Evolution of Tobacco and E-cigarette Experimentation and Use Among French Adolescents Aged 15-16 Years From 2018 to 2020: A Cross-sectional Observational Study

André Wamba

École normale supérieure de Yaoundé, Département des sciences de l'éducation, Université de Yaoundé I, Yaoundé,

Mabrouk Nekaa

UCT Pôle DocP2 CHU Saint-Étienne, Saint-Étienne,

Lara Leclerc

Mines Saint-Etienne, Université Lyon, Université Jean Monnet, INSERM, U 1059 Sainbiose, Centre CIS, F - Saint-Etienne,

Christine Denis-Vatant

UCT Pôle DocP2 CHU Saint-Étienne, Saint-Étienne,

Julien Masson

Institut national supérieur du professorat et de l'éducation (Académie de Lyon), Université Claude Bernard Lyon 1 – INSPé, Laboratoire P2S,

Jérémy Pourchez (✉ jeremie.pourchez@mines-stetienne.fr)

Mines Saint-Etienne, Université Lyon, Université Jean Monnet, INSERM, U 1059 Sainbiose, Centre CIS, F - Saint-Etienne,

Research Article

Keywords: tobacco and e-cigarette experimentation and use, French adolescents, cross-sectional observational study

Posted Date: January 17th, 2022

DOI: <https://doi.org/10.21203/rs.3.rs-1079012/v2>

License: This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

Background. We assessed and compared the evolution of tobacco and e-cigarette experimentation and use among French adolescents aged 15-16 years.

Methods. A descriptive, cross-sectional, observational study conducted in 2018-2020 among 7,883 Year 11 pupils attending 27 public secondary schools of the Loire department, France.

Results. From 2018 to 2020, 66.18% of adolescents were “non-vapers and non-smokers”, 19.76% were “vapers and smokers”, 7.90% were “non-vapers and smokers” and 6.15% were “vapers and non-smokers”. E-cigarette experimentation was more prevalent than tobacco experimentation (44.92% vs 41.67%), and daily vaping was less prevalent than daily smoking (5.40% vs 10.24%). More boys than girls were daily vapers or daily smokers. A decrease was observed in tobacco experimentation (from 41.22% in 2018 to 39.73% in 2020) and e-cigarette experimentation (from 50.28% in 2018 to 41.25% in 2020). Current vaping remained stable, with an increase in daily vaping. French adolescent vapers frequently use e-liquids with little or no nicotine or with fruit or sweet flavours.

Conclusions. Adolescents used e-cigarettes mainly for experimental and/or recreational purposes. The proportion of “non-vapers and non-smokers” tended to increase. “Non-vapers and smokers” tended to progress to the dual use of vaping and smoked tobacco products, with the likely intention to reduce or quit smoking.

Introduction

The rapid development of e-cigarette experimentation and use has been declared a major public health concern by the EU (Tobacco Products Directive 2014/40/EU) (1). Indeed, vaping could soon become widespread in the population. The practice has been shown to grow rapidly among youth (2–4), with data from the US indicating a high prevalence among non-smoking adolescents (5). More worrying still, a meta-analysis of UK studies found the risk of smoking traditional cigarettes to be vastly increased in adolescents who use e-cigarettes (6). In French adolescents aged 17 years, however, e-cigarette use has been shown to remain moderate and to be mainly initiated by daily smokers (7).

In fact, a major scientific controversy is currently ongoing based on contrasting perceptions of e-cigarettes. On one side of the debate are those who consider that vaping helps smokers reduce or quit smoking. Some authors note that e-cigarettes are perceived as a smoking cessation tool (3), with smokers themselves highlighting their therapeutic potential (8,9). Three Cochrane reviews find that nicotine e-cigarettes are more effective than nicotine substitutes in helping young adult smokers wean themselves off smoking (10–12). In the UK, the 2021 Public Health England report (13) concludes that e-cigarettes are an effective aid to smoking cessation and reduction, while Levy et al. (14) suggest that the observed reduction in smoking prevalence in the adult population is explained by the increased use of nicotine e-cigarettes. In France, Legleye et al. (15) report a 42% reduction in the risk of becoming a daily smoker in adolescents aged 17-18.5 years who experimented with e-cigarettes first, and Chyderiotis et al.

(16) confirm the absence of an increased risk of progression from vaping to daily smoking among adolescents aged 17 years.

On the other side of the debate are those who view vaping as a gateway to smoking. A detailed report of the *National Academies of Sciences, Engineering and Medicine* (17–19) describes e-cigarettes as a “gateway” object and concludes that they are associated with the risk of progression to smoking, especially when they contain nicotine. Likewise, a meta-analysis of 30 longitudinal studies from 22 different cohorts states that e-cigarette use can be considered a predictor of subsequent smoking (20). Several other studies (21–23) highlight an association between e-cigarette use and subsequent smoking initiation among adolescents and young adults. More generally, Brown et al. (24) and Kinnunen et al. (25) recommend caution over nicotine e-cigarettes, arguing that nicotine exposure can cause dependence and, consequently, the progression to smoking among young vapers. These various studies, however, should be interpreted with caution, as the factors underpinning the progression from e-cigarette experimentation to daily smoking are not yet clearly understood and must be clarified in future studies.

The contrasting perceptions of e-cigarettes have raised concerns among public health agencies about the uncertain impact of vaping in the general population, and especially in adolescents (7). Indeed, adolescence is a particularly sensitive age marked by experimentation with psychoactive products (26), with some studies showing that the majority of adult daily smokers began smoking at that age (27). Uncertainties about the impact of vaping are compounded by conflicting data on the evolution of vaping and smoking behaviour: while some studies report that adolescent and young adult vapers tend to progress to smoking over time (28), others observe a decrease in smoking prevalence and attribute it to the increase in e-cigarette use (14,26). In fact, the mechanisms behind these trends are not well understood, as few studies (8,29,30) have explored the expectations and motivations of youth who experiment and use e-cigarettes and/or tobacco products.

In France, cross-sectional studies data on vaping and smoking mainly rely on data published by public research organisations like *Santé Publique France* and the *Office Français des Drogues et des Toxicomanies* (OFDT) (31). These organisations conduct yearly surveys, including the *ESCAPAD* and *Baromètre Santé* surveys, to trace the evolution of e-cigarette and tobacco experimentation and use in the general population. According to the 2014-2019 *Baromètre Santé* survey (32), the prevalence of e-cigarette experimentation in adults aged 18-75 years was 34.4% in 2019, a figure very close to that reported for 2018 (34.7%) (33) but lower than that reported for 2017 (41.7%) (34). Moreover, in 2019, the prevalence of current vaping was 5.7% and that of daily vaping was 4.4% (32). These figures are higher than those reported for the year 2017 (3.8% for current vaping and 2.7% for daily vaping) (34) but fairly close to those reported for the year 2018 (5.3% for current vaping and 3.8% for daily vaping) (35), suggesting a stabilization of current and daily vaping in the general population. According to the 2020 *Baromètre Santé* survey (36), the prevalence of e-cigarette experimentation in adults aged 18-75 years was 37.4% in 2020, a figure slightly higher than those reported for the years 2019 (34.4%) (32), 2018 (34.7%) (33) and 2017 (41.7%) (34). Moreover, in 2020, the prevalence of current vaping was 5.4% and that of daily vaping was 4.3% (36). These figures are higher than those reported for the year 2017 (3.8%

for current vaping and 2.7% for daily vaping) (34) but fairly close to those reported for the years 2018 (5.3% for current vaping and 3.8% for daily vaping) (33) and 2019 (5.7% for current vaping and 4.4% for daily vaping) (32), suggesting a stabilization of current and daily vaping in the general population. As regards tobacco use, the 2020 *Baromètre Santé* survey reports a prevalence of current smoking of 31.8% in adults aged 18-75 years in 2020 (36). This figure is similar to those reported for the years 2017 (31.9%) (34) and 2018 (32.0%) (33) but represents a decrease of 2.5 points compared to 2014 (34.3%) (32). Lastly, a significant and continuous decline is observed in the prevalence of daily smoking between 2014 and 2019: from 28.5% in 2014 to 26.9% in 2017 (34), 25.4% in 2018 (33) and 24.0% in 2019 (32). While the prevalence of daily smoking increased slightly in 2020 (25.5%) (36), the difference is too small to contradict this downward trend.

Smoking and vaping behaviour among French adolescents appear to follow similar trends. Thus, according to the 2017 French *ESCAPAD* survey, the 2014-2017 period saw a sharp decline in the prevalence of tobacco experimentation (from 68.4% in 2014 to 59.0% in 2017) and that of daily smoking (from 32.4% in 2014 to 25.1% in 2017) in adolescents aged 17 years (37). More than one out of two (52.4%) adolescents aged 17 years experimented with e-cigarettes in 2017, a level similar to that reported in 2014 (53.3%) (7). Moreover, in 2017, the prevalence of occasional vaping was 34.9% in this population while daily vaping was almost non-existent (1.9%) (7). Lastly, monthly vaping decreased by five points between 2014 and 2017 (from 22.1–16.8%) (7).

It should be noted, however, that published data on smoking and vaping in France mainly concern adults aged 18-75 years or adolescents aged 17 years. The few available data on adolescents aged 15-16 years are often incomplete or outdated. While the *Health Behaviour in School-Aged Children* (HBSC) and the *European School Survey Project on School and Other Drugs* (ESPAD) do publish data on this particular age group, these four-yearly surveys mainly consist of overviews of national trends in Europe and of international comparisons of data on tobacco and e-cigarette experimentation and use. As such, they provide global and partial data that do not allow for cross-sectional studies or comparisons of smoking and vaping behaviour among adolescents aged 15-16 years in France.

For public health authorities to make fully informed decisions, it is crucial to better understand both the relationship between smoking and vaping at the pivotal age of 15-16 years and the motivations of adolescents for tobacco and e-cigarette experimentation and use. With a view to reinforcing French observational systems, we conducted a cross-sectional study to complement national data with regional data on smoking and vaping behaviour in the specific population of adolescents aged 15-16 years. Our main objective was to assess and compare the evolution of tobacco and e-cigarette experimentation and use among thousands of Year 11 pupils attending public secondary school in the Loire department. The point was to closely examine the evolution of smoking and vaping behaviour at the specific age of 15-16 years. Our secondary objective was to identify the motivations of French adolescents for vaping and smoking and to describe the characteristics of their preferred e-liquids (nicotine content, flavour).

Methods

A descriptive, cross-sectional, observational study was conducted from 2018 to 2020 in a population of 7,883 French adolescents aged 15-16 years and attending Year 11 in 27 public secondary schools of the Loire department, France. This population was quite representative of French population since the demographic indicators of the Loire department are fairly comparable to those of France as a whole. Thus, in 2017, the total population the Loire department was 762,941, 18.3% of whom were aged under 15 and 16.9% under 29, whereas the total population of France in 2021 was 67,422,241, 17.7% of whom were aged under 15 and 17.4% under 29. This study was approved by the ethics committee of Saint-Etienne University Hospital (CHU) and referenced under the number IRBN372018 / CHUSTE. It was carried out in partnership between the Departmental Services of National Education of the Loire, Saint-Etienne University Hospital and the Ecole Nationale Supérieure des Mines de Saint-Etienne.

Data was collected using self-administered questionnaires drawn up by a multidisciplinary team composed of a tobacco specialist, scientific mediators specialised in adolescence, a researcher in public health and educational sciences as well as aerosol experts and toxicologists specialised in smoking and vaping. Adolescents were asked to answer a number of questions on their experimentation and use of tobacco and e-cigarettes allowing to determine their vaping or smoking status as previously described in Denis-Vatant et al. (26) study. Preliminary reliability and validity tests were conducted with some of the adolescents during the design phase of the questionnaires to ensure proper understanding of the questions.

The 2018 questionnaire was completed in paper format and the 2019 and 2020 questionnaires were recorded online on the Google Forms platform. The questionnaires were mainly composed of closed-ended questions, with some semi-open-ended questions on the e-liquid flavours used, etc., and with an "Other" question for respondents to add any comments they wished. The data collected via the questionnaires met the confidentiality and anonymity requirements of the National Commission for Information Technology and Liberties (CNIL). They were divided into four main categories:

1. Basic demographic characteristics of study participants: sex and age. Note that age was not recorded in the generated database in order to guarantee the anonymity of adolescents;
2. Experimentation and use of tobacco products, as determined for each year of the study via the question: "Have you ever tried/used tobacco products?" Respondents were asked to specify their preferred types of tobacco products, the duration and frequency of their smoking habit;
3. Experimentation and use of vaping products, as determined for each year of the study via the question: "Have you ever tried/used vaping products?" Respondents were asked to specify their preferred types of vaping products, the flavour and nicotine content of the e-liquids they used, the duration and frequency of their vaping habit;
4. Motivations for experimenting with vaping and/or tobacco products ("Why did you start smoking or vaping?") and motivations for using vaping and/or tobacco products ("Why do you like smoking or vaping?");

The questionnaire was proposed to the adolescents by the school nurse of each high school included in the studies with the support of the National Education of the Loire. The adolescents completed the questionnaire under the guidance of the school nurse or, in his or her absence, of a teacher. The questionnaire was administered from January to July of each year, at a date and time decided in consultation with the school principal.

A protocol for administering the questionnaire was established to ensure that the students felt confident in responding. The objectives of the study were clearly explained both to the adolescents and to the nurses who were to help them complete the questionnaire. During questionnaire completion, the adolescents were seated alone at a desk to guarantee anonymity, to facilitate reading and to ensure that the answers given were personal. The maximum time for completing the questionnaire was 15 minutes. The topics covered were designed to fit within this time limit. They were told that they could speak to the school nurse if they had any questions about filling the questionnaire.

The analysis consisted in assessing and comparing the evolution of tobacco and e-cigarette experimentation and use from 2018 to 2020. Specifically, we sought to determine whether the prevalence of vaping and smoking increased, decreased or remained stable over the study period. The motivations of adolescents for vaping and smoking and their e-liquid preferences were also analysed, as was the evolution of these motivations and preferences over time. Questionnaires were processed anonymously using Excel® software. Statistical analyses were carried out using IBM SPSS Statistics 21® software. Percentages were compared in univariate analysis using the Chi-square test. Averages were compared using an analysis of variance or the non-parametric Kruskal-Wallis test, as appropriate. Pearson's correlation coefficient was calculated to determine the association between quantitative variables.

Results

A total of 7,883 adolescents aged 15-16 years were included in the study, namely 1,368 (17.35%) in 2018, 4,937 (62.63%) in 2019 and 1,578 (20.02%) in 2020. Overall, 4,069 (51.60%) girls and 3,814 (48.40%) boys responded to the questionnaire. While the sex ratio was similar in 2018 and 2019, there was a significant female predominance in 2020, with girls and boys constituting 57.35% (n=905) and 42.65% (n=673) of the sample, respectively (**Table 1**).

Evolution of tobacco experimentation and use

Overall, 41.67% (n=3,241) of adolescents reported having experimented with at least one tobacco product. The prevalence of current smoking was 27.51% (n=2,156), with more adolescents reporting occasional smoking (17.27%, n=1,351) than daily smoking (10.24%, n=805). **The** prevalence of use and experimentation of tobacco products for the 7,883 adolescents included in the study between 2018 and 2020 is shown in the **table 2**.

As the analysis by year indicates, the prevalence of tobacco experimentation remained broadly stable between 2018 (41.22%) and 2019 (42.41%) and then decreased in 2020 (39.73%). There was also a slight

decrease in the prevalence of daily smoking (from 10.86% in 2018 to 9.44% in 2020) and that of occasional smoking (from 17.11% in 2018 to 16.86% in 2020). The percentage of non-smokers remained stable between 2018 (72.02%) and 2019 (72.23%) and then increased by one point in 2020 (73.70%) (**Fig. 1**).

Evolution of tobacco experimentation and use by sex

Fewer girls than boys reported having experimented with at least one tobacco product (**Fig. 2**). Approximately one in four girls and one in three boys reported being current smokers. The prevalence of occasional smoking was lower in girls than in boys as was that of daily smoking. Over the study period, the prevalence of tobacco experimentation decreased slightly and gradually in girls from 40.24% in 2018 to 39.54% in 2019 and 37.90% in 2020. In boys, the prevalence of tobacco experimentation remained fairly stable between 2018 (42.17%) and 2020 (42.20%), despite a three-point increase in 2019 (45.34%). The prevalence of occasional smoking decreased slightly in boys from 21.08% in 2018 to 17.38% in 2020; however, it increased in girls from 13.01% in 2018 to 16.46% in 2020. The prevalence of daily smoking fell slightly in both sexes, with a lower prevalence in girls (7.85%) than in boys (11.59%) in 2020 (**Fig. 2**).

Evolution of e-cigarette experimentation and use

Overall, 44.92% (n=3,577) of adolescents reported having experimented with e-cigarettes. Moreover, 25.84% (n=1,977) reported being current vapers. The prevalence of occasional vaping was 20.44% (n=1,592) and that of daily vaping was 5.40% (n=385). **The** prevalence of use and experimentation of vaping products for the 7,883 adolescents included in the study between 2018 and 2020 is shown in the **Table 2**.

The analysis by year shows an important decrease in the prevalence of e-cigarette experimentation: from 50.28% in 2018 to only 44.60% in 2019 and 41.25% in 2020. The prevalence of occasional vaping remained stable between 2018 (19.96%) and 2020 (19.90%), despite a one-point increase in 2019 (20.74%). However, the prevalence of daily vaping increased significantly from 3.50% in 2018 to 5.13% in 2020 (**Fig. 3**).

Evolution of e-cigarette experimentation and use by sex

Fewer girls than boys reported having experimented with vaping products (**Fig. 4**). Almost four in five (78.76%, n=3,205) girls and a little less than three in four (70.74%, n=2,698) boys reported being non-vapers. Besides The prevalence of occasional vaping was lower in girls than in boys, as was that of daily vaping. Over the study period, the prevalence of e-cigarette experimentation decreased gradually in both sexes. In girls, the prevalence of e-cigarette experimentation decreased from 44.32% in 2018 to 38.82% in 2019 and 36.69% in 2020; in boys, it fell from 56.15% in 2018 to 50.49% in 2019 and 47.40% in 2020. By contrast, the prevalence of occasional vaping in girls increased by almost three points from 16.31% in 2018 to 19.01% in 2020. Lastly, the prevalence of daily vaping increased in both sexes. In girls, it

increased by one point from 2.27% in 2018 to 3.09% in 2020; in boys, it increased by three points from 4.69 in 2018 to 7.88% in 2020 (**Fig. 4**).

Evolution of vaping and smoking status

Overall, 66.18% (n=5,221) of adolescents were “non-vapers and non-smokers”, 19.76% (n=1,506) were “vapers and smokers”, 7.90% (n=673) were “non-vapers and smokers” and 6.15% (n=483) were “vapers and non-smokers”. The analysis of vaping and smoking status by year shows a significant increase in the prevalence of “non-vapers and non-smokers”, from 64.85% (n=887) in 2018 to 66.03% (n=3260) in 2019 and 67.81% (n=1,070) in 2020. The prevalence of “vapers and smokers” in 2020 (19.14%) was 1.42 points higher than in 2019 (20.56%) and 1.54 points lower than in 2018 (17.60%), but almost identical to the average prevalence of “vapers and smokers” for the entire study period (19.76% vs 19.14%). The prevalence of “non-vapers and smokers” fell significantly from 11.25% (n=154) in 2018 to only 7.21% (n=356) in 2019 and 7.16% (n=113) in 2020. As for the prevalence of “vapers and non-smokers”, it remained stable between 2018 (6.30%, n=86) and 2019 (6.20%, n=306) and then fell slightly in 2020 (5.89%, n=93). In contrast, the prevalence of “vapers and smokers” increased significantly from 17.60% (n=241) in 2018 to 20.56% (n=1,015) in 2019 and fell to 19.14% (n=302) in 2020 (**Fig. 5**).

Motivations for vaping and smoking

No variation was observed in the motivations for vaping and smoking over the study period. Accordingly, we chose to report only the findings for the year 2019, which accounted for 62.63% (n=4,937) of adolescents included in the study. The answers to the questions on motivations for tobacco and e-cigarette experimentation and use are shown in **Table 3**.

In 2019, 89.65% (n=4,426) and 91.73% (n=4,529) of adolescents, respectively, answered the following questions on motivations for experimentation: “Why did you start smoking?” and “Why did you start vaping?” The main motivations for experimenting with tobacco products were, in descending order, “curiosity” (36.98%, n=1,637), “to blow smoke” (10.57%, n=468), “to be like others” (03.45%, n=153), “to look cool” (02.30%, n=102) and “to look more adult” (01.28%, n=57). The main motivations for experimenting with e-cigarettes were similar: “curiosity” (34.88%, n=1,580), “to make vapour clouds” (20.60%, n=933), “the variety of flavours” (17.81%, n=807), “to reduce or quit smoking” (5.10%, n=231), “to save money/ cost” (4.08%, n=185), “to be like others” (01.16%, n=73), “to look cool” (01.17%, n=53) and “to look more adult” (0.52%, n=24).

The questions on motivations for use, “Why do you like smoking” and “Why do you like vaping?” were answered by 90.13% (n=4,450) and 94.65% (n=4,673) of adolescents, respectively. Apart from some respondents who reported that they “like nothing” about smoking (15.64%, n=696), adolescents reported using tobacco products for the following reasons: “to relax” (19.32%, n=860), “to blow smoke” (16.60%, n=739), “to be with friends” (16.04%, n=714), “for the taste” (10.78%, n=480) and “for the sensation of smoke in the throat” (5.21%, n=232). The most frequently mentioned motivations for using e-cigarettes were: “the variety of flavours” (12.02%, n=562), “to make vapour clouds” (11.53%, n=539), “to reduce or

quit smoking" (4.36%, n=204), to "save money/cost" (2.86%, n=134), "to look cool" (0.92%, n=43), "to be like others" (0.77% n=36) and "to look more adult" (0.55%, n=26).

Nicotine content and flavour of e-liquids used and preferred types of vaping products

Since little variation was observed over the period study in the nicotine content and flavour of the e-liquids used or in the preferred types of vaping products, we chose to report only the results for the year 2019 (n=4,937).

Thus, in 2019, 94.65% (n=4,673) of adolescents answered the question on the nicotine content of the e-liquids they used and 96.71% (n=4,775) the question on the e-liquid flavours they used. Almost one in four (22.06%, n=1,031) of the adolescents who answered the question on the nicotine content did not know the nicotine content of their e-liquids. Among those who knew the nicotine content of their e-liquids (77.94%, n=3,642), 16.47% (n=770) reported a content of 0 mg/ml, 8.23% (n=385) a content of 6 mg/ml, 8.19% (n=383) a content of 3 mg/ml, 4.68% (n=219) a content of 12 mg/ml, 2.69% (n=126) a content of 16 mg/ml. Adolescents who answered the question on e-liquid flavours reported preferring "fruit and other sweet flavours" (41.73%, n=1,993) followed by "mint flavour" (15.70%, n=750) and "tobacco flavour" (6.38%, n=305). The preferred types of vaping products were: box style (16.08%), pen style and box style (14.44%), pen style (6.12%), and then cigalike style, pen style and box style (1.50%).

Discussion

In France, a sharp decline in smoking prevalence has been observed among adults (36) and adolescents aged 17 years since 2014. In this context, our study aimed to assess and compare the evolution of smoking and vaping behaviour among French adolescents aged 15-16 years. Specifically, we sought to determine whether the prevalence of tobacco and e-cigarette experimentation and use increased, decreased or remained stable among Year 11 pupils attending public secondary school in the Loire department between 2018 and 2020.

On the one hand, we can compare the prevalence of tobacco use and experimentation obtained in our study to some results described in the literature. In our sample of adolescents aged 15-16 years, the average prevalence of tobacco experimentation over the study period was 41.67%. This figure is almost identical to the European average (41%) and slightly lower than the French average (45%) reported in the 2019 *ESPAD* report for adolescents of the same age (15-16 years) (38). The average prevalence of current smoking was 27.51%, which is nearly identical to the average prevalence reported by the OFDT (27.58%) for all French departments for the year 2021 (31) but lower than the European (30%) and French (34%) averages reported in the 2019 *ESPAD* report (38). The average prevalence of daily smoking (10.24%) was very close to the European average (10.0%) and slightly lower than the French average (12%), while that of occasional smoking (17.27%) was lower than both the European (20%) and French (22%) averages (38). Between 2018 and 2020, a continuous decline was observed in tobacco experimentation in our sample. A similar downwards trend was observed in the study by Chyderiotis et al. (16) and in the 2017 *ESCAPAD* survey (37) for adolescents aged 17 years. Likewise, the prevalence of daily smoking decreased

in our sample, which is perfectly consistent with the results of the 2015 and 2019 *ESPAD* reports for French adolescents aged 15-16 years (38,39). This decline is also in line with the findings of the 2017 (34) and 2018 *Baromètre Santé* surveys (40) for the adult population and those of the 2017 *ESCAPAD* survey (41). In the US, the study by Jarvis et al. (4) observed a similar decrease (20.4%) in smoking prevalence among adolescents (from 28.5% in 1999 to 8.1% in 2018), a trend that was associated with the increased market availability of e-cigarettes in the study by Sokol *et al.* (5).

On the other hand, we can compare the prevalence of vaping use and experimentation obtained in our study to some results described in the literature. The average prevalence of e-cigarette experimentation over the study period was 44.92%. This figure is higher than the European average (40%) and almost identical to the French average (46%) reported in the 2019 *ESPAD* report for adolescents of the same age (38). By contrast, the average prevalence of daily vaping was low at 5.40%. The prevalence of e-cigarette experimentation in our sample decreased from 50.28–41.25% between 2018 and 2020. However, if we compare the prevalence of e-cigarette experimentation for the year 2020 with that reported in the 2015 *ESPAD* report (35.1%) (39), we observe a considerable increase in this indicator over a period of 5 years. Conversely, the prevalence reported in the 2018 *EnCLASS* report (52.1%) (42) suggests a decrease in this indicator between 2018 and 2020. It should be noted that in the study by Hammond et al. (43), the prevalence of e-cigarette experimentation increased from 29.3% in 2017 to 40.6% in 2019 among adolescents aged 16-19 years. Over the same period, the study by Jarvis et al. (4) observed a statistically significant increase of 15.8% (from 11.7–27.5%) in the prevalence of past-30-day e-cigarette use among high school students in the US. In our sample of French adolescents, there was a moderate increase in daily vaping (from 3.50% in 2018 to 5.13% in 2020), but this finding needs to be confirmed in future studies.

Over the study period, the prevalence of current smoking was higher in boys than in girls, as was that of current vaping. These findings are in line with published data showing a male predominance in the prevalence of smoking and vaping in adolescents, young adults and the general population in France and beyond (26,41).

The prevalence of e-cigarette experimentation (44.92%) was higher than that of tobacco experimentation (41.67%) over the study period. This is consistent with French and international studies which show an increase in vaping prevalence and a simultaneous decrease in smoking prevalence in both the adolescent and adult populations. Thus, a meta-analysis of French studies found a simultaneous increase in e-cigarette use (from 10.0–39.0%) and decrease in tobacco use among lower secondary school pupils (from 15.3–10.9%) and higher secondary school pupils (from 38.3–33.5%) over the 2012-2014 period (44,45). Similarly, in the study by Walker et al. (2), all measures of e-cigarette use increased and all measures of tobacco use decreased or remained stable over the 2014-2019 period among New Zealand youth aged 14-15 years. Lastly, in the UK, the substantial reduction in smoking prevalence in the adult population was found to coincide with a rise in e-cigarette use between 2012 and 2019 (14). The upward trend in e-cigarette experimentation and use may be partly explained by the gradual progression from smoking to vaping in the general population, a shift in behaviour actually recommended by bodies such

as Public Health England and the French National Academy of Medicine. Note that our results can be viewed to be quite consistent with studies suggesting that e-cigarette use is increasingly dissociated from tobacco use among adolescents (16).

The secondary objective of our study was to determine the motivations for e-cigarette and tobacco experimentation and use among French adolescents aged 15-16 years. Curiosity was found to be the primary motivation for e-cigarette and tobacco experimentation (36.98% and 34.88%, respectively), which is consistent with earlier studies on the topic (8,46–48). Motivations for using tobacco included “to blow smoke” (16.60%) and “for the taste” (10.78%) and those for using e-cigarettes were primarily “to make vapour clouds” (11.53%) and “the variety of flavours” (12.02%), reflecting the playful aspect of vaping and smoking [47, 48]. Nearly one in five adolescents (19.32%) said that they smoked to “relax.” Furthermore, almost one in six reported smoking to “be with friends” (16.04%). The latter finding confirms the influence of peers on the decision to use psychoactive products [49] and highlights the need for studies to identify the factors that lead adolescents to resist peer pressure with regards to vaping or smoking. Finally, very few adolescents (4.36%) reported using e-cigarettes “to reduce or quit smoking,” in line with studies showing that the majority of adolescents vape for recreational rather than smoking cessation purposes (13,28,49). This finding nevertheless contrasts with those of the 2021 Eurobarometer survey [50] according to which the majority of adults initiate vaping in order to curb their tobacco consumption. Other studies have shown that motivations for vaping and smoking vary according to age (8,50), raising questions about the formation of consumption habits among adolescents. Future studies should explore the expectations of adolescents to shed light on their motivations for e-cigarette and tobacco experimentation and use. A better understanding of these expectations and motivations would help to develop educational intervention strategies that effectively combat early smoking in young adolescents, thereby preventing adult smoking.

The nicotine content and flavour of the e-liquids used were also investigated. Our results show that these did not vary over the study period. Most adolescent vapers did not know the nicotine content of the e-liquids they used. Those who did (77.94% of adolescents who answered the question on the nicotine content of their e-liquids) reported contents ranging from 0 to 16 mg/ml: the majority (16.47%) used nicotine-free e-liquids, while 0.34% and 2.69% reported nicotine contents of 16 mg/ml and 12 mg/ml, respectively. This finding suggests that the use of nicotine e-cigarettes can be quite marginal among French adolescents aged 15-16 years, which could partly explain why we found no increased risk of progression from vaping to smoked tobacco. In line with this, some US studies (51–53) have shown that adolescents who use nicotine-free e-cigarettes are less likely to become daily smokers than those who use nicotine e-cigarettes. Future studies are needed to understand the relationship between the nicotine content of e-liquids used and the progression from vaping to daily smoking among young adolescents. The most commonly used e-liquid flavours in our study population were fruit and other sweet flavours (41.73% of adolescents who answered the question on e-liquid flavours). This finding is comparable to the European average (48.00%) reported in the 2021 Eurobarometer survey (54); it is also consistent with studies showing that the appeal of e-cigarettes among young adolescents is associated with the use of sweet-flavoured e-liquids (43,54,55). Adolescents in our study reported preferring mint-flavoured e-liquids

(15.70% of adolescents who answered the question on e-liquid flavours) to tobacco-flavoured ones (6.38% of adolescents who answered this question), which could partly explain why the increase in daily vaping prevalence was not accompanied by a rise in daily smoking prevalence in this population. Interestingly, in the study by Friedman et al. (28), vaping non-tobacco-flavoured e-liquids was associated with increased smoking cessation in young adults (18-24 years) and was not associated with increased smoking initiation in adolescents (12-17 years). The relationship between the use of tobacco-flavoured e-liquids and smoking initiation among adolescents should be explored in future studies.

In our study, approximately one in five (19.76%) adolescents were dual users of vaping and smoked tobacco products. The exclusive use of either type of products was less frequent, as only 7.90% of adolescents were 'non-vapers and smokers' and 6.15% were 'vapers and non-smokers.' These results are consistent with other French studies conducted among adolescents aged 17 years (7) and with studies from the UK (6). Between 2018 and 2020, the proportion of "non-vapers and non-smokers" increased from 64.85–67.81%, while that of "vapers and non-smokers" remained stable with a slight decrease from 6.30–5.89%. Our analysis could not provide reliable results on the proportion of "non-vapers and smokers" who became "vapers and non-smokers" or "non-vapers and non-smokers". However, we did find that 2-3% of "non-vapers and smokers" seems to progress to the dual use of vaping and smoked tobacco products. This progression may be explained by the fact that exclusive smokers initiate vaping with the intent to reduce or quit smoking in the future. In this regard, the study by 2021 Eurobarometer survey (54) found dual users to be more likely to attempt to quit smoking than exclusive smokers. Yet, the progression from exclusive tobacco use to dual use could also be explained by a loss of interest in smoking and a concomitant desire to adopt exclusive vaping. The motivations for this progression have so far been studied by means of quantitative approaches (56,57) and should be clarified in future studies using qualitative methods.

Our most relevant finding for public health was the temporal coincidence between an increase in the prevalence of daily vaping and a decrease in that of daily smoking. This finding may be explained by the fact that adolescents who first experiment with e-cigarettes are more likely not to initiate smoking or to delay their entry into smoking. Thus, the study by Chyderiotis et al. (7) found that French adolescents aged 17 years who initially experiment with e-cigarettes have a very low risk of becoming daily smokers. Likewise, in the study by Friedman et al. (28), adolescent dual users who had experimented with e-cigarettes first were less likely to become daily smokers than those who had experimented with tobacco first. In the study by Legleye et al. (15), experimenting with e-cigarettes before tobacco cigarettes was associated with a 42% reduction in the risk of daily smoking among youth aged 18 to 21 years. Kalhoran et al. (58) found early e-cigarette use to be associated with higher odds of prolonged smoking abstinence, suggesting that e-cigarettes play a role in delaying smoking initiation (59). Lastly, the study by Coleman et al. (60), conducted in the same sample of US adults, noted that dual users who had initially experimented with e-cigarettes were more likely to quit smoking than those who had initially experimented with tobacco. Future studies are needed to determine the association between vaping initiation and smoking prevalence at the specific age of 15-16 years.

Study Limitations

Our study has several limitations. The use of cross-sectional and descriptive data made it impossible to perform a prospective analysis. However, our research team is currently conducting longitudinal cohort studies in France to explore the temporal evolution of vaping and smoking behaviour (including smoking cessation) between the ages of 15 and 18 years and to determine the relationship between e-cigarette use and tobacco use during adolescence. Furthermore, since our sample was limited to adolescents aged 15-16 years in the Loire department, our findings cannot be directly extrapolated to other populations. Lastly, although the nicotine content and flavour of the e-liquids used appear to be important indicators, we did not evaluate the link between these preferences and the expectations and motivations of adolescents. Future studies should examine whether adolescents who use nicotine e-liquids are more likely than those who use nicotine-free e-liquids to become daily smokers. Studies are also needed to determine the factors associated with successful or unsuccessful attempts at smoking cessation, with the duration of smoking cessation or abstinence, with occasional smoking relapse, and with resistance to relapse.

Conclusion

Our study shows that e-cigarette experimentation is significantly more prevalent than tobacco experimentation among French adolescents aged 15-16 years. Between 2018 and 2020 clear increase is observed in the prevalence of daily vaping. Their motivations for experimenting with e-cigarettes seems to be mainly associated with recreational leisure, much less so with the desire to reduce or quit smoking. No increase was observed in the progression from vaping to smoking in our sample. French adolescent vapers frequently use e-liquids with little or no nicotine or with fruit or sweet flavours. Besides, some “non-vapers and smokers” seems to switch to dual use, maybe with the likely intention to reduce or quit smoking. Given the increase in the proportion of “non-vapers and non-smokers” and the stabilization of e-cigarette use, the health situation of French adolescents aged 15-16 years can be said to have globally improved between 2018 and 2020.

Declarations

Ethics approval and consent to participate

The study was approved by the ethics committee of Saint-Etienne University Hospital (CHU) and referenced under the number IRBN372018/CHUSTE. The study obtained written informed consent from all research participants. The methods were carried out in accordance with the relevant guidelines and regulations set out in the Declaration of Helsinki. This study concerns minors. Informed consent has been obtained from the legal guardian (s) / legally authorized representatives of the minor participants.

Consent for publication

Not applicable

Availability of data and materials:

The datasets accessed in this research are owned and administered by the UMR INSERM U 1059 Sainbiose, “Écoles des Mines de Saint-Etienne” (Université Jean Monnet), Saint-Etienne, France. Availability is at the discretion of Écoles des Mines de Saint-Etienne (Université Jean Monnet), Saint-Étienne, France. The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

This work was supported by a grant from the French National Cancer Institute (INCa) and French Public Health Research Institute. Both funding agencies have no role in the study design, collection, analysis, or interpreting of the data, writing the manuscript, or the decision to submit the paper for publication.

Authors' contributions

A. Wamba drafted the manuscript; **J. Pourchez** and **M. Nekaa** did the analysis. All authors substantively read, revised the manuscript and have approved the final submitted version. All authors agreed to be personally accountable for their contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which they were not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature.

Acknowledgements

We would like to thank the *Ligue contre le cancer 42* and the National Cancer Institute (INCa) for their financial support. We also wish to thank the teaching teams and school nurses from high schools in the Loire department for their active participation, as well as the students who answered the questionnaires.

References

1. DIRECTIVE 2014/40/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL, of 3 April 2014. Directive 2014/40/EU of the European Parliament and of the Council of 3 April 2014 on the approximation of the laws, regulations and administrative provisions of the Member States concerning the manufacture, presentation and sale of tobacco and related products and repealing Directive 2001/37/EC (Text with EEA relevance) [Internet]. 2014 p. LL 127/1-127/38. Report No.: 2014/40/EU. Disponible sur: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0040>
2. Walker N, Parag V, Wong SF, Youdan B, Broughton B, Bullen C, et al. Use of e-cigarettes and smoked tobacco in youth aged 14–15 years in New Zealand: findings from repeated cross-sectional studies (2014–19). *The Lancet Public Health*. 2020;5(4):e204–12.

3. Hanafin J, Clancy L. A qualitative study of e-cigarette use among young people in Ireland: Incentives, disincentives, and putative cessation. *Plos one*. 2020;15(12):e0244203.
4. Jarvis M, Jackson S, West R, Brown J. Epidemic of youth nicotine addiction? What does the National Youth Tobacco Survey 2017-2019 reveal about high school e-cigarette use in the USA? *Qeios*. 2020;
5. Sokol NA, Feldman JM. High school seniors who used e-cigarettes may have otherwise been cigarette smokers: Evidence from Monitoring the Future (United States, 2009-2018). *Nicotine & tobacco research: official journal of the Society for Research on Nicotine and Tobacco* [Internet]. 2021 [cité 18 mai 2021]; Disponible sur: <http://docelec.univ-lyon1.fr/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=cmedm&AN=33991190&lang=fr&site=eds-live>
6. Aladeokin A, Haighton C. Is adolescent e-cigarette use associated with smoking in the United Kingdom?: a systematic review with meta-analysis. *Tobacco prevention & cessation*. 2019;5.
7. Chyderiotis S, Spilka S, Beck F. Usages de la cigarette électronique en France à 17 ans: résultats de l'enquête nationale ESCAPAD 2017. *Bulletin du Cancer*. 2019;106(12):1132–43.
8. Kinouani S, Leflot C, Vanderkam P, Auriacombe M, Langlois E, Tzourio C. Motivations for using electronic cigarettes in young adults: A systematic review. *Substance abuse*. 2020;41(3):315–22.
9. Berlin I. La cigarette électronique: outil thérapeutique, phénomène social ou business? *La Revue de Médecine Interne*. 2015;36(6):405–10.
10. Hartmann-Boyce J, McRobbie H, Butler AR, Lindson N, Bullen C, Begh R, et al. Electronic cigarettes for smoking cessation. *Cochrane database of systematic reviews*. 2021;(9).
11. McRobbie H, Bullen C, Hartmann-Boyce J, Hajek P. Electronic cigarettes for smoking cessation and reduction. *Cochrane Database of Systematic Reviews* [Internet]. 2014 [cité 24 nov 2020];(12). Disponible sur: <https://www.cochranelibrary.com/cdsr/doi/10.1002/14651858.CD010216.pub2/full>
12. Grabovac I, Oberndorfer M, Fischer J, Wiesinger W, Haider S, Dorner TE. Effectiveness of Electronic Cigarettes in Smoking Cessation: a Systematic Review and Meta-Analysis. *Nicotine & Tobacco Research*. 2020;
13. McNeill A, Brose L, Calder R, Simonavicius E, Robson D. Vaping in England: an evidence update including vaping for smoking cessation, February 2021. A report commissioned by Public Health England. London: Public Health England; 2021.
14. Levy DT, Sánchez-Romero LM, Li Y, Yuan Z, Travis N, Jarvis MJ, et al. England SimSmoke: the impact of nicotine vaping on smoking prevalence and smoking-attributable deaths in England. *Addiction*. 2020;
15. Legleye S, Aubin H-J, Falissard B, Beck F, Spilka S. Experimenting first with e-cigarettes versus first with cigarettes and transition to daily cigarette use among adolescents: the crucial effect of age at first experiment. *Addiction*. 2020;
16. Chyderiotis S, Benmarhnia T, Beck F, Spilka S, Legleye S. Does e-cigarette experimentation increase the transition to daily smoking among young ever-smokers in France? *Drug and Alcohol Dependence*

- [Internet]. 2020 [cité 26 nov 2020];208:107853. Disponible sur: <https://linkinghub.elsevier.com/retrieve/pii/S0376871620300181>
17. National Academies of Sciences E. Public Health Consequences of E-Cigarettes [Internet]. 2018 [cité 30 avr 2021]. Disponible sur: <https://www.nap.edu/catalog/24952/public-health-consequences-of-e-cigarettes>
 18. Daynard R. Public health consequences of e-cigarettes: a consensus study report of the National Academies of Sciences, Engineering, and Medicine. Springer; 2018.
 19. Stratton K, Kwan LY, Eaton DL. Public health consequences of e-cigarettes: consensus study report. Public health consequences of e-cigarettes: consensus study report. 2018;
 20. Adermark L, Galanti MR, Ryk C, Gilljam H, Hedman L. Prospective association between use of electronic cigarettes and use of conventional cigarettes-a systematic review and meta-analysis. ERJ Open Research. 2021;
 21. Martinelli T, Candel MJ, de Vries H, Talhout R, Knapen V, van Schayck CP, et al. Exploring the gateway hypothesis of e-cigarettes and tobacco: a prospective replication study among adolescents in the Netherlands and Flanders. Tobacco Control. 2021;
 22. Soneji S, Barrington-Trimis JL, Wills TA, Leventhal AM, Unger JB, Gibson LA, et al. Association between initial use of e-cigarettes and subsequent cigarette smoking among adolescents and young adults: a systematic review and meta-analysis. JAMA pediatrics. 2017;171(8):788–97.
 23. Zhong J, Cao S, Gong W, Fei F, Wang M. Electronic cigarettes use and intention to cigarette smoking among never-smoking adolescents and young adults: a meta-analysis. International journal of environmental research and public health. 2016;13(5):465.
 24. Brown R, Bauld L, de Lacy E, Hallingberg B, Maynard O, McKell J, et al. A qualitative study of e-cigarette emergence and the potential for renormalisation of smoking in UK youth. International Journal of Drug Policy. 2020;75:102598.
 25. Kinnunen JM, Ollila H, Minkkinen J, Lindfors PL, Timberlake DS, Rimpelä AH. Nicotine matters in predicting subsequent smoking after e-cigarette experimentation: a longitudinal study among Finnish adolescents. Drug and alcohol dependence. 2019;201:182–7.
 26. Denis-Vatant C, Merieux C, Leclerc L, Duc H, Berton C, Jarrige R, et al. Relations entre vapotage et tabagisme chez les adolescents en classe de seconde. Résultats d'une étude observationnelle descriptive transversale et monocentrique menée dans l'agglomération stéphanoise. Revue des Maladies Respiratoires [Internet]. 2019 [cité 12 juin 2020];36(7):850–60. Disponible sur: <http://www.sciencedirect.com/science/article/pii/S0761842519301317>
 27. Friedman AS, Buckell J, Sindelar JL. Patterns of youth cigarette experimentation and onset of habitual smoking. American journal of preventive medicine. 2019;56(6):803–10.
 28. Friedman AS, Xu S. Associations of flavored e-cigarette uptake with subsequent smoking initiation and cessation. JAMA network open. 2020;3(6):e203826–e203826.
 29. Kong G, Morean ME, Cavallo DA, Camenga DR, Krishnan-Sarin S. Reasons for electronic cigarette experimentation and discontinuation among adolescents and young adults. Nicotine & tobacco

- research. 2015;17(7):847–54.
30. Pierce JP, Distefan JM, Kaplan RM, Gilpin EA. The role of curiosity in smoking initiation. *Addictive behaviors*. 2005;30(4):685–96.
 31. Vuolo M, Janssen E, Le Nézet O, Spilka S. Community-and Individual-Level Risk Factors of Past Month E-cigarette Use among Adolescents in France. *Drug and Alcohol Dependence*. 2021;108823.
 32. Pasquereau A, Andler R, Arwidson P, Nguyen-Thanh V. Consommation de tabac parmi les adultes en 2020: bilan de cinq années de programme national contre le tabagisme, 2014-2019. *Bull Epidemiol Hebd*. 2021;14:273–81.
 33. Andler R, Richard JB, Guignard R, Quatremère G, Verrier F, Gane J, et al. Baisse de la prévalence du tabagisme quotidien parmi les adultes: résultats du Baromètre de Santé publique France 2018. *Bull Epidemiol Hebd*. 2019;15:271–7.
 34. Pasquereau A, Andler R, Guignard R, Richard J-B, Arwidson P, Nguyen-Thanh V. Le groupe Baromètre santé. La consommation de tabac en France: premiers résultats du Baromètre santé 2017. *Bull Epidemiol Hebd*. 2018;14–15(14–15):265–73.
 35. Pasquereau A, Quatremère G, Guignard R, Andler R, Verrier F, Pourchez J, et al. Baromètre de Santé publique France 2017. Usage de la cigarette électronique, tabagisme et opinions des 18-75 ans. *Santé publique France*. 2019;1–4.
 36. Pasquereau A, Andler R, Guignard R, Soullier N, Gautier A, Richard J-B, et al. consommation de tabac parmi les adultes en 2020: résultats du baromètre de santé publique france. *Bulletin Epidemiologique Hebdomadaire*. 2021;(8):131–9.
 37. Le Nézet O, Janssen E, Brissot A, Philippon A, Shah J, Chyderiotis S. Les comportements tabagiques à la fin de l'adolescence. *Bull Epidemiol Hebd* [Internet]. 2018;(14–15):274–82. Disponible sur: http://portaildocumentaire.santepubliquefrance.fr/exl-php/vue-consult/spf_internet_recherche/SPF00000196
 38. Mokinaro S, Vincente J, Benedetti E, Cerrai S, Colasante E, Arpa S, et al. ESPAD Report 2019: Results From European School Survey Project on Alcohol and Other Drugs. 2020;
 39. Kraus L, Nociar A. ESPAD report 2015: results from the European school survey project on alcohol and other drugs. European Monitoring Centre for Drugs and Drug Addiction; 2016.
 40. Andler R, Richard JB, Guignard R, Quatremère G, Verrier F, Gane J, et al. Reduction of daily smoking rate among adults: results from the 2018 santé publique france health barometer. *Bull Epidemiol Hebd*. 2019;15:271–7.
 41. Spilka S, Nezet O L, Janssen E, Brissot A, Shah J, Chyderiotis S. Les drogues à 17 ans: analyse de l'enquête ESCAPAD 2017. *Âge*. 2018;14(123):8p.
 42. Spilka S, Godeau E, Le Nézet O, Ehlinger V, Janssen E, Brissot A, et al. Usages d'alcool, de tabac et de cannabis chez les adolescents du secondaire en 2018. *Tendances*. 2019;132:1–4.
 43. Hammond D, Rynard VL, Reid JL. Changes in Prevalence of Vaping Among Youths in the United States, Canada, and England from 2017 to 2019. *JAMA Pediatrics* [Internet]. 2020 [cité 30 avr 2021];174(8):797–800. Disponible sur: <https://doi.org/10.1001/jamapediatrics.2020.0901>

44. Etude. Étude: les ados moins accros au tabac. Paris; 2014.
45. Gautier S, Kinouani S, Raherison C. Vapoter favorise-t-il le tabagisme chez les adolescents et les jeunes adultes ? Revue de la littérature. Sante Publique [Internet]. 2017 [cité 12 juin 2020];Vol. 29(3):333–40. Disponible sur: <https://www.cairn.info/revue-sante-publique-2017-3-page-333.htm>
46. Ebrahimi Kalan M, McKelvey K, Ibrahimou B, Trucco EM, Ben Taleb Z. The Road to Vaping: E-cigarette susceptibility and curiosity among US adolescents susceptible and nonsusceptible to cigarette smoking. Health Education & Behavior. 2020;47(5):696–705.
47. Villanti AC, Naud S, West JC, Pearson JL, Wackowski OA, Hair E, et al. Prospective associations between nicotine beliefs and tobacco-related susceptibility, curiosity, and use in US adults. Preventive Medicine. 2020;140:106285.
48. Stenger N, Chailleux E. Enquête sur l'usage de la cigarette électronique et du tabac en milieu scolaire. Revue des Maladies Respiratoires [Internet]. 2016 [cité 12 juin 2020];33(1):56–62. Disponible sur: <http://www.sciencedirect.com/science/article/pii/S0761842515002193>
49. Grabovac I, Oberndorfer M, Fischer J, Wiesinger W, Haider S, Dorner TE. Effectiveness of electronic cigarettes in smoking cessation: a systematic review and meta-analysis. Nicotine and Tobacco Research. 2021;23(4):625–34.
50. Gupta PS, Kalagher KM. Where There Is (No) Smoke, There Is Still Fire: a Review of Trends, Reasons for Use, Preferences and Harm Perceptions of Adolescent and Young Adult Electronic Cigarette Use. Current Pediatrics Reports. 2021;1–5.
51. Miech R, Johnston L, O'Malley PM, Bachman JG, Patrick ME. Adolescent vaping and nicotine use in 2017–2018—US national estimates. New England Journal of Medicine. 2019;380(2):192–3.
52. Goldenson NI, Leventhal AM, Stone MD, McConnell RS, Barrington-Trimis JL. Associations of Electronic Cigarette Nicotine Concentration With Subsequent Cigarette Smoking and Vaping Levels in Adolescents. JAMA Pediatr [Internet]. 1 déc 2017 [cité 26 mai 2021];171(12):1192. Disponible sur: <http://archpedi.jamanetwork.com/article.aspx?doi=10.1001/jamapediatrics.2017.3209>
53. Miech R, Leventhal A, Johnston L, O'Malley PM, Patrick ME, Barrington-Trimis J. Trends in Use and perceptions of nicotine vaping among US youth from 2017 to 2020. JAMA pediatrics. 2021;175(2):185–90.
54. Eurobarometer S. Attitudes of Europeans towards tobacco and electronic cigarettes. TNS Opinion Social. 2021;506.
55. Aleyan S, Ferro MA, Hitchman SC, Leatherdale ST. Does having one or more smoking friends mediate the transition from e-cigarette use to cigarette smoking: a longitudinal study of Canadian youth. Cancer Causes & Control. 2021;32(1):67–74.
56. Khouja JN, Suddell SF, Peters SE, Taylor AE, Munafò MR. Is e-cigarette use in non-smoking young adults associated with later smoking? A systematic review and meta-analysis. Tobacco control. 2021;30(1):8–15.
57. McCabe SE, Veliz P, McCabe VV, Boyd CJ. Initiation Sequence of E-Cigarette and Cigarette Smoking Among US Adolescents: A National Study. The American Journal on Addictions [Internet]. 2019 [cité

26 nov 2020];28(4):285–94. Disponible sur:

<https://onlinelibrary.wiley.com/doi/abs/10.1111/ajad.12886>

58. Kalkhoran S, Chang Y, Rigotti NA. Electronic cigarette use and cigarette abstinence over 2 years among US smokers in the population assessment of tobacco and health study. *Nicotine & Tobacco Research*. 2020;22(5):728–33.
59. Etter J. Gateway effects and electronic cigarettes. *Addiction*. 2018;113(10):1776–83.
60. Coleman B, Rostron B, Johnson SE, Persoskie A, Pearson J, Stanton C, et al. Transitions in electronic cigarette use among adults in the Population Assessment of Tobacco and Health (PATH) Study, Waves 1 and 2 (2013–2015). *Tobacco control*. 2019;28(1):50–9.

Tables

Table 1. Evolution of cross-sectional sample according to sex among French adolescents aged 15-16 years from 2018 to 2020

Years	Number of adolescents included	Sex				
		%	Girls	%	Men	%
2018	1368	17,35%	673	49.18%	695	50.82%
2019	4937	62,63%	2491	50.46%	2446	49.54%
2020	1578	20,02%	905	57.35%	673	42.65%
Total	7883	100%	4069	51.60%	3814	48.40%

Table 2. Prevalence (of use and experimentation) of tobacco and vaping products for the 7,883 adolescents included in the study between 2018 and 2020

		Tobacco products	Vaping products
Prevalence of use (n=7,883)	Daily use	10.24%	5.40%
	Occasional use	17.27%	20.44%
	Non-user	72.49%	74.16%
Prevalence of experimentation (n=7,883)	Experimenter	41.67%	44.92%
	Non-experimenter	58.33%	55.08%

Table 3. Motivations for vaping and smoking among French adolescents aged 15-16 years from 2018 to 2020

		Motivations for experimentation		Motivations for use	
E-Cigarettes		Number (N)	%	Number (N)	%
	« Curiosity »	1580	34.88%	/	/
	« To blow smoke »	933	20.60%	539	11.90%
	« The variety of Flavours »	807	17.81%	562	12.40%
	« To /reduce quit smoke »	231	05.10%	204	04.50%
	« Save money/cost »	185	04.08%	134	02.95%
	« To be like others »	73	01.61%	36	00.79%
	« To look cool »	53	01.17%	43	00.94%
	« To look more adult »	24	00.52%	26	00.57%
Smoking	« Curiosity »	1637	36.98%	/	/
	« To relax »	/	/	860	19.43%
	« To blow smoke »	739	16,69%	468	10.57%
	« To be with friends »	/	/	714	16.13%
	« Like nothing »	/	/	696	15.72%
	« For the taste »	/	/	480	10.84%
	« For the sensation of smoke in the throat	/	/	232	5.21%
	« To be like others »	153	03.45%	/	/
	« To look cool »	102	02.30%	/	/
	« To look more adult »	57	01.28%	/	/

Figures

Figure 1

Evolution of tobacco experimentation and use among French adolescents aged 15-16 years from 2018 to 2020

Figure 2

Evolution of tobacco experimentation and use according to sex among French adolescents aged 15-16 years from 2018 to 2020

Figure 3

Evolution of e-cigarette experimentation and use among French adolescents aged 15-16 years from 2018 to 2020

Figure 4

Evolution of e-cigarette experimentation and use according to sex among French adolescents aged 15-16 years from 2018 to 2020

Figure 5

Evolution of vaping and smoking behaviour among French adolescents aged 15-16 years from 2018 to 2020