

How does e-cigarette use affect smoking-related socioeconomic disparities in the US?

With emphasis on income levels

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Disclaimer

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- TL: This research was supported by a grant to BOTEK Analysis from Global Action to End Smoking (GA; formerly known as Foundation for Smoke-Free World), an independent, U.S. nonprofit 501(c)(3) grantmaking organization. GA played no role in the research design, implementation, data analysis, or interpretation of the results, nor did GA edit or approve any presentations or publications from the study. The contents, selection, and presentation of facts, as well as any opinions expressed, are the sole responsibility of the authors and should not be regarded as reflecting the positions of GA. Through September 2023, GA received charitable gifts from PMI Global Services Inc. (PMI), which manufactures cigarettes and other tobacco products. To complement the termination of its agreement with PMI, GA's Board of Directors established a new policy to not accept or seek any tobacco or non-medicinal nicotine industry funding.

Introduction

- Smoking prevalence is often concentrated among disadvantaged groups in a country
 - Lower income, less education, other SES
 - Racial or ethnic minorities
 - Disabled and mentally ill
- As noted earlier today, high-quality evidence indicates that e-cigarettes aid cessation from smoking (Hartmann-Boyce et al., 2022; Lindson et al., 2025).
- However, there is little conclusive direct evidence on how e-cigarette use may affect smoking-related health inequality
 - Lucherini et al (2019): systematic review => evidence is “somewhat inconsistent”.
 - Of poor econometric quality

Research questions

- Does use of e-cigarettes aid cessation from smoking (among US adults)?
- If so, is that also true for disadvantaged groups?
 - And to the same extent?
 - Can e-cigarettes help close socioeconomic gaps in smoking/cessation?

Empirical approaches

- Key empirical problem: The use of e-cigs may be endogenous with smoking/cessation behavior
 - Common liabilities in nicotine use at the individual level: genetic, environmental, etc.
 - Omitted variables: local tobacco control policies, etc.
- We've already seen today how panel data + Diff-in-diff estimation can allow causal inference

Empirical approaches using observational data

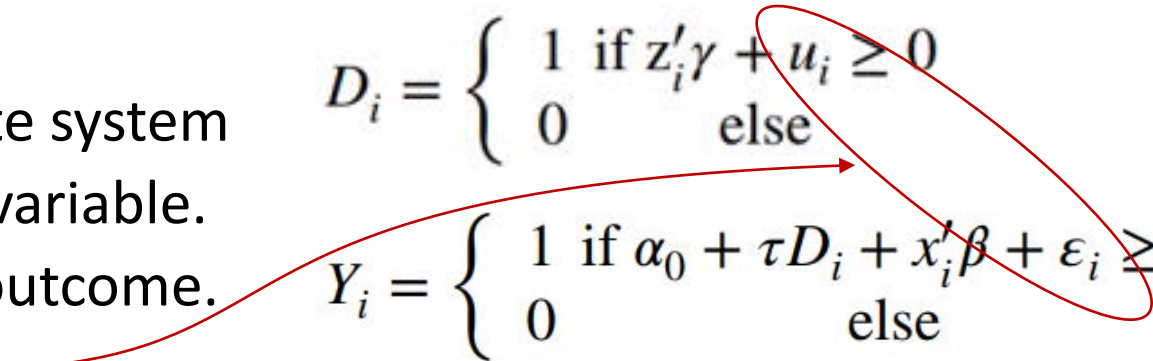
- What if you only have a cross-sectional survey?
 - What you should *not* do (which much of the public health literature does): treat use of e-cigarettes as exogenous and just run regressions

Empirical approaches using observational data

- Potential statistical solutions *if you only have a cross-sectional survey*
 - IV regression. Requires an instrument that determines e-cigarette use but does not independently (apart from e-cig use) affect smoking or cessation.
 - Works well with a strong instrument
 - Ignoring the binary nature of e-cig use and cessation may be problematic.
 - The selection-in-ecig-use is inherently nonlinear (e.g. probit or logit), and IV corrects for *linear* selection bias.
 - Many other possibilities (ignoring the doubly-binary nature of the problem)
 - Matching methods, Control functions, etc.

Empirical approaches using observational data

- Take the double-binary nature of selection and outcome seriously:
Model a continuum of “types” with a model for selection into use of e-cigarettes.
 - Triangular (doubly binary) bivariate system
 - D = e-cig use. Treated as a causal variable.
 - Y = cessation from smoking. The outcome.
 - Selection: u and ε are correlated.
 - ID: parametric (bivariate normal, copulas),
seminonparametric (De Luca, 2008; Gallant & Nychka, 1987), “less parametric” moment based (Wooldridge)
 - Do not *need* an instrument in z , but it helps a lot if you have one
- Prieger & Choi (2024), *J. Consumer Policy*

$$D_i = \begin{cases} 1 & \text{if } z_i' \gamma + u_i \geq 0 \\ 0 & \text{else} \end{cases}$$
$$Y_i = \begin{cases} 1 & \text{if } \alpha_0 + \tau D_i + x_i' \beta + \varepsilon_i \geq 0 \\ 0 & \text{else} \end{cases}$$


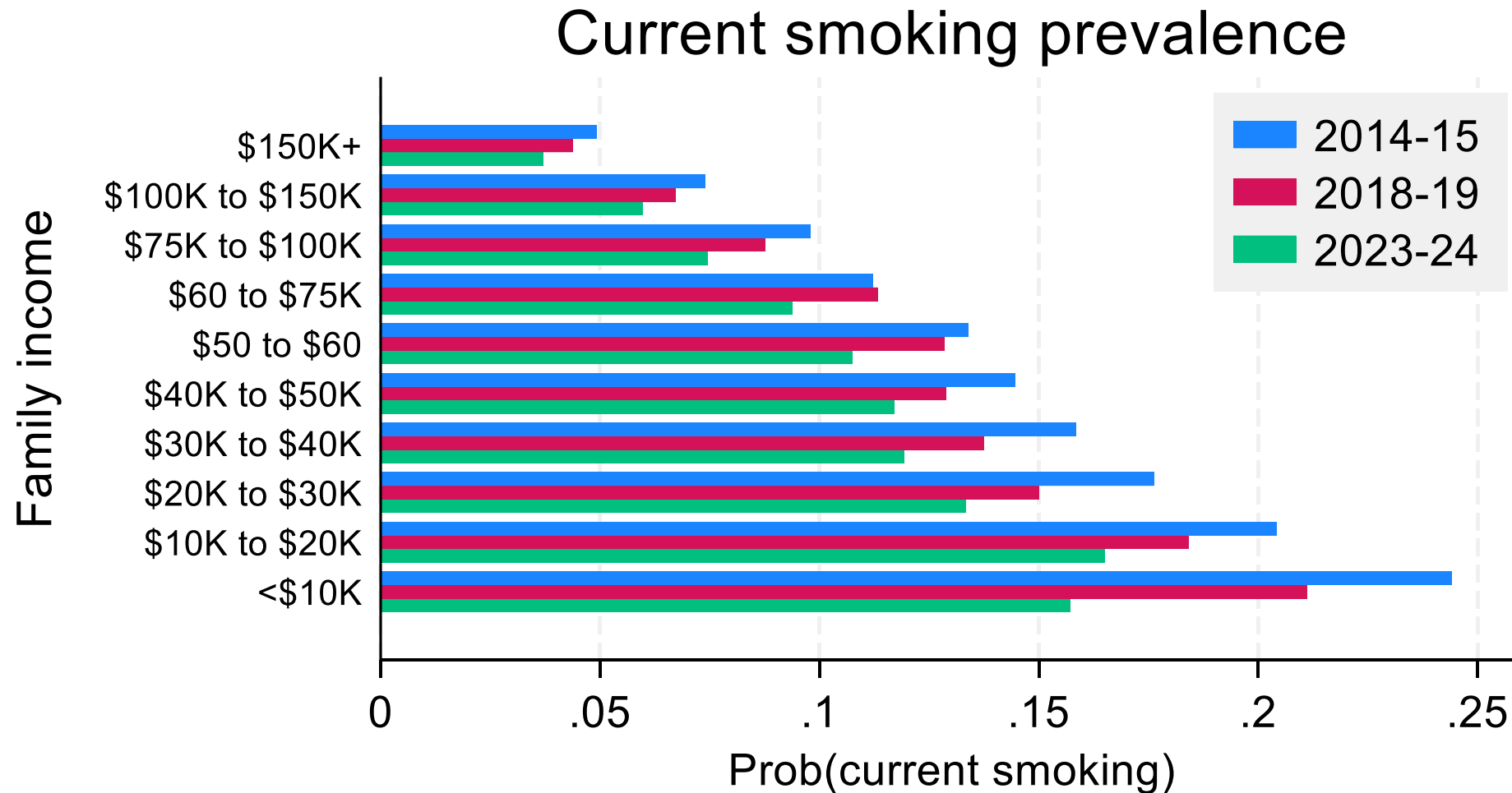


Brief description of our study

- CPS-Tobacco Use Supplement (TUS), 2014-2023 (3 waves)
- Examine people who were smoking 12 months before taking the survey.
 - Some were still smoking at time of survey
 - Some had quit (cessation)
 - Some used e-cigarettes during the past year, others did not
- All estimates will use survey weights
- SEs will account for complex survey design effects

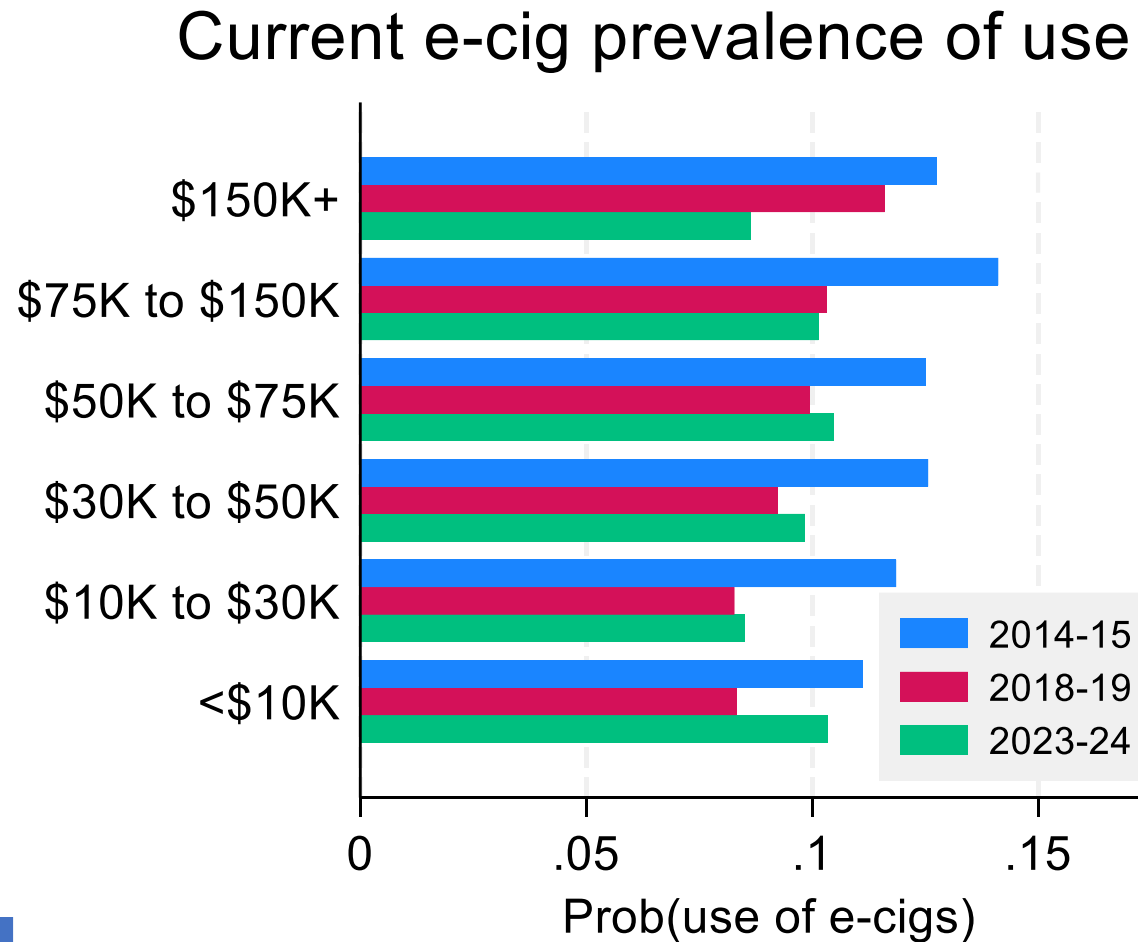
TUS: Who is still smoking?

The socioeconomic gradient in smoking



TUS: Among adult smokers, who is using e-cigarettes?

- Answer:
people of all income levels, roughly equally



χ^2 *p*-value for differences among income levels: 0.557

Regression-adjusted results for cessation

- Recall the outcome equation for $Y = \text{cessation from smoking}$ as a function of $D = \text{uses/used e-cigarettes in the past year}$ is

$$Y_i = \begin{cases} 1 & \text{if } \alpha_0 + \tau D_i + x_i' \beta + \varepsilon_i \geq 0 \\ 0 & \text{else} \end{cases}$$

Estimate this first treating D as exogenous

- OLS/LPM
- Logit
- Then estimate the double-binary triangular system
 - Bivariate probit, for initial results.

$$D_i = \begin{cases} 1 & \text{if } z_i' \gamma + u_i \geq 0 \\ 0 & \text{else} \end{cases}$$
$$Y_i = \begin{cases} 1 & \text{if } \alpha_0 + \tau D_i + x_i' \beta + \varepsilon_i \geq 0 \\ 0 & \text{else} \end{cases}$$

Impact of e-cigs on past-year cessation

Y = Past year cessation	Est. 0 LPM
E-cig use	0.086***
Add'l controls?	No
χ^2 (p-value)	0.000
R squared	0.026
N	50,934

Note that all regressions include individual controls and state & year fixed effects

- Personal Controls:
 - Family income
 - Sex, Race/ethnicity
 - Education
 - Married, Children in HH
 - Metro/nonmetro
 - Labor force status
 - Occupation & industry
 - Native-born
 - Addiction: time to 1st cig., cigs/day

** 5% significance

*** 1% significance

Impact of e-cigs on past-year cessation

Y = Past year cessation	Est. 0 LPM	Est. 1 LPM
E-cig use	0.086***	0.086***
Add'l controls?	No	Yes
χ^2 (p-value)	0.000	0.000
R squared	0.026	0.026
N	50,934	50,934

- **Personal Controls:** income, sex, race/ethnicity, education, married, children, metro, working, occupation, industry, native-born, addiction

- **Regulatory Controls:**
 - Cig taxes, sales licensing, smoke-free policies, Medicaid coverage of cessation treatments, alcohol taxes, cannabis laws

- All lagged one year from survey

- **Economic Controls:**
 - GDP growth, per cap. income, UE (all lagged)

- The effect size persists with add'l controls

Impact of e-cigs on past-year cessation

Y = Past year cessation	Est. 0 LPM	Est. 1 LPM	Est. 2 Logit
E-cig use	0.086***	0.086***	0.773***
Add'l controls?	No	Yes	Yes
χ^2 (p-value)	0.000	0.000	0.000
R squared	0.026	0.026	
N	50,934	50,934	50,934

- **Personal Controls:** income, sex, race/ethnicity, education, married, children, metro, working, occupation, industry, native-born, addiction

- **Regulatory Controls:**
 - Cig taxes, sales licensing, smoke-free policies, Medicaid coverage of cessation treatments, alcohol taxes, cannabis laws
 - All lagged one year from survey

- **Economic Controls:**
 - GDP growth, per cap. income, UE (all lagged)

- The effect persists with logit. OR $\approx$ 2.2

Impact of e-cigs on past-year cessation

Y = Past year cessation	Est. 0 LPM	Est. 1 LPM	Est. 2 Logit	Est. 3 LPM
E-cig use	0.086***	0.086***	0.773***	0.048***
Use (2015)				0.057***
Use (2018)				0.067***
Use (2019)				0.105***
Use (2022)				0.123***
Use (2023)				0.161***
Add'l controls?	No	Yes	Yes	Yes
χ^2 (p-value)	0.000	0.000	0.000	0.000
R squared	0.026	0.026		0.029
N	50,934	50,934	50,934	50,934

- The effect size grows over time

- Personal Controls:

Family income, sex, education, race/ethnicity, married, children in household, Labor force status, metro/nonmetro, occupation, industry, native-born

- Regulatory Controls:

- Cig taxes, sales licensing, smoke-free policies, Medicaid coverage of cessation treatments, alcohol taxes

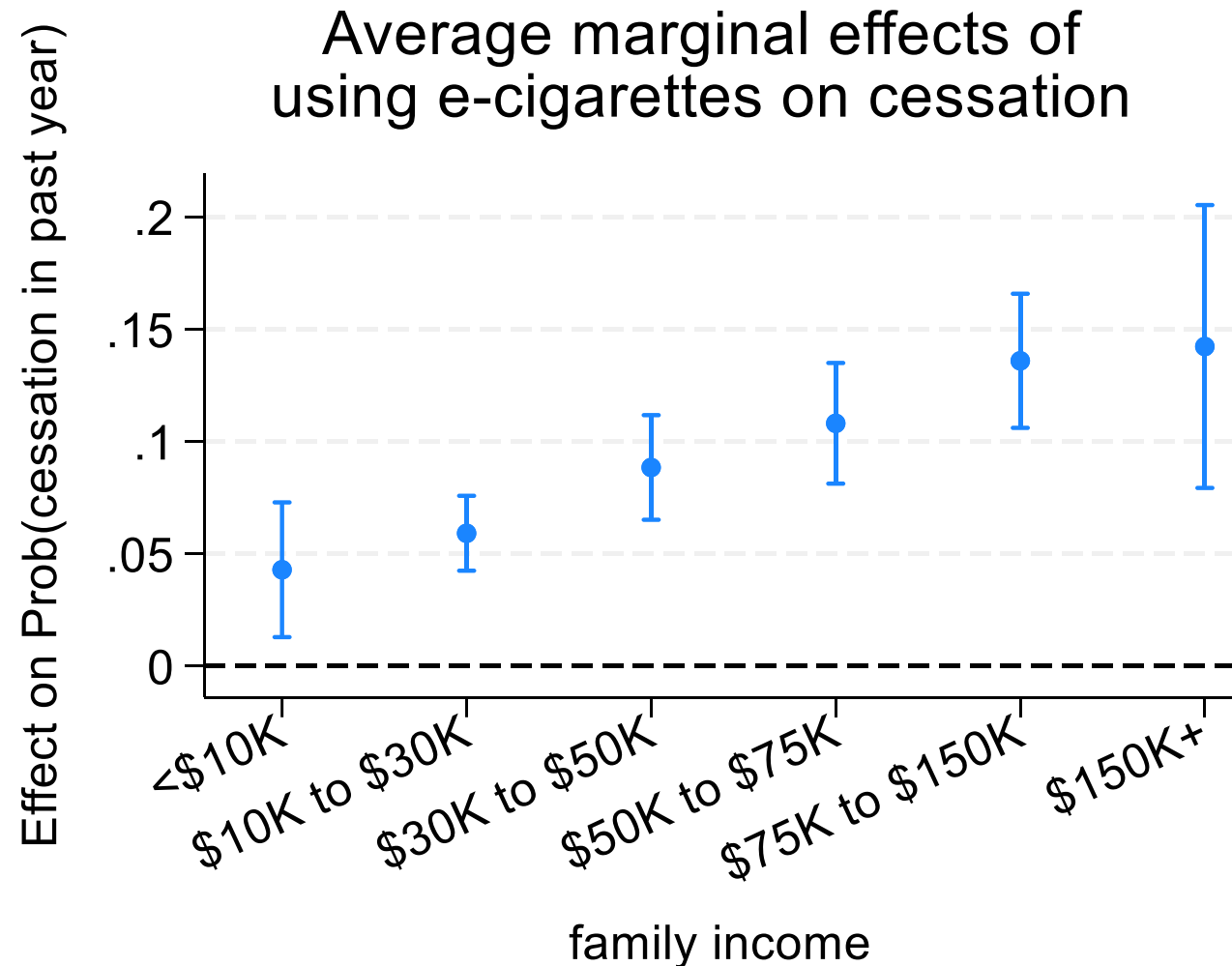
- All lagged one year from survey

- Economic Controls:

- GDP growth, per cap. income, UE (all lagged)

Impact of e-cigarettes by income group

- Regression: as before, but interact e-cigarette use with year *and* income
 - There are 36 relevant coefficients for the effect of e-cigs (6 income levels $\times$ 6 years)
 - summarize with the average marginal effects in the graph (ave. treatment effect on the treated: ATT)
- E-cigarettes are effective for cessation *for all incomes*
- However: effectiveness of e-cigs for cessation *increases with income* (p -value for equal effects = 0.000)

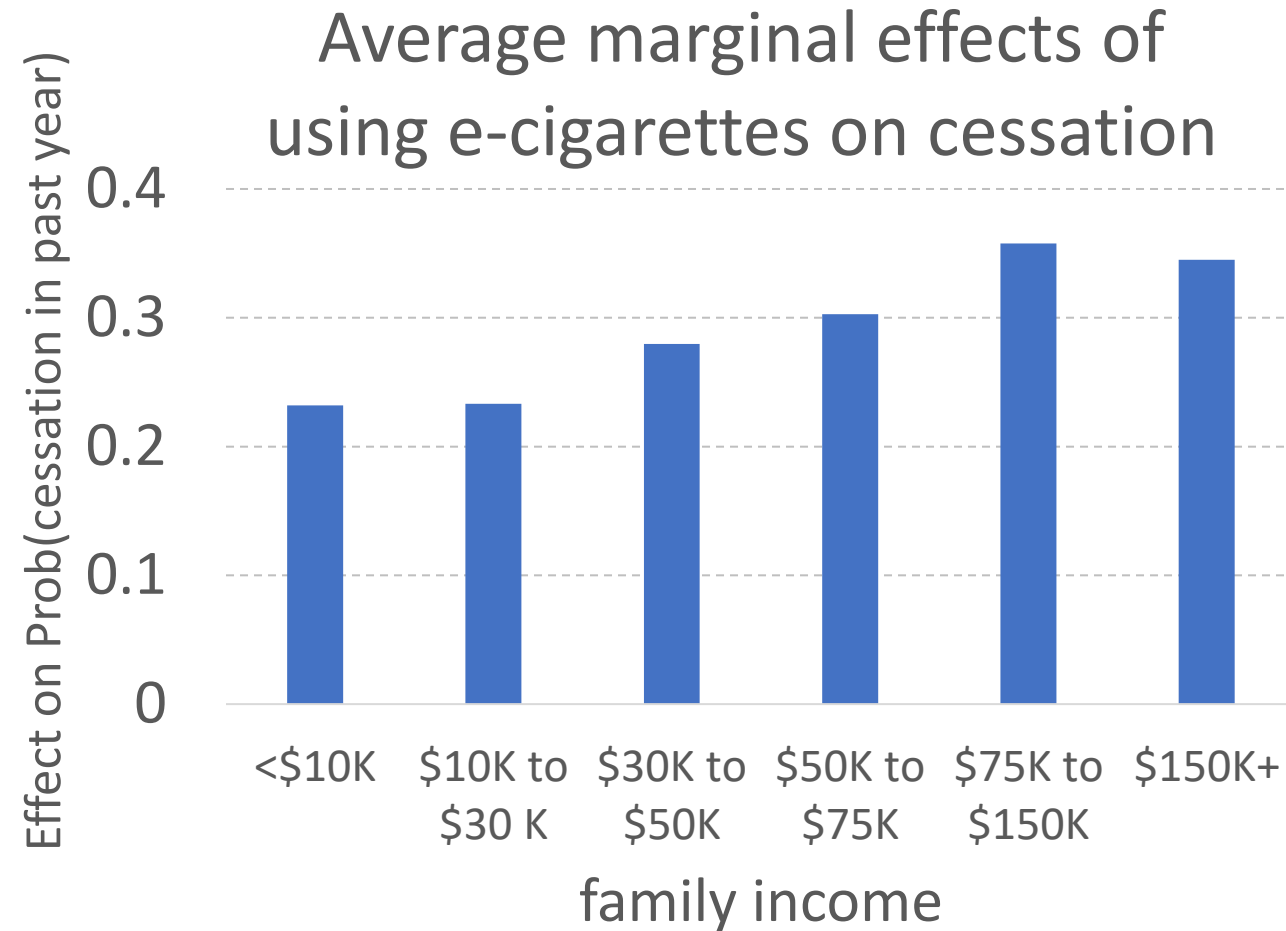


Impact of e-cigarettes by income, accounting for endogeneity of e-cigarette use

- Bivariate probit binary treatment effects model
 - Refer to the triangular model described earlier
- Excluded instruments in the equation for e-cigarette use:
 - E-cig taxes, e-cig retail licensing laws, the individual's workplace vaping rules, did anyone vape at work recently, state vape-free laws
 - Chi-squared statistic for their *relevance*: 109; p -value = 0.000

Impact of e-cigarettes by income, accounting for endogeneity of e-cigarette use

- Bivariate-probit binary treatment effects model
- Excluded instruments in the e-cig use equation:
 - E-cig taxes, e-cig retail licensing laws, the individual's workplace vaping rules, did anyone vape at work recently, state vape-free laws
 - Chi-squared stat on them: 109; p-value = 0.000
- There is sig. *negative* correlation between the cessation and e-cig use errors
 - Unobserved factors making e-cig use more likely (e.g. strong addiction) make cessation less likely
- Results for ATT are as before, *but even larger effects* (all are significant)



Conclusions

- E-cigarettes appear to aid cessation: +8.7** pp quitting in past year; 3x that after accounting for endogeneity of using e-cigarettes.
- Lower-income smokers' use of e-cigarettes *is as likely* as higher-income's
- But: Lower-income smokers benefit *less* from e-cigarettes for cessation
 - But still benefit: +4.3** pp for income <\$10K vs. +14.2** pp for income ≥\$150K
 - E-cigs may *absolutely* help low-income smokers quit, while *relatively* exacerbating inequities in prevalence of smoking
- Motivations for using e-cigarettes matter (from results not shown here)
 - E-cigs' efficacy for cessation is much greater when they are used for that purpose: +13.8** pp vs. +2.1** pp.
 - Potential policy implication: physician and public health messaging should consider encouraging their use for cessation (as in UK)

Final thoughts

- If e-cigarettes aren't helping disadvantaged groups to quit smoking as much as for high-income smokers, why not?
 - It isn't because lower income smokers are less likely to use e-cigarettes
 - Supplementary work: it isn't because they are less likely to use e-cigs for purposes of cessation
 - It is because they see less benefit for cessation (why?)
 - Requires continued investigation

Thank you!

