Differential Effects: When E-cigarette Policies Contribute to Health Inequities

Tobacco Online Policy Seminar

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Disclosure

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I have not received any tobacco-related funding in the last 10 years.

Introduction

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- E-cigarettes are a less harmful substitute for combustible tobacco
- Flavor restrictions decrease the appeal of vaping
- Tobacco use is higher among lower-educated and lower-SES groups

Questions

1. Does substitution in response to flavor restrictions differ by education?
2. Do these policies reduce or exacerbate existing disparities?

E-cigarettes and Health

- **Less unhealthy than combustible tobacco:** National Academies of Sciences, Engineering, and Medicine (2018); Dai et al. (2022); McNeill et al. (2022); Hiler et al. (2023); Hammond et al. (2025); Allcott and Rafkin (2022)
- **Useful for smoking cessation:** Lindson et al. (2025)
- **Contribute to nicotine initiation and addiction**

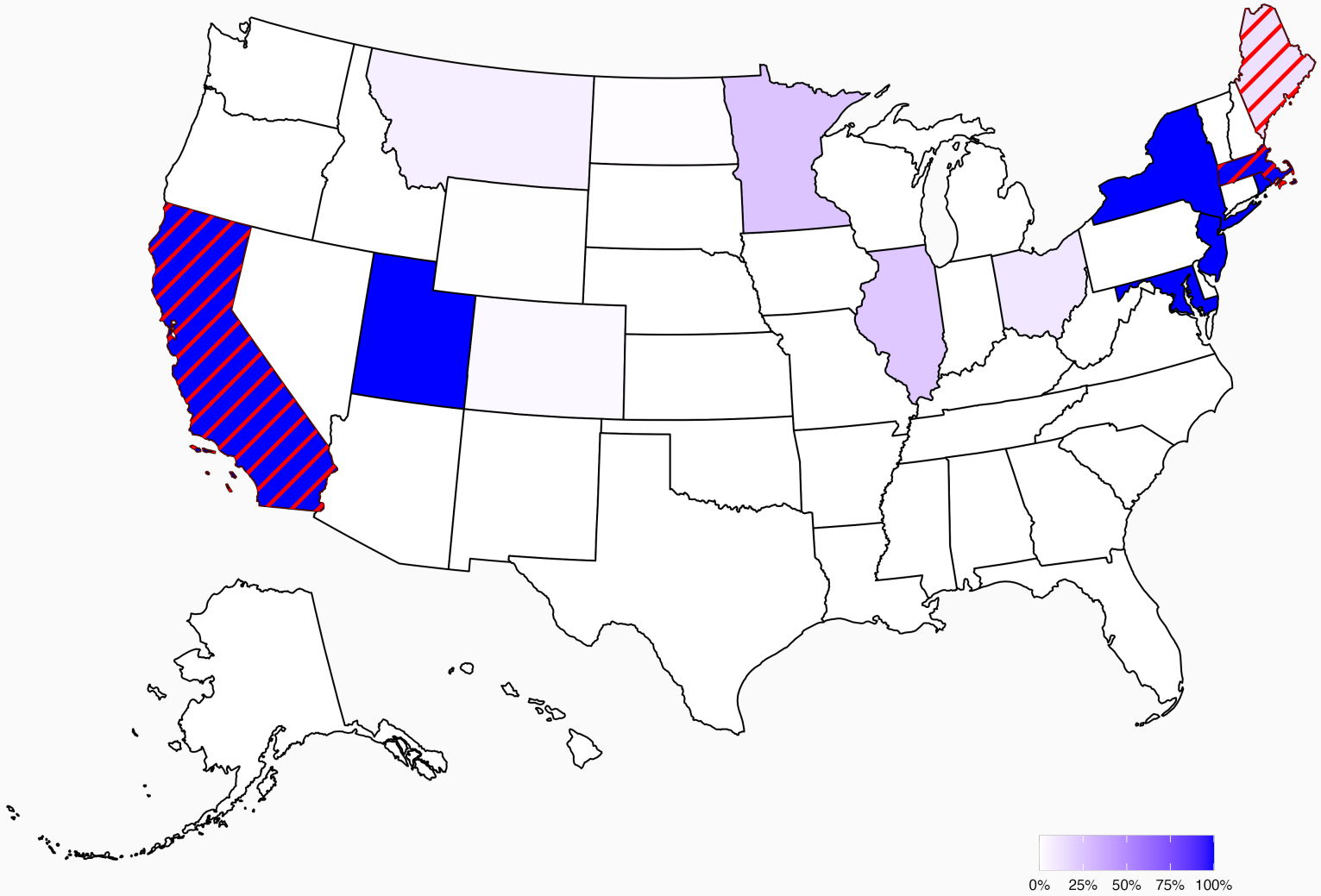
E-cigarettes and Substitution

- **MLSA:** Friedman (2015); Abouk and Adams (2017); Dutra et al. (2018); Dave et al. (2019); Pesko et al. (2020)
- **Tax (adults):** Pesko et al. (2020); Saffer et al. (2020); Friedman and Pesko (2022); Abouk et al. (2023)
- **Tax (youth):** Saffer et al. (2020); Pesko and Warman (2022)
- **Tax (sales data):** Allcott and Rafkin (2022); Cotti et al. (2022)
- **Flavor Restrictions:** Xu et al. (2022); Friedman et al. (2024); Chen et al. (2024); Saffer et al. (2025); Cotti et al. (2025); Friedman et al. (2025); Cheng et al. (2025)

E-cigarette Flavor Restrictions

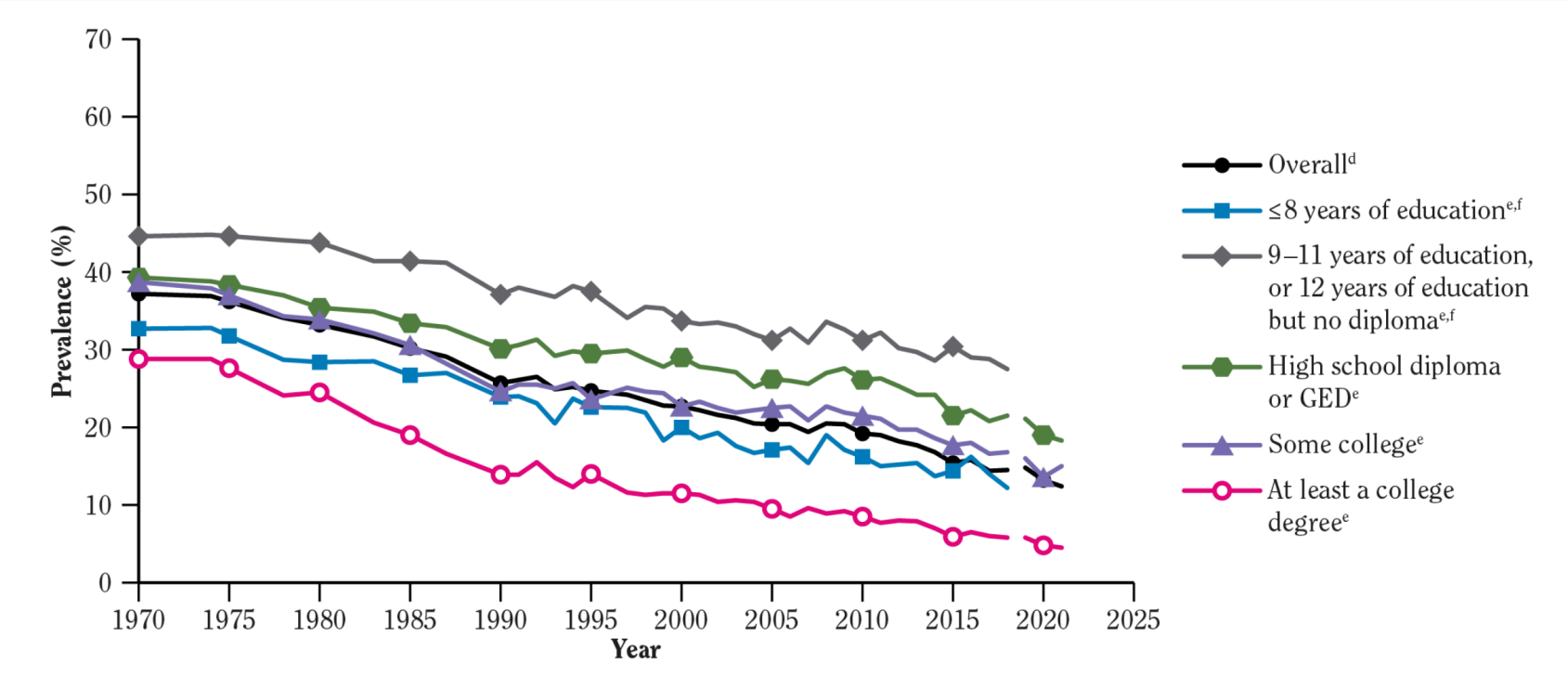
- As early as 2012 at local level
- Statewide bans as a consequence of EVALI in 2019
- Statewide flavor policies:
  - Massachusetts (2019)
  - Rhode Island (2020)
  - New Jersey (2020)
  - New York (2020)
  - Utah (2020)
  - California (2022)
- Other policies
  - Maryland (2020)
  - District of Columbia (2021)

E-cigarette Flavor Restrictions



Whitacre et al. (2025)

Current Smoking by Education



NHIS, 1970–2021. U.S. Department of Health and Human Services (2024) Fig 2.4

2024 no college - any college gap:

- 21-29: **+7.3**ppt
- 30-54: **+12.1**ppt

Education and Policy

1. **Differential Exposure**
   - By design, e.g., MLSA
   - Jurisdictional differences[1]
2. **Differential Responsiveness**
   - Causal effect of education
   - Common factor influencing education and response, e.g., time preference
   - Differences in choice set by education, e.g., health insurance
   - Greater benefit from a choice, e.g., due to higher addictive stock

[1] Centers for Disease Control and Prevention (2025); Hafez et al. (2019); Whitacre et al. (2025)

Response to Flavor Restrictions

Flavor restrictions decrease appeal of vaping, and could lead to substitution towards cigarettes for individuals who have:

1. Nicotine addiction (higher with stronger addiction)
2. Lower perceived risk of cigarettes relative to vapes
3. Lower social penalty from smoking (e.g., greater peer acceptance)

[2] U.S. Department of Health and Human Services (2024)

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2. Lower perceived risk of cigarettes relative to vapes
3. Lower social penalty from smoking (e.g., greater peer acceptance)

All three of these are more common among lower-educated groups.[2]

[2] U.S. Department of Health and Human Services (2024)

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2. Do these policies reduce or exacerbate existing disparities?

Data and Methods

Data - BRFSS

BRFSS, 2016-2024

- Balanced panel of 29 states with vaping questions in all years[3]
- No state has 2019 data on vaping
- 21-29 and 30-54 age groups
- Classify as **No College** or **Any College**

[3] Excludes California, DC, and New Jersey

Data - Flavor Policies

- %Pop covered by vaping flavor restriction (state + local)[4]
- State policies: Massachusetts, New York, Rhode Island, Utah
- Local policies only: Colorado, Illinois, Maine, Minnesota, North Dakota, and Ohio
- Separate Maryland policy[5]

[4] Whitacre et al. (2025)

[5] Friedman et al. (2025)

Difference-in-Differences

$$
\begin{aligned}
Y_{ist} = \beta_0 + \beta_1 FlvPol_{st} + \beta_2 Ed_{ist} + \beta_3 (FlvPol_{st} \times Ed_{ist}) \\
+ \gamma X_{ist} + \eta (Z_{st} \times Ed_{ist}) \\
+ \delta_t + (\delta_t \times Ed_{ist}) + \sigma_t + (\sigma_t \times Ed_{ist}) + \varepsilon_{ist}
\end{aligned}
\tag{1}
$$

- Y_{ist}: Current (past 30 day), Daily, Exclusive Smoking & Vaping
- Z_{ist}: Policy Covariates interacted with Ed_{ist}[6]
- X_{st}: Demographic and Policy Covariates[7]
- β_1 shows effect for any college group; $\beta_1 + \beta_3$ for no college

[6] FlvPol(MD), Combustible tobacco flv policy, Ban All ENDS, Interim flv ENDS Ban, Cigarette Tax, Cigar Tax, ENDS Tax, SFW, VFW

[7] Includes all covariates interacted with Ed_{ist} plus: sex, Race, Age, Cell Phone Survey, MCL, RCL, Beer Tax, COVID Deaths, Nonessential Business Closure, EVALI Deaths, (NY,UT,OR,MI) Interim EVALI Ban, Unemployment

Counterfactual National Policy Prediction, 2024

1. Run DD model
2. Set flavor policy variable to 1 for all states
3. Predict outcomes
4. Compare outcome means by education for 2024

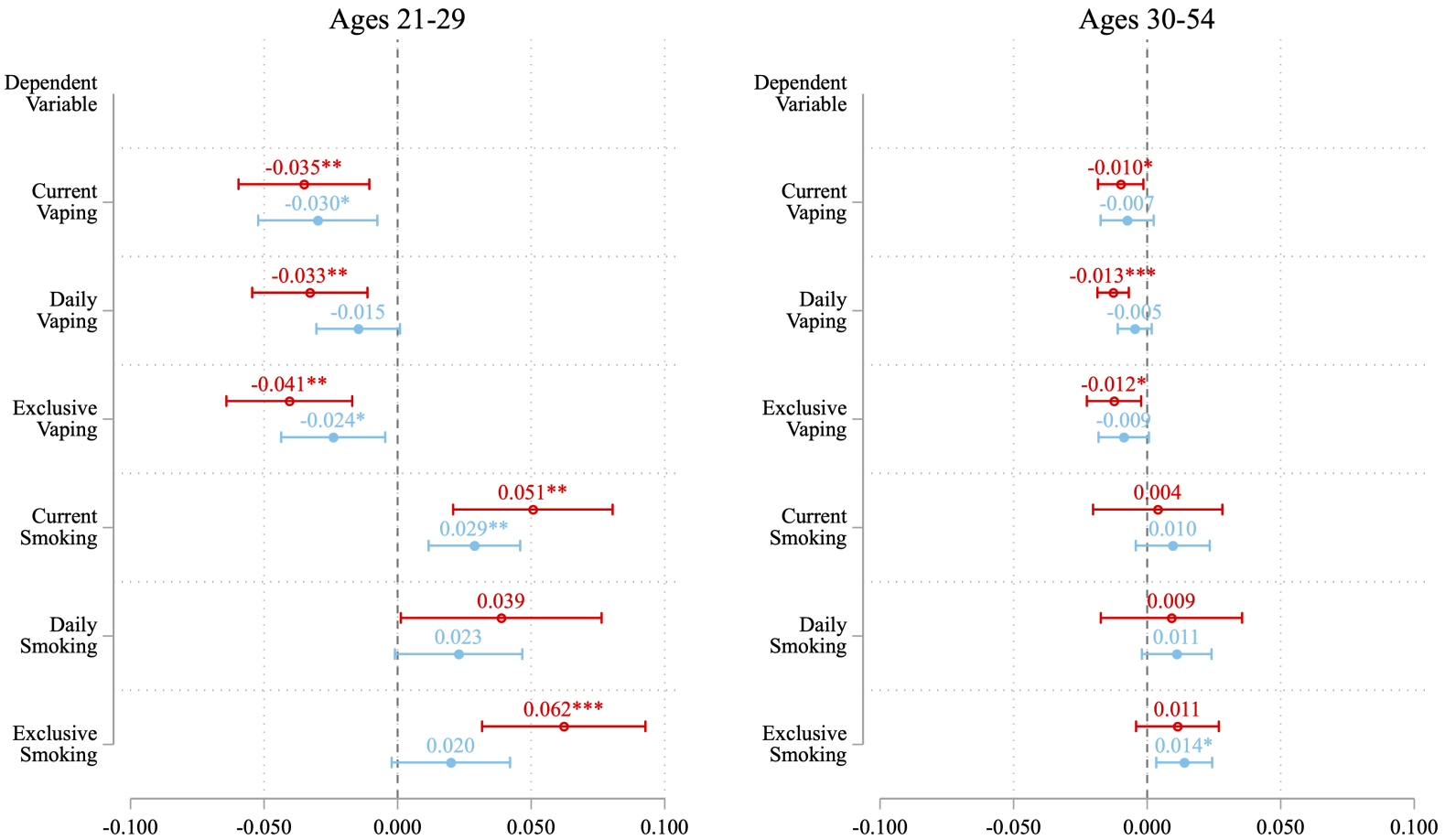
Results

Descriptive Findings

- Any College: more likely to be female, non-Hispanic, and white
- No College: Lower tobacco taxes, fewer local flavor policies, lower exposure to SFW and VFW laws
- Higher smoking and ENDS use among those with less education

Summary Statistics

Flavor Policy Effect by Education



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Daily Vaping, Exclusive Smoking difference** $p < 0.01$
Exclusive Vaping, Current Smoking difference† $p < 0.1$

Robustness

- Balanced panel composition CurENDS CurSmk
- Staggered policy adoption
- State+Local versus state only flavor restrictions Statewide
- Inference ES Vaping ES Smoking
- “Any college” versus college completion Alt Edu
- Sensitivity to individual treated states New York

Counterfactual National Policy, Education Gap, 21-29, 2024

Vaping	Current	Daily**	Exclusive†
2024 Gap	0.075	0.062	0.045
Δ Change in Gap	-0.007	-0.016	-0.015
% Change in Gap	-9%	-26%	-35%

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Smoking	Current†	Daily	Exclusive**
2024 Gap	0.073	0.043	0.043
Δ Change in Gap	+0.018	+0.013	+0.034
% Change in Gap	+25%	+31%	+79%

Vaping Smoking 30-54

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Simulated Changes Under National Policy, 21-29, 2024

- Using estimates from the American Community Survey:[8]

	Any College	No College
Exclusive Vapers	-370,000	-578,000
Exclusive Smokers	+370,000	+850,000
Dual Users	-60,000	+97,000

[8] Ruggles et al. (2025)

Projected Cancer Deaths Under National Policy, 21-29, 2024

- Cancer accounts for 34.1% of smoking-attributable mortality[9]
- $\sim$ 15% of smokers develop lung cancer[10]
- Lung cancer has a 5-year survival rate of approximately 30%[11]
- Assume vaping is half as likely to result in lung cancer as smoking (Note Allcott and Rafkin (2022) survey 37%)
- Any College: +34,000 cancer deaths
- No College: +39,000 cancer deaths
- Gap of 5,000 lives

[9] US Department of Health and Human Services (2014)

[10] Tindle et al. (2018)

[11] Surveillance Research Program, National Cancer Institute (2026)

Conclusion

Limitations

1. Limited vaping data, missing 2019
2. Marginal differences in coefficients $\Rightarrow$ Valid predictions?
3. How correlated are education and urbanicity? Urbanicity Testing
4. Nicotine initiation among under-21?

Summary and Implications

- Education disparities in smoking are substantial, even in younger age groups
- In response to flavor restrictions:
  - $\uparrow$ education $\Rightarrow \downarrow$ substitution to smoking
  - $\downarrow$ education $\Rightarrow \uparrow$ substitution to smoking
- Policy intended to reduce harm increases existing health disparities
- Does this extend to other policies on the education margin?
- Does this also occur along the margin of other disparities?

Appendix

Urbanicity versus Education Disparities

- Should urbanicity be incorported in the analysis?[12]
- Metropolitan status coded in CPS-TUS, 2014-2023
- Employ Kitagawa-Oaxaca-Blinder (KOB) decomposition[13]
- Compare Education and Metro Status
  - Metro Status explains $\sim$ 3% of Education Gap
  - Education explains $\sim$ 20% of Metro Status Gap
- Education is the more predictive covariate for disparities

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[12] Deryugina and Molitor (2021)

[13] Kitagawa (1955); Oaxaca (1973); Blinder (1973)

Summary Statistics, BRFSS, 2016-2024

	21-29		30-54	
	Any College	No College	Any College	No College
Current Vaping	0.112	0.166	0.055	0.078
Daily Vaping	0.048	0.085	0.025	0.034
Exclusive Vaping	0.086	0.107	0.034	0.039
Current Smoking	0.088	0.221	0.124	0.276
Daily Smoking	0.046	0.146	0.082	0.204
Exclusive Smoking	0.060	0.154	0.103	0.234

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Counterfactual National Policy, 30-54, 2024

Vaping	Current	Daily	Exclusive
2024	0.045	0.025	0.021
Δ	-0.002	-0.007	-0.003
% Change	-4%	-28%	-14%

Smoking	Current	Daily	Exclusive
2024	0.121	0.090	0.096
Δ	-0.004	-0.001	-0.002
% Change	-3%	-1%	-2%

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Heterogeneity by State: New York

- Dropping NY state $\rightarrow$ larger effects on smoking
- NYC has a prior flavor restriction
- Match BRFSS to BRFSS SMART[14] and identify respondents in NYC's five boroughs:
    1. Drop NYC, keep rest of NY State: attenuated estimate for smoking and vaping
    2. Drop NY State, keep NYC: increased effect, but less than dropping all of NY
- Conclusion: Flavor restriction was effective in NYC but state policy was less impactful

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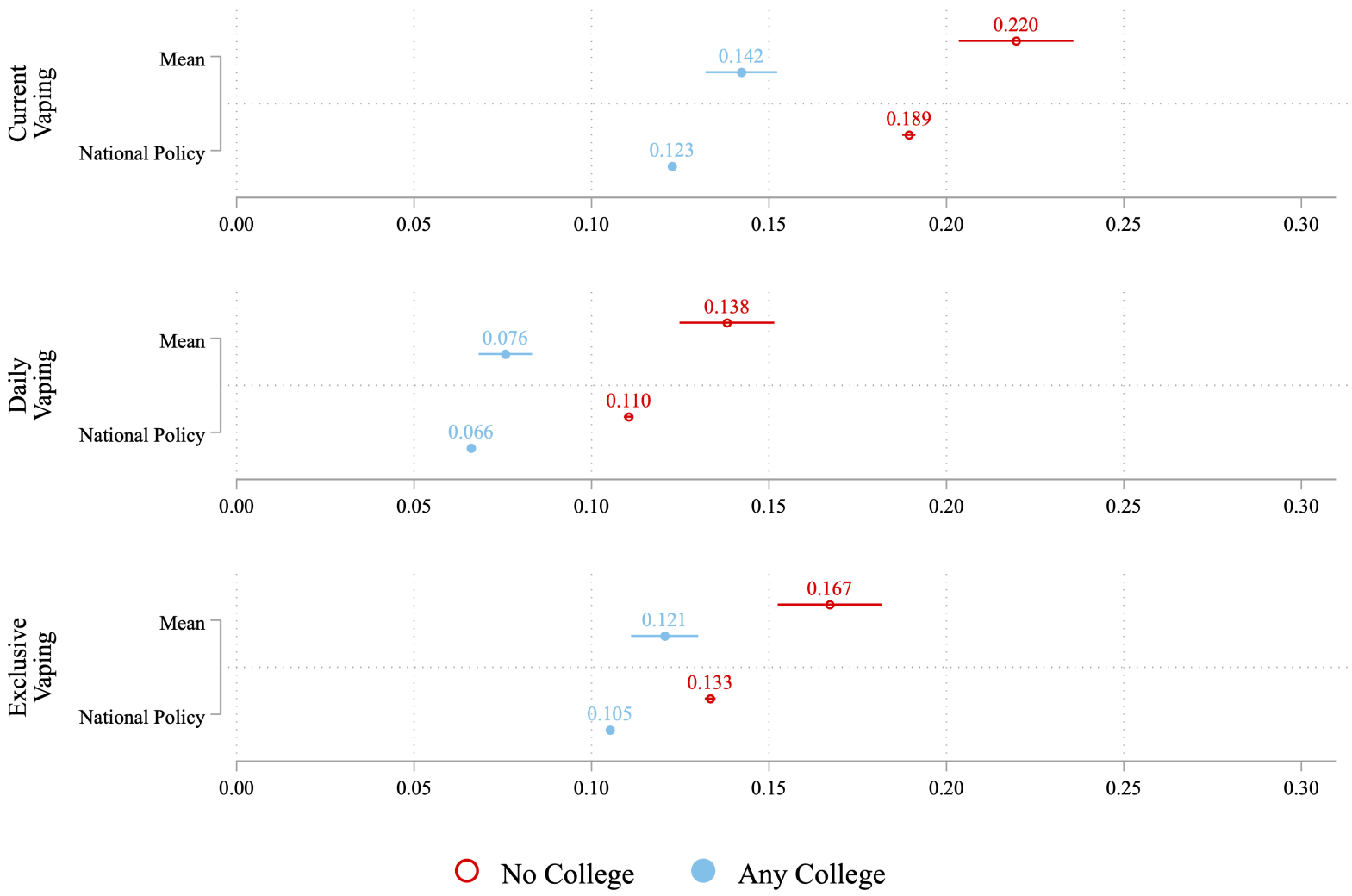
[14] Selected Metropolitan/Micropolitan Area Risk Trends

Counterfactual National Policy, Vaping, 21-29, 2024



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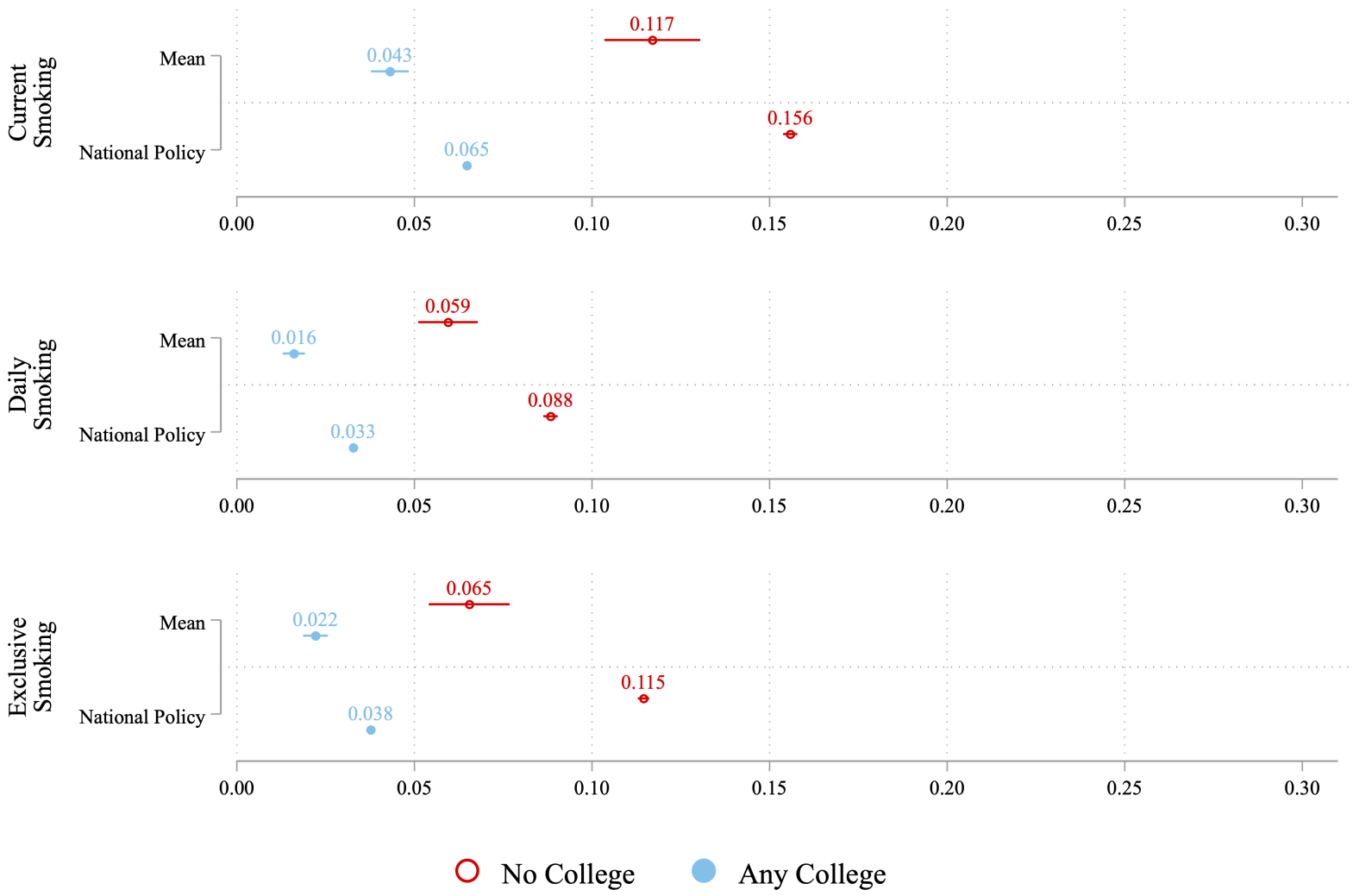
Counterfactual National Policy, Smoking, 21-29, 2024



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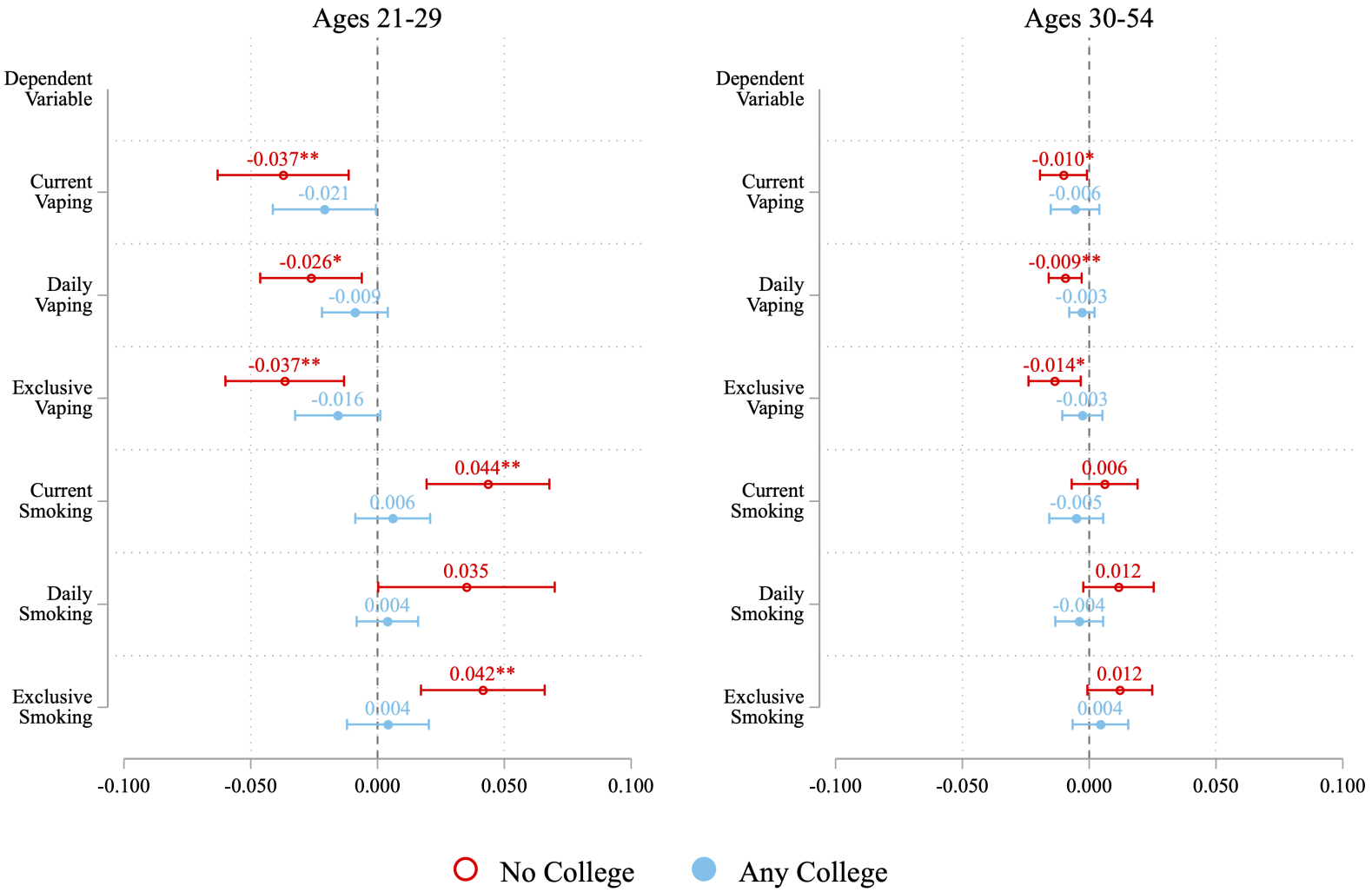
Alternate Education Specification



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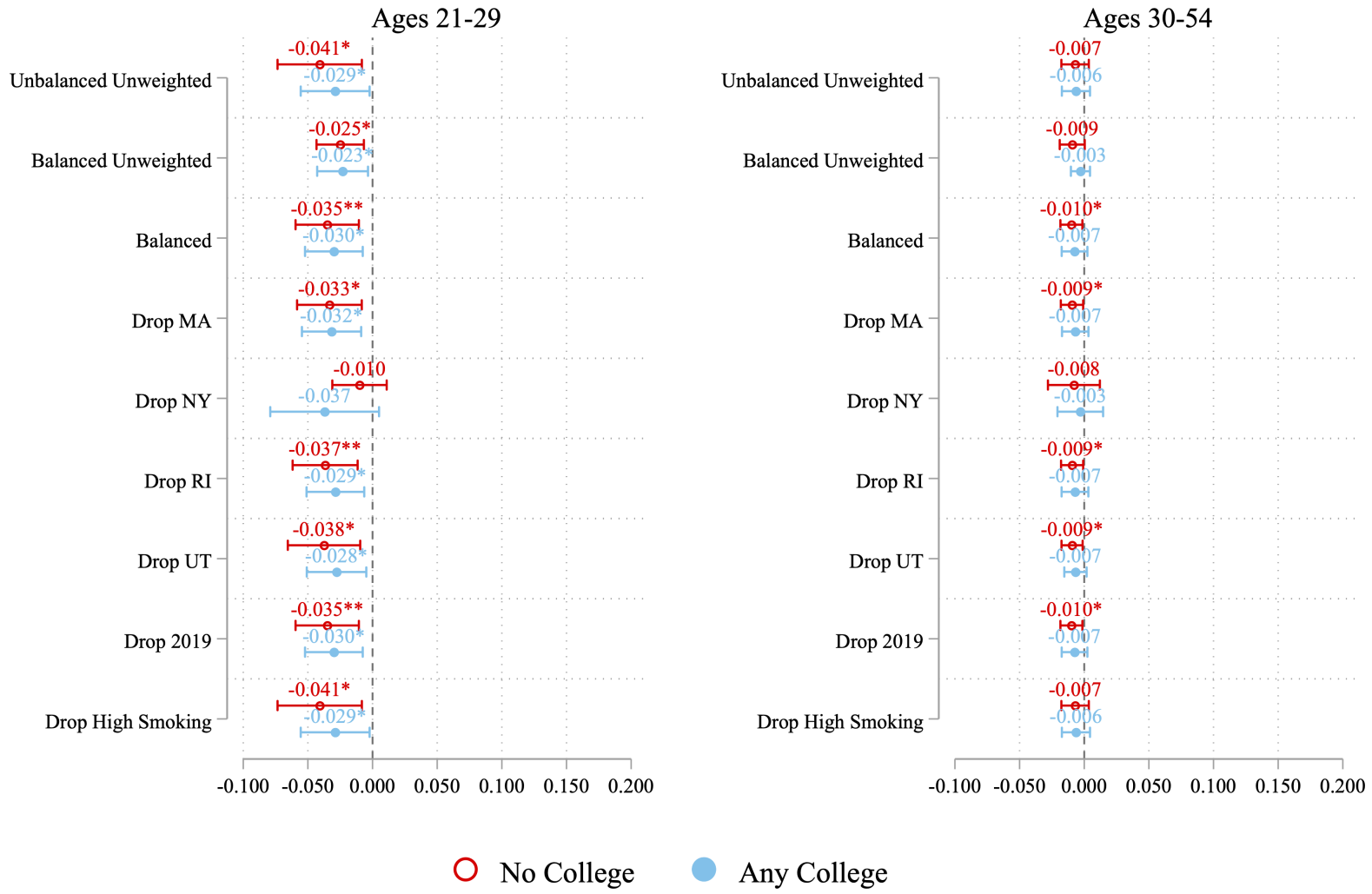
Robustness: Current ENDS



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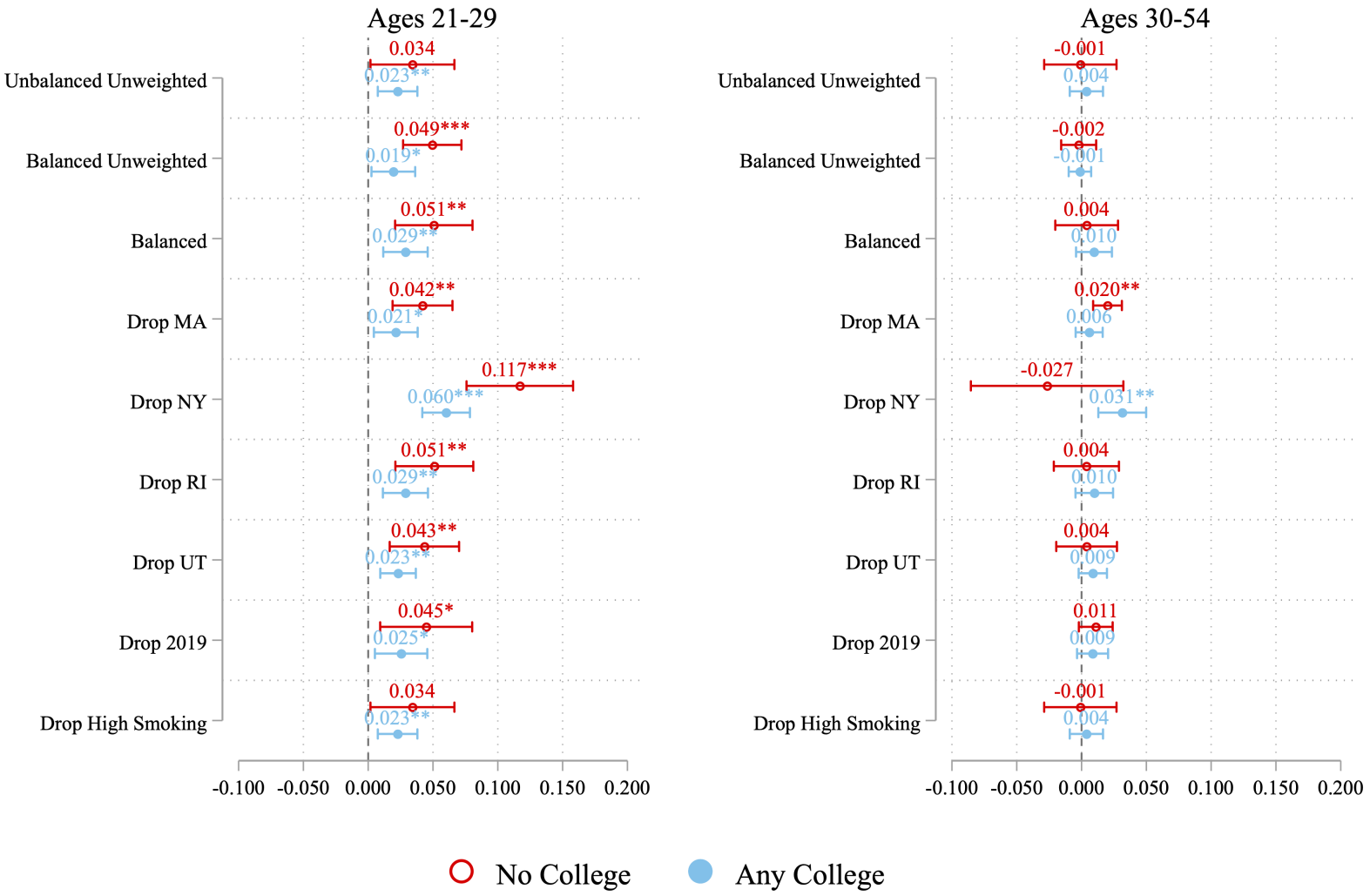
Robustness: Current Smoking



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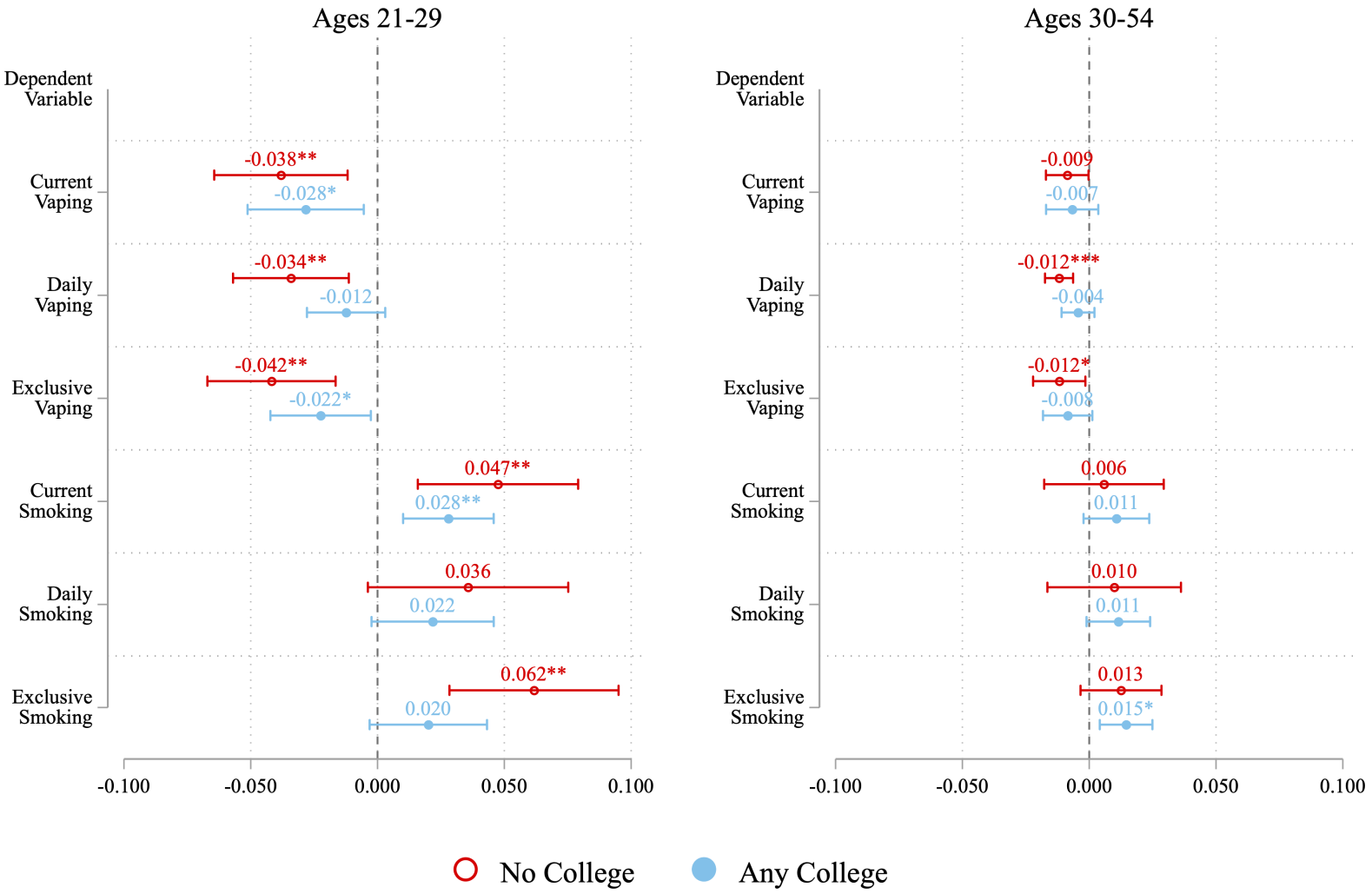
Robustness: Statewide Policies



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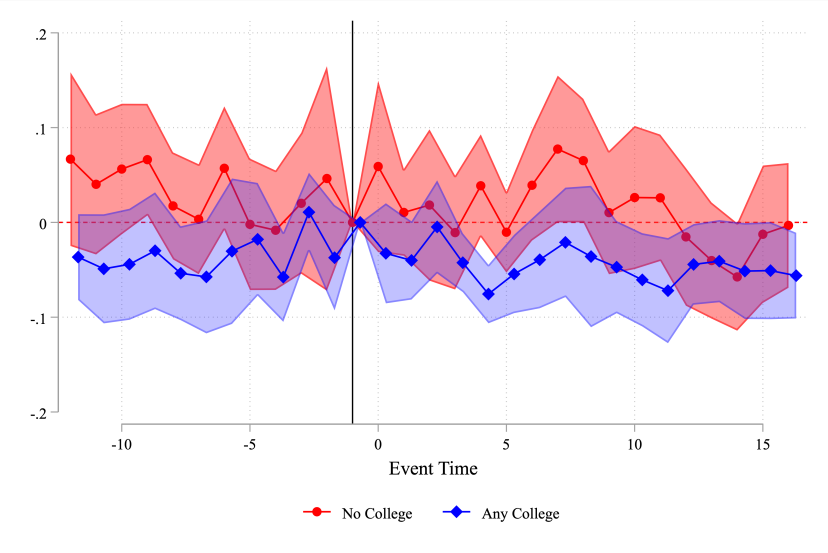
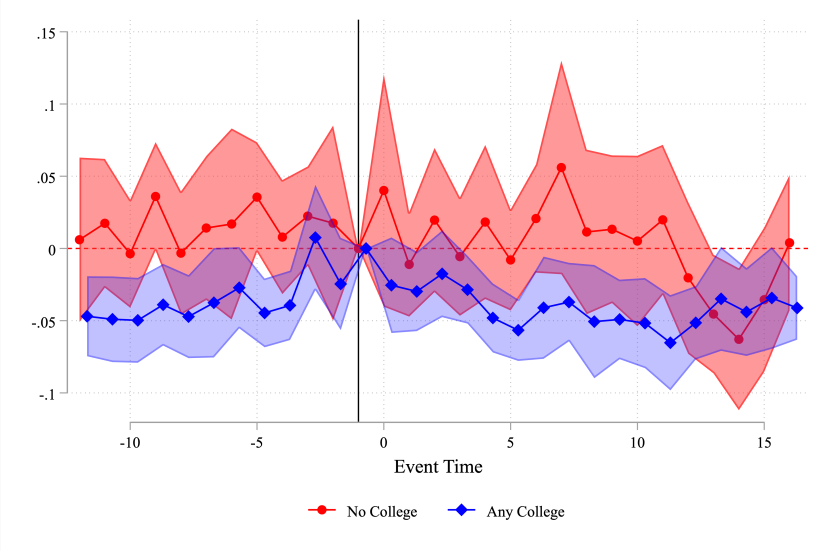
Event Study, ENDS Use, 21-29

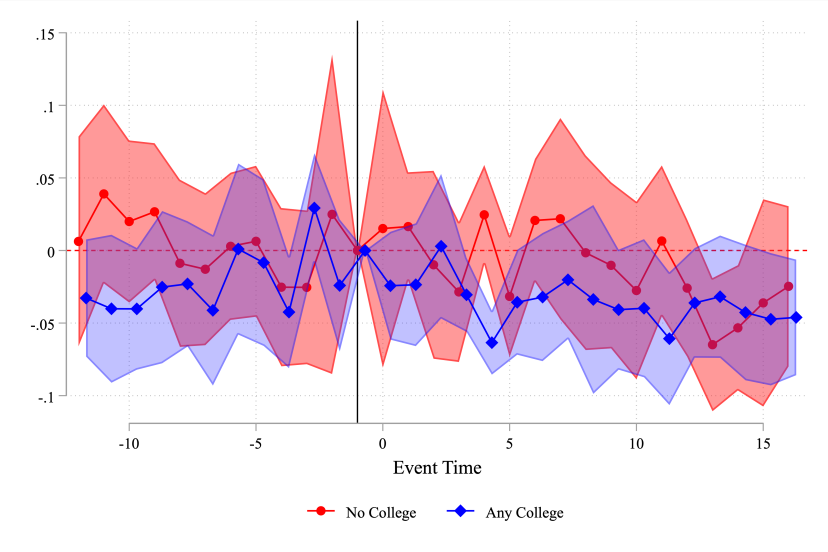
Current



Daily



Exclusive



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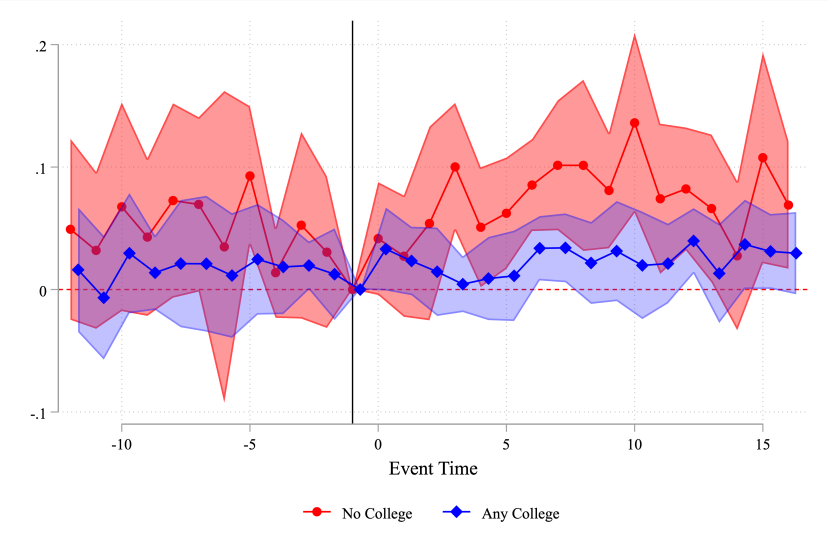
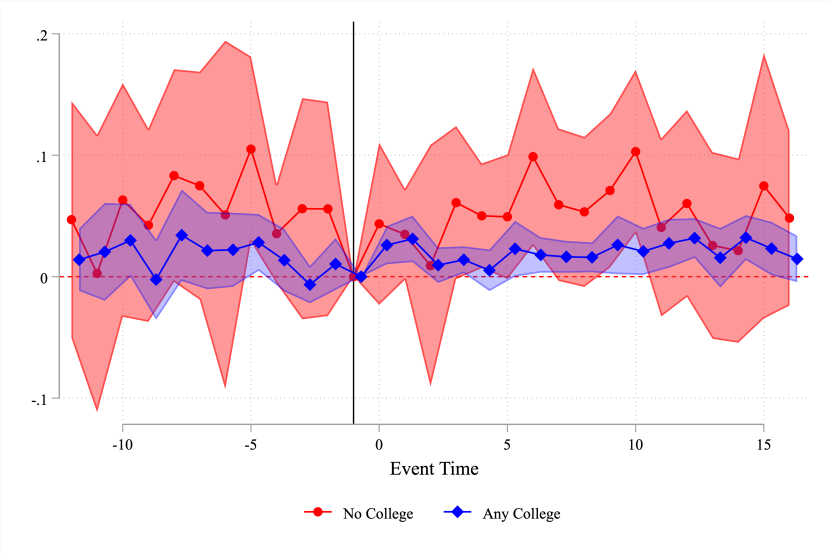
Event Study, Smoking, 21-29

Current



Daily



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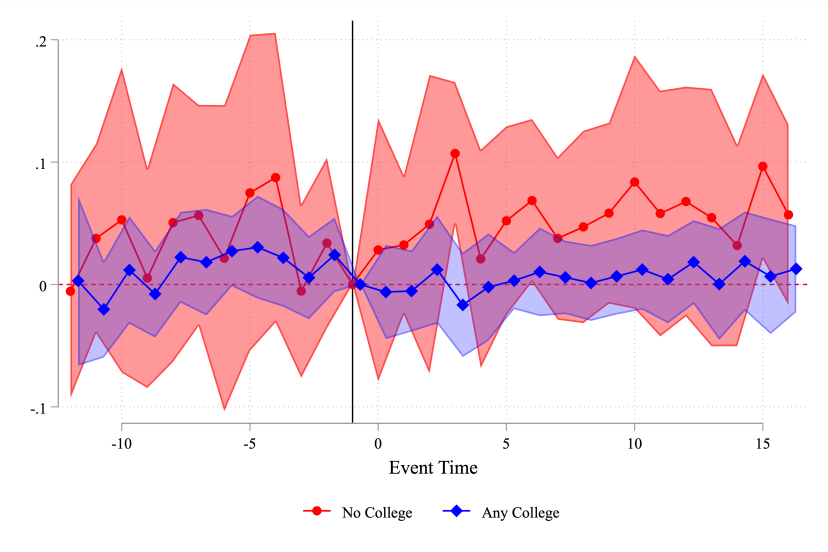

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Back

References

Abouk, R. and Adams, S. (2017). Bans on electronic cigarette sales to minors and smoking among high school students. *Journal of Health Economics*, 54:17–24.

Abouk, R., Courtemanche, C., Dave, D., Feng, B., Friedman, A. S., Maclean, J. C., Pesko, M. F., Sabia, J. J., and Safford, S. (2023). Intended and unintended effects of e-cigarette taxes on youth tobacco use. *Journal of Health Economics*, 87:102720.

Allcott, H. and Rafkin, C. (2022). Optimal Regulation of E-cigarettes: Theory and Evidence. *American Economic Journal: Economic Policy*, 14(4):1–50.

Blinder, A. S. (1973). Wage discrimination: reduced form and structural estimates. *Journal of Human resources*, pages 436–455.

Centers for Disease Control and Prevention (2025). State tobacco activities tracking and evaluation (STATE) system.

Chen, T., Jiang, L., and Prakash, S. (2024). Spatial Spillover Effects of State-Level Policies Banning Electronic Nicotine Delivery Systems. *American Journal of Health Economics*, 10(4):539–567. _eprint: https://doi.org/10.1086/726003.

Cheng, D., Lee, B., Jeffers, A. M., Stover, M., Kephart, L., Chadwick, G., Kruse, G. R., Evins, A. E., Rigotti, N. A., and Levy, D. E. (2025). State E-Cigarette Flavor Restrictions and Tobacco Product Use in Youths and Adults. *JAMA Network Open*, 8(7):e2524184.

Cotti, C., Courtemanche, C., Liang, Y., Maclean, J. C., Nesson, E., and Sabia, J. J. (2025). The effect of e-cigarette flavor bans on tobacco use. *Journal of Health Economics*, 102:103013.

Cotti, C., Courtemanche, C., Maclean, J. C., Nesson, E., Pesko, M. F., and Tefft, N. W. (2022). The effects of e-cigarette taxes on e-cigarette prices and tobacco product sales: evidence from retail panel data. *Journal of Health Economics*, 86:102676.

Dai, H., Benowitz, N. L., Achutan, C., Farazi, P. A., Degarege, A., and Khan, A. S. (2022). Exposure to toxicants associated with use and transitions between cigarettes, e-cigarettes, and no tobacco. *JAMA Network Open*, 5(2):e2147891.

Dave, D., Feng, B., and Pesko, M. F. (2019). The effects of e-cigarette minimum legal sale age laws on youth substance use. *Health Economics*, 28(3):419–436. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/hec.3854.

References ii

Deryugina, T. and Molitor, D. (2021). The causal effects of place on health and longevity. *Journal of Economic Perspectives*, 35(4):147–170.

Dutra, L. M., Glantz, S. A., Arrazola, R. A., and King, B. A. (2018). Impact of E-Cigarette Minimum Legal Sale Age Laws on Current Cigarette Smoking. *Journal of Adolescent Health*, 62(5):532–538.

Friedman, A. S. (2015). How does electronic cigarette access affect adolescent smoking? *Journal of Health Economics*, 44:300–308.

Friedman, A. S., Liber, A. C., Crippen, A., and Pesko, M. F. (2025). E-cigarette Flavor Restrictions' Effects on Tobacco Product Sales. *American Journal of Health Economics*.

Friedman, A. S. and Pesko, M. F. (2022). Young adult responses to taxes on cigarettes and electronic nicotine delivery systems. *Addiction (Abingdon, England)*, 117(12):3121–3128.

Friedman, A. S., Pesko, M. F., and Whitacre, T. R. (2024). Flavored E-Cigarette Sales Restrictions and Young Adult Tobacco Use. *JAMA Health Forum*, 5(12):e244594.

Hafez, A. Y., Gonzalez, M., Kulik, M. C., Vijayaraghavan, M., and Glantz, S. A. (2019). Uneven Access to Smoke-Free Laws and Policies and Its Effect on Health Equity in the United States: 2000–2019. *American Journal of Public Health*, 109(11):1568–1575.

Hammond, D., Reid, J. L., Goniewicz, M. L., McNeill, A., O'Connor, R. J., Corsetti, D., Brose, L. S., Schurr, B., and Robson, D. (2025). Biomarkers of Toxicant Exposure among Youth in Canada, England, and the United States Who Vape and/or Smoke Tobacco or Do Neither. *Cancer Epidemiology, Biomarkers & Prevention*, 34(5):815–824.

Hiler, M., Weidner, A.-S., Hull, L. C., Kurti, A. N., and Mishina, E. V. (2023). Systemic biomarkers of exposure associated with ENDS use: a scoping review. *Tobacco Control*, 32(4):480–488.

Kitagawa, E. M. (1955). Components of a Difference Between Two Rates. *Journal of the American Statistical Association*, 50(272):1168–1194.

Lindson, N., Livingstone-Banks, J., Butler, A., McRobbie, H., Bullen, C., Hajek, P., Wu, A., Begh, R., Theodoulou, A., Notley, C., Rigotti, N., Turner, T., Fanshawe, T., and Hartmann-Boyce, J. (2025). Electronic cigarettes for smoking cessation. *Cochrane Database of Systematic Reviews*, (11).

McNeill, A., Simonavičius, E., Brose, L., Taylor, E., East, K., Zuikova, E., Calder, R., and Robson, D. (2022). Nicotine vaping in England: an evidence update including health risks and perceptions, 2022. Technical report, Office for Health Improvement and Disparities.

National Academies of Sciences, Engineering, and Medicine (2018). *Public Health Consequences of E-Cigarettes*. The National Academies Press, Washington, DC.

References iii

Oaxaca, R. (1973). Male-female wage differentials in urban labor markets. *International economic review*, pages 693–709.

Pesko, M. F., Courtemanche, C. J., and Maclean, J. C. (2020). The effects of traditional cigarette and e-cigarette tax rates on adult tobacco product use. *Journal of Risk and Uncertainty*, 60(3):229–258.

Pesko, M. F. and Warman, C. (2022). Re-exploring the early relationship between teenage cigarette and e-cigarette use using price and tax changes. *Health Economics*, 31(1):137–153.

Ruggles, S., Flood, S., Sobek, M., Backman, D., Cooper, G., Drew, J. A. R., Richards, S., Rogers, R., Schroeder, J., and Williams, K. C. (2025). IPUMS USA: Version 16.0. Minneapolis, MN.

Saffer, H., Dench, D., Grossman, M., and Dave, D. (2020). E-cigarettes and adult smoking: evidence from Minnesota. *Journal of risk and uncertainty*, 60(3):207–228.

Saffer, H., Ozdogan, S., Grossman, M., Dench, D., and Dave, D. (2025). Comprehensive E-Cigarette Flavor Bans and Tobacco Use Among Youth and Adults. *Health Economics*, 34(12):2238–2254. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/hec.70030.

Surveillance Research Program, National Cancer Institute (2026). Lung and Bronchus — SEER Relative Survival Rates by Time Since Diagnosis, 2000–2022. Published: SEER*Explorer: An interactive website for SEER cancer statistics [Internet].

Tindle, H. A., Stevenson Duncan, M., Greevy, R. A., Vasan, R. S., Kundu, S., Massion, P. P., and Freiberg, M. S. (2018). Lifetime Smoking History and Risk of Lung Cancer: Results From the Framingham Heart Study. *JNCI Journal of the National Cancer Institute*, 110(11):1201–1207.

US Department of Health and Human Services (2014). *The Health Consequences of Smoking—50 Years of Progress: A Report of the Surgeon General*. Reports of the Surgeon General. Centers for Disease Control and Prevention (US), Atlanta (GA).

U.S. Department of Health and Human Services (2024). Eliminating Tobacco-Related Disease and Death: Addressing Disparities—A Report of the Surgeon General. Technical report, U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, Atlanta, GA.

Whitacre, T. R., Crippen, A., Monthrope, M., Narine, T., Liber, A. C., and Friedman, A. S. (2025). Tobacco product flavour policies in the USA. *Tobacco Control*.

Xu, Y., Jiang, L., Prakash, S., and Chen, T. (2022). The Impact of Banning Electronic Nicotine Delivery Systems on Combustible Cigarette Sales: Evidence From US State-Level Policies. *Value in Health*, 25(8):1352–1359.