



# Electronic cigarette marketing and smoking behaviour in adolescence: a cross-sectional study

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**ABSTRACT** The aim of this study was to investigate the association between exposure to electronic cigarette (e-cigarette) advertisements and use of e-cigarettes, combustible cigarettes and hookahs.

A cross-sectional survey of 6902 German students (mean age 13.1 years, 51.3% male) recruited in six German states was performed. Exposure to e-cigarette advertisements was measured with self-rated contact frequency to three advertising images. Multilevel mixed-effect logistic regression models were used to assess associations between exposure to e-cigarette advertisement and use of e-cigarettes, combustible cigarettes and hookahs (ever and past 30 days).

Overall, 38.8% of the students were exposed to e-cigarette advertisements; ever-use of e-cigarettes was 21.7%, of combustible cigarettes was 21.8% and of hookahs was 23.2%, and poly-use of all three products was 12.4%. Exposure to e-cigarette advertisements was positively related to ever and past 30-day use of e-cigarettes, combustible cigarettes, hookahs and combined use.

We concluded that a considerable number of German teenagers are exposed to e-cigarette advertisement. There was a clear exposure-behaviour link, indicating that advertising contact was associated with different kinds of “vaping” and also smoking behaviour. Although causal interpretation is not possible due to the cross-sectional design, findings raise concerns about the current tobacco control policies.



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**E-cigarette advertising reaches a considerable number of German teenagers. Exposure is positively related to use of e-cigarettes, combustible cigarettes and hookahs, and combined use. Findings raise concerns about the current tobacco control policies.** <http://ow.ly/mbWm30mspIT>

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## Introduction

During the last decade, electronic cigarettes (e-cigarettes) have rapidly risen in the general public's awareness, which is evident in their being one of the most popular tobacco products, with increasing use among adolescents today [1]. While conventional cigarette smoking has declined in Germany in adolescents aged 14–17 years since 2001, an opposing trend for use of e-cigarettes can be observed, and trends like “juuling” have been getting more attention among the youth. The popularity is reflected in the figures: currently, 20.2% of adolescents aged 14–17 years have ever used e-cigarettes in Germany [2]. Although it is assumed that exposure to potentially harmful ingredients from e-cigarettes is significantly lower than for combustible cigarettes, exposure to e-cigarette aerosols in adolescence and early adulthood is not risk free and can result in pulmonary toxicity [3, 4].

Despite increases in use and popularity, social and behavioural factors that have contributed to this rise have not been fully described, and studies that have been recently published have focused on association between combustible cigarette and e-cigarette use [5–11]. Some studies have paid particular attention to e-cigarette marketing and its relationship to “vaping” behaviour [7, 12–16]. Nevertheless, the influence of e-cigarette advertisements on e-cigarette use in adolescence has not been studied extensively. Although the study pool is still insufficient overall, some studies available have suggested that exposure to e-cigarette advertising contributes to the recent increase in e-cigarette use among the youth, and might persuade adolescent e-cigarette never-users to try e-cigarettes [13, 17–19]. In contrast to e-cigarette marketing actions, the impact of conventional cigarette marketing on youth smoking initiation and maintenance is well documented [20–22].

E-cigarette products, which are marketed in many varieties, represent a billion-dollar industry that has increased rapidly during recent years, with expenditures for the first and second quarters of 2013 in the USA representing more than double the expenditure for the year 2012 [23, 24]. Exposure to e-cigarette advertisements has risen rapidly, not only in the USA but also in Europe [7]. In Germany, different channels of cigarette and e-cigarette advertisements (internet, television, billboards, point of sale, radio) have been allowed, although article 13 of the World Health Organization (WHO) Framework Convention on Tobacco Control (FCTC) stipulates a comprehensive ban on tobacco advertising, promotion and sponsorship [25]. Countries all over the world follow these recommendations, but Germany implemented considerably weaker tobacco marketing policies in May 2016. Therefore, opportunities to date for the industry to promote the products are various: tobacco and e-cigarette marketing is permitted at the point of sale and on billboards, for instance in bus stations and in cinemas before movies that show after 18:00 h [26]. Hence, advertisements for e-cigarettes and tobacco products in Germany are visible in places where young people congregate.

Themes promoted in advertising for conventional tobacco products that evidently influence adolescents' cigarette smoking behaviour, namely rebellion, freedom, rule-breaking and independence, are also being used to advertise e-cigarettes [15, 27]. Hence, e-cigarette marketing could potentially promote conventional cigarette smoking [28] and undermine previous tobacco control actions [16].

The aim of this study was to estimate the amount of exposure to e-cigarette advertising of German adolescents and to examine the association between exposure and use of e-cigarettes. We also examined whether e-cigarette marketing is associated with other smoking behaviours, *i.e.* use of combustible cigarettes and hookahs as well as combined use. To our knowledge, this is the first study outside the USA that addresses the exposure–behaviour association between e-cigarette marketing and use of different smoking and vaping products in a large sample of adolescents.

## Methods

### Sample selection

In the summer of 2016, all secondary schools of randomly selected regions from six states of Germany (Baden-Württemberg, Mecklenburg-West Pomerania, North Rhine-Westphalia, Rhineland-Palatinate, Saxony and Schleswig-Holstein) were invited to participate in a cross-sectional survey on health behaviour in adolescents. The study was approved by the state ministries of cultural affairs, and ethical approval was obtained from the Ethical Committee of the German Psychological Society (reference RH 042015\_1).

The German school system has several types of secondary schools that mainly differ with regard to the academic skills of their students and graduation level. A total of 627 schools, representing all types of schools except for schools for students with special needs, were invited. Hence, 44 schools (7%) with 423 classes signed in and returned a registration form indicating their intention to participate in the study.

Data were collected through self-completed anonymous questionnaires. Assessment was carried out during one school period of 45 min in the autumn/winter of 2016/2017, administered by trained research staff or by instructed contact persons in school. All students were free to refuse participation. Students were assured that their individual information would not be seen by parents or teachers.

15 classes (3.5%) with 364 students dropped out due to withdrawn agreement to participate. Out of a total of 9732 students, 2461 students (25.3%) had to be excluded due to missing parental permission. 369 students (5.1%) were absent on the day of the survey, resulting in a final sample of 6902 students.

### *Outcome measures*

The main outcome variables were ever-use and current use of e-cigarettes, combustible cigarettes and hookahs, as well as dual use of e-cigarettes and combustible cigarettes, e-cigarettes and hookahs, and combustible cigarettes and hookahs, and poly-use (ever and current) of all three products. To assess ever-use, students were asked “How often have you ever vaped electronic cigarettes in your life?”, “How often have you ever smoked cigarettes in your life?” and “How often have you ever smoked hookahs in your life?” The answer categories were “never smoked”, “just a few puffs”, “1–19 times”, “20–100 times” and “>100 times” [29]. Current smoking and vaping frequency was measured by asking “How often do you vape/smoke electronic cigarettes/cigarettes/hookahs at present?” The answer categories were “not at all”, “less than once a month”, “at least once a month, but not weekly”, “at least once a week, but not daily” and “(almost) daily”. The main outcomes were dichotomised. For ever-use, this meant that no=“never”, and yes=“just a few puffs”, “1–19 times”, “20–100 times” or “>100 times”. For current use, the cut-off was use within the past 30 days, so that yes=“at least once a month, but not weekly”, “at least once a week, but not daily” or “(almost) daily”, and no=“not at all” or “less than once a month”.

### *Exposure measurement*

Exposure to advertisements has been operationalised in numerous ways across studies [22]. In the present study, the individual advertising contact frequency was approximated by providing fixed images of television commercials and internet e-cigarette advertisements.

Media report data (February–April 2016) from an independent media monitoring agency (AdVision digital, Hamburg, Germany) were used to provide detailed information on advertisements in order to select those with the greatest amount of money spent (in Euro). Three advertisements were selected and fixed images were presented to the students with all brand names eliminated. Two advertisements had been shown on television and one had been presented on the internet. The following e-cigarette brands were included in the survey: 1) vype, 2) be posh, and 3) iSmoker.

Students were asked to rate how often they had ever seen each advertisement extract (on a four-point scale with 1=“never”, 2=“1 to 4 times”, 3=“5 to 10 times” and 4=“more than 10 times”). An advertisement exposure scale was created and dichotomised, such that 0=“never being exposed to any advertisement” and 1=“being exposed to at least one advertisement”, in order to report whether adolescents were exposed to at least one of the selected e-cigarette advertisements.

### *Covariate adjustment*

Covariates were included to assess the independent association between exposure to e-cigarette advertising and adolescent e-cigarette use. They were derived from studies that focused on risk factors concerning advertisement and smoking/vaping behaviour [21, 30, 31].

Socioeconomic status was assessed by the MacArthur Scale of Subjective Social Status, showing the students an easy pictorial format that presents a “social ladder” and asks them to place an “x” on the rung on which they feel they stand [32]. Socioeconomic status was parsed into tertiles: low, medium and high.

Sensation seeking is central to research on the prevention of risky health behaviours and was assessed by two items (Cronbach’s  $\alpha=0.86$ ). Students were asked “How often do you do dangerous things, just to have fun?” and “How often do you do exciting things even though they are dangerous?”, with answer categories on a five-point scale from “never” to “very often” [33]. The following were also included in the survey: age, sex, migration status, substance use by at least one friend, and the consumer susceptibility to interpersonal influence scale (Cronbach’s  $\alpha=0.75$ ; in order to identify the tendency to the willingness to conform to the expectations of others regarding purchase [34]). All variables were included in the statistical models to receive estimates for the exposure–behaviour association after keeping other influencing factors constant.

### *Statistical analyses*

Multilevel mixed-effect logistic regressions were used to determine the association between exposure to e-cigarette advertisements and sample characteristics, in order to estimate crude odds ratios and corresponding 95% confidence intervals. To allow for nested data, random intercepts were included for three levels: state, schools and classes. Because of negligible intraclass coefficient for the state level, this level was omitted in final models.

To determine the association between exposure to e-cigarette advertisements and outcomes, multilevel mixed-effect logistic regressions with random intercepts were used. Outcomes were dichotomised. Models

TABLE 1 Descriptive sample statistics and use of electronic cigarettes, combustible cigarettes and hookahs

Characteristics	Total sample	Exposed to e-cigarette advertisements		Crude OR of e-cigarette advertisement exposure
		No (0=ref)	Yes (1)	
<b>Respondents</b>	6902 (100)	4193 (61.2)	2529 (38.8)	
<b>Mean±SD age years</b>	13.1±1.85	12.9±1.86	13.3±1.80	1.1 (1.1–1.2)***
<b>Sex</b>				
Female (0)	3356 (48.7)	2159 (50.2)	1194 (46.2)	1.2 (1.1–1.3)***
Male (1)	3533 (51.3)	2138 (49.8)	1388 (53.8)	
<b>School type</b>				
High academic level (0)	3541 (51.3)	2313 (53.7)	1221 (47.2)	1.3 (1.2–1.4)***
Lower academic level (1)	3361 (48.7)	1992 (46.3)	1366 (52.8)	
<b>Migration background</b>				
No (0)	5605 (81.3)	3547 (82.5)	2054 (79.6)	1.2 (1.1–1.4)**
Yes (1)	1288 (18.7)	745 (17.5)	528 (20.5)	
<b>Socioeconomic status<sup>#</sup></b>				
Low (0)	1307 (19.3)	823 (19.5)	484 (19.0)	1.0 (1.0–1.1)
Medium (1)	3568 (52.6)	2225 (52.6)	1338 (52.6)	
High (2)	1908 (28.1)	1183 (28.0)	721 (28.4)	
<b>Sensation seeking<sup>¶</sup></b>				
Low (0)	4046 (58.9)	2739 (63.9)	1304 (50.6)	1.7 (1.6–1.9)***
High (1)	2828 (41.1)	1551 (36.2)	1272 (49.4)	
<b>Consumer susceptibility to interpersonal influence<sup>¶</sup></b>				
Low (0)	3442 (50.5)	2295 (54.0)	1143 (44.6)	1.5 (1.3–1.6)***
High (1)	3377 (49.5)	1956 (46.0)	1420 (55.4)	
<b>Substance use<sup>+</sup></b>				
Ever e-cigarette use				
Yes (1)	1307 (21.7)	597 (15.9)	709 (31.0)	2.4 (2.1–2.7)***
No (0)	5536 (78.3)	3679 (84.1)	1851 (69.0)	
Current e-cigarette use				
Yes (1)	223 (3.9)	69 (1.9)	154 (7.1)	4.0 (2.9–5.5)***
No (0)	6628 (96.1)	4210 (98.1)	2411 (92.9)	
Ever cigarette smoking				
Yes (1)	1351 (21.8)	655 (17.1)	694 (29.3)	2.0 (1.7–2.3)***
No (0)	5499 (78.2)	3623 (82.9)	1870 (70.7)	
Current cigarette smoking				
Yes (1)	375 (6.0)	162 (4.2)	213 (8.8)	2.2 (1.8–2.8)***
No (0)	6475 (94.0)	4116 (95.8)	2351 (91.2)	
Ever hookah smoking				
Yes (1)	1388 (23.2)	644 (17.3)	743 (32.6)	2.3 (2.0–2.6)***
No (0)	5450 (76.8)	3629 (82.7)	1814 (67.4)	
Current hookah smoking				
Yes (1)	344 (6.1)	141 (4.2)	202 (9.2)	2.3 (1.8–3.0)***
No (0)	6499 (93.9)	4135 (95.8)	2357 (90.8)	
Ever dual-use e-cigarette/cigarette				
Yes (1)	874 (14.6)	381 (10.3)	493 (21.4)	2.4 (2.0–2.8)***
No (0)	5924 (85.4)	3870 (89.7)	2074 (78.6)	
Current dual-use e-cigarette/cigarette				
Yes (1)	94 (1.5)	26 (0.6)	68 (3.0)	4.9 (3.0–8.0)***
No (0)	6710 (98.5)	4227 (99.4)	2476 (97.0)	
Ever dual-use e-cigarette/hookah				
Yes (1)	988 (16.9)	427 (11.7)	560 (25.3)	2.6 (2.2–3.0)***
No (0)	5799 (83.1)	3820 (88.3)	1973 (74.7)	
Current dual-use e-cigarette/hookah				
Yes (1)	138 (2.5)	42 (1.2)	96 (4.6)	3.9 (2.6–5.8)***
No (0)	6660 (97.5)	4210 (98.8)	2443 (95.4)	
Ever dual-use cigarette/hookah				
Yes (1)	890 (14.9)	395 (10.9)	495 (21.4)	2.2 (1.9–2.6)***
No (0)	5933 (85.1)	3868 (89.1)	2057 (78.6)	
Current dual-use cigarette/hookah				
Yes (1)	115 (2.0)	38 (1.1)	77 (3.3)	3.2 (2.0–5.1)***
No (0)	6714 (98.0)	4229 (98.9)	2477 (96.7)	

Continued

TABLE 1 Continued

Characteristics	Total sample	Exposed to e-cigarette advertisements		Crude OR of e-cigarette advertisement exposure
		No (0=ref)	Yes (1)	
Ever poly-use e-cigarettes/cigarette/hookah				
Yes (1)	725 (12.4)	304 (8.5)	421 (18.6)	2.5 (2.1–2.9)***
No (0)	6049 (87.6)	3934 (91.5)	2108 (81.4)	
Current poly-use e-cigarettes/cigarette/hookah				
Yes (1)	62 (1.0)	15 (0.4)	47 (2.1)	5.3 (2.8–10.0)***
No (0)	6722 (99.0)	4288 (99.6)	2487 (97.9)	

Data are presented as n (%) or OR (95% CI), unless otherwise stated. Differences in sample size (total sample *versus* exposure to e-cigarette advertisements) are based on missing data. ref: reference. #: tertile split; †: median split; \*: substance use data were weighted to census data (age, sex, migration background, school type) to consider disproportion of selected sample; census data were obtained from the German Federal Office of Statistics. \*\*:  $p \leq 0.01$ ; \*\*\*:  $p \leq 0.001$ .

were adjusted for type of school (dichotomous), sex (dichotomous), age, migration status (dichotomous), sensation seeking, socioeconomic status, e-cigarette use of friends (dichotomous; yes/no), and consumer susceptibility to interpersonal influence scale. Given that e-cigarette use is associated with e-cigarette marketing and other use of tobacco, models that include combustible cigarette and hookah use as outcomes were controlled for e-cigarette ever-use. Adjusted odds ratios were reported. Missing data were handled by listwise deletion. Final data were weighted to census data, to account for nonresponse bias and increase representativeness. Weighting factors were age, sex, migration background and school type. All data analyses were conducted with Stata V.15.0 (Stata Corp, College Station, TX, USA). Multilevel mixed-effect logistic regressions were performed by using Stata's command "melogit".

## Results

### Description of the sample

The sample consisted of 6902 students with an equal sex distribution and mean $\pm$ SD age 13.1 $\pm$ 1.85 years (table 1). About half (51.3%) of the students were educated in schools with a high academic level (Gymnasiums). A background of migration was reported by 18.7%. Regarding subjective social status, about half of the sample placed itself in the middle of a social ladder, which, after tertile split for illustration purpose, equates to a medium subjective social status. The majority (58.9%) scored as a lower level for sensation seeking (median split).

### Exposure to e-cigarette advertisements

The television advertisements were shown in commercial breaks in German television from 20:00 h until 03:00 h. The internet advertisement was shown on well-known websites, *e.g.* for sport news, daily news and e-mailing programmes. The advertisement industry spent more than EUR 10 million in total on these selected e-cigarette advertisements. Exposure to at least one e-cigarette marketing message was found for 38.8% of the sample. Every fifth adolescent was exposed to e-cigarette internet advertising.

### Association between exposure to e-cigarette advertisements and smoking behaviour

E-cigarette use at least once in lifetime was reported by 21.7% of all students. Vaping e-cigarettes during the past 30 days (current e-cigarette use) was indicated by 3.9% of the students (table 1). Adolescents educated in schools with a lower academic level had a higher proportion with e-cigarette advertisement exposure, as did students that scored "high" on the sensation seeking scale, boys compared to girls, and those who were more likely to be willing to conform to the expectations of others regarding purchase.

To address adjusted associations of exposure to e-cigarette marketing and smoking/vaping behaviour, dual use and poly-use of products, multilevel mixed-effect logistic regressions were performed. Results are displayed in table 2 for ever-use and in table 3 for current use. Being exposed to e-cigarette marketing is significantly associated with each main outcome for ever-use and current use, even in models controlling for ever-use of e-cigarettes.

Besides exposure to e-cigarette marketing messages, age, sensation seeking and school type are associated with vaping/smoking behaviour in all models. Peer behaviour is of much importance for the sample: having at least one friend who smokes conventional cigarettes is related to each one of the outcomes.

TABLE 2 Relationships between exposure to e-cigarette advertisements and ever-use of electronic cigarettes, combustible cigarettes and hookahs

Outcomes (dichotomous) ever-use <sup>#</sup>	E-cigarette use <sup>¶</sup>	Cigarette use <sup>+</sup>	Hookah use <sup>§</sup>	E-cigarette/cigarette use <sup>+</sup>	E-cigarette/hookah use <sup>§</sup>	Cigarette/hookah use <sup>f</sup>	E-cigarette/cigarette/hookah use <sup>f</sup>
<b>Exposure to e-cigarette advertisements</b>	1.6 (1.3–1.8)***	1.2 (1.0–1.4)*	1.4 (1.2–1.7)***	1.6 (1.3–1.9)***	1.7 (1.4–2.0)***	1.4 (1.1–1.7)*	1.7 (1.4–2.1)***
<b>Age</b>	1.5 (1.4–1.5)***	1.4 (1.3–1.5)***	1.2 (1.2–1.4)***	1.5 (1.4–1.6)***	1.5 (1.4–1.6)***	1.4 (1.3–1.5)***	1.5 (1.4–1.6)***
<b>Sex (ref=female)</b>	1.5 (1.3–1.8)***	0.8 (0.7–1.0)*	1.3 (1.1–1.6)*	1.1 (0.9–1.3)	1.4 (1.2–1.7)***	0.9 (0.7–1.1)	1.1 (0.9–1.4)
<b>School type (ref=high)</b>	1.8 (1.4–2.4)***	1.8 (1.3–2.5)***	1.8 (1.4–2.2)***	2.0 (1.5–2.9)***	2.1 (1.6–2.8)***	1.6 (1.1–2.2)*	2.1 (1.4–2.9)***
<b>Migration background (ref=none)</b>	1.2 (0.9–1.4)	0.7 (0.5–0.9)*	2.2 (1.8–2.8)***	0.8 (0.6–1.1)	1.3 (1.0–1.7)*	1.1 (0.8–1.4)	1.0 (0.8–1.3)
<b>Socioeconomic status (ref=low)</b>	1.0 (1.0–1.1)	1.0 (0.9–1.0)	1.0 (1.0–1.1)	1.0 (0.9–1.1)	1.1 (1.0–1.2)*	1.0 (0.9–1.1)	1.0 (1.0–1.1)
<b>Sensation seeking (ref=low)</b>	1.7 (1.6–1.8)***	1.7 (1.6–1.9)***	1.5 (1.3–1.6)***	1.8 (1.7–2.0)***	1.7 (1.6–1.9)***	1.6 (1.4–1.8)***	1.8 (1.7–2.1)***
<b>Consumer susceptibility (ref=low)</b>	1.1 (1.0–1.2)	1.0 (0.9–1.1)	1.1 (1.0–1.3)*	1.1 (0.9–1.2)	1.1 (1.0–1.3)*	1.1 (0.9–1.3)	1.1 (0.9–1.2)
<b>E-cigarette use<sup>##</sup></b>		7.6 (6.2–9.3)***	14.9 (12.1–18.5)***			12.6 (9.9–16.0)***	
<b>At least one friend vaping e-cigarettes</b>	3.9 (3.1–4.8)***	0.9 (0.7–1.2)	0.9 (0.7–1.2)	3.5 (2.7–4.7)***	3.6 (2.8–4.7)***	0.9 (0.7–1.2)	3.1 (2.3–4.3)***
<b>At least one friend smoking cigarettes</b>	1.8 (1.5–2.3)***	4.6 (3.6–5.8)***	1.4 (1.1–1.7)***	4.1 (3.0–5.7)***	2.2 (1.7–2.8)***	4.6 (3.2–6.5)***	4.1 (2.8–5.9)***
<b>At least one friend smoking hookahs</b>	2.3 (1.8–2.9)***	1.7 (1.3–2.1)***	6.2 (4.7–8.2)***	2.2 (1.5–3.0)***	4.4 (3.1–6.2)***	5.2 (3.4–7.8)***	5.1 (3.3–8.1)***

Data are presented as adjusted odds ratio (95% CI). ref: reference. <sup>#</sup>: models adjusted for age, sex, migration background, school type, consumer susceptibility to interpersonal influence, socioeconomic status, sensation seeking, and e-cigarette use of at least one friend; <sup>¶</sup>: n=6573; <sup>+</sup>: n=6532; <sup>§</sup>: n=6523; <sup>f</sup>: n=6511; <sup>##</sup>: e-cigarette use was omitted where e-cigarette use was modelled as an outcome. \*: p<0.05; \*\*\*: p<0.001; all models allow for nested data (p<0.001).

TABLE 3 Relationships between exposure to e-cigarette advertisements and past 30-day use of electronic cigarettes, combustible cigarettes and hookahs

Outcomes (dichotomous) current use <sup>#</sup>	E-cigarette use <sup>¶</sup>	Cigarette use <sup>+</sup>	Hookah use <sup>§</sup>	E-cigarette/cigarette use <sup>f</sup>	E-cigarette/hookah use <sup>##</sup>	Cigarette/hookah use <sup>¶¶</sup>	E-cigarette/cigarette/hookah use <sup>++</sup>
<b>Exposure to e-cigarette advertisements</b>	2.3 (1.6–3.2)***	1.4 (1.1–1.9)*	1.3 (1.0–1.7)*	2.4 (1.5–4.1)***	2.2 (1.5–3.4)***	1.8 (1.1–2.9)*	3.4 (1.8–6.5)***
<b>Age</b>	1.3 (1.1–1.5)***	1.6 (1.4–1.8)***	1.4 (1.3–1.5)***	1.5 (1.2–1.8)***	1.3 (1.1–1.5)*	1.6 (1.3–1.9)***	1.8 (1.5–2.2)***
<b>Sex (ref=female)</b>	1.2 (0.9–1.7)	0.5 (0.4–0.6)***	1.0 (0.7–1.3)	0.5 (0.3–0.9)*	1.0 (0.7–1.5)	0.5 (0.3–0.9)*	0.4 (0.2–0.8)*
<b>School type (ref=high)</b>	2.1 (1.3–3.3)*	1.5 (0.9–2.5)	1.7 (1.1–2.6)*	2.2 (1.2–3.9)*	3.1 (1.7–5.5)***	1.4 (0.8–2.4)	2.8 (1.3–6.1)*
<b>Migration background (ref=none)</b>	0.9 (0.6–1.4)	0.4 (0.3–0.7)***	2.2 (1.6–3.0)***	0.4 (0.2–0.9)*	1.3 (0.8–2.0)	0.8 (0.4–1.3)	0.5 (0.2–1.2)
<b>Socioeconomic status (ref=low)</b>	1.1 (1.0–1.3)	0.9 (0.8–1.0)	1.1 (1.0–1.2)*	1.0 (0.9–1.2)	1.0 (1.0–1.3)	1.0 (0.9–1.2)	1.1 (0.9–1.3)
<b>Sensation seeking (ref=low)</b>	2.2 (1.9–2.6)***	1.8 (1.5–2.1)***	1.7 (1.5–1.9)***	2.8 (2.2–3.7)***	2.4 (2.0–2.9)***	2.3 (1.8–3.0)***	3.9 (2.8–5.5)***
<b>Consumer susceptibility (ref=low)</b>	1.1 (0.9–1.4)	1.1 (0.9–1.3)	1.3 (1.1–1.5)*	1.2 (0.9–1.6)	1.2 (0.9–1.5)	1.6 (1.2–2.1)***	1.3 (0.9–1.9)
<b>E-cigarette use</b>		7.7 (5.4–11.1)***	8.4 (5.8–12.3)***			11.5 (5.3–25.3)***	
<b>At least one friend vaping e-cigarettes<sup>§§</sup></b>	18.1 (6.2–52.6)***	1.0 (0.7–1.6)	1.8 (1.1–3.0)*	30.3 (3.8–240.5)***	30.5 (4.0–231.1)***	3.9 (1.5–10.3)*	
<b>At least one friend smoking cigarettes<sup>§§</sup></b>	2.3 (1.3–4.3)*	38.9 (9.3–163.1)***	1.4 (0.9–2.2)		1.7 (0.8–3.6)		
<b>At least one friend smoking hookahs<sup>§§</sup></b>	1.9 (0.9–4.2)	1.8 (1.0–3.2)*	11.5 (4.4–33.0)***	2.0 (0.6–7.2)	5.2 (1.2–22.6)*		

Data are presented as adjusted odds ratio (95% CI). ref: reference. <sup>#</sup>: models adjusted for age, sex, migration background, school type, consumer susceptibility to interpersonal influence, socioeconomic status, sensation seeking, and e-cigarette use of at least one friend; <sup>¶</sup>: n=6577; <sup>+</sup>: n=6531; <sup>§</sup>: n=6529; <sup>f</sup>: n=6540; <sup>##</sup>: n=6533; <sup>¶¶</sup>: n=6532; <sup>++</sup>: n=6575; <sup>§§</sup>: peer behaviour was omitted in some cases due to small cell frequencies, meaning that corresponding behaviour was also shown by peers. \*: p<0.05; \*\*\*: p<0.001; all models allow for nested data (p<0.05).



## Discussion

This study examined the association between exposure to e-cigarette marketing and smoking/vaping behaviour in a large sample of German adolescents. Our main findings suggest that, first, e-cigarette advertising reaches a considerable number of German teenagers, and secondly, as expected, exposure to e-cigarette advertisements is positively related to ever-use and past 30-day use of e-cigarettes, although advertising and promotion should not be targeted at children and adolescents. Thirdly, not only were the expected associations between exposure to advertising and e-cigarette use found, but associations were seen with use of combustible cigarettes and hookahs, and any kind of dual and poly-use of these products.

While cigarette smoking among adolescents is declining, e-cigarette products are emerging, showing prevalence of lifetime use of e-cigarettes among German students of 21.7% and current use of 3.9%. This prevalence of e-cigarette use is in line with that of other studies [2, 35]. Alongside the increase of e-cigarette use in Germany, the spending on marketing actions is also increasing, reaching millions of Euro, as the data for the selected stimulus material underline. Findings from the current study regarding exposure extent are consistent with previous research. FILIPPIDIS *et al.* [7] reported that four out of 10 youths and adults aged  $\geq 15$  years within the European Union were exposed to e-cigarette advertisements in 2014. Studies conducted in the USA have reported exposure rates for internet e-cigarette advertisements ranging from 37% to 44%, and for television advertisements of  $\sim 38\%$  for middle- and high-school students [15, 36].

Analyses of the exposure-behaviour association add evidence to the insufficient study pool in the field of the impact of e-cigarette marketing on youth behaviour. In line with other studies, the results show a significant relationship between higher exposure to e-cigarette advertisements and e-cigarette use (lifetime and past 30-day use) [12]. In concurrence with previous studies on e-cigarette risk factors, sensation seeking [5, 37], and perceived peer behaviour were also found to be strong predictors of adolescent e-cigarette use [38].

Besides the association between exposure to e-cigarette advertising and e-cigarette use, our results indicate that adolescent exposure to e-cigarette marketing was also associated with more conventional types of smoking, such as combustible cigarettes and hookahs. In addition, there was also an independent association for dual and poly-use of e-cigarettes, combustible cigarettes and/or hookahs. Associations of exposure to e-cigarette marketing and tobacco use among adolescents were also found in the USA [16, 28]. In comparison to recent studies on exposure to advertisements and tobacco use [7, 16], the validity of measurement of exposure is higher in the current study due to the method of providing images, and differs from self-reports of exposure through questionnaire items that assess if participants have seen any e-cigarette advertisements in general.

Two mechanisms can be taken into consideration that could explain how exposure to e-cigarette advertisements leads to an increase of tobacco smoking [16]. One indirect possibility is that through increasing e-cigarette use, the risk for conventional smoking increases [11, 39]. There are public health concerns that e-cigarette use may contribute to the development of a new population of cigarette smokers, and act as a “gateway” to future cigarette smoking [11, 39–42]. It is not yet fully understood whether e-cigarettes have the potential to cause physical and psychological dependence, but it is assumed that increasing familiarity with nicotine in adolescents used to nicotine consumption might lead to transition to conventional combustible cigarettes because higher doses of nicotine are required to produce the same initial effect [11, 43]. Besides nicotine addiction, the transition from e-cigarettes to conventional combustible cigarettes may be due to the similarity in habitual and ritual processes, and in accessibility. To eliminate the possibility that e-cigarette use confounds association between smoking behaviour and exposure to e-cigarette advertisements, we controlled for the influence of e-cigarette use in the models.

The second possible mechanism for exposure to e-cigarette advertisements leading to an increase of tobacco smoking is that exposure to marketing actions might increase the susceptibility to use of tobacco products directly, due to similarity in product shape and marketing themes for combustible cigarette and e-cigarette products [15, 27, 44, 45]. Considering the point that similar themes are used for advertising combustible cigarettes and e-cigarettes, following the recommendations of the WHO FCTC is uncontroversial, in particular when taking into account that residents of countries with permissive e-cigarette advertising restrictions and less restrictive e-cigarette regulations were more likely to notice advertisements than residents in countries with more restrictive e-cigarette regulations [46]. It has become clear that the way that strict regulations for e-cigarette marketing actions are implemented might affect not only adolescent vaping behaviour but also the use of combustible cigarettes, as our results indicate. E-cigarettes are expanding the tobacco market by attracting adolescents who would be unlikely to initiate using cigarettes [39, 47]. Hence, e-cigarettes and their advertisements could have the potential to interfere with previous tobacco control efforts, and also increase the renormalisation of smoking. Strict regulations to limit sales and decrease the appeal of e-cigarettes to adolescents and young adults are essential [48].

This study has several limitations that are inherent in any cross-sectional study. Cross-sectional data do not inform about the temporal sequence of events, and cannot be used to infer causality. In consequence,



the question of whether advertising precedes smoking/vaping behaviour or if smoking/vaping behaviour leads to higher attention to e-cigarette advertising cannot be finally clarified. This is the reason why longitudinal studies are needed.

Another limitation is that the implemented method did not use a representative sample of all e-cigarette marketing actions. Hence, it does not allow for a precise estimation of the total amount of e-cigarette advertisement exposure of German adolescents. Usage of tobacco products in association with advertisements could also be underestimated because of hidden advertisements in other channels, for instance cinemas and movies [49, 50]. Furthermore, the stimulus material included sources that are prohibited today, but were accessible for students before survey implementation. However, different channels of advertisements are still permitted (billboards, cinema spots and point of sale), which are still accessible for youth today [7]. Finally, all variables were assessed by self-reports, and can only be regarded as a proxy of the actual behaviour. This is an issue for every study using self-reports.

On the whole, this study also raises concerns about the control policies within Germany. Tobacco control actions within the European Union have led to low prevalence of conventional smoking, but policy makers should be aware of the impact of e-cigarette advertisements on adolescent tobacco use. The results of this study add to the evidence about the possible adverse effect of e-cigarette marketing on youth smoking behaviour. E-cigarette advertisements are not harmless, reach children and teenagers and could have the potential to undermine previous tobacco control measures. To protect the youth, e-cigarettes should be considered tobacco products and regulated as such [3], and tobacco control policies should protect the youth from exposure. In consequence, all forms of promotion and advertisement for e-cigarettes should be banned comprehensively, in accordance with article 13 of the WHO FCTC.

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