

New Zealand Youth19 survey: vaping has wider appeal than smoking in secondary school students, and most use nicotine-containing e-cigarettes

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The advent of e-cigarettes has brought both public health opportunities and risks.^{1,2} Vaping offers an alternative nicotine delivery system with lower health risks than combustible tobacco,³ so, for nicotine-dependent smokers, it is a potentially life-saving technology.⁴ However, vaping is not harmless. Recent reports have highlighted risks of acute lung injury and chronic risks to cardiovascular, respiratory and oral health as well as impacts of nicotine exposure on adolescent brain development.⁵⁻⁹ Since e-cigarettes have only been widely available for about 10 years, and the latency of respiratory illnesses caused by exposure to toxicants is typically 17–40 years,^{10,11} the impacts of long-term use are unknown. Qualitative evidence suggests that for young people the loss of autonomy and perceived 'weakness of character' associated with nicotine addiction can lead to negative self-perception,¹² therefore the psychological risks of vaping are also salient. For all of these reasons, vaping is not advised for non-smokers, particularly adolescents.¹³

Despite this advice, vaping among adolescents has increased sharply in recent years, particularly since 'pod' devices were introduced under brand names like JUUL and Vuse.^{14,15} Such 'fourth generation' devices generally contain nicotine; for example, the leading brands named above do not offer nicotine-free options. Pod devices emerged

Abstract

Objective: To investigate smoking and vaping in secondary school students (aged 13–18 years) in New Zealand (NZ) following the introduction of 'pod' e-cigarettes, which have been associated with the rapid escalation of youth vaping elsewhere.

Methods: Data on smoking and vaping were collected in 2019 as part of a comprehensive youth health survey (N=7,721).

Results: Vaping was 2–3 times more prevalent than smoking, with 10% of students vaping regularly (monthly or more often), and 6% weekly or more often, compared with 4% and 2%, respectively, for tobacco smoking. Nicotine-containing e-cigarettes were sometimes or always used by 80% of regular and 90% of weekly vapers. Regular and weekly smoking was rare in low deprivation (affluent) areas, whereas regular and weekly vaping prevalence was similar across the socioeconomic spectrum. More than 80% of ever-vapers (N=2732) reported they were non-smokers when they first vaped, and 49% of regular vapers (N=718) had never smoked.

Conclusions: A significant proportion of New Zealand adolescents, many of whom have never smoked, use nicotine-containing e-cigarettes regularly.

Implications for public health: Vaping is less harmful than smoking, but it is not harmless. Public health action is needed to support young non-smokers to remain smokefree and vape-free.

Key words: tobacco, smoking, e-cigarettes, vaping, adolescent

in the US from 2015 but were not easily available in New Zealand (NZ) until late 2018. Pod devices differ from earlier e-cigarettes in ease of use and sleek design. Many use 'nicotine salt' technology, which delivers nicotine more efficiently into the bloodstream and enables high nicotine concentrations without a harsh sensation in the mouth and throat.¹⁶ There is emerging evidence that the use of pod devices among adolescents is associated with higher nicotine exposure¹⁷

and nicotine dependence¹⁸ relative to other types of e-cigarette. Product development continues apace, with manufacturers using technical advances to increase nicotine yield per puff despite unchanged e-liquid composition (e.g. nicotine emissions in e-cigarette vapour can be increased by improving surface contact between the e-liquid and the heating coil).¹⁹

As well as the direct health effects of vaping and nicotine dependence, public health

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concern has centred on the possibility of vaping renormalising smoking and/or acting as a gateway to combustible tobacco use.¹³ Longitudinal studies consistently show that vaping in non-smoking youth is associated with a greatly increased risk of subsequent combustible tobacco use.^{20,21} However, whether this is a *causal* relationship, or due to common liability (i.e. factors that make individuals vulnerable to both vaping and smoking) remains under debate.²²

In the face of scientific uncertainty about the relative risks and benefits of e-cigarettes, jurisdictions have differed widely in their regulatory responses.²³ In New Zealand, after the Ministry of Health lost a court case against tobacco company Philip Morris (NZ) Ltd in March 2018, the market for vaping products was almost entirely unregulated until the implementation of new vaping-specific legislation from November 2020. During this regulatory vacuum, vaping promotions proliferated²⁴ and pod devices were heavily marketed to young people as lifestyle products.²⁵

By late 2019, community concerns attracted media attention including testimony from school principals about a growing 'epidemic' of nicotine addiction among students.^{26,27} Their observations appeared at odds with some researchers' conclusions that "daily use of e-cigarettes [in adolescents] is rare and is largely confined to those who have smoked"²⁸ and that vaping "might be displacing smoking" in New Zealand adolescents.²⁹ The Ministry of Health's vaping position statement also downplayed youth vaping, stating: "[V]aping products are attracting few people who have never smoked into regular vaping, including young people."³⁰ However, other researchers have offered alternative interpretations of New Zealand vaping and smoking data.^{31,32} Whether youth vaping should be considered a public health problem in New Zealand remains contested, as it does in many other countries.

To date, surveillance of vaping in New Zealand adolescents has focused on Year 10 students aged 14–15 years. Findings of the annual ASH Year 10 Snapshot (N=20,000–30,000) and biennial Youth Insights Surveys (N=2,600–2,900) show that, between 2016 and 2018/19, regular (at least monthly) smoking in this age group was stable³³ or increased slightly,^{34,35} while vaping increased markedly. The YIS survey found the prevalence of regular vaping increased

from 4% to 8% between 2016 and 2018.³³ The ASH survey found regular vaping increased from 4% to 12% and weekly vaping increased from 1% to 4% between 2016 and 2019.²⁹ A limitation to date has been the lack of New Zealand data on vaping across the full adolescent age range (13–18 years).

The Youth19 survey, a comprehensive health survey of 7,721 secondary students aged 13–18 years, enables this and other knowledge gaps to be addressed. Our study, which uses Youth19 data, investigates the prevalence and demographic patterning of vaping in secondary students. It investigates whether experimentation with e-cigarettes precedes or follows smoking and, importantly, it is the first study to report the prevalence of nicotine vaping since high-nicotine 'pod' e-cigarettes became available in New Zealand. Research conducted in 2018 found fewer than half of 14–15-year-olds reported using nicotine the last time they vaped.³³ It is important to ascertain whether the prevalence of nicotine use has changed as devices have evolved.

Methods

Survey design

We investigated smoking and vaping in secondary school students using data from the Youth19 survey, conducted May to September 2019.

Youth19 is a cross-sectional survey of New Zealand secondary school students (aged 13–18 years) in the Auckland, Northland and Waikato education regions. Combined, these regions include 47% of the New Zealand secondary school population.³⁶ Ethics approval was granted by the University of Auckland Human Subjects Ethics Committee (Reference #022244).

A two-stage cluster design was used. Schools were randomly selected from mainstream (public and private) schools with more than 50 students in Years 9–13. In each participating school, students were randomly selected from the school roll. In addition, four kura kaupapa Māori (i.e. schools in which the medium of instruction is Māori, New Zealand's indigenous language) with more than 50 students were purposively sampled, with all students invited to participate.

A total of 49 schools and 7,721 students participated. The school response rate was 57% and the student response rate was 60%. Characteristics of included schools and students have been published elsewhere, alongside further methodological details.³⁷

Outcome measures

Smoking prevalence

The smoking questions were introduced: *We would now like to ask some questions about smoking cigarettes (not including e-cigarettes, vaping or marijuana).* **Ever smoked** was based on the question: *Have you ever smoked a whole cigarette?* (Yes/No). Frequency of current smoking was based on the question: *How often do you smoke cigarettes now?* (Never; Occasionally; Once or twice a month; Once or twice a week; Most days; Daily). Respondents were categorized as engaging in **Regular smoking** (monthly or more often), or **Weekly smoking** (weekly or more often).

Vaping prevalence

Ever vaped was based on the question: *Have you ever vaped or used an e-cigarette?* (Yes/No). Frequency of current vaping was based on the question: *How often do you vape or use e-cigarettes now?* (Never; Occasionally; Once or twice a month; Once or twice a week; More than twice a week). Respondents were categorized as engaging in **Regular vaping** (monthly or more often), or **Weekly vaping** (weekly or more often).

Temporal sequence of use

Those who had ever vaped were asked: *When you first began vaping or using e-cigarettes did you smoke ordinary cigarettes (tobacco)?* (Yes/No).

Nicotine content

Those who had ever vaped were asked: *When you vape or use e-cigarettes do they contain nicotine?* (Yes, always; Yes, sometimes; No; Don't know).

Demographic variables

Sex (Male/Female) was based on sex at birth as this enabled the inclusion of all students (including transgender and non-binary students, N=66) using a dichotomous variable. Note that the transgender/non-binary group was too small to allow robust separate analysis.

Neighbourhood deprivation was based on participants' usual place of residence and the 2018 NZ Deprivation Index (NZDep18),³⁸ grouped into quintiles with 1–2 representing the least deprived and 9–10 representing the most deprived. NZDep18 is based on Census data on nine variables including income, employment, qualifications, access to home internet and living conditions.³⁸

Ethnicity: Students selected as many ethnicities as were relevant. For this study, a single ethnicity was assigned to each student, based on the Ministry of Health ethnicity prioritisation protocol: Māori, Pacific Peoples, Asian, Middle Eastern/Latin American/African (MELAA), Other, or European (comprising New Zealand European and other European).³⁹ Due to small numbers and heterogeneity, the MELAA and 'Other' groups were combined.

School year: In New Zealand, secondary schooling comprises Year 9 (age 13–14) to Year 13 (age 17–18).

Urban/rural classification was based on the size of the city, town or rural settlement in which participants usually lived. 'Urban' was defined as a population of 10,000 or more, 'small town' was 1,000–9,999 people, and 'rural' was fewer than 1,000 people.

Statistical analysis

We used descriptive statistics to determine smoking and vaping prevalence by demographic variables. We also calculated vaping prevalence by smoking status and vaping of nicotine by vaping frequency. All analyses were adjusted to account for unequal probability of selection and clustering at the school level. In the main analyses, findings were weighted to the secondary school population of the survey region, based on Ministry of Education data on sex, age, ethnicity and school decile. We calculated national estimates by weighting the findings to the New Zealand secondary school population. These national estimates (available in a Supplementary file) should be treated with caution since they assume no regional differences over and above differences in demographic composition.

Results

Prevalence and demographic patterning

Vaping was approximately 2–3 times more prevalent than smoking at all levels of use: ever, regular, and weekly (Table 1). About 38% of students reported ever vaping, 10% reported regular vaping, and 6% reported vaping weekly or more often. The respective figures for tobacco smoking were 15%, 4% and 2%.

The proportion who reported both smoking and vaping (i.e. dual use) was 2% for regular and 1% for weekly dual use. Dual use among Māori was double that of the general population.

Experimentation with vaping often began at a young age with 22% of Year 9 students (13–14 years) reporting they had tried vaping. Only 6% of this age group had tried smoking.

Both vaping and smoking prevalence increased with age/school year and both were more common in small towns than in urban or rural areas (though differences by locale were sometimes within the margin of error). In other respects, vaping was patterned differently from smoking. There were no sex differences for smoking; whereas, boys were more likely to vape than girls. The expected social gradient was apparent for smoking, with students in high-deprivation neighbourhoods (NZ Dep 9–10) markedly more likely to smoke than those in low-deprivation (more affluent) areas (Figure 1). In contrast, vaping was more evenly distributed across the socioeconomic spectrum.

Nicotine use

The use of nicotine-containing e-cigarettes was more prevalent in regular and weekly

vapers from affluent (NZDep1–4) compared with deprived (NZDep9–10) neighbourhoods (Table 1). The proportion of students reporting sometimes or always using nicotine-containing e-cigarettes was 51% of ever-vapers, 80% of regular vapers and 90% of weekly vapers, overall (Table 2).

Association between smoking and vaping

Vaping was more common among smokers than non-smokers: 89% of ever-smokers had tried vaping, compared with 29% of never-smokers (data not shown). Yet, never-smokers made up the vast majority (85%) of the sample, and therefore accounted for a significant proportion of vapers. Based on regional estimates, two-thirds (66%) of ever-vapers, nearly half (49%) of regular vapers, and about one-third (34%) of weekly vapers reported they had never smoked. Using national estimates, this translates to about 15,000 regular vapers and 6,700 weekly vapers in the New Zealand secondary school population (N=278, 266) who had never smoked. Detailed findings are presented in the Supplementary material (Table S2).

Temporal sequence of use

Students who had ever vaped were asked whether they smoked when they began vaping. As shown in Figure 2, a large majority (81%) of students reported they did not smoke when they first tried vaping (T1). Of these, 77% had not progressed beyond experimental (less than monthly) vaping and/or smoking when surveyed (T2). However, one in five (21%) of those who were non-smokers when they started vaping reported regular vaping, and a small proportion (2.4%) had become regular smokers – either in

Figure 1: Prevalence of Ever, Regular and Weekly smoking and vaping by neighbourhood deprivation, NZ secondary students, 2019.

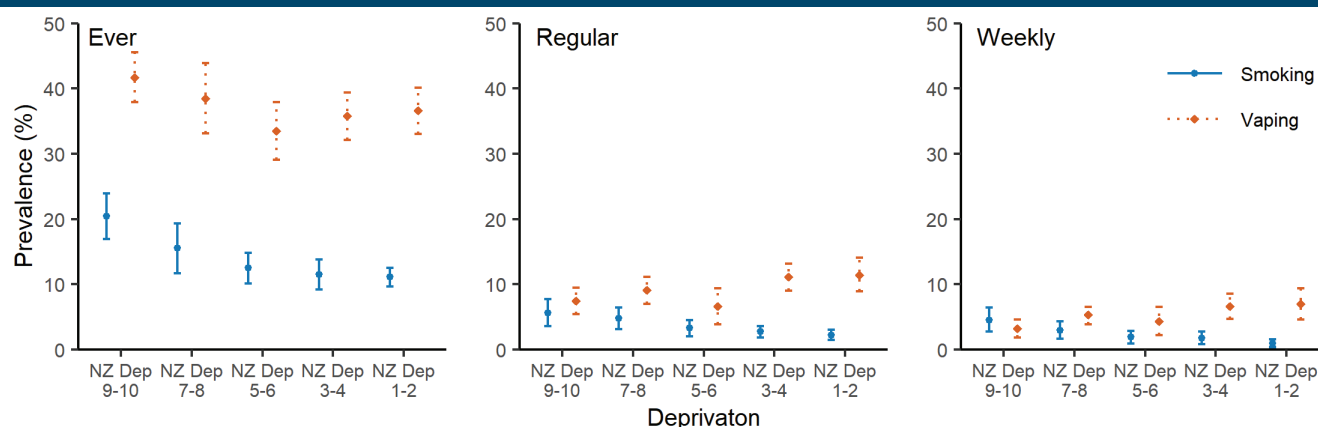


Table 1: Prevalence of vaping and smoking in NZ secondary students, 2019 – weighted regional estimates.

	Ever smoked N=7,163	Regular ^a smoking N=7,154	Weekly ^b Smoking N=7,154	Ever vaped N=7,164	Regular ^a vaping N=7,146	Regular ^a vaping with nicotine ^c N=7,143	Weekly ^b vaping N=7,146	Weekly ^b vaping with nicotine ^c N=7,140	Both vapes & smokes at least monthly N=7,099	Both vapes & smokes at least weekly N=7,099
	% [95% CI]	% [95% CI]	% [95% CI]	% [95% CI]	% [95% CI]	% [95% CI]	% [95% CI]	% [95% CI]	% [95% CI]	% [95% CI]
Total	14.8 [12.7–17.0]	3.8 [2.9–4.7]	2.4 [1.7–3.1]	37.9 [35.0–40.8]	9.8 [8.0–11.5]	7.6 [6.0–9.3]	5.8 [4.4–7.1]	5.1 [3.8–6.3]	2.1 [1.5–2.6]	1.0 [0.7–1.4]
Sex										
Female N=3,966	14.8 [11.7–17.8]	3.9 [2.7–5.0]	2.3 [1.4–3.2]	35.0 [31.5–38.5]	8.3 [6.2–10.5]	6.8 [5.1–8.5]	4.6 [3.3–5.9]	4.1 [2.8–5.4]	1.9 [1.1–2.7]	0.8 [0.4–1.2]
Male N=3,197	14.7 [12.4–17.1]	3.6 [2.5–4.6]	2.4 [1.5–3.3]	41.5 [38.4–44.6]	11.4 [9.8–13.1]	8.8 [6.9–10.6]	7.0 [5.4–8.5]	6.3 [4.7–7.9]	2.2 [1.5–2.9]	1.3 [0.7–1.9]
NZ Dep18 Decile										
9–10 (most deprived) N=1246	20.4 [16.9–23.9]	5.6 [3.6–7.7]	4.5 [2.7–6.4]	41.7 [37.9–45.6]	7.4 [5.4–9.5]	4.0 [2.3–5.6]	3.2 [1.8–6.4]	2.4 [1.1–3.6]	2.1 [1.1–3.1]	0.9 [0.3–1.6]
7–8 N=1,095	15.5 [11.7–19.3]	4.8 [3.1–6.4]	2.9 [1.6–4.3]	38.5 [33.1–43.9]	9.1 [7.0–11.1]	6.4 [4.6–8.2]	5.3 [3.8–6.5]	4.2 [2.8–5.6]	2.4 [1.2–3.7]	1.3 [0.3–2.3]
5–6 N=1,398	12.5 [10.1–14.8]	3.3 [2.0–4.5]	1.9 [0.9–2.8]	33.5 [29.1–37.9]	6.6 [3.8–9.4]	5.6 [3.1–8.1]	4.3 [2.2–6.5]	3.9 [2.0–5.8]	1.7 [0.8–2.7]	1.0 [0.3–1.7]
3–4 N=1,339	11.5 [9.2–13.8]	2.7 [1.8–3.6]	1.7 [0.8–2.7]	35.8 [32.1–39.4]	11.1 [9.0–13.1]	9.6 [7.7–11.4]	6.6 [4.7–8.5]	6.4 [4.5–8.2]	2.0 [1.4–2.7]	1.1 [0.3–1.8]
1–2 N=1,369	11.1 [9.6–12.5]	2.2 [1.4–3.0]	0.9 [0.3–1.5]	36.6 [33.0–40.1]	11.4 [8.9–14.1]	10.0 [7.6–12.5]	7.0 [4.6–9.4]	6.7 [4.2–9.2]	1.4 [0.7–2.2]	0.7 [0.2–1.2]
Ethnicity										
Māori N=1,348	25.8 [22.4–29.2]	7.3 [5.6–9.0]	4.9 [3.4–6.4]	55.5 [51.6–59.4]	12.9 [10.1–15.6]	9.1 [7.0–11.2]	7.7 [6.0–9.3]	6.5 [4.8–8.2]	4.0 [2.8–5.2]	2.2 [1.2–3.1]
Pacific N=809	21.2 [17.5–25.0]	6.2 [4.4–8.0]	4.6 [3.0–6.2]	44.4 [41.2–47.7]	7.3 [5.6–9.0]	3.8 [2.2–5.5]	2.4 [1.2–3.6]	1.4 [0.5–2.4]	1.7 [1.0–2.5]	0.7 [0.1–1.4]
Asian N=1,678	7.1 [5.2–9.0]	1.4 [0.8–2.1]	0.8 [0.4–1.2]	20.4 [17.0–23.9]	4.2 [3.1–5.3]	2.9 [2.1–3.8]	2.8 [2.0–3.6]	2.3 [1.5–3.1]	0.8 [0.3–1.2]	0.4 [0.1–0.8]
Other N=342	14.6 [10.0–19.1]	2.3 [0.6–4.0]	1.4 [0.2–2.6]	30.8 [24.2–37.3]	8.6 [5.0–12.1]	6.8 [3.4–10.2]	5.6 [2.4–8.7]	4.7 [1.6–7.7]	2.1 [0.4–3.8]	1.4 [0.2–2.7]
European N=2,975	13.3 [11.8–14.8]	3.2 [2.5–3.9]	1.8 [1.2–2.4]	40.3 [37.6–43.0]	12.4 [10.0–14.8]	11.2 [8.9–13.5]	7.6 [5.6–9.5]	7.3 [5.4–9.2]	2.2 [1.7–2.7]	1.0 [0.6–1.4]
School Year										
Year 9 (age 13–14) N=1,632	6.4 [4.8–8.1]	1.0 [0.4–1.5]	0.6 [0.2–1.0]	22.1 [18.6–25.6]	3.8 [2.7–5.0]	2.5 [1.6–3.4]	1.7 [1.0–2.4]	1.5 [0.9–2.1]	0.6 [0.2–0.9]	0.4 [0.1–0.7]
Year 10 (age 14–15) N=1,577	11.2 [8.6–13.8]	3.2 [2.0–4.5]	2.0 [1.2–2.8]	34.2 [28.7–39.6]	8.8 v[5.9–11.7]	6.8 [4.4–9.2]	4.6 [2.7–6.5]	4.0 [2.3–5.7]	2.0 [1.1–2.9]	1.1 [0.5–1.6]
Year 11 (age 15–16) N=1,551	17.2 [13.7–20.6]	4.9 [3.2–6.6]	2.9 [1.7–4.0]	43.3 [38.3–48.3]	10.7 [7.6–13.7]	8.1 [5.5–10.7]	6.2 [3.8–8.5]	5.3 [3.2–7.5]	2.6 [1.4–3.8]	1.3 [0.6–2.1]
Year 12 (age 16–17) N=1,348	20.5 [17.3–23.9]	4.6 [3.1–6.1]	3.2 [1.8–4.6]	46.1 [41.7–50.6]	13.7 [10.8–16.5]	10.7 [7.6–13.8]	8.2 [5.9–10.5]	7.2 [4.8–9.6]	2.1 [1.1–3.0]	0.9 [0.3–1.5]
Year 13 (age 17–18) N=1,016	21.3 [18.2–24.4]	5.5 [3.9–7.2]	3.6 [2.0–5.1]	48.1 [43.8–52.4]	13.2 [9.9–16.6]	11.9 [8.7–15.0]	9.4 [6.5–12.3]	8.7 [6.0–11.5]	3.1 [2.2–4.1]	1.5 [0.8–2.3]
Locale										
Urban N=4,880	12.7 [10.3–15.2]	3.2 [2.2–4.2]	2.1 [1.2–3.0]	35.0 [31.8–38.1]	8.2 [6.4–10.0]	6.4 [4.6–8.2]	4.8 [3.3–6.3]	4.1 [2.6–5.6]	1.6 [1.1–2.1]	0.9 [0.5–1.3]
Small town N=517	21.2 [17.5–24.8]	7.5 [5.7–9.2]	4.5 [2.7–6.2]	51.6 [47.0–56.1]	14.6 [11.8–17.5]	12.3 [9.7–14.9]	9.1 [6.7–11.5]	8.8 [6.4–11.2]	4.5 [3.0–6.0]	1.3 [0.4–2.2]
Rural N=1,051	17.8 [14.9–20.6]	4.3 [2.6–5.9]	2.6 [1.3–3.9]	41.2 [37.5–45.0]	11.2 [8.1–14.3]	8.8 [6.4–11.2]	6.2 [4.4–7.9]	6.0 [4.3–7.7]	2.4 [1.1–3.7]	1.1 [0.2–2.0]

Notes:

CI=Confidence interval

a: 'Regular' is defined as monthly or more often

b: 'Weekly' is defined as weekly or more often

c: 'Regular/weekly vaping with nicotine' combines regular or weekly vaping with 'sometimes' or 'always' using nicotine-containing e-cigarettes

combination with regular vaping (1.6%) or smoking exclusively (0.8%).

About one in five students (19%) reported that they smoked when they first tried vaping (T1). Smoking frequency at T1 (occasional, regular, weekly or daily) is unknown, but it is noteworthy that most smoking is experimental (less than monthly) in this age group. Just under half of this group (46%) neither smoked nor vaped regularly when surveyed (T2), suggesting use had remained or become experimental or stopped completely. About 17% of those who smoked when they started vaping (3% of ever-vapers) had progressed to regular vaping but were not smoking regularly at T2. These groups are likely to include students who used vaping to quit smoking or who switched from smoking to a lower-harm option, but the exact proportion cannot be determined. About 15% had become or remained regular smokers and were not vaping regularly, and a further 23% were both vaping and smoking regularly.

Discussion

This is the first New Zealand study to investigate vaping across the full adolescent age range (13–18 years). We found vaping was two to three times more prevalent than smoking in secondary school students. Ethnic, gender and socioeconomic patterning for vaping was different from smoking. About 85% of secondary students had never smoked a cigarette, and 81% of those who had used e-cigarettes reported they did not smoke when they first tried vaping. Never-smokers made up about two-thirds of ever-vapers, half of regular vapers and one-third of weekly vapers. The use of e-cigarettes containing nicotine was the norm, with about 80% of regular and 90% of weekly vapers reporting sometimes or always using nicotine. There was little evidence of vaping acting as a gateway to smoking. The findings were broadly consistent with previous New Zealand research,^{28,29,33} with two exceptions. Firstly, we found that regular vaping was highest in Māori and European ethnic groups. Elevated vaping in Europeans is consistent with international findings,⁴⁰ but it differs from another New Zealand study based on Year 10 students only, which found Māori and Pacific students were more likely to vape than non-Māori/non-Pacific, including Europeans.²⁹ A likely explanation is that Māori and Pacific students may tend to begin

Table 2: Proportion of adolescent vapers who report using nicotine-containing e-cigarettes – weighted regional estimates.

	E-cigarettes contain nicotine							
	Yes, always		Yes, sometimes		No, never		Don't know	
	n (N)	% [95%CI]	n (N)	% [95%CI]	n (N)	% [95%CI]	n (N)	% [95%CI]
Ever vaped	515 (2,732)	18.6 [15.1–22.1]	894 (2,732)	32.7 [30.1–35.2]	871 (2,732)	32.2 [28.6–35.7]	452 (2,732)	16.6 [13.7–19.5]
Vapes at least monthly	286 (717)	39.4 [31.2–47.5]	286 (717)	40.8 [35.6–46.0]	100 (717)	13.6 [9.1–18.1]	45 (717)	6.2 [3.8–8.7]
Vapes at least weekly	226 (420)	52.9 [43.6–62.2]	154 (420)	37.4 [30.3–44.4]	30 (420)	7.8 [3.9–11.6]	10 (420)	2.0 [0.5–3.5]

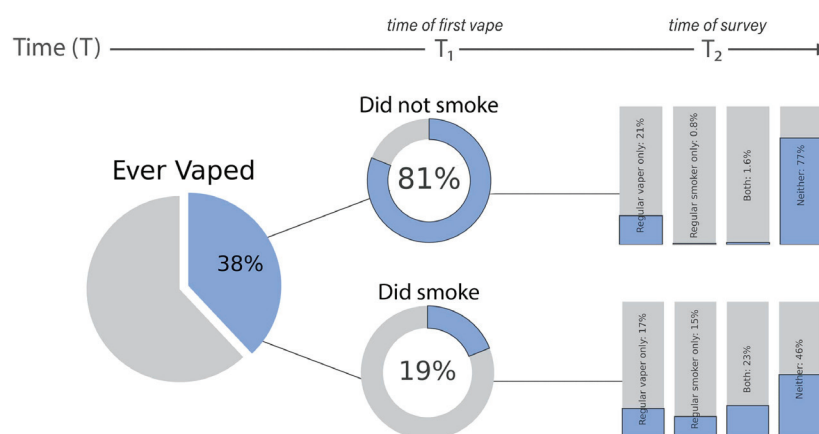
Notes:

CI=Confidence interval.

n= number of respondents in the category

N=denominator (the number who answered the relevant question)

Figure 2: Temporal sequence of smoking and vaping among those who have ever vaped.



substance use (including vaping) at an earlier age than other ethnic groups,⁴¹ therefore ethnic patterns in the 14–15 years age group may not reflect patterns in adolescents overall.

Secondly, our finding that about 80% of students who vape regularly use nicotine differs from a previous study, based on 2018 data, that found only 23% of 14–15-year-old current vapers reported using nicotine the last time they vaped. (A further 17% were unsure or did not respond to the question).³³ The change between 2018 and 2019 findings is likely to reflect much greater availability of nicotine-containing e-cigarettes in New Zealand since 2018 as a result of a landmark court case (Ministry of Health vs. Philip Morris [NZ] Ltd) and the arrival of pod devices in the country. A jump in adolescent use of nicotine-containing e-cigarettes following the introduction of pod devices is consistent with findings from the US, where growth in nicotine vaping between 2017 and 2018 was the largest increase in the use of any

substance in the 40-year history of the Monitoring the Future survey (e.g. prevalence of past year nicotine vaping increased from 16% to 25% among 15–16-year-olds).⁴²

Importantly, we found that the social gradient associated with smoking did not apply to vaping. Socioeconomic differences in vaping were small – most were within the margin of error – but ever vaping appeared to be more common in high-deprivation areas whereas regular/weekly vaping appeared to be more common in more affluent areas. Possible explanations for this pattern are: i) there may be a financial barrier to progressing from experimental to regular vaping (requiring one's own device) which differentially affects those in high deprivation neighbourhoods; ii) youth of higher socioeconomic status may be more likely to progress to regular vaping because they use more addictive high-nicotine pod devices^{17,18} as a result of being targeted by marketing for such devices. Our finding that students from more affluent areas were more likely to use nicotine-

containing e-cigarettes than those from deprived areas provides some support for the second explanation, as does trend data from the ASH Snapshot survey that show there was a sharp increase in vaping in mid- and high-decile schools (more affluent) but not in low decile schools between 2018 and 2019, following the arrival of pod devices.²⁹

Public health implications

About one in five ever-vapers reported that they smoked at the time they tried vaping, and some established adolescent smokers may have used vaping as a tool to successfully quit smoking. However, due to a lack of data on smoking frequency at vaping initiation, it was not possible to determine how many fit this category. The safety and efficacy of e-cigarettes for smoking cessation in those aged under 18 years have not been established, and current cessation guidelines for adolescents recommend the use of other supports including nicotine replacement therapy.^{43,44}

The public health implications of the rise in vaping may differ according to the background level of adolescent smoking in New Zealand communities. Our findings show that vaping of nicotine has emerged as a new public health risk in mid- to high-socioeconomic neighbourhoods, where a significant proportion of adolescents (the vast majority of whom would otherwise be nicotine-free and smokefree) are now exposed to vaping harms and potential nicotine addiction. What the rise in vaping means for Māori and Pacific youth and those in high deprivation areas is less clear. On one hand, vaping represents a lower-harm alternative for young people who might otherwise become smokers. On the other hand, young people from these communities in which adult smoking remains prevalent may be more vulnerable to transitioning from vaping to smoking due to pro-smoking socialisation and easier access to cigarettes via family and friends.⁴⁵ Examination of trend data from another New Zealand study provides insights into which of these possibilities has stronger empirical support. Walker et al. (2020) found regular and weekly smoking in 14-15-year-olds increased between 2016 and 2019 in almost all demographic groups, but particularly among Māori, with regular and weekly smoking increasing from 10.8% to 13.6% and 2.6% to 4.0%, respectively.²⁹ These findings suggest

that vaping is *not* displacing smoking in adolescents overall, or in groups vulnerable to smoking. Although we found that few adolescents had transitioned from non-smoking to regular smoking via e-cigarette use, the fact that smoking is increasing among New Zealand adolescents (and ethnic and socioeconomic differences are widening) is very concerning.

It is also concerning that 17% of those who had ever vaped did not know whether they had used nicotine or not. This lack of awareness suggests adolescents may be unknowingly exposing themselves to a highly addictive substance.⁴⁶ These findings underline the need for mandated on-pack warnings⁴⁷ and health education campaigns targeting youth.⁴⁸

Our findings challenge the idea that youth vaping is largely confined to existing smokers and suggest greater weight should be given to protecting young people from vaping harm (as well as smoking harm, which remains the primary concern). Legislation introduced in late 2020 now prohibits the sale of vaping products to those aged under 18 and most forms of e-cigarette marketing in New Zealand. These measures will go some way towards protecting young people, although we note that online marketing appears to have continued despite the ban.⁴⁹ We welcome the proposal in the draft Smokefree Aotearoa 2025 Action Plan (released in April 2021) to invest in social marketing campaigns aimed at “supporting young people to stay smokefree and vape-free”.⁵⁰ We note that prevention campaigns need to be targeted to the appropriate age group, which our findings show is younger for vaping than for smoking. We found one in five had already tried vaping by age 13–14 years.

Research conducted prior to the introduction of pod devices suggested few adolescents who experimented with vaping became regular users.¹ However, new generation high-nicotine e-cigarettes may be changing this pattern, with evidence indicating they increase the risk of nicotine dependence in non-smokers.^{17,18} It is notable that in jurisdictions where the maximum nicotine content of e-cigarettes is regulated (e.g. 20mg/ml in the UK and European Union) the prevalence of youth vaping is much lower than in New Zealand, while declines in adult smoking appear to be similar at the population level.⁵¹ Robust policy evaluation is needed, but limiting the nicotine content

of e-cigarettes in New Zealand should be considered.

Strengths and limitations

The findings should be interpreted in light of the strengths and limitations of the Youth19 survey. Strengths include a large and diverse sample, with findings weighted to the population, and coverage of the full adolescent age range. It is the first New Zealand study to collect data on nicotine use since ‘pod’ devices became available and to investigate temporal sequencing of smoking and vaping. Although Youth19 was a regional survey, both regional and national estimates were calculated to allow comparison with nationally representative surveys.

Limitations include the cross-sectional survey design and use of a retrospective self-report question about smoking status at the time of vaping initiation, which is less robust than prospective measurement of order of use. Retrospective data are subject to recall bias, and because the level of smoking (occasional, regular or daily) at the time of vaping initiation was not ascertained, interpretations about trajectories, and whether these were ‘positive’ or ‘negative’ from a public health perspective, were limited. The 2019 survey was the first in the Youth2000 series to collect data on vaping, so trend data for secondary students cannot be reported. Nor were we able to report data on daily vaping, since this was not collected.

The Youth19 survey did not collect data on the type (e.g. pod, tank) or brand of e-cigarettes used. Because product innovations and consumer preferences are evolving rapidly, and addictiveness and harm profile may differ between devices, future surveys should ascertain brands and device types that adolescents are using. Research suggests young people may not recognise new generation devices as ‘e-cigarettes’ or ‘vaping’ devices, and therefore use may be underestimated in the current survey.⁵² Using photos of devices in surveys may provide more accurate estimates of adolescent e-cigarette use.⁵² Vaping of cannabis should be explicitly included or excluded in survey questions.⁵³ Research on smoking and vaping in transgender and non-binary adolescents (and rainbow youth more broadly) is an area for future research, as overseas research suggests these populations have a higher prevalence of smoking and vaping than cis-gender and heterosexual adolescents.⁵⁴

Conclusions

Although e-cigarettes are less harmful than conventional cigarettes, they are not harmless. Policy makers need to find the right balance between making the switch to vaping easy for smokers while protecting young non-smokers from vaping harm. Our findings suggest that, during the 2018 to 2019 period in New Zealand, that balance was not achieved. E-cigarettes were virtually unregulated, coinciding with the arrival of high-nicotine pod devices that were heavily marketed to young people. We found that most adolescents did not vape or smoke regularly in 2019. However, vaping was much more prevalent than smoking, and regular vaping occurred among non-smokers as well as smokers, and among demographic groups less likely to smoke. Although a small number of adolescents may be using e-cigarettes as a lower-harm alternative to smoking, a larger number (who would otherwise be smoke-free and nicotine-free) are now at risk of nicotine addiction and exposed to toxicants through vaping. The authors welcome new legislation and proposed social marketing that, if implemented effectively, will go some way towards protecting young people from vaping and smoking harms. Ongoing monitoring of smoking and vaping across the adolescent age range is vital to determine whether New Zealand has now got the balance right.

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Supporting Information

Additional supporting information may be found in the online version of this article:

Supplementary Table 1: Prevalence of vaping and smoking and in NZ secondary students, 2019 – weighted national estimates.

Supplementary Table 2: Number and proportion of adolescent vapers who have never smoked, 2019, regional and national estimates.