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Education tracking and adolescent smoking: a counterfactual and prospective cohort study

Wen-Hsu Lin[1] & **Michael Gebel**[2]

Institute of Health and Welfare Policy, College of Medicine, National Yang-Ming University, Taipei, Taiwan[1] and Department of Sociology, University of Bamberg, Bamberg, Germany[2]

ABSTRACT

Background and Aims Adolescent smoking is a health issue and a potential health inequality issue. Education tracking, which is the placement of students into different school types and curricula based on their learning needs or abilities, is an indicator of inequality and risk factor of adolescent smoking. We examined the effect of educational tracking, dividing students into vocational and academic high school tracks, on adolescent smoking in Taiwan. **Design and Setting** Longitudinal panel data, collected annually from 2000 over a period of 6 years as part of the Taiwan Youth project, were used. **Participants** Adolescents (aged 13–18 years) from the first six waves of the Taiwan Youth Project were included in the project, of whom 2147 had clear information on track attendance in 10th grade, control variables in 7th/8th grades and smoking behavior in 8th grade (before track placement). Post-track smoking behavior was measured at 10th, 11th and 12th grades. **Measurements** The outcome variable was the self-reported smoking status in the 8th grade and between 10th and 12th grades. The treatment variable of interest was education tracking (vocational versus academic), which was conducted when the student was in 10th grade. Several important confounders were used for the difference-in-differences propensity score matching (e.g. parents' education and same classroom peer smoking). **Findings** Placement of a student in the vocational track increased the proportion of smokers by 3.3 percentage points in 10th grade (P = 0.039). The effect was even more pronounced in 11th grade (6.2 percentage points; P = 0.000) and 12th grade (5.9 percentage points; P = 0.003). **Conclusions** Education tracking (placement of students into different school curricula based on learning needs or abilities) appears to be a risk factor for adolescent smoking among Taiwanese adolescents.

Keywords Adolescent, education tracking, health inequality, propensity score matching, smoking, vocational education.

Correspondence to: Michael Gebel, Department of Sociology, University of Bamberg, 96045 Bamberg, Germany. E-mail: michael.gebel@uni-bamberg.de
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INTRODUCTION

Smoking is linked to various diseases [1] and is the most preventable cause of mortality [2]. The World Health Organization (WHO) has reported that, globally, tobacco accounts for more than 8 million deaths annually [3]. Of all smokers, adolescents (i.e. minors aged under 18 years) deserve further attention for several reasons. First, most adult smokers initiate smoking during adolescence [4], and adolescent smokers are more likely to become nicotine-dependent and continue their habit into adulthood [5–7]. In addition, smokers who become addicted during adolescence have the greatest risk of developing tobacco-related diseases at a later stage [8]. Secondly, adolescent smoking could result in other negative outcomes, including alcohol use, negative school performances [9,10], mental health issues [11] and substance use problems [12]. Finally, as Pollard *et al.* ([13], p. 678) state, adolescence is a 'critical period for successful smoking prevention and intervention', and there is a need to 'prevent the first puff' because neither adolescents nor their care-givers can distinguish between individuals who will become regular smokers and those who stop smoking [14].

Although adolescent smoking is a serious public health issue, some scholars note that it is also related to inequalities experienced with regard to health [15,16]. Studies show that the prevalence of smoking is higher among disadvantaged socio-economic groups [15,17]. Consequently, understanding risk factors of adolescent smoking is related to promoting both health and equality. Although socio-economic inequality may be shaped by various factors (e.g. family), one major factor is 'education differentiation' [18], which is implemented by education tracking. Education tracking refers to educational systems that place students into different curricula or school types based on their learning needs or abilities [18]. This policy achieves homogeneity within tracks and differences between tracks [18,19]. For example, school systems in Asia (e.g. China and Korea) and many European countries (e.g. Finland and Germany) stream students, based on their academic performance/ability, into two completely different tracks: academic (e.g. preparing for college entrance) and vocational (e.g. skill development and technical training). In some countries (e.g. Austria) this takes place early (e.g. at transition from 6th grade to 7th grade), while others (e.g. Taiwan) occur later (e.g. at transition from 9th grade to 10th grade). Several US and European (e.g. German) studies have linked family social economic status and tracking, with average socio-economic status (SES) in the academic track being higher than in the vocational track [20,21]. Educational tracking is also related to future income and educational differences [22], both of which make education tracking an early source of social inequality. Scholars have also noted that tracking systems often reflect economic inequality in society [23].

Previous studies from several countries (e.g. the United States, Jamaica and some European countries) have linked the vocational/low track to poorer adolescent health, with a higher incidence of depression, lower self-esteem [24,25] and lower self-rated health [26], as well as the proclivity to engage in risky behavior [27,28]. Some recent studies have also found relationships between the vocational/low track and adolescent substance use [29] and smoking [18,26,30]. For example, de Clercq *et al.* [30] found that adolescents from Belgium placed in the vocational track were more likely to smoke than students in the academic track.

Although few studies have already related adolescent smoking to being placed in a vocational track, this study aims at making several improvements. First, previous studies mainly investigated the effect of education tracking on adolescent smoking without studying the temporal dynamics of the effects. Drawing upon a longitudinal panel study from Taiwan, we investigate the effect of track placement on smoking behavior immediately after tracking; that is, at the beginning of high school and during the following high school years. Changes in the effects over time are expected, because of the temporal dynamics of peer groups. As students enter new environments, such as a high school, some previous social connections are disrupted and new connections are established over time. Given that adolescent smoking is often heavily influenced by peer group behavior and attitudes (i.e. socialization) [31,32], we expect the effect of education tracking to become stronger over time when peer groups are established and the influence of peers becomes stronger in the two different tracks [33,34]. Secondly, while previous studies controlled for many possible confounders, the estimated effects may be inaccurate [35] because of the confounding bias due to unobserved variables. Based on longitudinal panel data we employ 'within-person' comparisons that eliminate time-constant observed and unobserved confounding variables. In addition, we compare the changes over time between the two tracks, which allows us to eliminate common time effects. This may help in getting closer to the identification of the causal relationship and is important for policy implications [36]. Thirdly, most previous studies used western samples to record the effects of tracking. However, the effects of tracking on smoking are also expected to be found in Asian societies (e.g. China, Indonesia, South Korea, Japan and Taiwan), because tracking is extremely prevalent and the inequalities mentioned above were also found in these regions [29,37,38]. Furthermore, adolescent smoking has become a serious health issue in Asian societies [2,39,40]; hence, understanding the process by which educational tracking influences adolescent smoking is important.

Against this background, the current study uses a longitudinal panel sample from Taiwan aimed at answering two central research questions: (1) what is the effect of education tracking in high school on adolescent smoking; and (2) how does this effect vary over time in high school?

METHOD

Sample

Data were drawn from the Taiwan Youth Project (TYP) conducted by the Institute of Sociology, Academic Sinica, Taiwan. The TYP was a 10-year longitudinal research project which began in 2000, which followed participants for 10 years. The research team selected two counties (Taipei County and Yi-Lan County) and one city (Taipei City) from northern Taiwan, and strata were determined based on development indices. Participants were selected based on stratified cluster sampling. Before administering the survey, each student provided written consent. On the survey date, each student who had agreed to participate completed a self-administered survey questionnaire during regular class hours in a classroom where only research assistants were present.

The TYP project included two cohorts: J1 (7th graders, average age 13 years) and J3 (9th graders, average age 15 years). In Taiwan, tracking into the academic track (senior high school) versus the vocational track (senior vocational high school) is implemented at the beginning of 10th grade after 9 years of comprehensive schooling. The only measure of smoking behavior before track placement (treatment) was collected in the 8th grade, because there was no measurement of smoking behavior in the 9th grade. Hence, due to the lack of a pre-treatment outcome measurement, cohort J3 could not be used for this study, leaving only J1 for the analysis.

Our analyses were based on 2147 adolescents who gave clear information on track attendance in 10th grade, information on control variables in 7th/8th grade, and information on smoking behavior in 8th grade. These 2147 adolescents represent 83.1% of the baseline sample (7th grade), as 16.9% were disregarded because they did not have information on track placement in the 10th grade because of panel attrition or due to early school leaving (for the sample diagram, see Supporting information, Fig. S1). To account for the problem of decreasing sample size when considering smoking behavior among 11th and 12th grade students as an outcome, we employed multiple imputation to impute these missing cases. Consequently, our subsequent analyses of the effects of tracking on the incidence of smoking in 10th, 11th and 12th grade students was based on an equal number of 2147 adolescents (for sample description, see Table 1). Thus, the sample covered 7th to 12th grade students, who were 13-18 years old. The internal research board at the National Yang-Ming University approved the study (YM108005E).

Measures

Tracking

Tracking refers to 'stream students into different educational tracks according to their academic performance' ([38], p. 161). In Taiwan and several neighboring countries (e.g. China), tracking happened at the end of 9th grade. Students were placed based on entrance examination score in two different tracks: academic (general high school), which prepared students for college education; and vocational, which focused upon technical trainings and job preparation [38]. This variable was based on students' score on entrance examination placement; it was based on self-report on school attendance and name of attended school filled out by

Table 1 Descriptive statistics for all variables.

Variable	*% (n)*	*Variable*	*% (n)*
Education tracking		Gender	
Vocational track	52.63 (1130)	Male	50.02 (1074)
Academic track	47.37 (1017)	Female	49.98 (1073)
Smoking at 8th grade		Family location	
Yes	5.92 (127)	Taipei city	38.75 (832)
No	94.08 (2020)	Taipei county	38.75 (832)
Smoking at 10th grade		Yilan county	22.50 (483)
Yes	4.70 (101)	Family intactness	
No	95.30 (2046)	Divorced/separated	8.29 (178)
Smoking at 11th grade		Other status	91.71(1867)
Yes	8.57 (184)	Pubertal timing	
No	91.43 (1963)	Early	12.72 (273)
Smoking at 12th grade		Other status	87.28 (1855)
Yes	11.92 (256)	Romantic relationship	
No	88.08 (1891)	Yes	11.88 (255)
Peer smoking		No	88.12 (1892)
Yes	12.48 (268)	Class rank	
No	87.52 (1879)	Top five	16.49 (354)
		Other ranks	83.51 (1793)

Variable	*Minimum*	*Maximum*	*Mean (SD)*
Paternal education	6	18	11.18 (3.22)
Maternal education	6	18	10.60 (3.01)
Family cohesion	6	24	11.87 (3.86)
Parental control	3	15	7.11 (3.06)
Harsh discipline	3	15	4.52 (2.06)
Negative school environment	0	4	2.42 (1.25)
Self-esteem	4	16	10.91 (2.44)

n = 2147.

students in the 10th grade. Based on school name, students were grouped into the vocational (treatment indicator D = 1) and academic (D = 0) tracks. Both tracks last for 3 years, which is equivalent to a high school diploma in western countries. However, both tracks differ in the curricula offered. The former is geared toward vocational training and adopts a license-related curriculum, whereas the latter prepares students for regular 4-year college. In Taiwan, track switching during the 3-year period is very rare because of the entirely different systems and curricula followed by the students.

Smoking

Adolescent smoking behavior was measured in the 8th (i.e. prior to tracking), 10th (i.e. when tracking started) and 11th and 12th grades (i.e. when tracking was ongoing). The self-reported smoking behavior item was identical in all four waves, which asked adolescents to report their frequency of smoking in the past year (from none to very often). Because smoking and buying tobacco-related products during any of these four waves was illegal, the percentage of youths reporting smoking was low. Hence, in subsequent analyses, this variable was dichotomized with no smoking as the reference group (0) for each wave.

Control variables

We included several control variables to adjust the control group to the treatment group (see Supporting information, Table S1, for details on survey questions, response categories and reference group). These variables covered the most important life domains in adolescents' lives (family, school and individual) and were shown to be related to tracking and smoking in previous studies [10,13,14,41,42]. All control variables were measured in 7th/8th grades; that is, prior to the treatment and outcomes in order to avoid problems of overcontrol bias. Demographic variables included gender, family location, paternal and maternal educational level and family intactness. Gender was based on the biological sex, whereas the family location was derived from response to current location. From a multi-level perspective, the location is included as a fixed effect and not as a random effect specification because we only differentiate between three counties, which does not satisfy the typical threshold of level 2 units for applying the random effect specification [43]. Paternal and maternal education was based on their education degrees and were transformed into a continuous measure of years of education based on the typical duration of education programs in Taiwan. Family intactness was based parental marital status. For family variables, this study included family cohesion, parental control and parental discipline. Family cohesion was based on the summation of six family cohesion items (Cronbach's $\alpha = 0.82$), which were similar to the important components of the family environment scale (e.g. emotional bonding and support) [44] and captured the cohesion dimension as understood by the family system theory [45]. Both the variables which measured the degree of parental control as well as harsh discipline meted out were derived from a summation of three items ($\alpha = 0.75$; $\alpha = 0.73$). A negative school environment was based on four statements on the school situation in 7th grade. Finally, individual variables included pubertal timing, romantic relationships, class rank, self-esteem and the incidence of peer smoking. Pubertal timing was based on the pubertal development scale (PDS) [46]. The coding scheme was similar to previous studies [47,48]. The variable named 'romantic relationship' recorded whether the respondent reported to have a boy-/girlfriend in the 8th grade. Class rank was based on self-report on class rank in the past semester at 8th grade. Self-esteem was based on the summation of four items of Rosenberg's self-esteem items ($\alpha = 0.74$) [49]. Peer smoking was derived from adolescents' nomination of up to three friends in the 8th grade. A majority of the nominated friends were from the same class; hence, friends' self-report was used. Given the low smoking rate, this variable was dichotomized.

Table 1 shows the descriptive statistics. 52.63% of the adolescents attended a vocational track. Only 5.92% of adolescents reported smoking in 8th grade. The proportion of adolescents who smoked at the beginning of high school was lower (4.70% in 10th grade), but increased to 8.57% in 11th grade and 11.92% in 12th grade. Regarding the control variables, the percentage of respondents in a romantic relationship (11.88%) or experiencing parental divorce (8.29%) was relatively low. Paternal education was, on average, 11.18 years and maternal education 10.60 years. Families generally had good cohesion (mean = 11.87) and adolescents had moderate self-esteem (mean = 10.91).

Analytical strategy

This study uses a difference-in-differences propensity score matching (DID-PSM) approach (see Supporting information, Data S1). According to the DID approach [50,51], the average treatment effect on the treated (ATT, which is the effect of being in the vocational track on smoking behavior for those who are in the vocational track), is obtained by calculating the differences between the observed change in smoking behavior of the vocational group and the observed change in smoking behavior of the academic group. The change in outcomes is calculated with respect to the 8th grade, i.e. prior to the tracking. This strategy allows us to eliminate all individual fixed effects via the 'within-groups comparison' [50]. This is an advantage compared to random-effect panel models that rest on the problematic exogeneity assumption with respect to the unobserved individual fixed effects. In addition, any time-fixed effects that affect the vocational and academic track students equally are also eliminated by the 'between-groups comparison'. This is an advantage compared to standard one-way fixed or first-difference estimators, that only eliminate individual fixed effects.

Using the DID approach, identification is based on the common baseline trend assumption; that is, that both groups would experience the same change in smoking behavior in the absence of tracking. To make this assumption as plausible as possible, the DID approach is combined with a PSM approach, which aims at making the two groups similar (i.e. 'balanced') in terms of the distribution of the control variables [52,53]. Compared to regression-based covariate adjustment, PSM has the advantage that it does not rest on restrictive functional form assumptions because the outcome equation is estimated non-parametrically [53]. Epanechnikov kernel-matching was adopted because it reached the best balancing properties [52,54]. Standard errors were bootstrapped because there are no analytical standard errors for kernel matching and because a recent simulation study showed that bootstrapping is appropriate [55]. All analyses were conducted using the Stata 'psmatch2' ado [56].

Table 2 shows the balancing properties of the control variables before and after matching. Before matching there are large group differences. For example, pupils in the vocational track have a lower parental education level, experience a lower level of parental control and harsh parenting and are less likely to occupy a top five class rank. In addition, they are more likely to have peers who smoke, earlier pubertal timing, engage more often in romantic relationships and report a lower level of self-esteem. After performing the matching, the standardized bias of each control variable was sharply reduced and was below the threshold of 5%, which is the typical rule-of-thumb in a PSM analysis [53]. Also, the variance ratios move somewhat closer to the ideal value of 1.00. Overall, the statistics indicate a successful balancing of control variables after matching.

There were two types of missing data in this study: data which were missing due to non-responses to individual items and missing data for an entire participant due to attrition. We used multiple imputation to impute missing values. For imputing baseline control variables (i.e. missing due to non-response) in the 7th/8th grades, we included all baseline variables without missing value as predictors and variables with missing value as both predictors and being predicted. Five complete data sets were derived because the proportion of missing responses were very low (i.e. less than 1%). In addition, we also constrained the imputed value to fit the original response categories (e.g. integer value from 1 to 4 for self-esteem items). For imputing outcome variables (smoking) in the 11th and 12th grades (i.e. missing due to attrition) we used all the control variables mentioned above, including the treatment variable (education tracking), the pre-treatment 8th grade outcome variable and the post-treatment 10th grade outcome variable (smoking) as predictor to produce 20 complete data sets (e.g. missing percentage was 16.9% for 11th grade and 27.4% for 12th grade). All the imputations were conducted by using multiple imputation function in SPSS

Table 2 Balancing of control variables before and after matching.

	Pre-matching				*Post-matching*			
Variables	*Vocational*	*Academic*	*% bias*[a]	*VR*[2]	*Vocational*	*Academic*	*% bias*[1]	*VR*[b]
Gender	0.51	0.48	7.00		0.52	0.50	2.30	
Taipei county	0.42	0.35	13.90		0.42	0.42	0.00	
Yilan county	0.25	0.19	14.30		0.25	0.24	4.30	
Father education	10.39	12.07	−53.90	0.66	10.41	10.29	4.00	0.92
Mother's education	9.80	11.50	−58.60	0.59	9.81	9.88	−2.30	0.91
Family intactness	0.09	0.08	2.20		0.09	0.09	−1.50	
Family cohesion	12.14	11.57	14.80	1.02	12.14	12.12	0.70	0.99
Parental control	7.70	6.47	41.00	1.08	7.70	7.64	1.70	0.94
Harsh parenting	4.79	4.24	27.20	1.36	4.76	4.67	4.90	0.92
Negative school environment	2.36	2.47	−8.70	1.26	2.37	2.41	−3.50	1.13
Class rank	0.02	0.33	−88.80		0.02	0.02	0.50	
Peer smoke	0.15	0.09	18.80		0.15	0.15	1.30	
Pubertal timing	0.11	0.14	−9.30		0.11	0.12	−1.70	
Romantic relationship	0.14	0.09	16.80		0.14	0.14	−0.30	
Self-esteem	10.83	11.13	−12.30	0.97	10.83	10.87	−1.50	0.92

$n = 2147$. [a]% bias denotes the standardized percentage bias, which is defined for each control variable as the mean difference between treated and controls as % of the square root of the average of the variances of treated and controls. [b]Variance ratio (VR), which is defined for each continuous control variables as the ratio of the variance of the treated and the controls.

(version 24), which uses Markov chain Monte Carlo algorithm (MCMC). From these complete data sets, we generated the complete sample for subsequent analyses, which had a size of (n = 2147) across all analyses for the outcomes in 10th, 11th and 12th grades. This analysis was not pre-registered and the results should be considered exploratory.

Availability of data and material

The data sets generated and analyzed during the current study are available at the Survey Research Data Archive (https://srda.sinica.edu.tw/).

RESULTS

Table 3 shows the results of the DID-PSM analysis. The upper panel of Table 3 reports the estimated mean outcomes of the treated (vocational track) and the matched controls (academic track) at different grades. The results show that in 8th grade, i.e. before tracking began, the two groups already differed in smoking behavior, with the vocational track (0.082, i.e. 8.2%) having a higher incidence of smoking than the matched group from the academic track (0.059, i.e. 5.9%). This underlines the importance of using the DID approach to eliminate 'common bias' problems [50]. In 10th grade, the share of smokers slightly declined by −0.004, i.e. 0.4 percentage points for the vocational track students to 0.078 (i.e. 7.8%), whereas there was a strong decline by −0.037 (i.e. 3.7 percentage points) to 0.021 (i.e. 2.1%) among the matched group from the academic track. These percentage point changes in the share of smokers are again reported in the lower panel of Table 3 in the first row ('change in share of smokers 10th versus 8th grade').

In the ATT column, the ATT is calculated as the difference in the changes (−0.004 to −0.037), which is 0.033 (i.e. effect size of 3.3 percentage points; P = 0.039). Regarding the temporal dynamics, it can be seen in the upper panel of Table 3 that the proportion of smokers strongly increases to 0.132 (i.e. 13.2%) in 11th grade for the vocational track students and remains somewhat low at 0.047 (i.e. 4.7%) for the matched academic track students. In comparison to the pre-treatment level in the 8th grade, the proportion of smokers increased by 0.051 (i.e. 5.1 percentage points) for the treated group and declined by −0.011 (i.e. −1.1 percentage points) for the matched controls. This yields an ATT of 0.062 (i.e. effect size of 6.2 percentage points; P = 0.000) in 11th grade. In terms of effect sizes, the ATT in the 11th grade (6.2 percentage points) almost doubled compared to the 10th grade (3.3 percentage points).

In the 12th grade, the share of smokers further increases to 0.171 (i.e. 17.1%) for vocational track students and to 0.088 (i.e. 8.8%) for the matched academic track students (see upper panel of Table 3), which is equivalent to a 0.089 (i.e. 8.9 percentage points) increase in the share of smokers for the treated and a 0.030 (i.e. 3.0 percentage points) increase in the share of smokers for controls compared to the 8th grade (see lower panel of Table 3). The respective ATT in the last year of high school (12th grade) is

Table 3 The results of PSM + DID analysis.[a]

	Treated (vocational track)	*Matched controls (academic track)*
Share of smokers in 8th grade	0.082	0.059
Share of smokers in 10th grade	0.078	0.021
Share of smokers in 11th grade	0.132	0.047
Share of smokers in 12th grade	0.171	0.088

	Treated (vocational track)	*Matched controls (academic track)*	*ATT[a]*	*Bootstrapped SE[c]*	*t-statistic*	*P-value*	*Bias-corrected 95% CI[d]*
Change in share of smokers 10th versus 8th grade	−0.004	−0.037	0.033	0.016	20.063	0.039	(0.005, 0.069)
Change in share of smokers 11th versus 8th grade	0.051	−0.011	0.062	0.017	3.647	0.000	(0.032, 0.099)
Change in share of smokers 12th versus 8th grade	0.089	0.030	0.059	0.020	2.950	0.003	(0.022, 0.100)

n = 2147. [a]ATT = average treatment effect on the treated'; [b]in the upper panel, figures on 'share of smokers' multiplied by 100 can be interpreted as %. In the lower panel, with the exception of the columns 't-statistic' and 'P-value', figures on 'change in share of smokers' multiplied by 100 can be interpreted as percentage points; [c]bootstrapped standard errors (SE) with 2000 repetitions; [d]bias-corrected 95% confidence interval (CI) based on bootstrapped standard errors. PSM = propensity score matching; DID = difference-in-differences.

0.059 (i.e. effect size of 5.9 percentage points; $P = 0.003$), which is of a similar size as the ATT in 11th grade.

The above substantive results were re-analyzed with the same matching algorithm (i.e. kernel-matching) but with different kernel types (Supporting information, Table S2) and different bandwidths (Supporting information, Table S3). Furthermore, we also conducted the same analyses but without imputation in (Supporting information, Table S4). The results were fairly similar to the present results; hence, we have more confidence in the current results.

DISCUSSION

This study's descriptive findings demonstrated that students entering a vocational track were always more likely to smoke than those entering an academic track. With regard to our central research question we find that education tracking, as expected, exerted positive effects on smoking behavior. The group difference in smoking between vocational and academic track students was widened when compared to the pre-track situation. This initial effect was due to a decline in smoking behavior in 10th grade for the academic track students when entering a new school environment, whereas smoking behavior only marginally declined for vocational track students. Hence, these results further confirmed the hypothesis that health inequalities are established early in life. This substantive and positive result was consistently found each year in high school; consequently, the effects of education tracking persist during the 3 years of high school. The substantive results were important, given that we used DID-PSM that eliminated time-constant unobserved fixed effects and common trends (i.e. aging and life-cycle effects). These results echo previous findings that educational effects are important when analyzing adolescent substance use [29] in general and smoking in particular [18,30,57].

Regarding the temporal dynamics, we find that the effect of tracking on smoking doubles in the 11th grade compared to the smaller effect in the 10th grade and stabilizes in the 12th grade. The smaller effect in the first year (10th grade) in high school can be explained in two ways. First, social networks may not be yet fully established for first-year high schoolers, considering that peer effects have been documented [31,32]. In addition, the survey in the 10th grade was conducted in October, which is just 1 month after the beginning of a new semester.

Our results highlight the negative effect of education tracking on smoking and health inequalities. While most studies found that less educated people were more likely to have worse general health [58] and engage in risky behavior [59], this study, along with others [18,26,30], shows that the educational system might be a relevant factor in exacerbating the differences. Several reasons for this effect may be discussed. First, vocational tracking is often aimed at skill development and career preparation; hence, adolescents may engage in early 'adult-like' behavior such as smoking [60]. Secondly, the different curricula may socialize adolescents into different health habits that persist into adulthood [18,26]. Thirdly, in many societies where the track system is employed, academic track is often 'preferred' than the vocational track [29,33,34]. Hence, students that enter the academic track may receive favorable 'treatment' from their families and society as a whole [29]. In contrast, students who enter into the vocational track may not have such privileges [33,34]. Fourthly, as mentioned, peer effects may be responsible for the divergences in smoking behavior, given that previous studies often found that adolescents who were in the vocational tracks were more likely to smoke, which implicitly supply a 'delinquent peer model' to interact with [29]. Finally, studies have shown that adolescents who are placed in vocational tracks are more likely to experience negative emotions (e.g. depression) [25,33,34] which are criminogenic [61]. Given the overall small proportion of smokers among high schoolers, our effect sizes (3.3 percentage points in 10th grade 6.2 percentage points in 11th grade and 5.9 percentage points in 12th grade) are substantive. Pre-tracking differences were small [8.2% smokers in vocational track versus 5.9% smokers in the matched (academic) control group, i.e. 2.3 percentage points difference], but with the onset of tracking the differences in the proportion of smokers widened substantially. For example, in 12th grade, 17.1% of the students identified as smokers in the vocational track compared to 8.8% smokers in the matched (academic) control group. Thus, the education-specific smoking gap in 12th grade (17.1 versus 8.8%, i.e. 8.3 percentage points difference) is only partly (2.3 percentage points) due to pre-existing differences, while the great majority of the gap is induced by tracking (6.0 percentage points).

These gaps induced by tracking will result in a great number of adolescent smokers who are likely to continue smoking into adulthood and suffer from various diseases which may lead to a premature death, assuming that the gap between the two tracks remain the same. One official investigation in Taiwan also estimated that approximately 70% of adolescent smokers (aged under 18 years) will eventually become adult smokers [62]. It was also shown that graduates from university or above have the lowest incidence of smoking, which is lower than the smoking rate among high schoolers [63]. Given that most academic track students go on to university (e.g. more than 95%) [64], we expect that health inequalities due to educational inequalities will widen in the future. Secondly, even if the education-specific smoking gap does not prevail into the future, tracking has long-term negative health implications. Even if the gap becomes smaller at later ages long-term negative health effects are still expected, because vocational track students had started smoking earlier as a result of educational tracking [65].

In addition to health inequalities and general smoking behavior, our results also provide a clue to what could be used in an effective prevention strategy. Currently, two popular methods are employed in preventing smoking and its initiation: increasing cigarette excise taxes [66,67] and raising the minimum legal purchase age (MPLA) [68–70]. Furthermore, results suggest that reducing the negative effects of secondary school tracking may be a fruitful strategy. One possible way is to make tracking less dramatic (e.g. schools offer only one track) so that the negative effects are diminished [24]. In addition, providing support for students in a vocational track [71] may also be needed.

The strengths of this study were several. First, this study improves upon previous studies by investigating the temporal dynamics of the effect of education tracking on adolescent smoking. Secondly, DID-PSM is applied, with DID eliminating time-constant confounding variables and common time trends. In addition, the PSM makes the identifying assumption of the DID estimator of common baseline trends more plausible. Thirdly, the rich panel data from a non-western society also strengthened the current literature's external validity.

Several limitations must be addressed. First, our major outcome was adolescent self-report smoking. As mentioned in the measurement section, the legal age for adolescent to buy cigarette is 18 years; hence, adolescents may under-report their smoking behavior. Although some scholars were optimistic about the validity of self-reported smoking [72] and substance use [73] rates, others only had limited confidence [74]. We have no biomarker to validate our self-reported results, but would like to report that one national survey revealed a similar percentage (i.e. 6.6%) of junior high school smoking (i.e. 7–9th graders) in 2004 [75]. Similarly, students who are placed in a particular track may have different reporting styles. Hence, the estimated effects of track placement on smoking could be biased in either direction. However, one recent study demonstrated that the differences in the false reporting on substance abuse between socio-economic groups was minimal [76,77]. Another limitation of our measure of smoking is that our pre-treatment measure was not immediate (8th grade) prior to track placement because track placement was in the 10th grade. This may bias our results if the initial smoking difference between the treated group and the controls group in 8th grade changed in 9th grade. Furthermore, a general limitation of our measure of smoking is that it lacks frequency and quantity information.

Secondly, although PSM was employed to make the common baseline trend assumption of the DID estimator more plausible, a bias may remain in case of different unobserved baseline trends between the treatment and control groups. This will happen in PSM even after the adjustment of observed pre-treatment covariates, as PSM does not guarantee that unobserved variables are balanced, because only observed variables can be used in PSM as control variables. Another critique of PSM is that matching should not be performed based on propensity scores, but with the use of the coarsened exact matching method [78]. However, this critique is based on a simulation using the nearest-neighbor matching method without replacement as the PSM algorithm, but our approach is based on the Epanechnikov kernel algorithm, which has not been proved to have these problems so far. Moreover, it should be noted that this debate is about cross-section matching, but we have performed the matching with longitudinal panel data using the DID estimator as the key strategy. PSM is only used as an 'add-on' to make the common baseline trend assumption of the DID approach more plausible [79].

Thirdly, we opted for a static measurement of our control variables in the pre-treatment period to avoid a potential over-control bias that arises when controlling for changes in control variables when measuring the reaction to tracking. However, with this cautious approach, we may miss time-varying confounders after the onset of the treatment that may violate the DID-PSM identifying assumption of the common baseline trend.

Fourthly, we only used one cohort (J1) and not the other cohort (J3). However, this should not induce any bias, because the two cohorts are identical and differ by only 2 years. It is not expected that the causal effect of education tracking on smoking changed within 2 years. Nevertheless, sample selection issues with regard to external validity remain. The sample was limited to northern Taiwan; therefore, generalizability to the whole island and even other countries may be limited. However, given that many countries in both Asia (e.g. China and South Korea) and Europe (e.g. the Netherlands, Germany, and Belgium) have similar tracking systems, external validity may not have been seriously compromised.

CONCLUSION

Our results indicate that education tracking has detrimental effects on adolescent smoking by placing adolescents into different tracking systems, which increases the probability of smoking. Furthermore, these results show that education inequalities in health (smoking) begin as early as the 10th grade and become even larger in the 11th and 12th grades. Future research may build on these substantive results and investigate possible mechanisms, such as the school climate, which cause the changes in smoking rates [19].

Declaration of interests

None.

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Author contributions

Wen-Hsu Lin: Conceptualization; data curation; formal analysis; funding acquisition; investigation; methodology; project administration; resources; software; supervision; validation; visualization. **Michael Gebel:** Conceptualization; data curation; formal analysis; funding acquisition; investigation; methodology; project administration; resources; software; supervision; validation; visualization.

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Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Figure S1. Sample Diagram
Data S1. Detail analytical description and equation
Table S1 Description of all control variables
Table S2 The results of DID-PSM analysis with different kernel types
Table S3 The results of DID-PSM analysis with different bandwidth
Table S4 The results of DID-PSM analysis with available sample for 11th and 12th grade.

