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Educational inequalities in exposure to tobacco promotion at the point of sale among adolescents in four Dutch cities

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ABSTRACT

This study aimed to assess educational differences in adolescents' exposure to tobacco outlets. Data were collected among 312 13-17-year-old non-smoking secondary school students in four Dutch cities. In a smartphone app, exposure (≤10 m from outlet) was measured using GPS and participants reported their educational track (pre-vocational vs. pre-university). Associations were estimated in negative binomial regression models. Mean exposure to tobacco outlet was 16.6 times in 14 days. Pre-vocational education was associated with higher exposure compared to pre-university education (IRR:1.46, 95%CI:1.08–1.98), especially around school (IRR:2.61,95%CI:1.50–4.55). These differences may contribute to socioeconomic inequalities in smoking.

1. Introduction

In the Netherlands, 17% of adolescents aged 12–16 years have ever smoked. Of the 15-year-old adolescents, 13% have smoked in the past month, which is lower compared to the average past-month smoking prevalence in Europe (15%), but higher compared to countries such as Norway, Ireland and Belgium (8–12%) (Jongeren en riskant gedrag, 2019; Inchley et al., 2020). Among adolescents, educational level is strongly associated with smoking behaviour (de Looze et al., 2013; Schaap and Kunst, 2009). In 2019, students attending pre-vocational had more often ever smoked (24%) than pre-university students in secondary education (12%). As smoking at a young age is a predictor for becoming a regular smoker later in life, these inequalities in tobacco use may contribute to socio-economic differences in smoking, and, as consequence, inequalities in duration and quality of life (Sargent et al., 2017; Eikemo et al., 2014).

Exposure to tobacco products and advertising at tobacco outlets and point of sale (POS) increases the risk of adolescent smoking uptake (van der Sluijs et al., 2016; Mackintosh et al., 2012; Chan and Leatherdale, 2011). Visibility of POS tobacco promotion is likely to normalise smoking, as it supports a norm in which purchasing and using tobacco is totally normal (Pollay, 2007). Daily exposure to tobacco promotion at the POS may double the risk of smoking compared to once-a-week exposure (Spanopoulos et al., 2014; Paynter et al., 2009; Robertson et al., 2016). In addition, according to a systematic review, higher density of tobacco outlets was associated with higher smoking prevalence, greater tobacco use and smoking initiation, and lower cessation outcomes (Valiente et al., 2020; Finan et al., 2019; Nuyts et al., 2021).

There is limited evidence that adolescents' exposure to tobacco outlets/POS differs by socioeconomic indicators. Until now, neighbourhood differences have been studied. In Australia, disadvantaged neighbourhoods are more likely to have a higher density of tobacco outlets and in Scotland, there is more tobacco promotion at outlets in disadvantaged neighbourhoods (Marashi-Pour et al., 2015; Caryl et al., 2019). Scottish 10-11 year-old children from the most deprived areas were seven times more exposed compared with children from the least deprived areas, with peaks in exposure before and after school (Caryl et al., 2019). These socio-economic differences in exposure to promotion at tobacco outlets may contribute to inequalities in smoking.

Thus far, no research on socioeconomic inequalities in adolescent exposure to tobacco outlets has been carried out in continental Europe where the extent of residential segregation, in built and retail environments, as well as individual movement patterns, may be different from those in the USA. (Christiansen et al., 2016) This study is the first to study exposure to tobacco outlets in relation to educational level as an indicator of socioeconomic status. Educational level is a strong predictor of smoking in the European setting, and has the advantage of being measured at the individual level instead of neighbourhood level (Kim

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and Kwan, 2021; Moor et al., 2019).

The aim of this study is to assess educational differences in non-smoking adolescents' exposure to tobacco promotion at tobacco outlets in the Netherlands. We distinguish between exposure to all tobacco outlets and to tobacco outlets with different characteristics. We distinguish between (Jongeren en riskant gedrag, 2019) tobacco outlets around the school and not around the school (Inchley et al., 2020), three types of tobacco outlets: supermarkets, hospitality venues, and other types of tobacco outlets, and (de Looze et al., 2013) tobacco outlets with tobacco products and/or advertising visible from the outside of the outlet and without such visibility. This study is conducted in autumn 2020, when a tobacco display ban in supermarkets was in place, while other tobacco outlets were still allowed to visibly display tobacco products and advertising both inside and outside the outlet.

2. Methods

Data was collected in autumn 2020 (October–December). Survey and exposure to tobacco outlets data was collected among adolescents, recruited through 15 secondary schools in four major cities in the Netherlands: Amsterdam, Eindhoven, Haarlem and Zwolle (participation rate around 12%). These cities were selected to represent differences in population size and geographic location. Based on a 5-point urbanisation scale (number of residents per square kilometres (km^2)), these cities are moderate/high (Zwolle: 1000–2000) and high-density urban areas (Amsterdam, Haarlem, and Eindhoven: >2000) (Netherlands, 2021). Data was collected using a smartphone app, designed for this study. Schools were approached which sent their students an invitation to participate and to install the app.

2.1. Survey data

All participants used the smartphone app to fill in a questionnaire on their sociodemographic characteristics and smoking experience. Relevant variables for this study were, firstly, secondary school educational level. Adolescents reported their educational track ('What is your educational level?'). In the Netherlands, secondary schools provide three levels of educational tracks: preparatory vocational secondary education, senior general secondary education, and preparatory university secondary education. Adolescents are being classified to a track when they are 11–13 years old.". The educational track determines which tertiary education students can do after completing secondary education. The variable is dichotomized into pre-vocational and pre-university education. Pre-vocational education includes both preparatory vocational secondary education and senior general secondary education. These levels were combined, because adolescents attending these levels have similar risk of smoking initiation, and by combining these groups the statistical power was increased (Jongeren en riskant gedrag, 2019).

Participants also reported their month and year of birth, from which age was calculated (rounded to years), and reported their gender (female vs. male).

2.2. Exposure data

Prior to measuring tobacco outlet exposure, all outlets in the four cities were systematically mapped in a retail audit (September 2019–June 2020). During the audit, the exact location and characteristics of the tobacco outlets were determined (i.e. tobacco outlet type and visibility of tobacco products and promotion). For privacy reasons, collecting data on the exact time of exposure was not allowed.

Subsequently, the smartphone app registered for 14 days how often participants were close to a tobacco outlet, measured by GPS. Whenever the participant moved within a ca. 100 m radius from the outlet, the app measured at short time intervals the distance to the outlets' entrance. For each time the participant was within this radius, the minimum distance to the outlet was determined from all distance measurements. An exposure event was defined as the participant being within 10 m of the tobacco outlet (Caryl et al., 2019). These events were summed to obtain a discrete count score of the number of outlet exposures in 14 days. This is the 'total exposure'. For all exposure measures, extreme outliers (values three times outside the interquartile range) were replaced by the highest no outlier value.

We created seven exposure variables that specified where or to what type of tobacco outlet adolescents were exposed. The same method as for the total exposure was used, but the selection of exposure measurements differed between variables.

Two exposure variables measured exposure within a radius of 500 m around the school of the participant (school-related exposure) and outside this radius (non-school related exposure). This radius captured tobacco outlets that can be accessed during school time in a school break of 30 min (van der Horst et al., 2008). School-related exposure only included exposure to tobacco outlets within 500 m around school on schooldays (i.e., Monday to Friday, 10 days in total), whereas non-school-related exposure included all other exposures.

Three exposure variables measured exposure to, respectively, supermarkets, hospitality venues (i.e., hotel, restaurant and cafe) and other tobacco outlets (i.e., tobacco specialty shops and other shops that sell tobacco). We distinguished supermarkets and hospitality venues from other tobacco outlets, because supermarkets already implemented the display ban, thus had no visibility, and hospitality venues predominantly only locate vending machines inside which were to be banned the year after our study.

Two exposure variables measured exposure to tobacco outlets with external visibility of tobacco promotion, respectively outlets without such external visibility. The impact of exposure to outlets with external visibility is expected to be greater, because for exposure adolescents do not have to go inside. External visibility included signboards, advertising posters, and tobacco displays in front of the window.

2.3. Number of respondents

From 430 participants, 51,400 location measurements were collected. Exposure data were included if measured within 14 days after the first measurement. Due to privacy rules of the mobile app, the GPS function could be paused and turned off by the participant only. If participants used the pause function, the 14 day period was extended by the time in days that the app was paused.

On December 15th, 2020, a covid-19-related lockdown started in the Netherlands. Measurements within the period 15–31 December were therefore not representative for actual exposure, because schools and shops were closed. Participants were excluded when the first exposure data point was measured from December 9th (n = 57), as more than half of their exposure data was collected during lockdown. Exposure data from participants who started GPS measurements between 2 and 8 December was multiplied to obtain a total equivalent of 14 days, under the assumption that the data before lockdown (at least one week) were representative of a 14 day period (n = 60).

Smokers were excluded (n = 33), because smokers were expected to visit tobacco outlets more often to buy tobacco. Adolescents aged 18 and over were also excluded (n = 5), as well as 12-year olds (n = 21), because sampling was focussed on adolescents 13–17 years. Finally, post-secondary vocational students ('MBO', n = 2) were excluded, as this type of education is not covered by secondary education. After exclusions, the study population consisted of 312 non-smoking adolescents between 13 and 17 years old with a total of 22,324 location measurements.

2.4. Ethical considerations

Prior the data collection, informed consent was obtained from participants, or from their parents if participants were younger than 16

years of age. Participation in the study was voluntary and participants received a gift voucher worth ten euros as compensation. A Privacy Officer was involved in building the mobile app so that it complied with the General Data Protection Regulation. The Medical Ethics Review Committee of the Academic Medical Center reviewed the project (reference number: W19_305 # 19.363) concluded that the Medical research Involving Human Subjects Act does not apply to this study.

2.5. Data analysis

All statistical analyses were performed in SPSS ('Statistical Package for the Social Sciences') version 26 (Corp. I, 2017).

We used percentages, means, medians and interquartile ranges (IQR) to describe the participants' characteristics and their exposure to tobacco outlets.

To test the association between educational level (independent variable) and the exposure to tobacco outlets (dependent variable), we applied a Generalized Linear Model with negative binomial distribution and log link-function with random intercept for schools, as the participants were clustered in schools. This model is used, because exposure is a count variable with an over-dispersed count outcome. With this model an incidence rate ratio (IRR) is calculated, which indicates, in relative terms, how many times adolescents with pre-vocational education are exposed compared to their counterparts with pre-university education. This model is used for each exposure variable and included educational level, gender, age and city.

2.6. Sensitivity analysis

To test the robustness of the key results, four sensitivity analyses were performed: 1) using 20 and 30 m as minimum exposure distance, 2) using respectively a 300 m (Luke et al., 2011) and 800 m (Joo et al., 2015; D' Angelo et al., 2016) radius around the school to define school-related exposure, 3) excluding a school with an exceptionally high density of tobacco outlets within a 500 m radius as this might strongly determine results.

2.7. Post-hoc analysis

An additional analysis was performed to explore whether the differences in exposure by educational level are explained by the density of tobacco outlets around the school. We applied a Generalized Linear Model with negative binomial distribution and log link-function without a random intercept for schools. For each exposure variable, the analysis consisted of two steps. In Model 1 educational level, gender, age and city were included in the model. In Model 2, the tobacco outlet density around the school was added as a confounder (number of outlets within a 500 m radius). For non-school related exposure, we did not adjust for tobacco outlet density around school, because the school area was not included in this analysis. Therefore Model 1 was used instead of Model 2.

3. Results

Table 1 provides descriptive information of the study population. Most participants had pre-university education (69.6%). Girls were in majority (60.9%), and 16 year olds were the largest age group (27.2%). Most participants went to school in Amsterdam and Haarlem (both

Table 2
Description of exposure (≤10 m) of the study population to all tobacco outlets, and to tobacco outlets with specific characteristics, by educational level.

	Exposure to tobacco outlets (all educational levels)		
	Mean	Median	IQR
Total exposure (all tobacco outlets)	16.6	11.0	4.0–23.0
(Non)school-related tobacco outlets			
School-related (outlets around school) [a]	2.2	0.0	0.0–2.0
Non-school-related (outlets not around school) [b]	14.1	7.0	2.0–21.8
Tobacco outlet type			
Supermarket	5.7	3.0	1.0–9.0
Hospitality	3.5	1.0	0.0–5.0
Other tobacco outlets	6.8	3.0	1.0–9.0
Visibility of tobacco promotion at the tobacco outlet			
External visibility of tobacco promotion	7.8	4.0	1.0–10.8
Not external visibility of tobacco promotion	8.4	5.0	1.0–12.0

IQR = interquartile range.
Other tobacco outlets = petrol station, small outlet, tobacconist and vape shop.
[a] Number of exposures (≤10 m) within 500 m radius around school in 10 school days (Monday-Friday for two weeks) instead of all exposure in 14 days.
[b] Number of exposures (≤10 m) outside 500 m radius around school.

Table 1
Description of the study population (N = 312) by educational level.

	Total (both educational levels) (%)		Educational level			
			Pre-vocational (%)		Pre-university (%)	
N	312	(100)	95	(30.4)	217	(69.6)
Gender						
Male	122	(39.1)	45	(47.4)	77	(35.5)
Female	190	(60.9)	50	(52.6)	140	(64.5)
Age						
13	57	(18.3)	15	(15.8)	42	(19.4)
14	62	(19.9)	26	(27.4)	36	(16.6)
15	62	(19.9)	18	(18.9)	44	(20.3)
16	85	(27.2)	25	(26.3)	60	(27.6)
17	46	(14.7)	11	(11.6)	35	(16.1)
City						
Amsterdam	114	(36.5)	45	(47.4)	69	(31.8)
Eindhoven	40	(12.8)	23	(24.2)	17	(7.8)
Haarlem	114	(36.5)	27	(28.4)	87	(40.1)
Zwolle	44	(14.1)	0	(0)	44	(20.3)
Tobacco outlet density around school						
Mean	5.8[a]		2.9[b]		7.1[b]	
Median	3.0[a]		3.0[b]		3.0[b]	
IQR	2.0–6.8[a]		1.0–3.0[b]		1.0–12.0[b]	

IQR = interquartile range.
[a] Tobacco outlet density as the mean at school level.
[b] Tobacco outlet density as the mean on individual level.

36.5%).

Mean exposure to tobacco outlets was 16.6 times in 14 days (Table 2). Participants were mostly exposed to non-school related tobacco outlets (14.1 times), and slightly more exposed to tobacco outlets in 'other' outlets (6.8 times) and without external visibility of tobacco products and/or promotion (8.4 times).

Fig. 1 shows the distribution of exposure to tobacco outlets (≤10 m) in 14 days per educational level. Both in the pre-vocational and pre-university education group, the largest group has been exposed 1 to 9 times (pre-vocational: 38.3%; pre-university: 34.3%). In both education groups, frequency declined with higher exposure levels.

Table 3 shows the association between educational level and total exposure to tobacco outlets. The model shows that adolescents with pre-vocational education were 1.57 times more exposed (95%CI:1.10–2.25) than adolescents with pre-university education.

Table 4 shows the results for the seven specific exposure measures. This model showed results similar to Table 3. Adolescents with pre-vocational education were more exposed to tobacco outlets around school (IRR:2.61, 95%CI:1.50–4.55) than those with pre-university education. The association with tobacco outlets not around school was weaker and not statistically significant (IRR:1.43 95%CI:0.95–2.14). Adolescents with pre-vocational education were also more exposed to supermarkets (IRR:1.78, 95%CI:1.24–2.57) and hospitality venues (IRR:1.97, 95%CI:1.17–3.33) than those with pre-university education, but not to shops classified as 'other' (IRR:1.17, 95%CI:0.77–1.76). Adolescents with pre-vocational education were more exposed to tobacco outlets without external visibility (IRR:1.60, 95%CI:1.10–2.35) than those with pre-university education.

3.1. Sensitivity analysis

Most sensitivity analyses showed results very similar to the main analysis (Tables A1-A3). The sensitivity analyses using 20 (IRR: 1.46, 95%CI: 1.05–2.02) and 30 m (IRR: 1.44, 95%CI: 1.06–1.97) as minimum exposure distance showed weaker but still significant associations than 10 m. The sensitivity analyses using 300 and 800 m radius around school for school-related exposure showed larger educational differences for 300 m (IRR: 4.01, 95%CI: 0.94–17.17) and smaller educational differences for 800 m (IRR: 2.36, 95%CI: 1.48–3.77) compared to a 500 m radius.

Table 3
Incidence rate ratio (IRR) with 95% CI and p-value for the association between covariates and **total exposure to all tobacco outlets**.

	IRR (95% CI)	p-value
Educational level		
Pre-university	Ref	
Pre-vocational	1.57 (1.10–2.25)	0.01
Gender		
Male	Ref	
Female	0.91 (0.71–1.16)	0.44
Age		
13	Ref	
14	0.86 (0.59–1.27)	0.46
15	1.17 (0.80–1.71)	0.43
16	1.19 (0.83–1.69)	0.35
17	1.35 (0.89–2.04)	0.15
City		
Amsterdam	Ref	
Eindhoven	0.28 (0.10–0.77)	0.01
Haarlem	0.54 (0.24–1.26)	0.15
Zwolle	0.80 (0.22–2.86)	0.73

NB. Results from multilevel negative-binomial model with individuals at the first level and schools at the second level (random intercept). Included: educational level, gender, age and city.

Table 4
Incidence rate ratio (IRR) for pre-vocational educational level with 95% CI and p-value for the association between educational level and **exposure to tobacco outlets with specific characteristics**.

(Non)school-related exposure	IRR (95% CI)	p-value
Tobacco outlets around school	2.61 (1.50–4.55)	0.00
Tobacco outlets not around school	1.43 (0.95–2.14)	0.09
Tobacco outlet type		
Supermarket	1.78 (1.24–2.57)	0.00
Hospitality	1.97 (1.17–3.33)	0.01
Other [d]	1.17 (0.77–1.76)	0.47
Visibility of tobacco promotion at the tobacco outlet		
External visibility	1.31 (0.85–2.02)	0.22
No external visibility	1.60 (1.10–2.35)	0.02

Reference group is pre-university education.
[a] Multilevel for school adjusted model included: educational level, gender, age and city.
[b] Other tobacco outlets: petrol station, small outlet, tobacconist and vape shop.

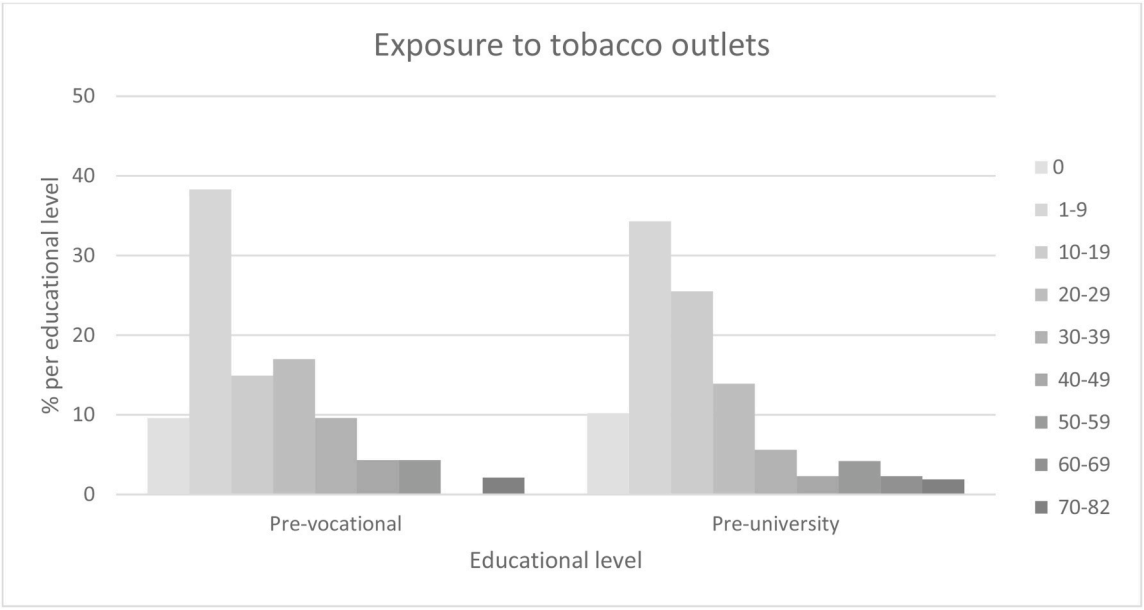

Fig. 1. Number of exposures (to all tobacco outlets) ≤10 m in 14 days, by educational level.

3.2. Post-hoc analysis

Table A4 shows the association between educational level and total exposure to tobacco outlets in a regular regression model, i.e. without a random intercept for schools. Model 1 shows no association (IRR:1.12, 95%CI:0.84–1.50). However, when controlled for tobacco outlet density around school, Model 2 shows that adolescents with pre-vocational education were 1.46 times more exposed (95%CI:1.08–1.98) than adolescents with pre-university education. A higher tobacco outlet density around the school was associated with more exposure (IRR:1.05, 95% CI:1.02–1.07).

4. Discussion

4.1. Key findings

The mean exposure to tobacco outlets was 16.6 times in 14 days. Pre-vocational education was associated with around 50% higher overall exposure compared to pre-university education when school related factors were controlled for. Educational level was associated more strongly with exposure to tobacco outlets around school compared to tobacco outlets outside the school-area. Educational level was also associated with more tobacco outlet exposure at supermarkets and hospitality venues, but not with shops classified as 'other', and more strongly with higher exposure to tobacco outlets without external visibility of tobacco promotion compared to tobacco outlets with external visibility.

4.2. Strengths and limitations

Whereas most previous studies were based self-reports of tobacco outlet exposure (Robertson et al., 2016; Marashi-Pour et al., 2015; Moor et al., 2019; Henriksen et al., 2008), our GPS-based measurements provided objective exposure data. In addition, we measured both educational level and exposure to tobacco outlets at the individual-level instead of neighbourhood level, and we included information about various characteristics of the outlets to which exposure could take place. Nonetheless, our study also has limitations that need evaluation.

First, the number of participants with a pre-university education was much higher than pre-vocational education. This is a result of data collection problems during the covid-19 pandemic. For schools it was a major challenge to continue classes and schools were therefore less inclined to participate in the study. This was generally more challenging for schools offering pre-vocational education, as their students needed more support than schools offering pre-university education. Due to these circumstances, the overall participation rate of pre-vocational schools and students was low. This could have influenced the associations if participation was selective and related to the level of exposure to tobacco outlets.

Second, generalisability to smaller cities and rural areas is limited, as participants were sampled in four major Dutch cities. Moreover, most of the included schools were located in Amsterdam and Haarlem, which implies that results might be influenced by specific circumstances in these cities.

Third, due to unknown timing of exposure, exposures on school days in the evening were partly non-school related and other exposures partly to closed outlets. However, with GPS-based exposure measurements it is uncertain whether participants have consciously seen tobacco products and advertising (Chen and Kwan, 2015). Nonetheless, a strength of this method is that it enables measuring not only conscious but also subconscious exposure, which also affects behaviour (Lovato et al., 2011).

4.3. Interpretation

We found an inverse association between educational level and exposure to tobacco outlets. A possible explanation is that adolescents with pre-vocational spend more time outdoors than those with pre-university education, leading to more time spent in retail environments. Previous research has shown that pre-vocational education is associated with more public open space use in Belgium and Australia (Van Hecke et al., 2018; Lin et al., 2014). Besides, research has shown that people with lower SES are visiting food stores more frequently and therefore possibly also their children (Ma et al., 2018). This corresponds to our finding that adolescents with pre-vocational education visit supermarkets more often than pre-vocational students.

We may rule out that the number of tobacco outlets around the school explains the observed educational differences, as we controlled the analysis for the tobacco outlet density around the school (Model 2, Table A4) or cluster-effects of school (Table 3). In our sample, pre-university schools had a higher tobacco outlet density than pre-vocational schools (hence the weaker association in Model 1, Table A4), however this may not be representative for all Dutch schools.

Our results are in line with previous research. A Scottish study found that adolescents' exposure to tobacco outlets was seven times higher in neighbourhoods with high compared to low deprivation (Caryl et al., 2019). This is a much larger difference than the about 50 percent that we observed. The discrepancy may be due to focus on neighbourhood differences in the Scottish study (Caryl et al., 2019), while the current study used individual-level SES. Using a location-based indicator of socio-economic status, instead of an individual-level indicator, could lead to larger differences, because location also determines population and tobacco outlet density. Moreover, Scotland may have larger neighbourhood-level differences than the Dutch cities in income levels, tobacco retail outlets density (Macdonald et al., 2018) and smoking prevalence (Laird et al., 2017; Kuipers et al., 1982).

Sensitivity analyses using 20 and 30 m as minimum exposure distance showed weaker associations than our default 10 m. This may indicate that adolescents in pre-vocational education may actually visit shops more often than pre-university students, instead of just walking or cycling by. However, it is also plausible that the use of wider margins led to more random misclassification, which resulted in a weaker association. The association between educational level and tobacco outlet exposure around the school was weaker when the radius around the school increased. Tobacco outlet exposure closer to school therefore seems to differ most between educational levels.

A relatively small part of total exposure took place within a 500 m radius around school (2.2. out of 16.6 time per week). Possibly, adolescents spend most of their time in the non-school environment, as this covers a much larger area than the 0.79 square kilometres included in the radius around each school. Nonetheless, pre-vocational students were 2.5–3 times more exposed to tobacco outlets around school than pre-university students. As for the main analysis, this difference was not due to a higher number of tobacco outlets around pre-vocational schools. Factors other than tobacco outlet density around the school, such as adolescents' mobility patterns during school time, play a role. Possibly, adolescents with pre-vocational education may be more likely to leave the school premises, for example to buy lunch in nearby supermarkets. Furthermore, pre-vocational students may interact more with smoking fellow students, and may accompany them when they buy tobacco products in break time.

We found that educational differences in exposure to tobacco outlets were particularly pronounced for shops where tobacco was not visible from outside the store. Such shops include supermarkets and hospitality venues, where we also found a stronger association. For hospitality venues there is a potential additional risk of exposure to seeing visitors smoking around these places.

4.4. Implications

Differences in exposure to tobacco outlets by educational level may contribute to educational inequalities in adolescent tobacco use (Spanopoulos et al., 2014; Paynter et al., 2009; Robertson et al., 2016). This

shows a need for reducing inequalities in adolescents' exposure to tobacco outlets including in the environment around school – even though this includes only a small part of all exposure – and outside school. As proposed in the 2018 Dutch National Prevention Agreement, the Dutch government has intentions to reduce the number of tobacco outlets and visibility of tobacco promotion at the outlets (National Prevention Agreement, 2018). In future years, the government plans to ban tobacco sales from vending machines in 2022 and supermarkets in 2024. As these are tobacco outlet types where we found educational differences in exposure, these policies may contribute to narrowing inequalities in smoking in the future.

Moreover, future research is needed understanding differences in the use of daily activity spaces between adolescents with different educational backgrounds to further reduce inequalities in exposure to tobacco outlets.

5. Conclusion

Adolescents enrolled in pre-vocational education were around 50% more often exposed to tobacco outlets compared to adolescents enrolled in pre-university education. These differences are problematic because they may contribute to observed educational inequalities in smoking. Reducing the number of tobacco outlets may contribute to reducing inequalities in adolescent smoking.

Declarations of interest

None.

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APPENDIX. SENSITIVITY ANALYSES

Exposure defined as ≤ 20 m/≤30m from tobacco outlet

Table A1
Incidence rate ratio (IRR) with 95% CI and p-value for the association between educational level and **total exposure to all tobacco outlets**, exposure defined as ≤20 and ≤ 30m from tobacco outlet.

IRR (95% CI) and p-value		
	Exposure defined as ≤20 m from tobacco outlet	Exposure defined as ≤30 m from tobacco outlet
Educational level		
Pre-university	Ref	Ref
Pre-vocational	1.46 (1.05–2.02) 0.02	1.44 (1.06–1.97) 0.02
Gender		
Male	Ref	Ref
Female	0.88 (0.71–1.10) 0.28	0.91 (0.73–1.13) 0.38
Age		
17	Ref	Ref
16	0.78 (0.56–1.13) 0.21	0.81 (0.58–1.14) 0.22
15	1.11 (0.78–1.57) 0.55	1.10 (0.79–1.54) 0.58
14	1.09 (0.79–1.50) 0.62	1.05 (0.77–1.44) 0.74
13	1.15 (0.79–1.67) 0.48	1.17 (0.82–1.68) 0.39
City		
Amsterdam	Ref	Ref
Eindhoven	0.25 (0.10–0.63) 0.00	0.22 (0.10–0.50) 0.00
Haarlem	0.46 (0.22–0.97) 0.04	0.38 (0.19–0.76) 0.01
Zwolle	0.68 (0.21–2.14) 0.50	0.60 (0.21–1.69) 0.33

Multilevel for school adjusted model included: educational level, gender, age and city.
School related defined as 300/800 m around school.

Table A2
Incidence rate ratio (IRR) with 95% CI and p-value for the association between educational level and **exposure to tobacco outlets within a 300/800m radius around the school.**

IRR (95% CI) and p-value		
	300 m radius around the school	800 m radius around the school
Educational level		
Pre-university	Ref	Ref
Pre-vocational	4.01 (0.94–17.17) 0.06	2.36 (1.48–3.77) 0.00
Gender		
Male	Ref	Ref
Female	1.09 (0.70–1.69) 0.71	0.97 (0.74–1.27) 0.82
Age		
17	Ref	Ref
16	1.61 (0.75–3.47) 0.22	0.93 (0.60–1.45) 0.75
15	1.33 (0.66–2.70) 0.42	0.88 (0.57–1.36) 0.56

(*continued on next page*)

Table A2 (*continued*)

IRR (95% CI) and p-value		
	300 m radius around the school	800 m radius around the school
14	0.79 (0.44–1.42) 0.42	0.94 (0.64–1.39) 0.77
13	1.10 (0.58–2.09) 0.77	1.48 (0.95–2.33) 0.08
City		
Amsterdam	Ref	Ref
Eindhoven	0.30 (0.01–12.51) 0.60	0.22 (0.04–1.19) 0.08
	2.81 (0.19–41.90) 0.45	0.93 (0.23–3.71) 0.92
Zwolle	–	0.45 (0.05–4.01) 0.48
Tobacco outlet density around school		
Per 1 outlet increase		

Multilevel for school adjusted model included: educational level, gender, age and city.

School with highest tobacco outlet density excluded

Table A3
Incidence rate ratio (IRR) with 95% CI and p-value for the association between educational level and **total exposure to all tobacco outlets**. School with the highest tobacco outlet density excluded from the data (N = 295).

	IRR (95% CI)	p-value
Educational level		
Pre-university	Ref	
Pre-vocational	1.57 (1.09–2.26)	0.02
Gender		
Male	Ref	
Female	0.91 (0.70–1.17)	0.46
Age		
13	Ref	
14	0.88 (0.59–1.32)	0.54
15	1.16 (0.77–1.74)	0.49
16	1.20 (0.82–1.76)	0.34
17	1.33 (0.86–2.06)	0.20
City		
Amsterdam	Ref	
Eindhoven	0.32 (0.13–0.80)	0.01
Haarlem	0.65 (0.31–1.38)	0.26
Zwolle	0.91 (0.30–2.83)	0.88

[a] Multilevel for school adjusted model included: educational level, gender, age and city.

Regular instead of multilevel analysis, including tobacco outlet density around school

Table A4
Incidence rate ratio (IRR) with 95% CI and p-value for the association between covariates and **total exposure to all tobacco outlets**.

	IRR (95% CI) and p-value	
	Model 1 [a]	Model 2 [b]
Educational level		
Pre-university	Ref	Ref
Pre-vocational	1.12 (0.84–1.50) 0.43	1.46 (1.08–1.98) 0.02
Gender		
Male	Ref	Ref
Female	0.98 (0.77–1.25) 0.88	0.91 (0.71–1.17) 0.47
Age		
13	Ref	Ref
14	0.82 (0.56–1.20) 0.30	0.90 (0.62–1.33) 0.60
15	1.08 (0.74–1.57) 0.70	1.19 (0.81–1.74) 0.38
16	1.17 (0.83–1.67) 0.37	1.17 (0.82–1.66) 0.39
17	1.17 (0.77–1.76) 0.46	1.24 (0.82–1.87) 0.32
City		
Amsterdam	Ref	Ref
Eindhoven	0.29 (0.20–0.44) 0.00	0.38 (0.25–0.57) 0.00
Haarlem	0.73 (0.55–0.96) 0.02	0.74 (0.56–0.98) 0.04
Zwolle	0.62 (0.42–0.90) 0.01	1.00 (0.64–1.54) 0.99
Tobacco outlet density around school		
Per 1 outlet increase		1.05 (1.02–1.07) 0.00

[a] Negative-binomial model included: educational level, gender, age and city.
[b] Negative-binomial model included: educational level, gender, age, city and tobacco outlet density around the school.

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