Waterpipe smoking and subsequent cigarette and e-cigarette use: a cohort study

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Abstract

Aim We tested the hypothesis that waterpipe smoking increases the likelihood to try conventional and electronic cigarettes.

Methods In 2017 and 2018, 2752 German adolescents (mean age: 14.9 years), who had never tried conventional cigarettes or e-cigarettes, took part in a longitudinal survey with a 6-month observational period. Multiple regression analyses tested the association between waterpipe use at baseline and first experimentation with e-cigarettes at follow-up. The models adjusted for risk-taking propensity (sensation seeking and experimentation with alcohol and marijuana), age, sex, migration background, type of school and peer substance use.

Results Some 381 adolescents (12.5% of the survey population) reported waterpipe smoking at baseline. The overall initiation rate during the 6 months was 4.9% (n=134) for conventional cigarettes and 10.5% (n=288) for e-cigarettes. Prior waterpipe smoking significantly predicted cigarette use (adjusted relative risk (ARR)=1.81, 95% CI 1.19–2.76), as well as e-cigarette use (ARR=3.29, 95% CI 2.53–4.28). In addition, a significant interaction between waterpipe use and sensation seeking was found (ARR=0.56, 95% CI 0.33–0.95), with waterpipe use being more predictive of later e-cigarette initiation for lower sensation-seeking individuals.

Discussion Waterpipe use predicted both later cigarette and e-cigarette use independent of all other assessed risk factors, indicating that waterpipe use might be a risk factor on its own. The results suggest that the association was stronger for adolescents with a lower risk-taking propensity, which brings this group into focus for prevention efforts. However, further research is needed to understand whether these associations are causal.

Introduction

Waterpipe tobacco smoking is gaining widespread popularity worldwide. Different terms have been interchangeably used globally for waterpipe depending on the region. These include "shisha", "boory", "goza", "narghile", "nargile", "arghile", "hookah" and "hubble bubble". Waterpipe smoking is popular among German youth too. In 2019, every fifth adolescent aged 12–17 years had already smoked a waterpipe (20.9%) at least once, and about 17% had tried cigarettes. About one in seven adolescents had already tried e-cigarettes (14.5%), and about one in nine had experimented with an e-hookah (11.0%) at least once in their lives [1].

One reason for this popularity among youth might be that waterpipe smoking is seen as considerably less harmful than cigarette smoking. To some degree these beliefs are associated with the flavouring of the tobacco, but the origin of the healthier waterpipe belief is largely uncertain [2].

Health risks of waterpipe smoking include exposure to toxic chemicals not filtered out by the water and risk of infectious disease when waterpipes are shared. Data from cohort, case–control and cross-sectional studies indicate that waterpipe smoking may be associated with respiratory diseases, cancer, cardiovascular diseases, periodontal diseases and a number of other negative health conditions and outcomes such as poorer pregnancy outcomes (*e.g.* low birthweight), metabolic syndrome and poorer mental health [3].

Tobacco and also most liquids of e-cigarettes contain nicotine. There are concerns that nicotine may act as a gateway drug on the brain, and that the use of nicotine-containing liquids in e-cigarettes could be a gateway to the use of conventional cigarettes [4, 5]. There is also a concern that waterpipe smoking can lead to the later initiation of cigarette smoking. Evidence that supports this hypothesis is supported by the results of a recent meta-analysis which included six prospective cohort studies [6].

Another explanation of the association between prior use of one nicotine-delivering device (e-cigarettes or waterpipes) and later use of another device (conventional cigarette) is given by the common liability theory, which posits that "high-risk" adolescents are expected to try all sorts of behaviours, and it is their high-risk status that explains the initiation of the initial substance as well as the subsequent use of the second substance [5, 7].

The aim of this study was to evaluate whether waterpipe use in adolescents is associated with increased risk of subsequent use of conventional cigarettes or e-cigarettes among German adolescents. No study to our knowledge has examined the association between initial waterpipe smoking and subsequent e-cigarette use. Although the long-term health effects of e-cigarette use are unknown, data indicate that the risk of becoming nicotine dependent is higher in e-cigarette users compared to waterpipe smokers [8]. We evaluated tobacco use behaviours over 6 months in a sample of German adolescents. We hypothesised that, after accounting for risk-taking propensity, those who used a waterpipe would be more likely to subsequently initiate use of cigarettes (hypothesis 1) and e-cigarettes (hypothesis 2).

Previous research suggests that the association between initial use of e-cigarettes and subsequent cigarette smoking is stronger for lower risk adolescents, *e.g.* adolescents which score low in the personality dimension "sensation seeking" [9, 10]. These findings are in line with the assumptions of the gateway hypothesis and could not be easily explained by the common liability theory. Hypothesis 3 is that there may be an interaction effect between prior waterpipe use and sensation seeking on the later experimentation with other nicotine-delivering devices (cigarettes or e-cigarettes) in line with the assumption of the gateway hypothesis.

Methods

Design, procedure and study sample

The data were obtained from a cluster-randomised study evaluating a school-based binge drinking programme ("Keep a Clear Head"). In the two-wave, two-arm (intervention *versus* control) prospective study presented here, a total of 74 schools with 323 classes from the German state of North Rhine-Westphalia participated. The sample consists of 25 gymnasium schools (in Germany, gymnasium schools focus on preparing students to enter a university) and 49 comprehensive schools (similar age but not intending to go on to university).

Data were collected through self-completed questionnaires in schools. Participants were given assurances about confidentiality and anonymity, and each completed questionnaire was placed in an envelope and sealed in front of participants. To permit linking of the baseline and follow-up survey, identical questionnaire front sheets allowed participants to generate an individual 7-character code (based on specified digits or letters from memorable names and dates, including date of birth and mother's first name), a procedure tested in previous studies [11].

The ethics committee of the German Society of Psychology had no ethical concerns (AZ RH 072017). Informed consent of students and their parents was obtained. This study was registered with the German Registry of Clinical Studies (DRKS00013273).

We selected students who at baseline had never used e-cigarettes or conventional cigarettes. Altogether, 6084 students were surveyed in November/December 2017 (response rate=74.5%), of whom some 3038 (49.9%) had used neither e-cigarettes nor conventional cigarettes. Between April and June 2018, we were able to successfully contact 2752 of these students (retention rate: 90.6%; mean±SD duration between the two waves: 133.6±21.7 days, R=82–211). At baseline, the study sample had a mean±SD age of 14.85±0.95 years, and 56.9% were female. Further sample demographics can be found in table 1.

TABLE 1 Sample characteristics and attrition analysis

	Baseline sample	Follow-up sample	Lost to follow-up	p-value attrition
Subjects n (%)	3038 (100)	2752 (90.6)	286 (9.4)	
Substance use ever				
Waterpipe	381 (12.5)	335 (12.2)	46 (16.1)	NS
Binge drinking	1266 (41.7)	1.141 (41.5)	125 (43.7)	NS
Marijuana use	42 (1.4)	39 (1.4)	3 (1.1)	NS
Sociodemographics				
Age years (mean±SD, R)	14.87–0.97, 11–19	14.85–0.95, 11–19	15.07–1.10, 13–19	NS
Sex (% female)	56.1	56.9	48.6	<0.05
Migration background, yes	935 (30.8)	825 (30.0)	110 (38.6)	<0.01
School type (% gymnasium)	48.7	50.3	33.2	<0.001
Personality and friend influence				
Sensation seeking (mean±SD)	1.91–0.85	1.90–0.84	2.07–0.90	<0.01
Friend waterpipe smoking, none	1203 (40.1)	1105 (40.5)	98 (35.4)	NS
Friend conventional cigarette smoking, none	1636 (54.8)	1501 (55.5)	131 (47.1)	NS
Friend e-cigarette vaping, none	1738 (58.2)	1586 (58.5)	152 (54.9)	NS

Data expressed as n (%) unless otherwise indicated. NS: nonsignificant.

Measures
Smoking and vaping
We assessed lifetime waterpipe/conventional cigarette/e-cigarette experience by asking, "How often have you smoked waterpipes/cigarettes/e-cigarettes in your life?" (never, tried only a little bit, 1–19 times, 20–100 times, >100 times). Answers were recoded as 0=never, and 1=all other options for every variable separately. Baseline never users were classified as having initiated neither cigarette nor e-cigarette use if they reported anything else than "never" at follow-up.

Controlling for confounding
Derived from the literature, we controlled for a number of covariates that could confound the relation between waterpipe smoking and trying cigarette or e-cigarette smoking, including personality and friend influences, sociodemographics and other substance use [12].

The following sociodemographic characteristics were collected: age ("I am __ years old"), sex, migration background (non-German language spoken predominately at home), type of school attended (gymnasium *versus* comprehensive school, a proxy of socioeconomic status) and participation in the binge drinking programme "Keep a Clear Head". Furthermore, ever binge drinking, *i.e.* four (females) or five (males) drinks in a row on one occasion in their lifetime, was measured. Marijuana use was assessed by asking, "How often have you used marijuana/cannabis in your life?" (never, tried only a little bit, 1–19 times, 20–100 times, >100 times). In addition, the personality construct sensation seeking was assessed using the 2-Item version of the Sensation Seeking Scale-Form (SSS-V14) [13]. Friends' use of waterpipes/cigarettes/e-cigarettes was assessed by asking, "How many of your friends are smoking/vaping waterpipes/cigarettes/e-cigarettes" with response categories "none, few, some, most, all".

Statistical analyses
All data analyses including regression analyses and Chi-squared tests were conducted using the Stata statistical software (version 15.1; StataCorp, College Station, TX, USA). Multivariable regression analysis was used to assess differences between adolescents who could be contacted and those who could not be contacted successfully at follow-up [14]. Missing data were addressed with listwise deletion. Predictions of smoking conventional cigarettes and vaping e-cigarettes were calculated using multivariable Poisson regressions with robust error variances [15] and association modelled as adjusted risk ratios (ARRs). Owing to the clustered data structure, random axis intercepts for the class levels were introduced. Age and sensation seeking were dichotomised at the median. In a further step of the analysis, interaction terms were used to test whether associations were stronger among students with a low-risk profile.

Results
Sample description and attrition analysis
Those students successfully followed up were largely similar to the baseline sample, but the ~10% lost to follow-up were more likely to be male, more likely to have a migration background, tended to be of lower

TABLE 2 Risk ratio for initiation of conventional cigarette or e-cigarette use within the 6-month follow-up period

Study variable at baseline	Initiation of conventional cigarette use		Initiation of e-cigarette use	
	ARR[#]	95% CI	ARR[#]	95% CI
Substance use ever				
Waterpipe	**1.81**	**1.19–2.76**	**3.29**	**2.53–4.28**
Binge drinking	**2.13**	**1.43–3.16**	**1.73**	**1.33–2.26**
Marijuana	0.81	0.25–2.63	0.82	0.40–1.70
Sociodemographics				
Age >median	1.38	0.92–2.05	0.87	0.67–1.13
Male	0.95	0.66–1.36	**1.90**	**1.48–2.45**
Migration background	1.07	0.71–1.60	1.23	0.94–1.62
School type "gymnasium"	**1.69**	**1.13–2.51**	1.24	0.95–1.62
Personality and friend influence				
Sensation seeking >median	**1.75**	**1.17–2.60**	**1.39**	**1.06–1.83**
Friend waterpipe smoking	0.96	0.59–1.54	**1.55**	**1.07–2.23**
Friend conventional cigarette smoking	**1.56**	**1.03–2.37**	1.10	0.83–1.45
Friend e-cigarette vaping	0.91	0.59–1.39	**1.36**	**1.02–1.81**

ARR: adjusted risk ratio; CI: confidence interval. [#]: statistically controlled for all variables in the table and participation in "Keep a Clear Head" programme, statistically relevant associations are marked in bold.

socioeconomic status and had higher sensation-seeking scores. More details on the sample description and the attrition analysis can be found in table 1.

Association between the variables studied and initiation of e-cigarette use

During the follow-up period, 134 of the 2752 formerly never smoking–never vaping adolescents (4.9%) initiated conventional cigarette use and 288 (10.5%) initiated vaping. First use of conventional cigarettes in the observational period occurred more often in the waterpipe users compared to nonusers (10.5% and 4.1%, respectively; Chi-squared (1) 25.63; p<0.001); first use of e-cigarettes was also more common among waterpipe users compared to nonusers (32.5% and 7.4%, respectively; Chi-squared (1) 198.32; p<0.001).

In the multivariable analyses (table 2), waterpipe smoking at baseline was independently associated with both initiation of conventional cigarette use (ARR 1.81, 95% CI 1.19–2.76) and initiation of e-cigarette use (ARR 3.29, 95% CI 2.53–4.27) at follow-up. Other risk factors for initiation of conventional cigarette use included attending a comprehensive school, higher sensation-seeking scores, binge drinking and having friends who were smoking conventional cigarettes. Other risk factors associated with initiation of e-cigarette use included being male, higher sensation-seeking scores, binge drinking and having friends who were waterpipe or e-cigarette smokers.

As shown in figure 1, the adjusted association between baseline waterpipe use and vaping initiation was stronger for persons with low scores in sensation seeking (ARR=4.39, 95% CI 2.69–7.18, p<0.01) compared to those with high scores (ARR=2.91, 95% CI 2.14–3.96, p<0.01; test for interaction: ARR=0.56, 95% CI 0.33–0.95, p<0.05). There was no significant effect modification on sensation seeking for cigarette-smoking initiation (ARR=0.53, 95% CI 0.22–1.25).

Discussion

This study replicates work from three other countries in showing an independent longitudinal association between initial use of waterpipe and subsequent experimentation with cigarette smoking (hypothesis 1) [16]. We extend the literature by also showing that waterpipe use also predicts later e-cigarette initiation (hypothesis 2). Both associations seem to be independent of a number of covariates that describe the risk status of the adolescent—use of another substance, low socioeconomic status, substance use by peers and sensation seeking. Moreover, by showing that low-risk adolescents have higher risk of being affected by initial waterpipe use, the interaction analysis makes unmeasured confounding less likely. In aggregate, the results point toward a gateway effect, rather than a common liability effect (hypothesis 3).
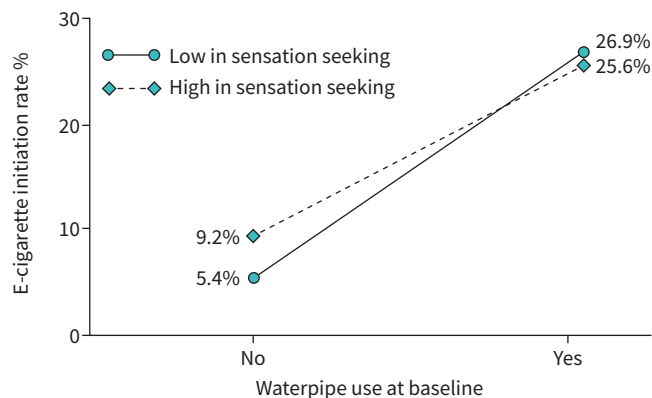
FIGURE 1 Adjusted association between initiation of use of e-cigarettes and use of waterpipe in relation to sensation seeking (adjusted for all study variables).

If one adheres to the gateway hypothesis, the question becomes what it is about the initial substance that could increase risk of later use. The obvious characteristic of concern is that cigarettes, e-cigarettes and waterpipe devices all deliver nicotine in doses that could trigger the process of becoming addicted to nicotine. There is also evidence that the flavours in tobacco and e-cigarettes may play a role in continuing use [17]. Also psychosocial factors such as use and attitudes about waterpipe/cigarette/e-cigarette use in the home and among friends, as well as the perception of positive social interactions among youth may play a role in the gateway process [18].

Limitations

One of the most critical threats to the validity of any longitudinal research is the bias caused by study attrition. The retention rate of 90.6% in this study lies above the recommended follow-up thresholds of 60–80% in cohort studies [19]. Missing to follow-up was not at random, because higher risk adolescents, *i.e.* students who have higher sensation-seeking scores, migration background, not attending a gymnasium and male sex were more likely to be lost to follow-up. Thus, our findings about adolescents with higher risk may be less certain. As a further limitation, the question should be discussed whether the result "ever smoked" is a clinical or health-relevant parameter at all. A recent meta-analysis of representative surveys with 216 314 respondents found that over two-thirds of people who try one cigarette become, at least temporarily, daily smokers [20]. The finding supports strongly the need to reduce experimentation among adolescents.

Policy implications

Students perceive waterpipe use as a safer alternative to conventional cigarettes [21]. In addition, few public health messages target the population with anti-waterpipe messages. A lack of information regarding the dangers and potential harms of waterpipe use may be misinterpreted as a sign of "safety", which inadvertently may imply a suggestion of no need for safety measures. Furthermore, nearly unregulated, Instagram and other social media are promoting the use of waterpipes [22]. For these reasons, education campaigns in schools and colleges and also mass media campaigns are needed to inform about the possible health risks of waterpipe smoking.

In many countries around the world, there is little regulation of the manufacture, distribution or sale of waterpipes. In the US and Europe, shisha lounges are most popular in college towns and urban areas and are regarded by many young people as a novel and chic way to socialise. It seems anachronistic to allow such venues, while at the same time countries such as the US or European countries have a comprehensive smoking ban in bars and restaurants in place.

Conclusion

Among high school students in Germany, those who had tried a waterpipe at baseline were more likely to report initiation of cigarette and e-cigarette smoking over the next 6 months compared with nonusers. Results suggest that waterpipe use is an independent risk factor for starting to use other nicotine devices as well. Further research is needed to understand whether these associations are causal, *i.e.* if some kind of physiological or psychological gateway process is in action.

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