

Use of e-cigarettes and smoked tobacco in youth aged 14–15 years in New Zealand: findings from repeated cross-sectional studies (2014–19)

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Summary

Background Media reports of a vaping epidemic among youth have raised concerns about the creation of a new generation of nicotine-dependent individuals who could graduate to cigarette smoking. We investigated the use of e-cigarettes and cigarettes in the youth of New Zealand from 2014 to 2019, with focus on daily use of these products as an indicator of potential dependence.

Methods We analysed data from the Action for Smokefree 2025 Year-10 survey, an annual cross-sectional survey of tobacco use undertaken by almost half of all school students aged 14–15 years (21504–31021 students). The survey includes questions on whether students had ever smoked (even just a few puffs) and their current smoking behaviour (at least once a day, week, or month, or less often than once a month). In 2014, a question was added asking if students had ever tried an e-cigarette. Subsequent surveys asked about e-cigarette use at least once a day, week, or month, or less often than once a month. We compared the frequency of e-cigarette use with cigarette smoking by survey year, age, gender, ethnicity, and school decile (a proxy for socioeconomic status). We did χ^2 analyses to compare categorical variables and Cochran-Armitage trend tests to assess changes over time. Multiple logistic regression was used to determine predictors of e-cigarette and cigarette use in 2019.

Findings All measures of e-cigarette use increased and all measures of cigarette use decreased or remained static over time. Although the proportion of students who had ever tried e-cigarettes in 2019 (37.3%, 10 093 of 27 083), exceeded the proportion who had ever smoked (19.6%, 5375 of 27 354), daily use of products was low: e-cigarettes (3.1%, 832 of 26 532), cigarettes (2.1%, 575 of 27 212), both (0.6%, 159 of 27 633). In 2019, daily use of e-cigarettes was very low in never-smokers (0.8%, 175 of 21 385). Students who were Māori, Pacific, gender diverse, or from low-decile and mid-decile schools were more likely to be daily users of e-cigarettes or cigarettes, and males were more likely to be daily e-cigarette users, but less likely to smoke daily than females.

Interpretation The overall decline in smoking over the past 6 years in New Zealand youth suggests that e-cigarettes might be displacing smoking. Ongoing monitoring will be important to determine whether the liberalisation of e-cigarette availability and marketing in New Zealand has any effect on long-term patterns of daily e-cigarette and cigarette use.

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Introduction

International media reports of increasing e-cigarette use (vaping) by youth have prompted concerns that e-cigarettes are creating a new generation of nicotine-dependent individuals and potentially acting as a gateway to smoking. We investigated potential evidence of this issue in adolescents in New Zealand. New Zealand has implemented strong tobacco control measures and has committed to being smoke free by 2025 (defined as less than 5% of the adult population smoking daily). E-cigarettes have been legally available for sale to adults aged 18 years and older in New Zealand since 2010. However, advertising or selling e-cigarettes or e-liquid that contain nicotine, or making a cessation claim about e-cigarettes was illegal, because Medsafe (New Zealand's

authority for licensing medicines) considers e-cigarettes a medicine if a cessation claim is made. However, low levels of enforcement, and allowance for 3 months of nicotine e-liquid to be imported for personal use, meant that nicotine e-liquids have been available for many years. On March 12, 2018, nicotine-containing e-cigarettes and e-liquids were permitted by the Government, in addition to reduced harm tobacco products such as smokeless tobacco and heat-not-burn products, which were previously illegal.

New Zealand's adult daily smoking prevalence has been steadily declining, although differences in smoking prevalence persist between ethnic and socioeconomic groups. For example, the most recent New Zealand Health Survey (13752 adults aged 15 years or older, from

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Research in context

Evidence before this study

We searched MEDLINE (Ovid), Embase, and PsycINFO for articles in the English language published between Jan 1, 2004 (e-cigarettes were not available before 2004) and Aug 31, 2019, that compared daily use of e-cigarettes with daily tobacco use by adolescents. We used the following search terms (e-cig\$ OR electr\$ cigar\$ OR electronic nicotine OR [vape or vaper or vapers or vaping]) AND (adolescent AND cross-sectional studies AND Tobacco Smoking). We identified 50 articles, only two of which presented data on daily use of e-cigarettes and tobacco smoking. The first paper reported on a 2013 cross-sectional survey of 9–10th grade high school students (n=1941, mean age 14.6 years) in Hawaii, USA. Daily use of e-cigarettes was 2% compared with less than 1% for cigarettes. A second study presented data from the US 2015 National Youth Risk Behavior Survey (n=15 624, 9–12th grade high school students, ages not reported), with daily use of e-cigarettes reported as 0.8%, compared with 0.6% for cigarettes. Neither paper reported on whether the e-cigarettes contained nicotine or other substances.

Added value of this study

Our study adds to the limited evidence base on daily use of e-cigarettes compared with daily cigarette smoking in

adolescents. To our knowledge, our study is the first from a country with strong tobacco control measures (including a ban on tobacco advertising and display, a national smoke free goal, and a ban on the sale of nicotine-containing e-cigarettes before March, 2018) that provides detailed analysis of the youth population who use e-cigarettes or smoke cigarettes daily.

Implications of all the available evidence

Daily use of e-cigarettes and daily cigarette smoking was very low in US youth in 2013 and 2015, and in New Zealand youth between 2015 and 2019. These findings do not support claims of an epidemic of dependence on vaping in either country, although e-cigarette and cigarette use should continue to be monitored at least annually. Our analysis identified subgroups of the population for whom appropriate support around the harms of smoking can be directed. Future youth surveys should report on daily use of e-cigarettes in the context of daily smoking prevalence as a more specific indicator of potential nicotine dependence, and collect information on whether the e-cigarettes used contain nicotine.

July 1, 2018, to June 30, 2019) showed that 12.5% of participants smoked daily, with higher prevalence noted in Māori (indigenous New Zealanders; 30.9%), Pacific people (21.4%), and people from the lowest socioeconomic group (24.0%).¹ By contrast, daily use of e-cigarettes (nicotine use unknown) in adults, although increasing, remains very low (3.2%).¹

Information on youth smoking and e-cigarette use in New Zealand is collected by the government-funded New Zealand Youth Tobacco Monitor (NZYTM), a collaboration between Action for Smokefree 2025 (ASH) and the Health Promotion Agency. The NZYTM consists of two national school-based surveys: the biannual Youth Insights Survey (YIS) reaching approximately 3000 students from Year 10 (typically aged 14–15 years), and the annual ASH Year 10 Snapshot Survey reaching approximately 26 000 students from Year 10. Questions on e-cigarette use were added to the YIS in 2012 and to the ASH Year 10 Survey in 2014. The youth surveys are important as Year 10 is a key time for smoking initiation in New Zealand.² Data from the YIS indicate an increase in the proportion of Year-10 students who have used e-cigarettes, from 7% in 2012 to 29% in 2016^{3,4} (with 1% vaping daily in 2016).⁴ We compare youth uptake of e-cigarettes (on the basis of data from the larger ASH Year 10 Survey), to cigarette smoking for the years 2014–19. We focus on daily use as an indication of potential dependence, and describe patterns of use according to ethnicity, gender, and school decile (an indicator of the extent a school

draws their students from low socioeconomic communities).

Methods

Study design and participants

Each year, principals or deputy principals of all New Zealand schools with Year-10 students are invited to participate in the ASH Year 10 Snapshot Survey from May to July, 30 days into term two of the four term school year so that the responses represent school term time, rather than holiday time. Written consent to participate is provided by principals. Completed forms are sent by courier to the study centre for scanning and coding before analysis. Details of participating schools are confidential. The Multi-region Ethics Committee approved all surveys (MEC/07/10/141).

Procedures

In participating schools, teachers distribute the paper-based questionnaire to all Year-10 students. On the day of the survey students can choose whether to participate but are not informed of the survey's subject or sponsor before the survey is presented, to avoid discussion and potential response bias. The survey takes under 10 min to complete and is anonymous.

The surveys had 22–24 required questions and the surveys for each year are provided in the appendix (pp 14–25). Questions reported on in this paper include age, gender, self-identified ethnicity (students could select more than one ethnicity) and school decile. Gender

See Online for appendix

options were male and female until 2018, with a third option of gender diverse added in 2019 (a definition of gender diverse was not provided). Decile is used in this study as a proxy for socioeconomic status. Decile ranges

from 1 to 10, where decile 1 schools are the 10% of schools with the highest proportion of students from low socioeconomic communities, and decile 10 schools are the 10% of schools with the lowest proportion of

	Total sample (n)	Ever tried*		Daily use		Daily use		Daily use	
		E-cigarettes	p value	Cigarettes	p value	E-cigarettes	p value	Cigarettes	p value
Year									
2014	31 021	6337/30 444 (20.8%)	<0.0001†	7156/31 021 (23.1%)	<0.0001†	NA	<0.0001†	865/30746 (2.8%)	<0.0001†
2015	21 504	4887/21 234 (23.0%)	..	4586/21 504 (21.3%)	..	224/21 098 (1.1%)	..	525/21 504 (2.4%)	..
2016	24 847	6149/24 556 (25.0%)	..	5124/24 847 (20.6%)	..	336/24 333 (1.4%)	..	523/23 931 (2.2%)	..
2017	27 005	7776/26 720 (29.1%)	..	4872/27 005 (18.0%)	..	509/26 525 (1.9%)	..	550/26 593 (2.1%)	..
2018	28 756	9480/28 433 (33.3%)	<0.0001‡	5443/28 756 (18.9%)	0.031‡	494/27 693 (1.8%)	<0.0001‡	543/28 591 (1.9%)	0.075‡
2019	27 354	10 093/27 083 (37.3%)	..	5375/27 354 (19.6%)	..	832/26 532 (3.1%)	..	575/27 212 (2.1%)	..
Ethnicity									
Māori									
2014	6304	2124/6152 (34.5%)	..	2726/6304 (43.2%)	..	NA	..	445/6210 (7.2%)	..
2015	4553	1734/4469 (38.8%)	..	1858/4553 (40.8%)	..	96/4421 (2.2%)	..	274/4553 (6.0%)	..
2016	5227	2189/5134 (42.6%)	..	2119/5227 (40.5%)	..	156/5036 (3.1%)	..	290/4945 (5.9%)	..
2017	5617	2900/5541 (52.3%)	..	2003/5617 (35.7%)	..	245/5458 (4.5%)	..	293/5496 (5.3%)	..
2018	6082	3423/5983 (57.2%)	0.15‡	2235/6082 (36.7%)	0.29‡	233/5778 (4.0%)	<0.0001‡	313/6018 (5.2%)	0.19‡
2019	5664	3265/5577 (58.5%)	..	2136/5664 (37.7%)	..	318/5412 (5.9%)	..	323/5601 (5.8%)	..
Pacific									
2014	3147	811/3055 (26.5%)	..	939/3147 (29.8%)	..	NA	..	101/3100 (3.3%)	..
2015	1975	553/1925 (28.7%)	..	583/1975 (29.5%)	..	50/1911 (2.6%)	..	70/1975 (3.5%)	..
2016	2500	738/2450 (30.1%)	..	729/2500 (29.2%)	..	63/2422 (2.6%)	..	77/2399 (3.2%)	..
2017	2467	773/2410 (32.1%)	..	570/2467 (23.1%)	..	87/2382 (3.7%)	..	85/2405 (3.5%)	..
2018	2614	1046/2556 (40.9%)	0.58‡	644/2614 (24.6%)	0.18‡	70/2460 (2.8%)	0.043‡	76/2581 (2.9%)	0.93‡
2019	2346	963/2308 (41.7%)	..	540/2346 (23.0%)	..	88/2237 (3.9%)	..	67/2325 (2.9%)	..
Non-Māori non-Pacific									
2014	21 569	3402/21 236 (16.0%)	..	3491/21 569 (16.2%)	..	NA	..	319/21 435 (1.5%)	..
2015	14 976	2600/14 840 (17.5%)	..	2145/14 976 (14.3%)	..	78/14 766 (0.5%)	..	181/14 976 (1.2%)	..
2016	17 120	3222/16 972 (19.0%)	..	2276/17 120 (13.3%)	..	117/16 875 (0.7%)	..	156/16 587 (0.9%)	..
2017	18 921	4103/18 769 (21.9%)	..	2299/18 921 (12.2%)	..	177/18 685 (0.9%)	..	172/18 692 (0.9%)	..
2018	20 060	5011/19 894 (25.2%)	<0.0001‡	2564/20 060 (12.8%)	0.0007‡	191/19 455 (1.0%)	<0.0001‡	154/19 992 (0.8%)	0.044‡
2019	19 344	5865/19 198 (30.6%)	..	2699/19 344 (14.0%)	..	426/18 883 (2.3%)	..	185/19 286 (1.0%)	..
Gender									
Male									
2014	15 084	3439/14 741 (23.3%)	..	3337/15 084 (22.1%)	..	NA	..	368/14 945 (2.5%)	..
2015	10 740	2813/10 561 (26.6%)	..	2219/10 740 (20.7%)	..	145/10 493 (1.4%)	..	211/10 740 (2.0%)	..
2016	11 731	3452/11 560 (29.9%)	..	2479/11 731 (21.1%)	..	225/11 423 (2.0%)	..	263/11 240 (2.3%)	..
2017	13 088	4325/12 910 (33.5%)	..	2313/13 088 (17.7%)	..	322/12 811 (2.5%)	..	245/12 846 (1.9%)	..
2018	13 653	5056/13 446 (37.6%)	<0.0001‡	2586/13 653 (18.9%)	0.85‡	304/13 038 (2.3%)	0.0001‡	252/13 555 (1.9%)	0.78‡
2019	13 173	5275/13 002 (40.6%)	..	2507/13 173 (19.0%)	..	464/12 668 (3.7%)	..	237/13 089 (1.8%)	..
Female									
2014	15 937	2898/15 703 (18.5%)	..	3819/15 937 (24.0%)	..	NA	..	497/15 801 (3.1%)	..
2015	10 764	2074/10 673 (19.4%)	..	2367/10 764 (22.0%)	..	79/10 605 (0.7%)	..	314/10 764 (2.9%)	..
2016	13 116	2697/12 996 (20.8%)	..	2645/13 116 (20.2%)	..	111/12 910 (0.9%)	..	260/12 691 (2.0%)	..
2017	13 917	3451/13 810 (25.0%)	..	2559/13 917 (18.4%)	..	187/13 714 (1.4%)	..	305/13 747 (2.2%)	..
2018	15 103	4424/14 987 (29.5%)	<0.0001‡	2857/15 103 (18.9%)	0.18‡	190/14 655 (1.3%)	<0.0001‡	291/15 036 (1.9%)	0.15‡
2019	13 723	4560/13 635 (33.4%)	..	2681/13 723 (19.5%)	..	321/13 429 (2.4%)	..	298/13 666 (2.2%)	..
Gender diverse									
2019	458	258/446 (57.8%)	..	187/458 (40.8%)	..	47/435 (10.8%)	..	40/457 (8.8%)	..

(Table 1 continues on next page)

	Total sample (n)	Ever tried*		Daily use					
		E-cigarettes	p value	Cigarettes	p value	E-cigarettes	p values	Cigarettes	p value
(Continued from previous page)									
Socioeconomic status									
School decile 1-4									
2014	4804	1259/4674 (26.9%)		1748/4804 (36.4%)		NA		245/4735 (5.2%)	
2015	3786	1149/3700 (31.1%)		1316/3786 (34.8%)		86/3674 (2.3%)		200/3786 (5.3%)	
2016	4110	1356/4012 (33.8%)		1460/4110 (35.5%)		106/3962 (2.7%)		211/3922 (5.4%)	
2017	3917	1605/3826 (41.9%)		1217/3917 (31.1%)		184/3787 (4.9%)		207/3820 (5.4%)	
2018	4084	2072/4004 (51.7%)		1374/4084 (33.6%)		166/3862 (4.3%)		217/4037 (5.4%)	
2019	3543	1824/3496 (52.2%)		1205/3543 (34.0%)		165/3358 (4.9%)		210/3497 (6.0%)	
School decile 5-7									
2014	13 612	2859/13 348 (21.4%)		3407/13 612 (25.0%)		NA		441/13 482 (3.3%)	
2015	10 542	2457/10 422 (23.6%)		2366/10 542 (22.4%)		95/10 343 (0.9%)		263/10 542 (2.5%)	
2016	11 332	2974/11 219 (26.5%)		2406/11 332 (21.2%)		156/11 107 (1.4%)		227/10 925 (2.1%)	
2017	12 146	3926/12 028 (32.6%)		2463/12 146 (20.3%)		234/11 933 (2.0%)		260/11 960 (2.2%)	
2018	13 805	4793/13 640 (35.1%)		2725/13 805 (19.7%)		237/13 248 (1.8%)		249/13 725 (1.8%)	
2019	12 878	5019/12 735 (39.4%)		2684/12 878 (20.8%)		413/12 480 (3.3%)		264/12 807 (2.1%)	
School decile 8-10									
2014	12 598	2219/12 415 (17.9%)		2000/12 598 (15.9%)		NA		179/12 522 (1.4%)	
2015	7144	1280/7080 (18.1%)		903/7144 (12.6%)		43/7049 (0.6%)		62/7144 (0.9%)	
2016	9281	1800/9202 (19.6%)		1246/9281 (13.4%)		72/9142 (0.8%)		85/8961 (0.9%)	
2017	10 891	2238/10 816 (20.7%)		1185/10 891 (10.9%)		91/10 755 (0.8%)		83/10 762 (0.8%)	
2018	10 832	2597/10 755 (24.1%)		1326/10 832 (12.2%)		90/10 549 (0.9%)		74/10 794 (0.7%)	
2019	10 821	3213/10 742 (29.9%)		1459/10 821 (13.5%)		252/10 585 (2.4%)		98/10 797 (0.9%)	

NA=not available. *Ever tried, defined as ever tried an e-cigarette (even a single puff or vape) or ever tried a cigarette. †Cochran-Armitage trend test (over time). ‡χ² test comparing 2018 with 2019.

Table 1: Use of e-cigarettes compared with use of cigarettes for Year 10-students in New Zealand, 2014-19

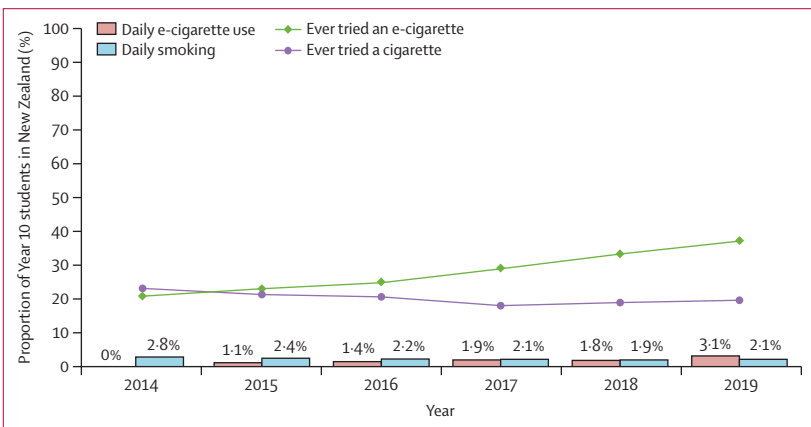


Figure: Use of e-cigarettes and cigarette smoking in Year-10 students in New Zealand, 2014-19
Cochran-Armitage trend test found that all four groups showed a statistically significant trend over time, $p < 0.0001$.

students from low socioeconomic communities. Smoking questions included: have you ever smoked a cigarette, even just a few puffs; and how often do you smoke now (with response options of: I have never smoked or I do not smoke now, at least once a day, at least once a week, at least once a month, and less often than once a month). The 2014 survey was the first to

include a question on e-cigarettes, asking students if they had “ever tried e-cigarettes”. In subsequent surveys a second e-cigarette question was added on current use of an e-cigarette (with response options of: never tried, at least once a day, at least once a week, at least once a month, and less often than once a month). From 2016 onwards, additional information was added to the questions to clarify that e-cigarettes can also be known as “e-cigs, vapes or personal vaporisers”. No pictures of e-cigarettes were provided, and no questions were asked about use of nicotine or flavours, whether e-cigarettes were used to help quit smoking, or use of other forms of combustible tobacco or nicotine.

Statistical analysis

Analyses were restricted to students aged 14 and 15 years who had complete data on gender, ethnicity, and whether they had ever smoked a cigarette. Simple descriptive data are presented related to smoking status (ever tried, regular use, monthly, weekly, and daily use), e-cigarette use (ever tried, regular use, monthly, weekly, and daily use), and dual use (smokes daily and uses an e-cigarette daily), according to survey year, gender, ethnicity, and school decile. Ever tried is defined as having ever tried an e-cigarette or cigarette. Regular use is defined as at least daily, weekly, or monthly use. We used the Statistics

New Zealand standard to allocate students who identify with more than one ethnic group into a single category for analysis; specifically, students were prioritised as Māori, Pacific, or non-Māori non-Pacific (ie, European, Asian, and other ethnic groups). We did χ^2 analyses to compare categorical variables and Cochran-Armitage trend tests to assess changes over time. For the 2019 data, we used multiple logistic regression analyses to determine predictors of e-cigarette and cigarette use, and included ethnicity (Māori vs non-Māori non-Pacific; Pacific vs non-Māori non-Pacific), gender (male vs female; gender diverse vs female), and socioeconomic status (low school decile vs high school decile; mid school decile vs high school decile) in the model and calculated odds ratios and 95% CI. All analyses were done with SAS version 9.4.

Role of the funding source

The funder of the study had no role in the study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

Between 2014 and 2019, the proportion of schools in New Zealand with a Year-10 class that participated in the survey ranged from 39% to 54% (mean 50%, SD 5.8) and student participation ranged from 36% to 52% (mean 45%, SD 5.4; appendix p 3). Demographic characteristics were similar across survey years, with about 21% of students identifying as Māori, 9% as Pacific, 51% female, and 15% from low-decile schools (appendix pp 3–4). The sample moderately and consistently under-represented students from low-decile schools and over-represented students from mid-decile schools (appendix pp 3–4).

Between 2014 and 2019, there was a significant increase in the proportion of students who had ever tried e-cigarettes: from 20.8% (6337 of 30444) to 37.3% (10093 of 27083; $p < 0.0001$), and the proportion who had ever smoked cigarettes decreased significantly from 23.1% (7156 of 31021) to 19.6% (5375 of 27354; $p < 0.0001$, table 1; figure). This pattern was the same irrespective of ethnicity, gender, and school decile (table 1). Between 2018 and 2019 (a period when access to nicotine e-cigarettes increased in New Zealand) the proportion of students who had ever tried e-cigarettes increased from 33.3% (9480 of 28433) to 37.3% (10093 of 27083; $p < 0.0001$), with significant increases noted for non-Māori non-Pacific students, male and female students, and students from mid-decile and high-decile schools (table 1). A small but significant increase in the proportion of students who had ever smoked a cigarette (even a puff) was also observed between 2018 and 2019: from 18.9% (5443 of 28756) to 19.6% (5375 of 27354; $p = 0.031$), with significant increases noted for non-Māori non-Pacific students, and students from mid-decile and

	E-cigarettes		Cigarettes	
	OR (95% CI)	p value	OR (95% CI)	p value
Ever tried				
Ethnicity				
Non-Māori non-Pacific	1 (ref)	..	1 (ref)	..
Māori	2.86 (2.69–3.06)	<0.0001	3.14 (2.92–3.37)	<0.0001
Pacific	1.40 (1.27–1.53)	<0.0001	1.45 (1.30–1.62)	<0.0001
Gender				
Female	1 (ref)	..	1 (ref)	..
Male	1.38 (1.31–1.45)	<0.0001	0.96 (0.90–1.02)	0.17
Gender diverse	2.81 (2.31–3.42)	<0.0001	2.99 (2.45–3.65)	<0.0001
Socioeconomic status				
High	1 (ref)	..	1 (ref)	..
Low	1.72 (1.53–1.88)	<0.0001	2.15 (1.95–2.37)	<0.0001
Medium	1.34 (1.26–1.41)	<0.0001	1.45 (1.35–1.55)	<0.0001
Daily use				
Ethnicity				
Non-Māori non-Pacific	1 (ref)	..	1 (ref)	..
Māori	2.52 (2.15–2.95)	<0.0001	4.54 (3.74–5.52)	<0.0001
Pacific	1.62 (1.27–2.07)	0.0001	1.94 (1.43–2.62)	<0.0001
Gender				
Female	1 (ref)	..	1 (ref)	..
Male	1.56 (1.35–1.80)	<0.0001	0.80 (0.67–0.95)	0.013
Gender diverse	4.98 (3.59–6.89)	<0.0001	4.34 (3.02–6.23)	<0.0001
Socioeconomic status				
High	1 (ref)	..	1 (ref)	..
Low	1.39 (1.12–1.73)	0.015	3.74 (2.88–4.86)	<0.0001
Medium	1.21 (1.03–1.42)	0.021	1.78 (1.41–2.26)	<0.0001

OR=odds ratio.

Table 2: Multiple logistic regression analyses of e-cigarette and tobacco use in 2019 for key demographic variables

high-decile schools (table 1). In 2019, Māori students were almost three times more likely to have ever tried e-cigarettes or tobacco cigarettes, and Pacific students were almost 1.5 times more likely to have ever tried e-cigarettes or tobacco cigarettes than were non-Māori non-Pacific students (table 2). Students from low-decile and mid-decile schools were significantly more likely to have ever tried e-cigarettes or ever smoked cigarettes than were those from high-decile schools (table 2). Students who were gender diverse were three times more likely to have ever tried e-cigarettes or cigarettes than were female students, and male students were more likely to have ever tried an e-cigarette than were female students (table 2).

Daily e-cigarette use significantly increased between 2015 and 2019, and daily use of cigarettes significantly declined between 2014 and 2019 (table 1, figure). However, daily use of either product was very low (<4%), irrespective of the year (table 1, figure). Between 2018 and 2019 the proportion of students who were daily e-cigarette users increased from 1.8% (494 of 27693) to 3.1% (832 of 26532; $p < 0.0001$), with significant increases

	Total sample (n)	Ever tried e-cigarettes*	Daily use of e-cigarettes
Never smoked			
2014	23 479	2613/23 479 (11.1%)	NA
2015	16 760	2196/16 760 (13.1)	59/16 665 (0.4%)
2016	19 525	2800/19 525 (14.3%)	84/19 402 (0.4%)
2017	21 917	3997/21 917 (18.2%)	164/21 775 (0.8%)
2018	23 059	4862/23 059 (21.1%)	101/22 513 (0.4%)
2019	21 776	5349/21 776 (24.6%)	175/21 385 (0.8%)
Regular smoker†			
2014	1806	1285/1806 (71.2%)	NA
2015	1127	828/1127 (73.5%)	88/1114 (7.9%)
2016	1088	861/1088 (79.1%)	125/1064 (11.7%)
2017	1254	1118/1254 (89.2%)	181/1242 (14.6%)
2018	1400	1323/1400 (94.5%)	194/1351 (14.4%)
2019	1553	1488/1553 (95.8%)	364/1513 (24.1%)
Daily smoker			
2014	833	634/833 (76.1%)	NA
2015	509	398/509 (78.2%)	50/499 (10.0%)
2016	513	414/513 (80.7%)	85/498 (17.1%)
2017	530	486/530 (91.7%)	109/520 (21.0%)
2018	533	504/533 (94.6%)	99/509 (19.4%)
2019	548	518/548 (94.5%)	159/536 (29.7%)

All groups had a statistically significant increase over time (Cochran-Armitage trend test, $p < 0.0001$). NA=not available. *Ever tried, defined as ever tried an e-cigarette (even a single puff or vape). †Regular use, defined as smoked at least daily, weekly, or monthly.

Table 3: E-cigarette use according to smoking status in Year 10 students in New Zealand, 2014–19

noted for all subgroups except for students from low-decile schools (table 1). There was no change in the prevalence of daily smoking between 2018 and 2019, overall and by subgroup, with the exception of non-Māori non-Pacific students, for which a small but significant increase in daily smoking was observed from 0.8% (154 of 19 992) in 2018 to 1.0% (185 of 19 286; $p = 0.044$; table 1). In 2019, daily use of e-cigarettes was 2.5-times higher and daily smoking 4.5-times higher in Māori students than in non-Māori non-Pacific students (table 2). We observed a social gradient, with low-decile and mid-decile schools significantly more likely to have students who were daily users of e-cigarettes or cigarettes than high-decile schools (table 2). Male students were about 1.5 times more likely than female students to use e-cigarettes daily, but less likely to smoke cigarettes daily (table 2). Students who were gender diverse were five times more likely to be daily e-cigarette users and more than four times more likely to smoke daily than female students. The prevalence patterns of regular, monthly, and weekly use of e-cigarettes or cigarettes are consistent with those of daily use (appendix pp 5–10).

In absolute numbers, over the past 5–6 years, most students who had ever tried e-cigarettes were non-smokers, but very few were daily e-cigarette users. In 2019, 24.6% (5349 of 21 776) of non-smokers reported

ever trying an e-cigarette, but only 0.8% (175 of 21 385) were daily users of e-cigarettes (table 3). In comparison, almost all regular or daily smokers in 2019 had tried an e-cigarette (table 3), and about a third of daily smokers also used e-cigarettes daily (equivalent to 0.6% [159 of 27 633] of all Year-10 students surveyed).

Discussion

Between 2014 and 2019, an increase in the proportion of 14–15 year old students who had ever tried an e-cigarette was observed, along with a general decline in the proportion of youth who had ever smoked cigarettes. In 2019, the proportion of Year-10 students who had ever tried an e-cigarette exceeded the proportion who had ever tried a cigarette, irrespective of ethnicity, gender, or school decile. A small but significant increase in those who had ever tried a cigarette was noted between 2018 and 2019 (overall, and for non-Māori non-Pacific students and students from mid-decile and high-decile schools), but no significant increase in daily cigarette use was observed (except for in non-Māori non-Pacific students). Ever tried or daily use of an e-cigarette in 2019 was predominantly in existing smokers and students who were Māori, Pacific, male, gender diverse, or from low-decile and mid-decile schools. However, between 2015 and 2019, daily use of either product was extremely low. Daily use of e-cigarettes by non-smokers was rare.

Our findings emphasise that the overall pattern of increasing e-cigarette use observed in the smaller YIS^{3,4} is continuing. The YIS reports on the key predictors of ever trying e-cigarettes, namely: male gender, having a higher weekly allowance, being close friends with someone who smoked, having used other tobacco products (that were not cigarettes) in the past month, and having ever smoked marijuana or engaged in binge drinking.³ More recent data on reasons for use of e-cigarettes by New Zealand youth are not available. No data exist on how the students obtained e-cigarettes.

Our finding that ever having smoked is declining while having ever tried an e-cigarette is increasing among New Zealand youth is consistent with data from youth in the UK^{5–7} and the USA,^{8–10} but it differs from Canada, where among youth aged 16–19 years an increase in ever having used an e-cigarette or cigarette from 2017 to 2018 was observed.¹⁰ A narrative review of e-cigarettes and equity found that e-cigarette use is more common in Caucasians, male middle-school and high-school students, and those who are more affluent.¹¹ We also observed a higher prevalence of e-cigarette use in male students, and e-cigarette and cigarette use was more prevalent in less affluent populations and Māori, a finding also seen in New Zealand adults.¹ On the basis of this finding, and the decline in smoking in New Zealand youth and adults, we hypothesise that e-cigarettes might be displacing smoking in populations that have the highest prevalence of tobacco-related mortality and

morbidity. The lower price of e-cigarettes compared with cigarettes in New Zealand could be one reason for this change, given that people who smoke in these populations are extremely price sensitive.¹² Our observation of high amounts of experimentation with e-cigarettes or cigarettes, but a low amount of regular use, has also been observed in youth surveys from other countries,^{5–10,13–16} despite the different between-country policies. Notably, data on daily e-cigarette use and daily smoking are rarely published, despite the public health importance of these measures; we found only two papers presenting these data.^{17,18} One was a survey of 1941 high-school students in Hawaii, USA, in 2013, which found that 2% of students used e-cigarettes daily and 0.8% smoked tobacco daily.¹⁷ The second paper, reporting on the US 2015 National Youth Risk Behavior Survey (n=15 624), found that 0.8% of students had used e-cigarettes daily in the past 30 days and 0.6% had smoked cigarettes daily in the past 30 days.¹⁸ Neither paper reported daily use by demographic variables, whether nicotine was vaped, or data on daily dual use (although the 2015 study found that past 30-day use of e-cigarettes in past 30-day users of cigarettes was 7.5%).¹⁸ This broader definition of dual use has been used in other youth surveys, with findings ranging from 0.3% to 1.6%.^{13,19} These studies are more than 4 years old, and therefore might not reflect current youth uptake in the USA given the rapidly evolving e-cigarette market. The US ‘Monitoring the Future’ surveys reported a higher proportion of frequent nicotine vaping by youth in 2019 than was observed in the aforementioned studies (ie, prevalence of ≥ 20 days use in the past 30 days was 1.9% for 8th grade, 6.9% for 10th grade, and 11.7% for 12th grade).¹⁵ The 2019 US National Youth Tobacco Survey found the prevalence of more than 20 day use in the past 30 days was approximately 9.2% (927 of 10 097) for e-cigarettes and 1.8% for cigarettes (178 of 10 097) in all high-school students surveyed (numerators estimated from percentages provided in table 3 of this publication).¹⁶ A number of surveys between 2015 and 2018 from other countries have reported on e-cigarette use by adolescents who have never smoked, with those having ever tried an e-cigarette ranging from 4% to 20%.^{6,10} use of more than 15 days in the past 30 days ranging from 0.1% to 1.5%,⁶ and weekly use ranging from 0.1% to 0.5%.¹⁰

In New Zealand, the mean duration from smoking initiation to daily use is 2.5 years.² We investigated smoking and e-cigarette use in older youth and young adults in New Zealand and found similar patterns of use to the Year-10 population. Although the prevalence of daily smoking in 15–17 years olds was higher than that seen in 14–15 year olds in 2014 (5.8% vs 2.8%), daily smoking in 15–17 year olds has decreased over time (from 5.8% in 2014–15 to 3.0% in 2018–19).¹ Daily smoking has also decreased over time among 18–24-year-olds (20.2% in 2014–15 to 15.0% in 2018–19) and 25–34-year-olds (19.3% in 2015–16 to 15.5% in 2018–19).¹ In comparison, daily e-cigarette use in these age groups

increased over time (15–17 years, from 0.1% in 2015–16 to 1.7% in 2018–19; 18–24 years, from 1.0% in 2015–16 to 4.5% in 2018–19; 25–34 years, from 1.1% in 2015–16 to 5.1% in 2018–19).¹ Whether these cohorts of e-cigarette users are smokers, ex-smokers, people who had never smoked, or people who had experimented with e-cigarettes in the past and moved to more regular use over time remains unknown. However, a 2016 online survey of New Zealand vapers (n=218) found that the majority were smokers or ex-smokers—ie, only 1.4% of vapers had never smoked.²⁰

Strengths of our study include the large sample size, enabling detailed reporting by demographic variables and frequency of product use. Many youth surveys only report on the proportion of youth who have ever tried e-cigarettes or regular use of e-cigarettes or cigarettes (commonly defined as use in the past 30 days), and either fail to capture or do not report information on daily use, or define use as 20 days or more in the past 30 days (with the denominator as use in the last 30 days). A second strength is the inclusion of a large Māori student sample, enabling greater precision in the prevalence estimates for this indigenous population. Having robust data for Māori is important, given that this population have a higher prevalence of tobacco use and resulting inequity in health status than do non-Māori populations in New Zealand. Another strength included recording use of e-cigarettes and cigarettes by gender diverse youth, which has previously never been reported in New Zealand (more detailed analysis of this population will be the focus of a subsequent paper).

We acknowledge the limitations of the study. First, findings are not fully generalisable; although each wave of the survey was large, only a third to half of the Year-10 population completed each survey. However, the sample population closely matches the total Year-10 population in age, gender, ethnicity, and in high-decile schools. Second, e-cigarette use might be underestimated because no pictures were used to prompt recall, and the wide variety of terms used to describe e-cigarettes were not provided until 2016 (and even then, were not exhaustive). Third, data were not weighted to account for the under-representation of students from low-decile schools or over-representation of students from mid-decile schools, so findings might not fully reflect product use in these population subgroups. Fourth, no question asked if nicotine was used in the e-cigarettes or the types or brands of e-cigarettes used. This information is also not available from other sources, although two New Zealand surveys of adults (2016, 218 vapers;²⁰ 2017–18, 1099 current and ex-smokers)²¹ reported that the majority of e-cigarette users had tank-type devices and used nicotine. Advertising and sale of nicotine e-liquid was prohibited in New Zealand until March 12, 2018 (although known to be available) so we cannot assume students trying e-cigarettes were exposed to nicotine. We used daily product use as an indicator of potential nicotine

dependence, but not all daily users are dependent.²² Fifth, the survey did not ask about other sources of nicotine (eg, nicotine replacement therapy) or tobacco products (eg, cigarillos, cigars, heated tobacco products). No data from New Zealand are available on the use of such products by this age cohort. The use of other tobacco products is likely to be extremely low on the basis of New Zealand tobacco return data (in 2016, cigars and cigarillos made up 0.4% of the New Zealand tobacco market and pipe tobacco made up 0.09%²³) and smokeless tobacco and heated tobacco products were banned in New Zealand before March 12, 2018. Sixth, multiple tests of significance were undertaken, increasing the chances of type 1 error. Finally, because these surveys are cross-sectional in design, we are unable to determine a student's progression from e-cigarette use to cigarette use, or vice versa. International evidence also indicates that vaping is not leading to subsequent smoking in young people, although the quality of the evidence is not always robust.^{24–26} Even if trying e-cigarettes leads to more regular use, or increased smoking initiation in some youth, these behaviours should be weighed against the possibility that e-cigarettes could decrease the risk of smoking initiation and support smoking cessation.^{26–30}

In conclusion, our findings do not support the notion of a so-called vaping epidemic in New Zealand or a large youth population dependent on vaping—a finding consistent with the scarce international evidence. Experimentation with e-cigarettes appears consistent with a risk-taking youth population,^{3,17,31} and is likely to be less harmful than other behaviours such as hazardous drinking in the past 12 months (11.0% of 15–17-year-olds and 41.6% of 18–24-year-olds in 2018–2019) and use of cannabis in the past 12 months (28.6% of 15–24-year-olds in 2018–19).¹ Although a small yet significant increase in daily e-cigarette use by youth over the past year was observed (but no statistically significant increase observed in daily cigarette smoking), we are unable to determine whether these changes were directly related to the March, 2018, change in access to nicotine e-cigarettes in New Zealand. However, there has been a marked increase in marketing and availability of e-cigarettes, and an emergence and promotion of new heated tobacco products on the New Zealand market in the past 12 months, meaning that the situation should continue to be monitored closely. Future surveys of this nature should include questions on vaping nicotine (although 2013–14 UK data reported that 33–40% of students did not know if nicotine was in their device)⁷ and nicotine dependence, reasons for using e-cigarettes, device type and how it was obtained, perceptions of relative harm, and other sources of tobacco and nicotine. Finally, more detailed information on the frequency of e-cigarette use is vital; commonly used terms such as ever tried and regular use (eg, at least daily, weekly, or monthly use) are likely to reflect experimenting behaviour (as often seen in youth) and not dependence. However, daily use is

more likely to indicate dependence. Any proposed vaping legislation in New Zealand should strike a balance between encouraging adult smokers to switch to vaping and ensuring that daily vaping in youth remains low.

Contributors

BB and SFW oversaw the conduct of the study and data collection. SFW and VP did the statistical analyses, with all other authors interpreting the data. NW led the writing of the first draft of the manuscript, and all authors were involved in subsequent drafts; NW is guarantor for this paper. All authors read and approved the final manuscript.

Declaration of interests

NW, VP, and CB report grants from New Zealand Ministry of Health, during the conduct of the study; grants from Pfizer, and the Health Research Council of New Zealand, outside of the submitted work; and have undertaken a trial of e-cigarettes used with and without nicotine patches for smoking cessation (with e-cigarettes purchased from a New Zealand e-cigarette online retailer (NZVAPOR, <https://www.nzvapor.com/>), e-liquid purchased from Nicopharm, Australia (<https://www.nicopharm.com.au/>), and nicotine patches supplied by the New Zealand Government via their contract with Novartis (Sydney, Australia). NZVAPOR also provided, (at no cost to trial participants) online and phone support regarding use of the e-cigarettes. Neither NZVAPOR nor Nicopharm have links with the tobacco industry. None of the aforementioned parties had any role in the design, conduct, analysis, or interpretation of the trial findings, or writing of the resulting publication. CB also reports personal fees from Johnson and Johnson, grants from Cure Kids Foundation, and other funds from Sanitarium outside of the submitted work. SFW reports grants from New Zealand Ministry of Health, during the conduct of the study. RB, BY, and BB declare no competing interests.

Data sharing

Requests for access to the data or study documents will be considered for cases in which proposed use aligns with public good purposes, does not conflict with other requests or planned use by the study authors or the New Zealand Youth Tobacco Monitor Research Coordinating Group, and the requestor is willing to sign a data access agreement. Contact is through the corresponding author.

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