E-cigarette taxes on pre-pregnancy & prenatal smoking and birth outcomes

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Blurb

• Applied health economist by trade (GSU PhD in Public Policy, 2018)

• Two main work streams @AIR
  • Operation and implementation support for the Advanced APMs
  • Development and testing of healthcare quality measures

• External research on program and policy evaluation
Disclaimer

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• Content is solely the responsibility of the authors & does not necessarily represent the official views of the National Institutes of Health and does not represent the views of AIR
Overview

• What’s the impact of e-cig tax rates on pre-pregnancy & prenatal smoking and birth outcomes?
  – Expectant mothers and those expecting to become pregnant may be motivated to quit smoking using e-cigs

• A growing number of states & counties have levied e-cig taxes
  – MN was the first state to levy an ad valorem tax on e-cigs in 2010
  – E-cig taxes have been in effect in 34 jurisdictions by Dec 2020
  – Tax adoption is staggered
    – Standardized e-cig tax rate

• U.S birth records data (2013 to 2020) – collaborative effort btwn National Center for Health Statistics (NCHS) and the States
  – Pre-pregnancy (3mo before pregnancy) smoking
  – Prenatal smoking (any & avg. number smoked/day)
  – Birth outcomes

• Presenting new results from those in the working paper; results subject to change
• Hypothesis
  – ☢ E-cig tax adoption ➔ ☢ cost of e-cigs ➔ ⇑ use of e-cigs ➔ ☢ or ⇑ cig smoking ➔ ☢ or ⇑ birth outcomes

• E-cig taxes
  – ⇑ pre-pregnancy & 3rd trimester vaping
  – ☢ pre-pregnancy & prenatal smoking by 0.4 – 0.5 ppt (7% – 9%)
  – Limited impact on birth outcomes
Structure

1. Background
2. Data, variables, and methods
3. Results
4. Extensions (brief)
5. Summary and discussion
E-cigarette Regulations

• Potential substitutability of traditional cigs & e-cigs presents a challenge to policymakers
  » Taxing & restricting access to e-cigarettes may help ↓ nicotine intake
  » But may ↓ harm reduction & cessation efforts among smokers
  » E-cigs contain fewer toxicants than combustible tobacco, but are not harmless
    (National Academies of Sciences, Engineering, and Medicine 2018)

• States & localities have adopted e-cig policies in various forms

• As of October 2021
  » Early policies focused on youth access (51 states)
  » Next, states adopted policies prohibiting use in bar (19 states), restaurants (20 states), & private worksites (18 states)
  » More recent efforts have focused on taxation (30 states)
Tobacco Product Use During Pregnancy

• Per CDC, smoking while pregnant increases the risk for pregnancy complications, is harmful to babies before and after they are born, and is strongly discouraged by healthcare professionals
  – 7.2% of women smoked cigs while pregnant (CDC, 2018)
  – Behavior linked with low birthweight, preterm birth, & birth defects
Tobacco Product Use During Pregnancy

• Vaping while pregnant is also discouraged, as nicotine
  – is a health danger for pregnant women and developing babies
  – can damage a developing baby’s brain and lungs
  – can lead to
    » low birthweight
    » preterm birth
    » impaired early life health and human capital development
    » infant mortality
    » later-life proclivity to nicotine-containing products

• PRAMS data for two states in 2015 (Kapaya et al., 2019)
  – 10.8% vaped in the three months prior to pregnancy
  – 7.0% vaped at the time of pregnancy
  – 5.8% vaped in the first trimester
  – 1.4% vaped at birth
Tobacco Product Use During Pregnancy

• Many pregnant women perceive e-cigs as less harmful than traditional cigs for the fetus & helpful in smoking cessation
  – e.g., Wagner, Camerota, & Propper (2017)

• Vaping while pregnant can cause similar harms to the fetus as does the use of traditional cigs
  – Whittington et al. (2018) – Literature review

• Health benefits of vaping over smoking during pregnancy aren’t clear
  – Vaping during pregnancy is worse than not using any nicotine products
Literature

- Small literature on the effects of e-cigarette policies on pre-pregnancy & prenatal smoking, & birth outcomes
- Three studies explore the effect of e-cigarette policy variation on prenatal smoking using birth records
  - E-cig indoor air laws ↓ prenatal smoking cessation for pregnant women, had little effect on birth outcomes (Cooper & Pesko, 2017), but ↑ infant mortality (Cooper & Pesko, 2022)
  - E-cig MLSA laws ↓ prenatal smoking cessation rates for rural pregnant teens but had little effect on birth outcomes (Pesko & Currie, 2019)
- Few studies examine how cigarette taxation affected pre-pregnancy and prenatal smoking
- Studies focusing on e-cig tax rates generally found evidence of substitution in other populations
Birth Records Data

National Center for Health Statistics

- Administrative data; Restricted use; Contain geocodes
- Collected and used the most recent data available (2020)
- Introduced the revised birth record form in 2003
  » Revised form contains Qs on smoking in each trimester & 3 months prior to pregnancy (pre-pregnancy)
    ◦ However, this info is self-reported
  » State’s adoption of revised form is staggered
- No info on e-cigarette use yet
Building The Main Analysis Sample

Started sample in Jan 2013, defined by conception month and conception year

- Birth records data only provide birth delivery date. Thus, need to estimate pregnancy date
  - 3 critical pieces: birth year, birth month, and gestational length (weeks)
  - Few assumptions:
    - Birth month = the end of the month (not start of the month) (e.g., June means 6/30 and not 6/1)
    - Gestational length (week) = start of the week (e.g., week 30 means full 29 weeks and day 1 in the 30th week and not full 30 weeks)
    - Baby was born in the middle of the month and middle of the week
    - 1st trimester = point of ovulation (16 days since conception)
    - 2nd trimester = week 14 of conception
    - 3rd trimester = week 28 of conception
    - Pre-pregnancy = 3 months prior to the point of ovulation
Building The Main Analysis Sample

- Ended sample in Dec 2019, defined by conception month and conception year
  - Doesn’t mean births occurred in 2020 are excluded; therefore, births in 2020 from conception in 2019 are included
- Removed CT, NJ, and RI due to low adoption rate of revised birth record form by 2013 (sample starting year)
- Removed moms with missing smoking info, gestational length info, residing overseas, and non-singleton births (very modest deletion in each)
- Removed births in HI in 2013 due to very high pct. of missing smoking info
- Retained moms with missing info in demographics (very few records)
  - Recoded missing into a separate category and controlled for in model
- Main analysis sample ≈ 25M records (births) over study period
Other Analysis Samples

  - Generally, a one-year lag
  - Similar data cleaning logic applied

- Panel version of birth records data (2013 – 2020)
  - Take advantage of four time points in the birth records data
    » 3 months before pregnancy, 1\textsuperscript{st} trimester, 2\textsuperscript{nd} trimester, and 3\textsuperscript{rd} trimester
  - Data reshape (wide \rightarrow long)

- Pregnancy Risk Assessment Monitoring System (PRAMS)
  - Vaping questions; descriptive analysis
Main Outcome Variables (Cigarette Consumption)

• Any prenatal smoking (0-1)
  – 1: reported smoking cigarettes in any of the trimesters. 0: otherwise

• Avg. number of cigarettes smoked per day during pregnancy (continuous)
  – Simple weighted avg. of # of cigs smoked in each of the trimesters

• Number of trimesters smoked cigs
  – Categorical (0, 1, 2, 3)

• Any pre-pregnancy smoking (0-1)
  – Pre-pregnancy means no more than 3 months prior to pregnancy

• Any pre-pregnancy vaping (0-1); any 3rd trimester vaping (0-1)
Main Outcome Variables (Birth Outcomes)

- Gestational length (weeks)
- Premature birth (0-1)
  - 1: gestational length < 37 weeks; 0: otherwise
- Birth weight (in grams)
- Low birth weight (0-1)
  - 1: birth weight < 2500 grams; 0: otherwise
- Small for gestational age (0-1)
  - 1: for a given gestational length, birth weight < 25th pctl. of the birth weight dist. 0: otherwise
- Extra small for gestational age (0-1)
  - 1: like the above, but use 10th pctl. as cutoff
- Five min Apgar score (categorical)
  - 5 categories; each is scored 0, 1, or 2; so Apgar ranges from 0 to 10
- Same-year infant death (0-1)
Main Regressor (Standardized E-cig Tax Rate)

- By 2020, a total of 29 localities (mostly states; excluding localities in AK) has levied taxes on e-cigs.

  - Unlike cig taxes (fixed amt. per pack), e-cig taxes are *unit-specific*.
  - Fixed tax amt. per fluid milliliter (mL) and/or container.
  - Percent tax on the wholesale price; ad valorem.
  - Percent tax on the retail price; sales taxes.

![Graph showing frequency of tax types](image)
Main Regressor (Standardized E-cig Tax Rate)

- **Cotti C, et al. (2021)** – **Tob Control** introduced a publicly available dataset of standardized e-cig taxes, measured as *an average tax rate per mL of fluid* at the state-county-year-quarter level.

- **How they did it (high-level)**
  - NielsenIQ Retail Scanner Data (store-UPC-week level)
  - UPC-level e-cig sales (qty. and $) + e-cig product characteristics
  - Convert ad valorem and other taxes to their excise tax equivalent for each tax jurisdiction
  - Ad valorem $\rightarrow$ Tax per fluid mL

\[Tax\ per\ mL_{loc,t} = ad\ valorem\ rate_{loc,t} \times wholesale\ price\ per\ mL_{t=2013} \times (1 - markup)\]

- Estimation of wholesale price per fluid mL in 2013
  - Calculate the sales-weighted avg. retail price per fluid mL across jurisdictions NOT adopting e-cig tax by the end of 2020 in year 2013
  - Use only 2013 (year 1 NRSD started categorizing e-cigs) to reduce the influence of other time-varying factors
  - Subtract an estimated retailer markup of 35%
Main Regressor (Standardized E-cig Tax Rate)

- Analogously,
  - Sales tax $\rightarrow$ Tax per fluid mL
    \[
    Tax\ per\ mL_{loc,t} = sales\ tax\ rate_{loc,t} \times retail\ price\ per\ mL_{t=2013}
    \]
    - Calculate the sales-weighted avg. retail price per fluid mL across jurisdictions NOT adopting e-cig tax by the end of 2020 in year 2013
    - Use only 2013 to reduce the influence of other time-varying factors
  - Tax per container $\rightarrow$ Tax per fluid mL
    \[
    Tax\ per\ mL_{loc,t} = tax\ per\ container_{loc,t} \times container\ per\ mL_{t=2013}
    \]
    - Calculate the sales-weighted avg. container per fluid mL across jurisdictions NOT adopting e-cig tax by the end of 2020 in year 2013
    - Use only 2013 to reduce the influence of other time-varying factors

- We merge the standardized e-cig tax rate to birth records data at the level of state-county-conception(year)-conception(quarter)
Main Regressor (Standardized E-cig Tax Rate)

Comparison of standardized e-cig tax rate to the total (federal + state + local) cig tax rate over time

Population-weighted national avg; Qtr4 of each year
Main Regressor (Standardized E-cig Tax Rate)

Number of Codified E-cigarette Tax Changes Over The Study Period

- 2013: 1 change
- 2014: 0 changes
- 2015: 4 changes
- 2016: 5 changes
- 2017: 4 changes
- 2018: 4 changes
- 2019: 11 changes
Localities W/ E-cig Tax By The End of Study Period
Add’l Policy Controls

• Cigarette tax rate (federal + state + local)
  » Source: CDC STATE System + American Non-Smokers Rights Foundation

• Index of indoor smoking restrictions (private workplaces, bars, and restaurants)
  » Pct. of population in a given county/year/quarter subject to the comprehensive ban
  » Source: American Non-Smokers Rights Foundation

• Index of indoor vaping restrictions (similar to the above)

• Any e-cigarette minimum legal sales age law
  » Source: CDC STATE System + American Non-Smokers Rights Foundation

• Index of Tobacco 21 Law
  » Source: Tobacco21.org

• Fraction of quarter over year for a given state with temporary e-cig sales ban
  » Source: Authors’ review of public information

• Fraction of quarter over year for a given state with ACA Medicaid expansion
  » Source: Kaiser Family Foundation + Maclean, Pesko, and Hill (2019) – Economic Inquiry (link)
Mother’s Demographics

All demographic variables are categorized and their missing values are included as a separate category

» Age at the time of delivery
» Race
» Primary source of payment (e.g., Medicaid, Private insurance, Self-pay, etc.)
» Marital status
» Education status
» Mother’s total birth counts (living and dead)
Empirical Methods – Cross-sectional

\[ \text{Outcome} = \beta_1 Tax + \Theta \cdot Dmgrpchs + \Phi \cdot \text{Policy}_\text{Cntrls} + \text{FEs} + \varepsilon \]

- What’s the level of these variables?

  1. each record in the birth records data denotes a birth delivery for a woman residing in a given state, county, year, and month.
    - Recall, we est. conception year and month for every birth
    - Outcome vars and demographics are at this level
  2. Standardized e-cig tax rates are at the level of state, county, conception(year), and conception(quarter)
    - Recall, we merged e-cig taxes to each row in birth data using the geocode info (residence) and est. conception year and conception quarter.
Empirical Methods – Cross-sectional

\[ \text{Outcome} = \beta_1 \text{Tax} + \Theta \cdot \text{Dmgrphcs} + \Phi \cdot \text{Policy}_\text{Cntrls} + \text{FEs} + \epsilon \]

• What’s the level of these variables?
  » ③ some policy variables are at the same level as standardized e-cig tax rate, and they are:
    • Total cig tax rate, index of indoor smoking (vaping) restrictions, any e-cig MLSA law, any tobacco 21 law
  » ④ some policy variables are at the level of state, conception year, and conception quarter, and they are:
    • Fraction of quarter over year with temporary vape ban and with ACA Medicaid expansion
Empirical Methods – Cross-sectional

\[ \text{Outcome} = \beta_1 \text{Tax} + \Theta \cdot \text{Dmgrophcs} + \Phi \cdot \text{Policy_Cntrls} + \text{FEs} + \epsilon \]

- What are the fixed effects (FEs)?
  - ① FEs = dummy variables (each category is controlled for by itself)
  - ② County FEs
  - ③ Time FEs = conception year × conception month (e.g., 2015-Jan)
  - ④ Mixed FEs = state of residence × conception year (e.g., MD-2015)

- How we handle standard errors?
  - Cluster them at the level of state with a small tweak: we treat Cook County, IL and Montgomery County, MD as if they were states
Empirical Methods – Panel Analysis

• How did we reshape the original birth records data

\[
\text{Outcome} = \beta_1 \text{Tax} + \Theta \cdot \text{Dmgrpchs} + \Phi \cdot \text{Policy_Cntrls} + \text{FEs} + \epsilon
\]

• How policies get merged into this long-fmted dataset?
  » Geo-location + Year of trimester (0,1,2,3) start + Qtr of trimester (0,1,2,3) start

• What are the fixed effects (FEs)?
  » Birth FEs + Trimester FEs

• No need for demographics

• Cluster std.errs in the same fashion
Summary Statistics (Selected Few)

Pct. of smoking cigarettes during pre-pregnancy
Pct. of smoking cigarettes during pregnancy

Δ% = -22.8%
Δ% = -22.6%
Δ% = -22.4%
Summary Statistics (Selected Few)

Avg. # of cigarettes smoked/day during pre-pregnancy
Avg. # of cigarettes smoked/day during pregnancy

Δ% = - 50.4%
Δ% = - 51.4%
Δ% = - 48.8%
Summary Statistics (Selected Few)

Avg. # of cigarettes smoked/day during 1st, 2nd, and 3rd trimester

- All: Δ% = - 25.3%
- Tax adopters: Δ% = - 25.4%
- Non-tax adopters: Δ% = - 23.5%
Summary Regression Results (selected few)

Effects of Stdzd E-cig Tax Rate on Any Pre-pregnancy Vaping and Any 3rd Trimester Vaping

Note: each shape-color combination denotes a separate regression PRAMS data; Full set of controls (demographics + policies) is included in regressions

b = -0.013
Δ% = -32%

b = -0.009
Δ% = -82%
Summary Regression Results (selected few)

Effects of Stdzd E-cig Tax Rate on Pre-pregnancy, Prenatal Smoking and # of Trimesters Smoked Cigs

Note: each shape-color combination denotes a separate regression. Full set of controls (demographics + policies) is included in regressions.

- $b = 0.005$, $\Delta% = 5.7%$
- $b = 0.004$, $\Delta% = 5.6%$
- $b = 0.010$, $\Delta% = 5.6%$
Summary Regression Results (selected few)

Effects of Stdzd E-cig Tax Rate on Avg. # of Cigs Smoked/Day During Pregnancy, Avg. # of Cigs Smoked/Day Among Smokers During Pregnancy, and Avg. # Cigs Smoked/Day Among Smokers During Pre-pregnancy

Note: each shape-color combination denotes a separate regression
Full set of controls (demographics + policies) is included in regressions
Summary Regression Results (Event-Study, ES)

Note: Leads and lags denote the relative difference in months between mom’s pregnancy and the time e-cigarette taxes went into effect.

**Reference group**: moms whose pregnancy precedes e-cigarette tax implementation by 9 to 12 months

Full set of controls (demographics + policies) is included in regressions
Summary Regression Results (ES)

Effects of E-cig Tax On Avg. # of Cigarettes Smoked During Pregnancy

Note: Leads and lags denote the relative difference in months between mom’s pregnancy and the time e-cigarette taxes went into effect.

Full set of controls (demographics + policies) is included in regressions.
Note: Each shape-color combination denotes a separate (sub-sample) regression.

Full set of controls (demographics + policies) is included in regressions.
Summary Regression Results (Tax Effect Het.)

Effects of Stdzd E-cig Tax Rate On Prob. of *Prenatal* Smoking

Note: Each shape-color combination denotes a separate (sub-sample) regression.

Full set of controls (demographics + policies) is included in regressions.
Summary Regression Results (Panel Analysis)

Effects of Stdzd E-cig Tax Rate on
Any Smoking,
Avg. # of Cig Smoked/Day (Among Smokers), and
Avg. # Cig Smoked/Day
During Pregnancy

Note: Each shape-color combination denotes a separate regression.
Policy variables, Birth FEs, and Trimester FEs are controlled for in regressions.
Summary Regression Results (Birth Outcomes)

Note: Each shape-color combination denotes a separate regression. The full set of controls (demographics + policies + FEs) is controlled for in regressions.
Extension – Robustness Checks

1. Replace standardized e-cig tax rate with its dichotomized version (0-1)
   » Address concerns raised in recent literature on the conventional DD setup
   » Execute Goodman-Bacon decomposition

2. Compare βs across models that a) without demographic nor policy controls; b) with demographics only; c) with both demographics and policy controls
   » Note, FEs are always in

3. Shift the reference group used in ES-style regression to a different point

4. Examine the extent to which e-cig tax effect is correlated with composition of births (i.e., is pregnancy itself affected by e-cig taxes)

5. Check balance of data (or correlates of e-cigarette taxes and demographics and policy controls)

6. Start the analysis sample in 2011

7. Cluster standard errors at a different level

8. Check sensitivity of results to using a different retailer markup rate

9. And many more …
Extension – (Leave-One-Out Analysis)

Effects of Stdzd E-cig Tax Rate On Prob. of Pre-pregnancy Smoking
Extension – (Leave-One-Out Analysis)

Effects of Stdzd E-cig Tax Rate On Prob. of Prenatal Smoking
Summary of Findings

1. What we investigated?
   » Impact of e-cigarette taxes (in particular, the standardized e-cig tax rate) on pre-pregnancy and prenatal smoking and vaping, and birth outcomes

2. What we found?
   » E-cig taxes led to higher pre-pregnancy and prenatal smoking
   » The increased prenatal smoking is likely not due to e-cig taxes alone
     ◦ Some portion of the increase may be carry-over from the increased pre-pregnancy smoking
   » Smoking declines monotonically as the birth date nears, and increased prenatal smoking attributable to e-cig taxes is concerning → discouraged smoking cessation
   » Combine the first-stage effect from PRAMS: for every 3 moms who didn’t use e-cigs due to higher e-cig taxes, one of them used cigarettes instead
   » No stat. sig impact on birth outcomes (nicotine is harmful for fetal dev. regardless of tobacco products + small effects on cigarette smoking to have meaningful birth impacts)
Discussion (Brief)

While no stat. sig. effect on birth outcomes, increased smoking during pregnancy is concerning from a public health standpoint:

» Pre-pregnancy smoking carried over to prenatal smoking, which may carry over to post-pregnancy smoking: Negative childhood development issues due to second-hand smoke exposure

» Missed opportunity for smoking cessation for the mother, with potentially harmful consequences for her own health
Discussion (Brief)

Current literature on smoking during pregnancy and the health of newborn

» Smoking during pregnancy is the number one risk factor for having a low birth weight infant (Almond et al., 2005)

» In-utero exposure to cigarette smoke has been shown to directly impact the developing brain and impair early health and human capital development (Breslau et al., 1994; Bublitz and Stroud, 2011; Basten et al., 2015; Banderali et al., 2015; Akshoomoff et al., 2017)

» Reduced prenatal smoking improves children’s human capital development, especially for low socioeconomic status children (Settele and Van Ewijk, 2018)

E-cigarettes continue to alter the tobacco marketplace. Active policy area across the country.
The Effect of E-Cigarette Taxes on Pre-pregnancy and Prenatal Smoking

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