

Gateway theory

There is a longitudinal association between adolescent vaping and smoking initiation. However after adjusting for covariates (common risk factors eg demographic characteristics, use of other psychoactive substances, perceived peer cigarette use, risk-taking, socially maladaptive behaviors, attitude toward smoking, and parental education using propensity scoring), the association reduces substantially or disappears completely

Expert groups			
Pesko M. United States public health officials need to correct e-cigarette health misinformation. Addiction 2023	2023	Michael F. Pesko; K. Michael Cummings; Clifford E. Douglas; Jonathan Foulds; Thomas Miller; Nancy A. Rigotti; Kenneth E. Warner	Significant evidence now exists that this association between vaping and smoking is not causal. Survey data show youth cigarette use declining steadily despite vaping increasing.
ASH brief for local authorities on youth vaping. Action on Smoking and Health, UK. August 2022	2022	Action and Health UK. Annual surveys	<p>There is NOT strong evidence that vaping is a gateway into smoking. Some who try vaping first may go on to smoke cigarettes, but this association works both ways and there are common risk factors for both behaviours; this does not prove that vaping caused subsequent smoking.</p> <p>If vaping were a gateway into smoking, you'd expect as vaping increased that smoking rates would stop declining or start to increase again. To the contrary between 2012 and 2018 when e-cigarette use grew rapidly from a low base in England, smoking rates continued to fall. Among 11-15 year olds current smoking fell from 8% to 5% and ever having tried smoking from 23% to 16%, and among those aged 16+ smoking rates fell from 20% to 16%, which DOES NOT support the gateway hypothesis.</p>
Commentaries			
Delnevo C. e-Cigarette and Cigarette Use Among Youth: Gateway or Common Liability? JAMA Network Open 2023	2023	Invited editorial, JAMA	At the population level, e-cigarettes do not appear to be a gateway to cigarette smoking. Collectively, concerns about a gateway effect and a potential increase in youth cigarette use following the introduction of e-cigarettes to the US market are not supported by the data.
Studies			
Kim S. The relationship between Electronic cigarettes and smoking is largely attributable to shared risk factors. Nicotine Tobacco Research 2019	2019	This study uses propensity score methods to robustly adjust for 14 associated shared risk factors - demographic characteristics, use of other psychoactive substances, perceived peer cigarette use, risk-taking, socially maladaptive behaviors, attitude toward smoking,	The apparent relationship between e-cigarette use and current conventional smoking is fully explained by shared risk factors , thus failing to support claims that e-cigarettes have a causal effect on concurrent conventional smoking among youth.

		and parental education using propensity scoring	
Lee PN. Considerations related to vaping as a possible gateway into cigarette smoking: an analytical review. F1000Research 2019	2019	Review of 15 studies of the gateway effect, examining how extensively they adjusted for confounders, and examined trends in youth smoking and e-cigarette use from national surveys.	A true gateway effect in youths has not yet been demonstrated. Even if it were, e-cigarette introduction may well have had a beneficial population health impact.
Cheng HG. E-cig use and onset of first cigarette smoking among adolescents. An empirical test of the 'common liability' theory F1000 Res 2020	2020	PATH study We include various sets of covariates that have been shown to be associated with smoking onset.	After controlling for a latent construct representing a “common liability to use tobacco products”, ever e-cigarette use does not predict the onset of cigarette smoking Our findings provide supporting evidence for the ‘common liability’ theory for the US youth population as a whole.
Sun R. K Is adolescent e-cigarette use associated with subsequent smoking A new look. Nicotine Tobacco Research 2021	2021	Longitudinal data from PATH Study 2013-2019 Comprehensive adjustment for risk factor variables. “No previous study has included all of the covariates in the present study”	Among adolescent never cigarette smokers, those who had ever used e-cigarettes at baseline, compared with never e-cigarette users, exhibited modest or non-significant increases in subsequent past 12-month or past 30-day smoking when adjusting for a more complete set of behavioral risk factors. With the full set of covariates, the results for the last two wave comparisons were nonsignificant for past 12-month smoking
Sun R. Association of e-cig use by US adolescents with subsequent persistent cig smoking. JAMA N Open 2023	2023	Longitudinal data of non-smoking adolescents age 12-17, from PATH Study 2015-2019. Examined the association of adolescent e-cigarette use at baseline with continued cigarette smoking 3 years later, following smoking initiation a year after baseline	Regardless of e-cigarette use status, few cigarette-naïve adolescents (4.1%) initiated cigarette smoking and even fewer (<2.5%) continued to smoke at all in 3 years. There is a positive association between e-cigarette use and subsequent smoking in terms of aORs. However, given the low prevalence of smoking, the absolute risks of continued smoking for both e-cigarette users and nonusers and the risk differences between them are very small. The change in the prevalence of cigarette smoking due to e-cigarette use at the population level is, thus, also very small.
Wamba A. Impact of ecig experimentation and use on smoking behaviour among adolescents 15-16 in the Loire Department, France. TPC 2023	2023	Observational, cross sectional N=6622, aged 15-16	Our data suggest that vaping has a rather marginal impact on smoking initiation among French adolescents aged 15–16 years in the Loire department. They therefore neither confirm nor completely disprove the gateway effect theory, relating to use of tobacco subsequent to vaping.
Shahab L. Unpacking the gateway hypothesis of e-cigarette use. The need for triangulation of individual	2022	Analysis using triangulation of different kinds of studies	Based on the current balance of evidence, using triangulated data from recent population-level cross-contextual comparisons, individual-level genetic analyses and modelling, we do believe, however, that causal claims about a strong gateway effect

and population-level data. Nicotine Tobacco Research 2022			from e-cigarettes to smoking are unlikely to hold, while it remains too early to preclude other smaller or opposing effects.
Pesola F. Effects of reduced-risk nicotine-delivery products on smoking prevalence and cigarette sales: an observational study. Public Health Research	2023	pre-specified dynamic time series analyses to explore associations between use and sales of alternative nicotine-delivery products and smoking prevalence and cigarette sales , and time series analyses to compare trends of smoking prevalence in countries with different nicotine product policies: AU, UK, US	Prof Peter Hajek : ““The results of this study alleviate the concern that access to e-cigarettes and other low-risk nicotine products promote smoking. There is no sign of that, and there are some signs that they in fact compete against cigarettes, but more data over a longer time period are needed to determine the size of this effect.”
Delnevo CD. Dramatic Reductions in Cigarette Smoking Prevalence among High School Youth from 1991 to 2022 Unlikely to Have Been Undermined by E-Cigarettes. IJERPH	2023	Population study Examined trends in the MTF, NYRBS and NYTS from 1991-2022	Current cigarette smoking reached its peak in 1997, and then significantly declined from 1997 to 2013 in the NYRBS and MTF and similarly in the NYTS from 1999 to 2018. Declines in current smoking then accelerated in all surveys through to 2022. These findings suggest dramatic successes in reducing youth smoking since the late 1990s, with more rapid declines in prevalence in the past decade. “Concerns about a potential rise in adolescent cigarette use following the introduction of e-cigarettes to the U.S. market in the early 2010s are not supported by the data. In fact, the emergence of e-cigarettes has coincided with the most rapid declines in cigarette use over the past thirty years”

Diversion studies

Modelling and population studies suggest that vaping is diverting young people from smoking. Smoking and vaping are ‘economic substitutes’

Modelling studies			
Foxon F. Electronic Cigarettes, Nicotine Use Trends, and Use Initiation Ages among US Adolescents from 1999–2018. Addiction 2020	2020	Population trend modelling NYTS. Adolescents 12-17. Projections from counterfactual models on data from 1999-2009 compared to actual trends based on data 1999-2018	Observed adolescent cigarette smoking from 2010-2018 is lower than expected based on trends from pre-2010, coinciding with a rise in adolescent e-cigarette use
Selya AS. Trends in ecig use and conventional smoking - quantifying a possible diversion effect US adolescents.	2021	NYTS 2000-2019. Adolescents 12-17. Simulation model	A simulation model shows that a substantial diversion effect is needed to explain observed nicotine use trends among US adolescents, and it must be larger than any possible opposing catalyst effect, if present.

Addiction 2021			
Sokol NA. High school seniors who used ecigs may have otherwise been cig smokers. Nic Tob Res 2021	2021	MTF 2009-2018, 12 th grade. Modelling study. Compared forecasted to observed smoking and ecig prevalence annually	The decline in current smoking among 12th graders has accelerated since e-cigarettes have become available from 2014. The introduction of e-cigarettes has coincided with an acceleration in the decline in youth smoking rates, suggesting e-cigarettes may have replaced cigarette smoking
Other studies			
Walker N. Use of e-cigarettes and smoked tobacco in youth aged 14–15 years in New Zealand: findings from repeated cross-sectional studies (2014–19). Lancet Pub Health 2020.	2020	Annual ASH Year 10 survey 2014-2019. Adolescents 14-15. Repeat cross sectional studies	All measures of e-cigarette use increased and all measures of cigarette use decreased or remained static over time. The overall decline in smoking over the past 6 years in New Zealand youth suggests that e-cigarettes might be displacing smoking.

Natural experiments

“Additional evidence inconsistent with the causal connection between youth nicotine vaping and smoking uptake comes from natural experiments evaluating how e-cigarette restrictions adopted by some localities but not others at a given point in time have impacted youth cigarette smoking. Collectively, these natural experiment studies suggest that e-cigarettes reduce youth cigarette use in the aggregate, which aligns with observed trends.”

Access			
Friedman, A. S. How does electronic cigarette access affect adolescent smoking? Journal of Health Economics. 2015	2015	Smoking rates in US states with bans on e-cigarette sales to minors 12-17 compared to smoking rates in states with no ban	Reducing e-cigarette access increases smoking among 12 to 17 year olds. Bans yield a statistically significant 0.9 percentage point increase in recent smoking in this age group, relative to states without such bans.
<i>Abouk R. Bans on electronic cigarette sales to minors and smoking among high school students. J Health Econ. 2017</i>	2017	US 12 th grade students Changes in smoking and vaping in 3 US states before and after e-cigarette youth sales bans (data from MTF); compared to control states with no ban	E-cigarette sales bans to youth reduce the incidence of cigarette smoking and of e-cigarette usage [Note study with different findings]
Prices and tax			
Cantrell, J., Impact of e-cigarette and cigarette prices on youth and young adult e-cigarette and cigarette	2020	Aged 15-21 2014-2016	“Higher cigarette prices were associated with increased past 30-day e-cigarette use, indicating e-cigarettes may serve as a substitute for cigarettes. Depending on model specifications, the results indicated that a 10% increase in

behaviour: Evidence from a national longitudinal cohort. Tobacco Control, 2020			cigarette prices could increase e-cigarette use by 5.8%–9.4%”
Pesko, M. F. Re-exploring the early relationship between teenage cigarette and e-cigarette use using price and tax changes. Health Economics, 2022	2022	Cigarette prices from Nielson Smoking and ecig data from NYTS 2011-2015	“Our study contributes some evidence that e-cigarettes and cigarettes are economic substitutes for youth. A \$1 increase in e-cigarette cartridge prices, for example, causes teenagers to smoke 4.6 extra cigarettes per month (3 extra packs among teenager smokers)”
Abouk, R. Intended and unintended effects of e-cigarette taxes on youth tobacco use. Journal of Health Economics, 2023	2023	Monitoring the Future and the Youth Risk Behavior Surveillance System 2010-2019. Comparing 10 states and 2 large counties	We find that ENDS taxes reduce youth ENDS consumption, with estimated ENDS tax elasticities of -0.06 to -0.21. However, we estimate sizable positive cigarette cross-tax effects , suggesting economic substitution between cigarettes and ENDS for youth. These substitution effects are particularly large for frequent cigarette smoking. We conclude that the unintended effects of ENDS taxation may considerably undercut or even outweigh any public health gains.
Age of sale			
Pesko, M. F. The influence of electronic cigarette age purchasing restrictions on adolescent tobacco and marijuana use. Preventive Medicine. 2016	2016	Adolescent smoking rates in US states with minimum legal age of purchase compared with states with no restrictions	We found causal evidence that ENDS age purchasing restrictions increased adolescent regular cigarette use by 0.8 percentage points. ENDS. We document a concerning trend of cigarette smoking among adolescents increasing when ENDS become more difficult to purchase
Dave, D. The effects of e-cigarette minimum legal sale age laws on youth substance use. Health 2019	2019	YRBSS data US State differences	“our findings suggest a possible unintended effect of e-cigarette MLSA laws (minimum legal age of sale laws)—rising cigarette use in the short term while youth are restricted from purchasing e-cigarettes. Our results suggest that these laws increased youth smoking participation by about one percentage point,”
Pesko MF, Currie JM. E-cigarette minimum legal sale age laws and traditional cigarette use among rural pregnant teenagers. J HealthEcon. 2019	2019	Birth records, National Center for Health Statistics US MLSA state laws	“We use cross-sectional and panel data models to find that e-cigarette minimum legal sale age laws increase underage pregnant teenagers’ smoking by 2.1 percentage points”
Pesko, M. F. Effects of e-cigarette minimum legal sales ages on youth tobacco use in the United States. Journal of Risk and Uncertainty. 2023	2023	NYTS, multiple waves 2000-2017, <18 years, n= 251,229 Compares US states with MLSAs with states without MLSAs	Minimum legal sale age for e-cigarette are estimated to reduce lifetime e-cigarette use by approximately 25% and increase daily cigarette use and daily cigar use by approximately 35% . Therefore, these MLSAs operate as intended in reducing e-cigarette use, although at the expense of more dangerous combustible tobacco use.

Vaping first

There is growing evidence that those who vape first (before smoking) are less likely to smoke later, compared to those who smoke first

<p>Chyderiotis S. Does e-cigarette experimentation increase the transition to daily smoking among young ever-smokers in France? Drug Alcohol Depend 2020</p>	<p>2020</p>	<p>French study of 39,115 adolescents</p>	<p>We found no evidence of an increased risk of transitioning to daily smoking at 17 among ever-smokers who also experimented with e-cigarettes</p>
<p>Shahab L. Association of initial e-cigarette and other tobacco product use with subsequent smoking in adolescents. Tob Control 2021</p>	<p>2021</p>	<p>NYTS 2014-2017, Cross sectional propensity matched control study of 78,265 adolescents</p>	<p>Relative to behavioural controls, adolescents who tried e-cigarettes first were less likely to have ever smoked cigarettes (26% vs CT (42.4%; OR 0.48, 95% CI 0.40 to 0.57) Around a quarter of e-cigarette initiators go on to try cigarettes subsequently. However <1% of adolescents trying an e-cigarette first became established cigarette smokers, This study suggests that for adolescents initiation with e-cigarettes is associated with a reduced risk of subsequent cigarette smoking compared with initiators with other combustible and non-combustible tobacco products use, and propensity score matched adolescents without initial e-cigarette use. This suggests that, over the time period considered, e-cigarettes were unlikely to have acted as an important gateway towards cigarette smoking and may, in fact, have acted as a gateway away from smoking for vulnerable adolescents;</p>
<p>Legleye S. Experimenting first with e-cigarette versus first with cigarette and transition to daily cigarette use among adolescents. Addiction 2021</p>	<p>2021</p>	<p>French adolescents (n = 24 111), aged 17 to 18.5 years,</p>	<p>Experimenting with e-cigarettes first (as opposed to tobacco first) appears to be associated with a reduction in the risk of daily tobacco smoking among French adolescents aged 17–18.5. Exposure reduced the risk of transition to daily smoking: RR = 0.58, 95% confidence interval (CI) = 0.54, 0.62.</p>
<p>Xu S. Relationships Between E-cigarette Use and Subsequent Cigarette Initiation Among Adolescents in the PATH Study : an Entropy Balancing Propensity Score Analysis. Prev Sci 2021</p>	<p>2021</p>	<p>PATH study Waves 1-3 entropy balancing propensity score analysis</p>	<p>Use of e-cigarettes in nicotine- and tobacco-naïve youth is associated with an increased risk of subsequently using combustible cigarettes but the risk is an order of magnitude higher if they start with a combustible cigarette. (OR = 25.79, 95% CI = (9.68, 68.72)).</p>
<p>Stanton CA. Predictors of E-cigarette and Cigarette Use Trajectory Classes from Early Adolescence to Emerging Adulthood Across Four Years (2013-2017) of the PATH Study. Nicotine Tobacco Research 2023</p>	<p>2023</p>	<p>PATH study 2013-2017, n+ 10,086</p>	<p>There was no evidence that initiation with e-cigarettes as the first product tried was associated with cigarette progression</p>

Mus S. First tobacco product tried and current use of cigarettes and ecigs among adolescents from Guatemala City. SPM 2023	2023	Cross sectional study, 10 schools, grade 8-12. N=2,870	Guatemalan adolescents who had previously tried tobacco products indicated that those who first tried e-cigarettes were less likely to be current smokers , whether they were exclusively smoking or dual using, compared to those who first experiment with cigarettes.
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Decline in or stable smoking

Increases in youth vaping have been accompanied by an accelerated decline in smoking since vaping became popular in the US, UK and New Zealand, suggesting either no overall gateway effect or at most, a small gateway effect that is outweighed by the much larger number moving from smoking to vaping

Levy DT. Examining the relationship of vaping to smoking initiation among US youth and young adults: a reality check. Tobacco control. 2019	2019	NYTS, MTF, YRBS Linear statistical regression model	Observed adolescent cigarette smoking from 2014-2017 is lower than expected based on trends from pre-2014, coinciding with a rise in adolescent e-cigarette use “While trying electronic cigarettes may causally increase smoking among some youth, the aggregate effect at the population level appears to be negligible ”
Centers for Disease Control and Prevention. Smoking & tobacco use; Historical NYTS data and documentation, 1999-2021. 2021	2021	NYTS	Accelerated decline in youth smoking since 2013 as vaping increased. Vaping now decreasing substantially since 2020

			<p style="text-align: center;">Cigarette smoking and Vaping, US High schoolers National Youth Tobacco Surveys (CDC) Grades 9-12, ages 15-18 Past 30-day use</p> <table border="1"> <caption>Estimated data from the graph</caption> <thead> <tr> <th>Year</th> <th>Smoking (%)</th> <th>Vaping (%)</th> </tr> </thead> <tbody> <tr><td>2004</td><td>22.3</td><td>0</td></tr> <tr><td>2005</td><td>20.0</td><td>0</td></tr> <tr><td>2006</td><td>19.0</td><td>0</td></tr> <tr><td>2007</td><td>18.5</td><td>0</td></tr> <tr><td>2008</td><td>18.0</td><td>0</td></tr> <tr><td>2009</td><td>17.5</td><td>0</td></tr> <tr><td>2010</td><td>17.0</td><td>0</td></tr> <tr><td>2011</td><td>16.5</td><td>0</td></tr> <tr><td>2012</td><td>16.0</td><td>0</td></tr> <tr><td>2013</td><td>15.5</td><td>0</td></tr> <tr><td>2014</td><td>14.5</td><td>1.5</td></tr> <tr><td>2015</td><td>14.0</td><td>3.0</td></tr> <tr><td>2016</td><td>13.5</td><td>4.5</td></tr> <tr><td>2017</td><td>13.0</td><td>6.0</td></tr> <tr><td>2018</td><td>12.5</td><td>7.5</td></tr> <tr><td>2019</td><td>12.0</td><td>27.5</td></tr> <tr><td>2020</td><td>11.5</td><td>19.0</td></tr> <tr><td>2021</td><td>11.0</td><td>11.5</td></tr> <tr><td>2022</td><td>2.0</td><td>14.1</td></tr> </tbody> </table>	Year	Smoking (%)	Vaping (%)	2004	22.3	0	2005	20.0	0	2006	19.0	0	2007	18.5	0	2008	18.0	0	2009	17.5	0	2010	17.0	0	2011	16.5	0	2012	16.0	0	2013	15.5	0	2014	14.5	1.5	2015	14.0	3.0	2016	13.5	4.5	2017	13.0	6.0	2018	12.5	7.5	2019	12.0	27.5	2020	11.5	19.0	2021	11.0	11.5	2022	2.0	14.1	
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<p>Meza, R. Trends in tobacco use among adolescents by grade, sex, and race, 1991-2019. JAMA Network Open, 2021</p>	2021	<p>Monitoring the Future survey, US 1991-2019 Students in 8th, 10th, 12th grades</p>	<p>This cross-sectional study suggests that, despite the increase in the prevalence of e-cigarette use among adolescents between 2011 and 2019, the prevalence of cigarette and smokeless tobacco use has decreased more rapidly during the same period compared with earlier years.</p>																																																													
<p>NHS Digital. Smoking, drinking and drug use among young people in England, 2021. 2022</p>	2022	<p>NHS Digital 2003-2021 11-15 year olds</p>	<p>The decline in smoking accelerated after 2013 as vaping became more popular</p>																																																													
<p>ASH year 10 survey 2022</p>		<p>Annual smoking and vaping survey, year 10. New Zealand</p>	<p>Accelerated decline in smoking since vaping legalised in 2020 and youth vaping increased. Daily smoking now 1.1%</p>																																																													
<p>Sreeramareddy C. Changes in e-cigarette use, cigarette smoking, and dual use among the youth (13-15 years) in 10 countries (2013-2019) - analyses of Global Youth Tobacco Surveys (GYTS). Nic Tob Res 2023</p>	2023	<p>Vaping and smoking 2013-19 in 13-15 year olds 10 countries: Georgia, Iraq, Italy, Latvia, Montenegro, Paraguay, Peru, Qatar, Romania, and San Marino</p>	<p>Cigarette smoking significantly declined in Italy, Latvia, Peru, and San Marino ($p < 0.05$) (the countries with the highest vaping rates) but remains unchanged in other countries.</p>																																																													

Association not causation

Scully M. E-cigarette use and other risk factors associated with tobacco smoking susceptibility among Australian adolescents. ANZJPH 2023	2017	ASSAD 2017 Cross sectional 12-17yo Victorian youth n-3410	Survey of Victorian youth 12-17y <ul style="list-style-type: none"> → Finds #ecig use associated with "susceptibility" to smoke → Admits unable to draw causal inferences → But then argues for regulations to reduce youth vaping to reduce smoking!