The Effects of Smoking Cessation on Mental Health: Evidence from a Randomized Trial

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Overview

1. Disclosures

2. Introduction and Motivation

3. Lung Health Study

4. Data

5. Empirical Method

6. Results
   - Long-Run Effects
   - Short-Run Effects

7. Conclusion
Disclosures

- We have not received any funding for this project
- We have not received any tobacco-related funding in the past
- There are no additional conflicts of interest to disclose
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Smoking and Mental Health

- Smoking is harmful to the smoker and those around them
  - Anti-tobacco policies deter take-up (e.g., taxes) or encourage cessation (e.g., nicotine replacement therapy)
  - Should take into account unintended effects on mental health

- Mental illness is costly
  - 1 in 5 adults in the U.S. in 2019 (SAMHSA 2020)
  - Treatment increases earnings, improves physical health, and increases parental investments in children (Ridley et al. 2020)
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Relationship between Smoking and Mental Health

- Those with mental illness are 2-3x more likely to be smokers
  - Causal mechanisms not well-understood
    - Hypothesis 1: smoking $\rightarrow$ worse mental health
    - Hypothesis 2: poor mental health $\rightarrow$ smoking
    - Hypothesis 3: not causally related, coincide due to SES, genetics, etc.

- Effects of nicotine
  - Psychoactive drug, acts as stimulant and depressant
    - may worsen OR relieve anxiety & depression (Picciotto et al, 2002)
  - Use of nicotine as “self-medication” (hypothesis 2)
    - teenagers initiate begin after stressful events (Friedman, 2020);
    - smokers report smoking improves mood (withdrawal?)
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Effects unrelated to nicotine

- Behavioral changes
  - alcohol as complement (Dee, 1999); social activities
- Depression due to decline in physical health

Thus, smoking and mental health may be related in many ways

- comparisons of mental health b/w smokers and non-smokers are likely biased
- need exogenous variation to estimate causal effects
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Lung Health Study

- Re-use data from the Lung Health Study (LHS).
  - Randomized controlled trial w/ smokers at risk for COPD
  - Goal: Study effect of prescription inhaler on COPD onset
  - Treatment: intensive cessation intervention + inhaler
  - Followed for the next five years
  - Randomization → clean estimation of causal effects

- Study participants included 5,887 at-risk smokers, age 35-65
  - recruited in 1987-1988 at 10 clinical centers in U.S. and Canada
  - no serious illnesses or plans to move away from the clinic area
  - Note, participants more White, college-educated, motivated to quit than average smoker
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Lung Health Study: Treatment

- Three equal groups: two treatment arms, one control arm
  - Treated individuals undergo cessation program in early 1989
    - One group got prescription inhaler, other gets placebo

Smoking cessation program:

1. Physician’s message about lung impairment and disease risk
2. “10 week, 12-session group program emphasizing cognitive and behavioral strategies for cessation”
3. Support from family members
4. 6 months of nicotine gum
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Lung Health Study

- 5 years of follow-up (1990-1994)
  - Treated individuals return to clinic every 4 months
    - Promote inhaler usage, prevent relapse
  - All individuals re-interviewed annually (5x)
    - Health and healthcare info, pulmonary testing to validate cessation

- Success or failure?
  - Cessation program highly effective (sustained quit: 22% vs. 5%)
  - Attrition low (96% in year 5)
  - BUT inhaler had little added benefit, study deemed “failure” (Anthonisen et al, 1994)
    - Many measures left un-examined
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Prior Research using LHS to Estimate Causal Effects

- Increased cessation and lung function after 5 and 11 years (Kanner et al., 1996; Anthonisen et al., 1994; Anthonisen et al., 2002)

- Lower rates of respiratory illness at 5 years (Kanner et al., 2001)

- Reduction in mortality at 14.5 years (Anthonisen et al., 2005)

- No difference in alcohol usage at 1 year (Murray et al., 1996)

- Increase in BMI of .8 to 1.9 points, or 11-12 lbs for avg male (Courtemanche et al., 2018)

- Spouses also more likely to quit smoking (Fletcher and Marksteiner, 2017)
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Data: Mental Health Outcomes

“Indicate the extent to which you have been troubled in the last four months by any of the following [conditions]: Severe (3), Moderate (2), Mild (1), or Not at all (0).”

- Irritability, insomnia, mood changes, nervousness, psych. illness
- **Distress Scale**$_{it} =$ sum scores across conditions, for $i$ in year $t$
- **Severe Distress**$_{it} =$ share of conditions for which $i$ indicates “severe” in year $t$

- List presc. drugs over last 12 months, bring bottles
- **Anti-Depressant**$_{it} =$ any anti-depressant taken by $i$ in year $t$
- **Anti-Anxiety**$_{it} =$ any anti-anxiety drug taken by $i$ in year $t$
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Data: Outcomes

Short vs. Long-Run Effects of Quitting

- differentiate b/w effects of nicotine withdrawal and long-term effects
  - withdrawal may affect 1st interview (+2 months after nic gum runs out)

- For each outcome $Y$, define

  - $Y_{\text{short-run}} = Y_{i1}$
  - $Y_{\text{long-run}} = (1/4) \sum_{2}^{5} Y_{it}$
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Empirical Method

We estimate the causal effect of cessation program as follows:

\[ Y_i = \alpha + \beta \text{Treatment}_i + \epsilon_i \]  

- \( Y_i \) is a measure of smoking or mental health
- \( \text{Treatment}_i \) indicates \( i \) is assigned to either treatment arm
- Adjust \( \epsilon_i \) for heteroskedasticity across individuals
- Alternative approach: IV using cigarettes per day

Random assignment \( \rightarrow \) \( \text{Treatment}_i \) is independent of \( \epsilon_i \)

- Confirm balanced sample
- \( \rightarrow \) \( \beta \) measures causal effect of cessation intervention on \( Y_i \)
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Gender Heterogeneity

- Existing evidence suggests heterogeneous effects by gender
  - Men historically more likely to smoke (Holford et al. 2014)
  - Smoking activates male smokers’ reward pathways more (Cosgrove et al. 2014), specifically tied to nicotine (Perkins and Karelitz, 2015)

- Estimate effects separately for men and women
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Smoking Behavior

- Treatment effects on long-run smoking behavior:
  - Sustained quitting ↑ 16.9 pp (307%)
    - men are more responsive than women (337% vs. 262%)
  - Treatment works primarily to increase sustained quitting
    - women somewhat more likely to relapse
  - Cigs/day ↓ 8.1 (38%)
    - treatment also works on intensive margin
    - similar % declines for men and women
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Mental Health Outcomes

- **Treatment effects on long-run mental health:**
  - Overall, small and insig. effects on distress scale
    - For men, small and insig. increase
    - For women, ↓ 0.25 (10%)
  - Effects by components of distress scale:
    - For women, insomnia and nervousness scores ↓ 18% and 13%
  - Severe distress
    - For men, ↑ 0.48, 37% of mean
    - Small, negative for women
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Treatment effects on long-run mental health:

- Likelihood of taking anti-depressants or anti-anxiety drugs
  - for men, marginally significant increase in anxiolytics of 0.7pp (33%)
  - for women, negative effects, but imprecise
  - no differences in 2SLS estimates

To summarize:

- Women’s mental health improved, through reductions in insomnia and nervousness (not Rx)
- For men, comparatively worse effects on mental health
  - no decline overall, but a small increase in severe disturbances
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Smoking and Mental Health

- Treatment effects on short-run outcomes:
  - Current quit $\uparrow$ 26.0 pp (279%)
  - Cigs/day $\downarrow$ 12.4 (47.9%)
    - Larger than long-term measures
    - Marginally larger effects for men
  - Distress scale $\uparrow$ 0.21 (12%)
  - Severe distress $\uparrow$ 0.01 (28%)
    - Positive for both men and women
    - Not statistically different
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- Relationship b/w smoking and mental health is not well-understood
  - (1) Smoking $\rightarrow$ poor mental health
  - (2) Poor mental health $\rightarrow$ smoking
  - (3) No causal relationship

- Use Lung Health Study to estimate effects of cessation on mental health
  - women experience long-run mental health gains (1)
  - no evidence of improvements for men (3)
    - in fact, small increase in severe disturbances (2)

- Policies that aim to reduce cigarette consumption may have mental health benefits, in particular for women
  - Cessation policies and mental health supports may be complementary policies, in particular for men
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Contribution

- New evidence on causal effects of smoking on mental health
  - Inform anti-smoking policy, esp. cessation efforts
    - Under ACA, increased use of cessation aids by low-SES individuals (Cotti et al., 2019)
    - Generate welfare benefits in long-run for women
    - For men, anti-smoking policy and mental health supports may be complementary
    - Implications for e-cigarettes, which deliver nicotine

- Use caution in extrapolating our results
  - LHS is more white, urban, & college-educated; only 35-65; at-risk for COPD
  - Participants want to quit
  - Treatment includes behavioral/cognitive elements (likely short-term)
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<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Treatment</th>
<th>Control</th>
<th>Diff</th>
<th>P-Val</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>48.45</td>
<td>48.48</td>
<td>0.03</td>
<td>0.86</td>
</tr>
<tr>
<td>Male</td>
<td>0.62</td>
<td>0.64</td>
<td>0.02</td>
<td>0.21</td>
</tr>
<tr>
<td>no HS Diploma</td>
<td>0.12</td>
<td>0.12</td>
<td>-0.00</td>
<td>0.78</td>
</tr>
<tr>
<td>HS Diploma</td>
<td>0.30</td>
<td>0.29</td>
<td>-0.01</td>
<td>0.40</td>
</tr>
<tr>
<td>Cigs. per Day</td>
<td>31.29</td>
<td>30.99</td>
<td>-0.31</td>
<td>0.39</td>
</tr>
<tr>
<td>Age, First Cigarette</td>
<td>17.43</td>
<td>17.57</td>
<td>0.14</td>
<td>0.20</td>
</tr>
<tr>
<td>Total Distress Score</td>
<td>1.89</td>
<td>1.81</td>
<td>-0.08</td>
<td>0.25</td>
</tr>
<tr>
<td>Distress: Severe</td>
<td>0.02</td>
<td>0.02</td>
<td>-0.00</td>
<td>0.76</td>
</tr>
<tr>
<td>Irritability, Past 4 Mos.</td>
<td>0.55</td>
<td>0.52</td>
<td>-0.02</td>
<td>0.28</td>
</tr>
<tr>
<td>Insomnia, Past 4 Mos.</td>
<td>0.40</td>
<td>0.39</td>
<td>-0.01</td>
<td>0.74</td>
</tr>
<tr>
<td>Mood Changes, Past 4 Mos.</td>
<td>0.40</td>
<td>0.40</td>
<td>-0.01</td>
<td>0.74</td>
</tr>
<tr>
<td>Nervous, Past 4 Mos.</td>
<td>0.49</td>
<td>0.46</td>
<td>-0.03</td>
<td>0.14</td>
</tr>
<tr>
<td>Psych. Problems, Past 4 Mos.</td>
<td>0.05</td>
<td>0.05</td>
<td>-0.01</td>
<td>0.50</td>
</tr>
<tr>
<td>Anti-Depress., Past Year</td>
<td>0.01</td>
<td>0.02</td>
<td>0.00</td>
<td>0.43</td>
</tr>
<tr>
<td>Anxiolytic, Past Year</td>
<td>0.03</td>
<td>0.02</td>
<td>-0.00</td>
<td>0.84</td>
</tr>
<tr>
<td>Observations</td>
<td>3,812</td>
<td>1,893</td>
<td>5,705</td>
<td>5,705</td>
</tr>
</tbody>
</table>

Sample has non-missing values of long-run distress scale and Rx outcomes.
Long-Run Effects of Cessation Program on Distress Score Components

Notes: Displayed above are point estimates and 95% confidence intervals corresponding to $\beta$ from Eq. (1).
### Table: Long-Run Effects of the Cessation Program on Smoking, Part 1

<table>
<thead>
<tr>
<th></th>
<th>(1) Sustained Quit</th>
<th>(2) Current Quit</th>
<th>(3) Cigs per Day</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: All</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>0.1689</td>
<td>0.1894</td>
<td>-8.0687</td>
</tr>
<tr>
<td></td>
<td>(0.0086)</td>
<td>(0.0101)</td>
<td>(0.3674)</td>
</tr>
<tr>
<td></td>
<td>[0.0000]</td>
<td>[0.0000]</td>
<td>[0.0000]</td>
</tr>
<tr>
<td>Obs.</td>
<td>5,627</td>
<td>5,705</td>
<td>5,705</td>
</tr>
<tr>
<td>Control Mean</td>
<td>0.0546</td>
<td>0.1724</td>
<td>21.4838</td>
</tr>
</tbody>
</table>

Notes: The dataset is the Lung Health Study, limited to individuals with non-missing values of the dependent variable and the long-run distress score. Each point estimate, heteroskedasticity-robust standard error (in parentheses) and p-value (in brackets) is from a separate regression estimating Eq. 1. At the bottom of the table, we report p-values from a Chi-squared test of whether the difference in coefficients for men and women is equal to 0.
## Table: Long-Run Effects of the Cessation Program on Smoking, Part 2

<table>
<thead>
<tr>
<th>Panel</th>
<th>Sustained Quit</th>
<th>Current Quit</th>
<th>Cigs per Day</th>
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<tbody>
<tr>
<td><strong>Panel B: Men</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>0.1843</td>
<td>0.1922</td>
<td>-8.6535</td>
</tr>
<tr>
<td>(0.0110)</td>
<td>(0.0129)</td>
<td>(0.4880)</td>
<td></td>
</tr>
<tr>
<td>[0.0000]</td>
<td>[0.0000]</td>
<td>[0.0000]</td>
<td></td>
</tr>
<tr>
<td>Obs.</td>
<td>3,519</td>
<td>3,575</td>
<td>3,575</td>
</tr>
<tr>
<td>Control Mean</td>
<td>0.0546</td>
<td>0.1779</td>
<td>22.4267</td>
</tr>
<tr>
<td><strong>Panel C: Women</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>0.1438</td>
<td>0.1854</td>
<td>-6.9925</td>
</tr>
<tr>
<td>(0.0137)</td>
<td>(0.0163)</td>
<td>(0.5374)</td>
<td></td>
</tr>
<tr>
<td>[0.0000]</td>
<td>[0.0000]</td>
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<tr>
<td>Obs.</td>
<td>2,108</td>
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<tr>
<td>Control Mean</td>
<td>0.0547</td>
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<td>19.8210</td>
</tr>
<tr>
<td>P-Value, Men-Women</td>
<td>0.0214</td>
<td>0.7420</td>
<td>0.0221</td>
</tr>
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</table>

Meckel and Rittenhouse, 2022
### Table: Long-Run Effects of Cessation Program on Mental Health, Part 1

<table>
<thead>
<tr>
<th></th>
<th>(1) Distress Scale</th>
<th>(2) Distress: Severe</th>
<th>(3) Anxiolytic</th>
<th>(4) Anti-Depressant</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: All</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>-0.0436</td>
<td>0.0016</td>
<td>0.0082</td>
<td>-0.0024</td>
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<tr>
<td></td>
<td>(0.0671)</td>
<td>(0.0020)</td>
<td>(0.0072)</td>
<td>(0.0074)</td>
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<tr>
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<td>[0.4187]</td>
<td>[0.2563]</td>
<td>[0.7514]</td>
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<td>5,705</td>
<td>5,705</td>
<td>5,705</td>
<td>5,705</td>
</tr>
<tr>
<td>Control Mean</td>
<td>1.7719</td>
<td>0.0204</td>
<td>0.0681</td>
<td>0.0766</td>
</tr>
</tbody>
</table>

Notes: Each point estimate, heteroskedasticity-robust standard error (in parentheses) and p-value (in brackets) is from a separate regression estimating Eq. 1. We estimate IV regressions of the effects of smoking cigarettes on these outcomes (Eq. 3) separately for men and women. At the bottom of the table, we report the difference between these estimates and the p-value from a Chi-squared test of whether the difference in coefficients is equal to 0.
<table>
<thead>
<tr>
<th></th>
<th>Panel B: Men</th>
<th>Panel C: Women</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1) Distress Scale</td>
<td>(2) Dist: Severe</td>
</tr>
<tr>
<td></td>
<td>(3) Anxiolytic</td>
<td>(4) Anti-Dep.</td>
</tr>
<tr>
<td>Treatment</td>
<td>0.0558 (0.0762)</td>
<td>0.0048 (0.0022)</td>
</tr>
<tr>
<td></td>
<td>[0.4644]</td>
<td>[0.0259]</td>
</tr>
<tr>
<td></td>
<td>0.0068 (0.0039)</td>
<td>0.0026 (0.0044)</td>
</tr>
<tr>
<td></td>
<td>[0.5557]</td>
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</tr>
<tr>
<td>Obs.</td>
<td>3,575</td>
<td>3,575</td>
</tr>
<tr>
<td>Control Mean</td>
<td>1.4151</td>
<td>0.0131</td>
</tr>
<tr>
<td></td>
<td>0.0206</td>
<td>0.0266</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>-0.2510 (0.1231)</td>
<td>-0.0046 (0.0038)</td>
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<td>[0.0416]</td>
<td>[0.2307]</td>
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<tr>
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<td>-0.0020 (0.0071)</td>
<td>0.0055 (0.0076)</td>
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<td>[0.7747]</td>
<td>[0.4714]</td>
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<tr>
<td>Obs.</td>
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<td>2,130</td>
</tr>
<tr>
<td>Control Mean</td>
<td>2.4010</td>
<td>0.0334</td>
</tr>
<tr>
<td></td>
<td>0.0448</td>
<td>0.0523</td>
</tr>
<tr>
<td>Diff, M-W: b/cigs</td>
<td>-0.0423 (0.0309)</td>
<td>-0.0012 (0.0438)</td>
</tr>
<tr>
<td>P-Value</td>
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<td>0.3326</td>
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<td></td>
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<td>0.6897</td>
</tr>
<tr>
<td>(1) Quit Cigs/Day Distress Scale Dist.: Severe Anxiolytic Anti-Dep.</td>
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</tr>
<tr>
<td>----------------------</td>
<td>-------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Treatment</td>
<td>Treatment</td>
<td>Treatment</td>
</tr>
<tr>
<td>0.2604 (0.0102)</td>
<td>-12.3920 (0.3649)</td>
<td>0.2113 (0.0704)</td>
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<td>[0.0000]</td>
<td>[0.0000]</td>
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<td>5,474</td>
</tr>
<tr>
<td>Control Mean</td>
<td>0.0930</td>
<td>25.9182</td>
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</tbody>
</table>

Notes: Each point estimate, heteroskedasticity-robust standard error (in parentheses) and p-value (in brackets) is from a separate regression estimating Eq. 1. At the bottom of Columns (2) and (3), we report the p-value from a Chi-squared test of whether the coefficient estimates for men and women are equal. At the bottom of Columns (3)-(5), we report the difference between these estimates and the p-value from a test of whether they are equal.
## Table: Short-Run Effects of Cessation Program, Part 2

<table>
<thead>
<tr>
<th></th>
<th>(1) Quit Cigs/Day</th>
<th>(2) Distress Scale</th>
<th>(3) Dist.: Severe</th>
<th>(4) Anxiolytic</th>
<th>(5) Anti-Dep.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel B: Men</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>0.2735 (0.0129)</td>
<td>-13.7460 (0.4766)</td>
<td>0.2286 (0.0813)</td>
<td>0.0056 (0.0026)</td>
<td>0.0013 (0.0050)</td>
</tr>
<tr>
<td></td>
<td>[0.0000]</td>
<td>[0.0000]</td>
<td>[0.0050]</td>
<td>[0.0334]</td>
<td>[0.7942]</td>
</tr>
<tr>
<td>Obs.</td>
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<td>3,418</td>
<td>3,410</td>
<td>3,427</td>
<td>3,427</td>
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<td>27.4547</td>
<td>1.3804</td>
<td>0.0117</td>
<td>0.0190</td>
</tr>
<tr>
<td><strong>Panel C: Women</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>0.2386 (0.0168)</td>
<td>-10.0173 (0.5450)</td>
<td>0.1470 (0.1272)</td>
<td>0.0036 (0.0049)</td>
<td>-0.0002 (0.0084)</td>
</tr>
<tr>
<td></td>
<td>[0.0000]</td>
<td>[0.0000]</td>
<td>[0.2482]</td>
<td>[0.4700]</td>
<td>[0.9813]</td>
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<tr>
<td>Obs.</td>
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<td>2,066</td>
<td>2,064</td>
<td>2,070</td>
<td>2,070</td>
</tr>
<tr>
<td>Control Mean</td>
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<td>23.2489</td>
<td>2.1940</td>
<td>0.0291</td>
<td>0.0330</td>
</tr>
<tr>
<td>Diff, M-W: b/cigs</td>
<td>-0.0033</td>
<td>0.0000</td>
<td>-0.0001</td>
<td>0.0003</td>
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<tr>
<td>P-Value</td>
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<td>0.0000</td>
<td>0.7927</td>
<td>0.9376</td>
<td>0.9026</td>
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</table>

Meckel and Rittenhouse, 2022

Smoking Cessation and Mental Health

August 11, 2022
<table>
<thead>
<tr>
<th></th>
<th>(1) Distress Scale</th>
<th>(2) Distress: Severe</th>
<th>(3) Anxiolytic</th>
<th>(4) Anti-Dep.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: Men</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg. Cigarettes per Day, Years 2-5</td>
<td>-0.0064 (0.0089) [0.4666]</td>
<td>-0.0006 (0.0003) [0.0285]</td>
<td>-0.0008 (0.0005) [0.0836]</td>
<td>0.0003 (0.0005) [0.5560]</td>
</tr>
<tr>
<td>Obs.</td>
<td>3,575</td>
<td>3,575</td>
<td>3,575</td>
<td>3,575</td>
</tr>
<tr>
<td>Control Mean, Men</td>
<td>1.4151</td>
<td>0.0131</td>
<td>0.0206</td>
<td>0.0266</td>
</tr>
<tr>
<td>F-Statistic</td>
<td>315</td>
<td>315</td>
<td>315</td>
<td>315</td>
</tr>
<tr>
<td><strong>Panel B: Women</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg. Cigarettes per Day, Years 2-5</td>
<td>0.0359 (0.0175) [0.0403]</td>
<td>0.0007 (0.0005) [0.2284]</td>
<td>0.0003 (0.0010) [0.7749]</td>
<td>0.0008 (0.0011) [0.4726]</td>
</tr>
<tr>
<td>Obs.</td>
<td>2,130</td>
<td>2,130</td>
<td>2,130</td>
<td>2,130</td>
</tr>
<tr>
<td>Control Mean, Women</td>
<td>2.4010</td>
<td>0.0334</td>
<td>0.0448</td>
<td>0.0523</td>
</tr>
<tr>
<td>F-Statistic</td>
<td>169</td>
<td>169</td>
<td>169</td>
<td>169</td>
</tr>
</tbody>
</table>

Meckel and Rittenhouse, 2022

Smoking Cessation and Mental Health

August 11, 2022
**Table: Long-Run Effects on Distress Score Components, Part 1**

<table>
<thead>
<tr>
<th></th>
<th>(1) Irritation</th>
<th>(2) Insomnia</th>
<th>(3) Moodiness</th>
<th>(4) Nervous</th>
<th>(5) Psych. Illness</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: All</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>-0.0084</td>
<td>-0.0300</td>
<td>-0.0058</td>
<td>-0.0057</td>
<td>0.0068</td>
</tr>
<tr>
<td></td>
<td>(0.0195)</td>
<td>(0.0212)</td>
<td>(0.0175)</td>
<td>(0.0193)</td>
<td>(0.0092)</td>
</tr>
<tr>
<td></td>
<td>[0.6674]</td>
<td>[0.1578]</td>
<td>[0.7398]</td>
<td>[0.7699]</td>
<td>[0.4598]</td>
</tr>
<tr>
<td>Obs.</td>
<td>5,705</td>
<td>5,705</td>
<td>5,705</td>
<td>5,705</td>
<td>5,705</td>
</tr>
<tr>
<td>Control Mean</td>
<td>0.4697</td>
<td>0.4526</td>
<td>0.3589</td>
<td>0.4057</td>
<td>0.0850</td>
</tr>
</tbody>
</table>

Each point estimate, heteroskedasticity-robust standard error (in parentheses) and p-value (in brackets) is from a separate 2SLS regression estimating Eq. 3. At the bottom of the table, we report the F-Statistic from the first stage regression (Eq. 2).
### Table: Long-Run Effects on Distress Score Components, Part 2

<table>
<thead>
<tr>
<th></th>
<th>(1) Irritation</th>
<th>(2) Insomnia</th>
<th>(3) Moodiness</th>
<th>(4) Nervous</th>
<th>(5) Psych. Illness</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel B: Men</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>0.0078</td>
<td>0.0157</td>
<td>-0.0076</td>
<td>0.0287</td>
<td>0.0112</td>
</tr>
<tr>
<td></td>
<td>(0.0226)</td>
<td>(0.0237)</td>
<td>(0.0205)</td>
<td>(0.0212)</td>
<td>(0.0104)</td>
</tr>
<tr>
<td></td>
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<td>[0.5086]</td>
<td>[0.7104]</td>
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<td>3,575</td>
<td>3,575</td>
<td>3,575</td>
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<tr>
<td>Control Mean</td>
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<td>0.3411</td>
<td>0.3096</td>
<td>0.3037</td>
<td>0.0648</td>
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<tr>
<td><strong>Panel C: Women</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>-0.0440</td>
<td>-0.1188</td>
<td>-0.0091</td>
<td>-0.0748</td>
<td>-0.0029</td>
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<td>(0.0354)</td>
<td>(0.0399)</td>
<td>(0.0317)</td>
<td>(0.0369)</td>
<td>(0.0174)</td>
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<tr>
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<td>[0.2137]</td>
<td>[0.0030]</td>
<td>[0.7747]</td>
<td>[0.0427]</td>
<td>[0.8674]</td>
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<td>2,130</td>
<td>2,130</td>
<td>2,130</td>
<td>2,130</td>
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<tr>
<td>Control Mean</td>
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<td>Diff, M-W: b/cigs</td>
<td>-0.0072</td>
<td>-0.0188</td>
<td>-0.0004</td>
<td>-0.0140</td>
<td>-0.0017</td>
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<td>0.0030</td>
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<td>0.5363</td>
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<td></td>
<td>(1) Distress Scale</td>
<td>(2) Distress: Severe</td>
<td>(3) Anxiolytic</td>
<td>(4) Anti-Dep.</td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td>--------------------</td>
<td>----------------------</td>
<td>----------------</td>
<td>--------------</td>
<td></td>
</tr>
<tr>
<td><strong>Panel A: Men</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg. Cigarettes per Day, Year 1</td>
<td>-0.0161 (0.0058) [0.0054]</td>
<td>-0.0004 (0.0002) [0.0388]</td>
<td>-0.0001 (0.0003) [0.7941]</td>
<td>-0.0002 (0.0003) [0.5351]</td>
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<td>Obs.</td>
<td>3,575</td>
<td>3,575</td>
<td>3,575</td>
<td>3,575</td>
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</tr>
<tr>
<td>Control Mean, Men</td>
<td>1.3804</td>
<td>0.0117</td>
<td>0.0190</td>
<td>0.0112</td>
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</tr>
<tr>
<td>F-Statistic</td>
<td>71</td>
<td>71</td>
<td>71</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td><strong>Panel B: Women</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg. Cigarettes per Day, Year 1</td>
<td>-0.0128 (0.0112) [0.2514]</td>
<td>-0.0003 (0.0005) [0.4736]</td>
<td>0.0000 (0.0008) [0.9813]</td>
<td>-0.0004 (0.0007) [0.5608]</td>
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</tr>
<tr>
<td>Obs.</td>
<td>2,130</td>
<td>2,130</td>
<td>2,130</td>
<td>2,130</td>
<td></td>
</tr>
<tr>
<td>Control Mean, Women</td>
<td>2.1940</td>
<td>0.0291</td>
<td>0.0330</td>
<td>0.0255</td>
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</tr>
<tr>
<td>F-Statistic</td>
<td>27</td>
<td>27</td>
<td>27</td>
<td>27</td>
<td></td>
</tr>
</tbody>
</table>
Dynamic Effects of Cessation Program on Distress Scale

Sample: All

Sample: Men

Sample: Women
Dynamic Effects of Cessation Program on Severe Distress
Dynamic Effects of Cessation Program on Anxiolytic Usage

Sample: All

Sample: Men

Sample: Women
Dynamic Effects of Cessation Program on Anti-Depressant Usage

Sample: All

Sample: Men

Sample: Women
<table>
<thead>
<tr>
<th></th>
<th>(1) Distress Scale</th>
<th>(2) Distress: Severe</th>
<th>(3) Anxiolytic</th>
<th>(4) Anti-Depressant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment × Year 1</td>
<td>0.2188</td>
<td>0.0054</td>
<td>0.0005</td>
<td>0.0035</td>
</tr>
<tr>
<td></td>
<td>(0.0697)</td>
<td>(0.0025)</td>
<td>(0.0044)</td>
<td>(0.0037)</td>
</tr>
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<td></td>
<td>[0.0017]</td>
<td>[0.0283]</td>
<td>[0.9083]</td>
<td>[0.3561]</td>
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<tr>
<td>Treatment × Year 2</td>
<td>0.0075</td>
<td>0.0037</td>
<td>0.0034</td>
<td>0.0028</td>
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<tr>
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<td>(0.0657)</td>
<td>(0.0023)</td>
<td>(0.0047)</td>
<td>(0.0048)</td>
</tr>
<tr>
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<td>[0.9089]</td>
<td>[0.1030]</td>
<td>[0.4772]</td>
<td>[0.5569]</td>
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<td>Treatment × Year 3</td>
<td>-0.0354</td>
<td>0.0011</td>
<td>0.0042</td>
<td>-0.0024</td>
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<td>(0.0020)</td>
<td>(0.0049)</td>
<td>(0.0050)</td>
</tr>
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<td>[0.5665]</td>
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<td>[0.3890]</td>
<td>[0.6271]</td>
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<tr>
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<td>0.0054</td>
<td>-0.0065</td>
</tr>
<tr>
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<td>(0.0620)</td>
<td>(0.0020)</td>
<td>(0.0049)</td>
<td>(0.0052)</td>
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<td>[0.1995]</td>
<td>[0.7580]</td>
<td>[0.2617]</td>
<td>[0.2138]</td>
</tr>
<tr>
<td>Treatment × Year 5</td>
<td>-0.0083</td>
<td>-0.0009</td>
<td>0.0080</td>
<td>-0.0064</td>
</tr>
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<td>Table: Dynamic Effects of Cessation Program on Mental Health, Men</td>
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<tr>
<td><strong>Distress Scale</strong></td>
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<td><strong>Anxiolytic</strong></td>
<td><strong>Anti-Depressant</strong></td>
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<tr>
<td><strong>Treatment × Year 1</strong></td>
<td>0.2423</td>
<td>0.0062</td>
<td>0.0004</td>
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<td>(0.0805)</td>
<td>(0.0026)</td>
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<td>0.0040</td>
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<td>(0.0760)</td>
<td>(0.0026)</td>
<td>(0.0050)</td>
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<tr>
<td><strong>Treatment × Year 3</strong></td>
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<td>0.0035</td>
<td>0.0093</td>
<td>-0.0021</td>
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<tr>
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<td>(0.0019)</td>
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<tr>
<td><strong>Treatment × Year 4</strong></td>
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<tr>
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<td>(0.0021)</td>
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<td><strong>Treatment × Year 5</strong></td>
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Table: Dynamic Effects of Cessation Program on Mental Health, Women

<table>
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<tr>
<th></th>
<th>(1) Distress Scale</th>
<th>(2) Distress: Severe</th>
<th>(3) Anxiolytic</th>
<th>(4) Anti-Depressant</th>
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<td>(0.0096)</td>
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<td>-0.0058</td>
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<td>(0.0043)</td>
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<td>Treatment × Year 4</td>
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</table>

Notes: The dataset is the Lung Health Study, limited to women with non-missing values of the dependent variable in each of the five annual interviews. Each observation is a unique combination of participant ID and interview year. Each point estimate, standard error (in parentheses) and p-value (in brackets) is from a separate regression estimating Eq. 4. The dependent variable in Column (1) is equal to the sum of the distress scores across the five mental health conditions, as reported in a given interview year. The dependent variable in Column (2) is equal to an indicator for severe distress, averaged across the five mental health conditions. The dependent variables for Columns (3) and (4) are equal to indicators for whether the participant took anti-anxiety drugs or anti-depressants over the 12 months before the given interview date. All specifications include fixed effects for each interview year, and the constant term is excluded. Standard errors are clustered at the level of participant ID.