The Impact of a Vape Ban on Cigarette Smoking and Life Expectancy

Kathleen Hui
October 20, 2023

*Researcher(s)’ own analyses calculated (or derived) based in part on data from Nielsen Consumer LLC and marketing databases provided through the NielsenIQ Datasets at the Kilts Center for Marketing Data Center at The University of Chicago Booth School of Business. The conclusions drawn from the NielsenIQ data are those of the researcher(s) and do not reflect the views of NielsenIQ. NielsenIQ is not responsible for, had no role in, and was not involved in analyzing and preparing the results reported herein.
Disclosure

Funding: Horowitz Foundation for Social Policy

No tobacco related funding in last 10 years
Vapes: a controversial tobacco product

- Vapes are believed to be less harmful than cigarettes (CDC, NASEM)
- Vapes may help older smokers quit smoking cigarettes, but may also encourage youth to become addicted and vape/smoke throughout life
- Policymakers have banned the sale of vapes
  - In 34 countries (e.g. India, Brazil, Japan)
  - Within the US (e.g. Massachusetts, San Francisco, Beverly Hills)
- Health harm depends on smoking and vaping persistence and the age of use
  - Smoking at older stages of life is particularly detrimental to life expectancy (Darden et al 2018, Doll et al 2004, Jha et al 2013)
Research question

Q: Would banning the sale of vapes in the US benefit public health?

Key idea: Vape ban → Δ Life cycle profile of tobacco use → Δ Health

Key considerations:

- Substitution between cigarettes and vapes
- Addictiveness of cigarettes and vapes
- Age-specific health effect
I estimate the impact of a potential US vape ban on smoking behavior and life expectancy

- Document patterns of substitution, addiction, and use over life cycle
  - Panel data on multiple cohorts of youth and adults, cigarette and vape addiction measures
This paper

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- Simulate choice over the life cycle with and without a vape ban
- Map life cycle profile of tobacco use to life expectancy
- Compare recommendation to shorter term analyses that do not simulate life cycle choices
Preview of results

Impact of a US vape ban

- Average life expectancy in current US population ↓ by 26 days (total 12M life-years)
- Life expectancy ↓ for all but the youngest cohort (12 to 14 in 2019)

What drives these findings?

- Older individuals are more likely to substitute to cigarettes when vapes are banned
- Effects range from 1% of 14 year old vapers to 75% of 45 year old vapers
- However, vapers who substitute to smoking smoke more persistently than they vaped
- Individuals vape more in youth than in adulthood, so a vape ban prevents vaping earlier in life but generates smoking later

Shorter term analysis can underestimate long term cumulative health impacts

- Do not fully capture differences in persistent and age-specific health harms between cigarettes and vapes
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Related literature

- Impact of vape regulation on smoking
  - Proposed advertising bans and price changes Chen Rao 2020, Tuchman 2019
  - Optimal taxation Allcott Rafkin 2022

  **This paper:** Impact of national vape ban on tobacco use over life cycle. Implication for life expectancy. Differential impacts on youth and adults.


  **This paper:** Allow product addictiveness to reflect changing nicotine levels of new good.


  **This paper:** Study health impact of national ban on harm reduction method.


  **This paper:** Application to vape regulation.
Why a national vape ban? Why a structural model?

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Why a national vape ban? Why a structural model?

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- US Food and Drug Administration (FDA) has increasingly acquired authority to regulate and ban vaping products
  - Authorized 23 vape products, denied >99% of applications, authorization can be rescinded
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- Natural experiment: State-level vape bans in 2019
  (Katchmar Gunawan Siegel 2021, Xu et al 2022)
  - Can identify impact of state-level vape ban within time frame and population studied
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  (Katchmar Gunawan Siegel 2021, Xu et al 2022)
  - Can identify impact of state-level vape ban within time frame and population studied
  - This paper: Impact of national vape ban on life cycle tobacco use and life expectancy
Questions?
Population Assessment of Tobacco and Health

- Annual panel survey of youth age 12-17 and adults (5 waves, 2014-2019)
  - Entering in 2014: Main cohort age 12 to 65+
  - Entering in 2017: Replenishment cohort age 12 to 65+
  - Entering in other years: Youth age 12-14

- Current consumption: Days smoked and vaped in last 30 days
- Consumption history: Ever tried cigarettes (vapes), smoked 100+ cigs in life, ever vaped regularly
- Addiction: e.g. My use of cigarettes (vapes) is out of control (1-5)
- Health: e.g. high blood pressure, asthma, lung cancer, reported health
- Demographics: Age, education, race, sex, census region (midwest, south, northeast, west)

Nielsen Retail Measurement Services

- Cigarette and vape prices at census region level, 2014-2019
Smoking prevalent among ages 25-54, vaping prevalent among youth.
Vaping appears less addictive than smoking

- More young abstainers transition to vaping than smoking
- However, more young vapers transition to abstaining than continue vaping
- In contrast, more young smokers continue smoking than transition to abstaining
- Smoking and vaping are persistent but smoking is more persistent than vaping
Vapers are more likely than abstainers to transition to smoking

- Vapers are more likely than abstainers to transition to smoking
- If vaping caused smoking, vape regulation should also decrease smoking
- However, natural experiments find that vape regulation increases smoking
- Possible explanation: individuals who like to vape also like to smoke
How is addiction measured?

- 5 survey responses measuring addiction to $j \in \{\text{cigarettes, vapes}\}$.
  - Do you ever have strong cravings for $j$? (0 no, 1 yes)
  - I frequently crave $j$. (1 not at all - 5 extremely like me)
  - Have you ever felt like you really needed to use $j$? (0 no, 1 yes)
  - My $j$ use is out of control. (1 not at all - 5 extremely like me)
  - I find myself reaching for $j$ without thinking about it. (1 not at all - 5 extremely like me)

- Reduced to first component from Multiple Correspondence Analysis, $A^c, A^v \in [0, 1]$

- Cigarette (vape) addiction available for individuals who smoked (vaped) this or last year

- Allows products to change in addictiveness over time in addiction model
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- Cigarette (vape) addiction available for individuals who smoked (vaped) this or last year
  - Assume no addiction if don’t use for 2 years
- Allows products to change in addictiveness over time in addiction model
Cigarette addiction is high for smokers and low for non-smokers.
Vapes appear less addictive than cigarettes

Addiction for new tobacco users

<table>
<thead>
<tr>
<th>Year</th>
<th>Cigarette addiction after smoking</th>
<th>Vape addiction after vaping</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>0.6</td>
<td>0.2</td>
</tr>
<tr>
<td>2016</td>
<td>0.4</td>
<td>0.15</td>
</tr>
<tr>
<td>2017</td>
<td>0.4</td>
<td>0.25</td>
</tr>
<tr>
<td>2019</td>
<td>0.6</td>
<td>0.4</td>
</tr>
</tbody>
</table>
At the same age, younger cohorts smoke less and vape more
Data summary: Implications for a vape ban

- Vapers may not vape for long
- Vapers who switch to smoking may smoke longer than they would have vaped
- Vapers are more likely than abstainers to transition to smoking. 2 explanations:
  1. Gateway effect → Vape ban prevents future vaping and smoking
  2. Correlated taste for vaping and smoking → Vape ban drives vapers to smoke
- As they age, young cohorts will vape more and smoke less than current adults
Model framework

Individuals’ choices are driven by personal and product characteristics

- Observable to researcher: addiction, choice last year, ever tried cigarettes, health, demographics, prices, product attractiveness in year $t$
- Unobservable to researcher: Inherent propensity to enjoy cigarettes and vapes
  - Model two classes of individuals who differ in unobservable taste for cigarettes and vapes
Model

class

cohort

\begin{align*}
\text{age}_0 &= p_0, \xi_0 \\
\text{age}_1 &= p_1, \xi_1 \\
\text{age}_2 &= p_2, \xi_2
\end{align*}

\begin{align*}
t_0 \\
t_1 \\
t_2
\end{align*}
Model

\[ \text{class} \]

\[ \text{cohort} \]

\[ A^c_0, A^w_0, h_0 \]

<table>
<thead>
<tr>
<th>age_0</th>
<th>age_1</th>
<th>age_2</th>
</tr>
</thead>
<tbody>
<tr>
<td>( p_0, \xi_0 )</td>
<td>( p_1, \xi_1 )</td>
<td>( p_2, \xi_2 )</td>
</tr>
</tbody>
</table>

\[ t_0 \quad t_1 \quad t_2 \]
Model

\[ \text{age}_0, p_0, \xi_0 \]

\[ \text{age}_1, p_1, \xi_1 \]

\[ \text{age}_2, p_2, \xi_2 \]

\[ A_0^c, A_0^v, h_0 \]

\[ t_0 \quad t_1 \quad t_2 \]
Model

\[
\begin{align*}
\text{age}_0 & : p_0, \xi_0 \\
\text{age}_1 & : p_1, \xi_1 \\
\text{age}_2 & : p_2, \xi_2 \\
\end{align*}
\]

\[
\begin{align*}
A^c_0, A^v_0, h_0 & \quad A^c_1, A^v_1, h_1 \\
\end{align*}
\]

\[
\begin{align*}
t_0 & \quad t_1 & \quad t_2
\end{align*}
\]
Model

\[
\begin{align*}
&\text{class} \\
&\text{cohort} \\
\downarrow \\
\text{Choice}_0 \quad \text{Choice}_1 \\
\downarrow \\
A_c^0, A_v^0, h_0 \quad A_c^1, A_v^1, h_1 \\
\end{align*}
\]
The model is described with the following components:

- **Class**:
  - **Cohort**:\( p_0, \xi_0 \)
  - **Age**:\( p_1, \xi_1 \)
  - **Age**:\( p_2, \xi_2 \)

- **Choice**:
  - **Choice 0**:\( A_0^c, A_0^v, h_0 \)
  - **Choice 1**:\( A_1^c, A_1^v, h_1 \)
  - **Choice 2**:\( A_2^c, A_2^v, h_2 \)

- **Time Points**:
  - \( t_0 \)
  - \( t_1 \)
  - \( t_2 \)
Model

- \( \text{Model cohort} \)
- \( \text{class} \)
- \( \text{cohort} \)

\[
\begin{align*}
&\text{Choice}_0 \\
&\text{Choice}_1 \\
&\text{Choice}_2
\end{align*}
\]

- \( \text{age}_0, p_0, \xi_0 \)
- \( \text{age}_1, p_1, \xi_1 \)
- \( \text{age}_2, p_2, \xi_2 \)

- \( A_0^c, A_0^v, h_0 \)
- \( A_1^c, A_1^v, h_1 \)
- \( A_2^c, A_2^v, h_2 \)

- \( t_0 \)
- \( t_1 \)
- \( t_2 \)
Model fit

- Data
- Latent class model
Questions?
Counterfactuals

- Cohort of individuals age 12+ in 2019
- Fix price and product quality (FE) at 2019 levels
- Simulate future choices with and without a 2019 vape ban over 1 year, 5 years, life cycle
- Map tobacco life cycle profile to life expectancy
1 year after ban: Older vapers are more likely to switch to smoking

![Bar chart showing percent of deterred vapers who switch to smoking by age in 2019. The chart shows a significant increase in the percentage of vapers who switch to smoking among the 45 to 54 age group.](chart.png)
5 years after ban: Temporary vaping ↓ and persistent smoking ↑

- Most vape use is temporary
5 years after ban: Temporary vaping ↓ and persistent smoking ↑

- Of individuals that now smoke all 5 years, 15% increased the number of years they smoked by more than the decrease in number of years they vaped
Calculating life expectancy

- Map $\Delta$ persistence and age of tobacco use over life cycle to $\Delta$ life expectancy
  - Smokers that quit before 40 have similar life expectancy as never smokers (Darden et al 2018, Doll et al 2004, Jha et al 2013, Pirie et al 2013)
  - Darden et al (2018): Smoking from 18 to death decreases life expectancy by 4.3 years
- I focus on tobacco use from age 49-59
- Assumptions
  - Smoking and vaping before age 40 does not decrease life expectancy
  - Starting at age 40, each year of smoking decreases life expectancy by 1.6 months
    \[
    \left( \frac{1.6}{12} \times (75.5 - 39 - 4.3) \right) = 4.3
    \]
    - Each year of vaping decreases life expectancy by $1.6 \times RR$ months (Relative Risk of harm)
    - $RR = .25$ from survey of tobacco scholars (Allcott Rafkin 2022)
    - Pattern of smoking and vaping from 55-59 persists until death
Vape ban decreases life expectancy for all but the youngest cohort

- For youngest cohort, benefit from decreased vaping outweighs increase in smoking
- Across cohorts, life expectancy decreases by 26 days on average (12M life-years total)
Implications for other vape regulations

- Subsidizing vapes for existing smokers may improve health (e.g., prescription model)
- Flavor bans may improve life expectancy if only young cohorts enjoy flavors
- Next steps: Alternative policies
  - Nicotine product standards
  - Taxes and subsidies
    - IV using state taxes, minimum age of sale laws
  - Prescription model
    - Vapes available when individual meets threshold for cigarette addiction
Conclusion

- I develop and estimate a dynamic panel model of cigarette and vape demand
- I simulate the effect of a vape ban on tobacco use over the life cycle and life expectancy
- A vape ban would not improve average life expectancy
  - Decrease of 26 days on average (12M life-years total), assuming vapes are 25% as harmful as cigarettes
  - Life expectancy decreases for all but the youngest cohort
- Vape regulation should consider persistence and age of tobacco use over the life cycle
  - Shorter term analyses would underestimate the negative impact of a vape ban
PATH vs other national surveys

Percentage of adults and youth who smoke/vape

- **Adult**
  - **Smoker - NHIS/NYTS**
  - **Smoker - PATH**
  - **Vaper - NHIS/NYTS**
  - **Vaper - PATH**

- **Youth**
  - **Smoker - NHIS/NYTS**
  - **Smoker - PATH**
  - **Vaper - NHIS/NYTS**
  - **Vaper - PATH**
Vape addiction distribution

Graph showing the distribution of individuals who abstain, smoke, and vape at different levels of $A_{t+1}$.
## Choice Estimates

<table>
<thead>
<tr>
<th>Coefficient Type</th>
<th>Variable</th>
<th>Class 1</th>
<th>Class 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cigarette and vape utility</td>
<td>price</td>
<td>0.01</td>
<td>-0.27</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.3)</td>
<td>(0.26)</td>
</tr>
<tr>
<td>Cigarette utility</td>
<td>intercept</td>
<td>-7.63***</td>
<td>-5.92***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.98)</td>
<td>(1.85)</td>
</tr>
<tr>
<td></td>
<td>ever try cigarette&lt;sub&gt;_t-1&lt;/sub&gt;</td>
<td>2.63***</td>
<td>2.93***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.2)</td>
<td>(0.26)</td>
</tr>
<tr>
<td></td>
<td>smoker&lt;sub&gt;_t-1&lt;/sub&gt;</td>
<td>1.31***</td>
<td>5.85***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.13)</td>
<td>(0.25)</td>
</tr>
<tr>
<td></td>
<td>vapor&lt;sub&gt;_t-1&lt;/sub&gt;</td>
<td>0.61**</td>
<td>3.68***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.25)</td>
<td>(0.23)</td>
</tr>
<tr>
<td></td>
<td>A&lt;sub&gt;f&lt;/sub&gt;</td>
<td>1.73***</td>
<td>4.7***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.13)</td>
<td>(0.33)</td>
</tr>
<tr>
<td></td>
<td>A&lt;sub&gt;f'&lt;/sub&gt;</td>
<td>0.92**</td>
<td>1.44***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.37)</td>
<td>(0.51)</td>
</tr>
<tr>
<td></td>
<td>bh&lt;sub&gt;_t&lt;/sub&gt;</td>
<td>-0.11</td>
<td>1.1**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.34)</td>
<td>(0.53)</td>
</tr>
<tr>
<td></td>
<td>2019</td>
<td>-0.39***</td>
<td>-0.81***</td>
</tr>
<tr>
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<td>(0.13)</td>
<td>(0.23)</td>
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<tr>
<td>Vape utility</td>
<td>intercept</td>
<td>-6.19***</td>
<td>-4.59***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.32)</td>
<td>(1.28)</td>
</tr>
<tr>
<td></td>
<td>ever try cigarette&lt;sub&gt;_t-1&lt;/sub&gt;</td>
<td>1.41***</td>
<td>1.19***</td>
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<td></td>
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<td>(0.12)</td>
<td>(0.22)</td>
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<td>smoker&lt;sub&gt;_t-1&lt;/sub&gt;</td>
<td>0.59**</td>
<td>3.78***</td>
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<td></td>
<td>(0.24)</td>
<td>(0.25)</td>
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<tr>
<td></td>
<td>vapor&lt;sub&gt;_t-1&lt;/sub&gt;</td>
<td>0.29</td>
<td>5.68***</td>
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<td></td>
<td></td>
<td>(0.37)</td>
<td>(0.22)</td>
</tr>
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<td></td>
<td>A&lt;sub&gt;f&lt;/sub&gt;</td>
<td>1.24***</td>
<td>3.83***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.29)</td>
<td>(0.33)</td>
</tr>
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<td></td>
<td>A&lt;sub&gt;f'&lt;/sub&gt;</td>
<td>2.11***</td>
<td>3.98***</td>
</tr>
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<td></td>
<td></td>
<td>(0.48)</td>
<td>(0.46)</td>
</tr>
<tr>
<td></td>
<td>bh&lt;sub&gt;_t&lt;/sub&gt;</td>
<td>-1.35</td>
<td>-0.27</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.1)</td>
<td>(0.6)</td>
</tr>
<tr>
<td></td>
<td>2019</td>
<td>2.36***</td>
<td>-0.48</td>
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</tr>
</tbody>
</table>
Younger cohorts are more likely to be in class 1, and strongly prefer vapes over cigarettes.
Ever tried cigarettes when enter panel × Age when enter panel

- Interpretation
- Class probability
|                          | \( P(A_{t+1}^v > 0) \) | \( A_{t+1}^v | A_{t+1}^v > 0 \) |
|--------------------------|-------------------------|-------------------------|
| **Logistic**             |                         |                         |
| Constant                 | -6.52*** (0.14)         | 0.25*** (0.03)          |
| ever tried vape_{t-1}    | 2.30*** (0.07)          | 0.02 (0.02)             |
| smoke_t                  | 2.66*** (0.21)          | 0.06 (0.05)             |
| vape_t                   | 7.53*** (0.24)          | 0.11** (0.04)           |
| \( A_t^v \)              | 6.38*** (0.27)          | 0.22*** (0.04)          |
| smoke_t \times ever tried vape_{t-1} | -0.39** (0.15) | -0.04 (0.04) |
| vape_t \times ever tried vape_{t-1} | -2.40*** (0.15) | -0.02 (0.02) |
| smoke_t \times \( A_t^v \) | -1.58*** (0.32)         | 0.03 (0.05)             |
| vape_t \times \( A_t^v \) | -2.48*** (0.49)         | 0.18*** (0.04)          |
| Age FE                   | Y                       | Y                       |
| Age-choice interaction   | Y                       | Y                       |
| Year FE                  | Y                       | Y                       |
| Year-choice interact     | Y                       | Y                       |
| Observations             | 111,286                 | 4,296                   |
| R²                       |                         | 0.28                    |
| Log Likelihood           | -9,264.20               |                         |

*\( p < 0.05; **p < 0.01; ***p < 0.001 \)

Note: Reference age is 18-24 and reference year is 2015.
Model fit: Cohort age 15-17 in 2019

- Data — Latent class model

- Data — Latent class model
Short run: Older vapers are more likely to switch to smoking
Older vapers lose several months of life expectancy.

Many older individuals would not have vaped, but among older vapers, life expectancy decreases by up to 10 months.
Vape ban decreases life expectancy for all but the youngest cohort

<table>
<thead>
<tr>
<th>Age in 2019</th>
<th>Avg change in years vaped Before age 40</th>
<th>Age 40-59</th>
<th>Avg change in years smoked Before age 40</th>
<th>Age 40-59</th>
<th>Avg change in months lived</th>
<th>RR = .25</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 to 14</td>
<td>-3.4</td>
<td>-3.0</td>
<td>0.6</td>
<td>0.7</td>
<td></td>
<td>0.10</td>
</tr>
<tr>
<td>15 to 17</td>
<td>-3.3</td>
<td>-2.8</td>
<td>0.6</td>
<td>0.7</td>
<td></td>
<td>-0.03</td>
</tr>
<tr>
<td>18 to 20</td>
<td>-2.6</td>
<td>-2.0</td>
<td>0.5</td>
<td>0.6</td>
<td></td>
<td>-0.23</td>
</tr>
<tr>
<td>21 to 24</td>
<td>-1.1</td>
<td>-0.6</td>
<td>0.3</td>
<td>0.3</td>
<td></td>
<td>-0.39</td>
</tr>
<tr>
<td>25 to 34</td>
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<td>-0.4</td>
<td>0.3</td>
<td>0.6</td>
<td></td>
<td>-1.15</td>
</tr>
<tr>
<td>35 to 39</td>
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<td>-0.8</td>
<td>0.1</td>
<td>0.8</td>
<td></td>
<td>-1.54</td>
</tr>
<tr>
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<td>-0.6</td>
<td>0.0</td>
<td>0.5</td>
<td></td>
<td>-1.00</td>
</tr>
<tr>
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<td>0.0</td>
<td>0.4</td>
<td></td>
<td>-1.19</td>
</tr>
<tr>
<td>50 to 54</td>
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<td>-0.2</td>
<td>0.0</td>
<td>0.1</td>
<td></td>
<td>-0.48</td>
</tr>
</tbody>
</table>

- Vaping prevents more vaping before middle age than during middle age
- Vape ban generates more smoking in middle age than before middle age