smoking intensity (cigs)								
≤ 5	2,419	12.4 (10.3, 14.5)	1,517	17.6 (15.0, 20.2)	2,074	24.9 (21.1, 28.6)	9.4 (4.4, 14.5)	4.8 (–0.4, 10.1)
6–10	444	10.8 (5.4, 16.2)	313	18.0 (10.1, 25.9)	402	16.2 (10.6, 21.8)	5.4 (–2.3, 13.1)	–1.8 (–11.0, 6.8)
11–20	182	8.9 (1.8, 16)	160	16.5 (7.4, 25.6)	141	14.7 (7.5, 21.8)	5.8 (–4.2, 15.8)	–1.8 (–13.2, 9.6)
> 20	118	8.7 (1.6, 15.8)	74	12.9 (2.4, 23.3)	73	25.4 (9.5, 41.3)	15.9 (–2.2, 33.9)	11.7 (–8.0, 31.5)
Purchasing patterns								
Pack	2,811	10.4 (8.6, 12.2)	1,941	18.3 (15.6, 21.0)	1,915	20.5 (16.5, 24.5)	10.0 (5.7, 14.4)	2.1 (–2.7, 6.9)
Individual sticks	212	23.5 (14.3, 32.7)	128	18.5 (10.2, 27.0)	106	38.1 (24.5, 51.6)	14.7 (–1.5, 30.8)	19.7 (3.7, 35.6)
Carton	213	15.5 (7, 24.1)	228	10.1 (4.6, 15.6)	206	22.7 (14.2, 31.2)	7.2 (–4.8, 19.2)	12.6 (2.2, 23.1)
18-year-olds								
Total	1,625	9.6 (7.5, 11.7)	979	15.7 (11.1, 20.3)	1,275	19.1 (16.0, 22.2)	9.5 (5.6, 13.4)	3.4 (–2.5, 9.2)
Sex								
Boys	1,458	8.9 (6.8, 11)	888	15.8 (11.5, 20.2)	1,105	20.4 (16.9, 23.8)	11.4 (7.9, 14.9)	4.5 (–1.2, 10.3)
Girls	167	17.7 (9.5, 25.9)	91	14.7 (1.5, 27.9)	170	11.2 (4.8, 17.7)	–6.5 (–17.5, 4.5)	–3.5 (–19.1, 12.0)
Residence								
Urban	754	8.2 (4.9, 11.4)	447	12.8 (8.7, 16.9)	646	17.6 (13.8, 21.5)	10.6 (7.1, 14.2)	4.8 (–1.0, 10.7)
Rural	871	10.3 (7.7, 13.0)	532	18.0 (10.8, 25.3)	629	20.6 (15.7, 25.4)	10.4 (4.5, 16.3)	2.8 (–6.5, 12.2)
School type								
Middle school	25	66.7 (46.6, 86.8)	11	25.3 (0.0, 65.4)	1	–	–66.7 (–92.2, –41.1)	–
High school	1,600	9.1 (7.1, 11.2)	968	15.7 (11.1, 20.3)	1,274	19.1 (16.1, 22.2)	10.0 (6.2, 13.8)	3.5 (–2.4, 9.3)
Geographic region								
Central	449	10.4 (6.6, 14.3)	185	8.1 (4.4, 11.8)	235	20.1 (13.1, 27.2)	9.7 (1.7, 17.7)	12.0 (4.2, 19.8)
Eastern	318	8.1 (3.4, 12.8)	254	14.6 (6.7, 22.5)	274	16.1 (9.7, 22.6)	8.0 (–0.2, 16.2)	1.5 (–8.6, 11.6)
Western	858	9.7 (6.7, 12.7)	540	19.9 (12.2, 27.6)	766	20.3 (16.4, 24.1)	10.6 (5.3, 15.8)	0.3 (–9.3, 9.9)

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Characteristic	2019		2021		2023		2019–2023 Absolute change, % (95% *CI*)	2021–2023 Absolute change, % (95% *CI*)
	Sample size	Weighted % (95% *CI*)	Sample size	Weighted % (95% *CI*)	Sample size	Weighted % (95% *CI*)		
Pocket money (RMB)								
≤ 10	186	14.2 (5.7, 22.7)	120	10.0 (2.6, 17.4)	8	19.2 (0.0, 53.1)	5.0 (–29.4, 39.4)	9.2 (–25.9, 44.2)
11–30	257	11.5 (6.0, 17.1)	147	23.5 (9.3, 37.8)	58	16.0 (3.3, 28.6)	4.4 (–9.7, 18.6)	–7.6 (–26.6, 11.3)
31–50	250	10.2 (5.8, 14.5)	251	13.1 (7.2, 18.9)	101	19.4 (7.2, 31.7)	9.3 (–3.6, 22.1)	6.3 (–7.5, 19.9)
≥ 51	931	7.8 (5.2, 10.5)	455	17.1 (10.3, 23.8)	668	18.3 (13.8, 22.9)	10.5 (5.1, 15.8)	1.2 (–7.5, 9.9)
Cigarette use								
No	96	19.1 (7.6, 30.6)	50	21.0 (2.8, 39.2)	268	21.6 (14.2, 29.0)	2.5 (–11.1, 16.2)	0.6 (–21.9, 23.0)
Yes	1,477	8.9 (6.7, 11.0)	893	15.6 (10.7, 20.5)	948	18.7 (15.3, 22.1)	9.8 (5.7, 14.0)	3.1 (–3.2, 9.4)
Smoking frequency (days)								
0	96	19.1 (7.6, 30.6)	50	21.0 (2.8, 39.2)	268	21.6 (14.2, 29.0)	2.5 (–11.1, 16.2)	0.6 (–21.9, 23.0)
1–9	496	9.7 (5.8, 13.7)	307	16.2 (9.0, 23.4)	363	21.8 (15.8, 27.8)	12.1 (4.9, 19.4)	5.6 (–3.9, 15.1)
10–19	278	9.4 (3.9, 15.0)	141	15.3 (8.6, 22.0)	159	13.8 (6.7, 20.8)	4.4 (–4.9, 13.7)	–1.5 (–11.1, 8.1)
20–30	703	8.0 (5.0, 11)	445	15.2 (8.4, 22.0)	426	17.9 (12.6, 23.2)	9.9 (3.7, 16.2)	2.7 (–6.3, 11.7)
Smoking intensity (cigs)								
≤ 5	1,198	10.2 (7.8, 12.6)	616	14.3 (9.5, 19.2)	930	21.9 (17.6, 26.1)	12.5 (6.7, 18.3)	7.6 (0.3, 15.0)
6–10	222	6.0 (2.5, 9.6)	145	22.3 (9.8, 34.8)	168	10.9 (4.3, 17.6)	4.7 (–2.9, 12.4)	–11.6 (–25.6, 2.4)
11–20	94	7.9 (0.0, 15.8)	75	5.3 (0.7, 9.9)	78	14.8 (0.0, 29.9)	7.0 (–9.8, 23.9)	9.6 (–6.3, 25.5)
> 20	54	10.1 (0, 23.5)	50	14.9 (0.9, 29.0)	25	12.6 (0.0, 27.3)	2.5 (–17.1, 22.0)	–2.4 (–24.7, 19.9)
Purchasing pattern								
Pack	1,387	8.5 (6.2, 10.9)	807	13.6 (10.3, 17.0)	885	18.9 (15.2, 22.7)	10.4 (6.0, 14.9)	5.3 (0.1, 10.5)
Individual sticks	106	13.7 (4.3, 23.0)	49	41.6 (14.0, 69.2)	45	33.6 (15.9, 51.3)	20.2 (–0.7, 41.2)	–7.7 (–41.5, 26.0)
Carton	108	14.7 (3.6, 25.8)	103	16.6 (2.2, 30.9)	87	18.5 (5.3, 31.6)	3.7 (–13.5, 21.0)	1.8 (–17.6, 21.2)

adjusting for covariates including residence, geographic region, school type, sex, pocket money, smoking frequency, smoking intensity, and tobacco purchasing pattern, the change in the denial rate for 17-year-olds from 2019 to 2023 did not significantly surpass that for 18-year-olds (Model 1: Odds ratio [*OR*] = 0.84, 95% *CI*: 0.52, 1.34, *P* = 0.46; Table 3). This null association was consistent among smokers who had purchased cigarettes in the past 30 days (Model 2: *OR* = 0.78, 95% *CI*: 0.48, 1.26, *P* = 0.31; Table 3). Sensitivity analyses using alternative age groupings yielded similar results (Supplementary Table S2). These results suggest that the enhanced penalties introduced in 2021 have not yet translated into a statistically discernible increase in the denial rate for the protected cohort (17-year-olds) relative to the control group (18-year-olds). To our knowledge, no other concurrent nationwide policy changes would specifically explain a differential shift in denial rates between these ages. The persistently high rate of successful cigarette purchases among minors indicates that stricter penalties alone are insufficient. Effective reduction in youth access to tobacco likely requires more systematic enforcement, such as integrated electronic age-verification systems, to ensure compliance at the

point of sale.

This study benefited from a large, nationally representative sample of Chinese secondary school students and was the first to employ a DID design to evaluate this specific policy, enhancing the robustness of our trend analysis. However, several limitations should be considered. The nationwide ban on tobacco sales to minors precluded a traditional control group, so our DID approach instead compared 17- and 18-year-olds. Age was self-reported without verification against birth dates, which may have caused some exposure misclassification and potentially led to an underestimation of the policy effect. Furthermore, our data captured only purchases from conventional retail outlets, excluding tobacco obtained online or through informal sources. Consequently, our findings may not fully reflect overall tobacco access among minors.

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Table 3. Logistic DID regression analyses of the effect of the revised tobacco policies on cigarette purchase denials

Variables	Model 1			Model 2		
	Estimate	Odds ratio (95% *CI*)	*P*-value	Estimate	Odds ratio (95% *CI*)	*P*-value
Age (17 *vs.* 18)	0.26	1.30 (1.03, 1.64)	0.03*	0.33	1.39 (1.08, 1.78)	0.01*
Policy implementation (2023 *vs.* 2019)	0.72	2.06 (1.38, 3.08)	< 0.01*	0.73	2.08 (1.38, 3.14)	< 0.01*
Interaction	–0.18	0.84 (0.52, 1.34)	0.46	–0.25	0.78 (0.48, 1.26)	0.31
Residence (ref = Rural)			0.98			0.997
Urban	0.002	1.00 (0.82, 1.23)		–0.0002	1.00 (0.81, 1.23)	
Geographic region (ref = Eastern)			0.08			0.10
Central	–0.02	0.98 (0.73, 1.31)		–0.02	0.98 (0.73, 1.33)	
Western	0.24	1.27 (0.98, 1.64)		0.23	1.26 (0.97, 1.62)	
School type (ref = Middle school)			0.37			0.06
High school	–0.08	0.85 (0.59, 1.21)		–0.18	0.70 (0.48, 1.02)	
Sex (ref = Girls)			0.54			0.38
Boys	–0.04	0.92 (0.70, 1.21)		–0.06	0.89 (0.67, 1.16)	
Pocket money per week (ref = ≤ 10 RMB)			0.12			0.14
11–30 RMB	0.13	1.13 (0.75, 1.72)		0.11	1.11 (0.71, 1.74)	
31–50 RMB	0.10	1.11 (0.76, 1.61)		0.11	1.11 (0.76, 1.64)	
≥ 51 RMB	–0.11	0.89 (0.63, 1.27)		–0.11	0.89 (0.62, 1.29)	
Smoking frequency (ref = 1–9 days)			0.30			0.19
0 days	0.06	1.06 (0.77, 1.47)		–	–	–
10–19 days	0.08	1.09 (0.85, 1.39)		0.08	1.09 (0.85, 1.39)	
20–30 days	–0.16	0.85 (0.69, 1.05)		–0.16	0.85 (0.69, 1.05)	
Smoking intensity (ref = ≤ 5 cigs)			0.18			0.17
6–10 cigs	–0.13	0.88 (0.64, 1.20)		–0.14	0.87 (0.64, 1.19)	
11–20 cigs	–0.30	0.74 (0.49, 1.14)		–0.30	0.74 (0.48, 1.13)	
> 20 cigs	–0.51	0.60 (0.35, 1.04)		–0.52	0.59 (0.34, 1.03)	
Purchasing pattern (ref = Individual sticks)			< 0.01*			< 0.01*
Pack	–0.59	0.55 (0.39, 0.78)		–0.62	0.54 (0.38, 0.76)	
Carton	–0.38	0.68 (0.43, 1.09)		–0.38	0.69 (0.42, 1.12)	

Note. *$P < 0.05$. Model 1 focused on students who had purchased cigarettes in the past 30 days. Model 2 targeted current smokers who had purchased cigarettes.

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Competing Interests The authors have no conflicts of interest to report.

Ethics These three surveys were approved by the Institutional Review Board of the Chinese Center for Disease Control and Prevention (China CDC; 2019: No. 202008, 2021: No. 202110, 2023: No.202301).

Authors' Contributions QX, XZ, LX, and SL had full access to all data in the study. QX and XZ were responsible for data cleansing, data analysis, and manuscript drafting. SL was responsible for study design and manuscript revision. LS, YY, DX, XH, MZ, QM, HJ, and XL supervised data interpretation. QX and XZ contributed equally to this work. The corresponding author had final responsibility for the decision to submit the manuscript for publication. All authors reviewed and approved the final manuscript.

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[&]These authors contributed equally to this work.

[#]Correspondence should be addressed to Shiwei Liu, PhD, Tel: 86-10-63185150, E-mail: liusw@chinacdc.cn

Biographical notes of the first authors: Qingqing Xu, majoring in tobacco control, E-mail: xuqing__qing @163.com; Xinying Zeng, majoring in tobacco control, E-mail: zengxinying1987@126.com

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