Modeling of E-cigarette Use

David Levy, PhD
Georgetown University
Purposes of Modeling

• Hypothetical Policies:
  Potential Future Policies (given current policies) ->
  E-Cigarette and Cigarette Use Patterns -> Health Outcomes

• Predictive: Examining Past and Predicting Future Behavior:
  Past Policies-> Past and Future Smoking and E-cigarette Use ->
  Health Outcomes

• Heuristic: Understanding system aspects, helping to determine the information needed to evaluate public health impacts
Previous Models:

- Modified Risk Products:
  - FTC model: Scandia (Vugrin et al)*
  - Industry models: Bachand and Sulsky; Bachand, Sulsky, Curtin, Risk Anal; Poland B, Teischinger, NTR; Weitkunat et al., Reg Tox


* Most e-cigarette models meant to be predictive rather than hypothetical
Hypothetic Impacts: Two Scenarios

STRUCTURE

- Both scenarios involve hypothetical rates of switching from cigarettes to e-cigarettes over a ten year period to the residual cigarette prevalence
- Project from 2016 to 2100 by age and gender for US
- Model includes current and former cigarette and e-cigarette prevalence
- Model calculates cigarette and e-cigarette attributable deaths and life year lost

*Levy et al. 2017, Tobacco Control*
The Two Scenarios

ASSUMPTIONS

OPTIMISTIC
1. Excess mortality risk of e-cigarettes at 5% that of cigarettes
2. Cessation from cigarettes and e-cigarettes at the 100% the rate of cigarette cessation pre-strategy
3. Initiation at the 100% the rate of cigarette initiation pre-strategy
4. Residual cigarette prevalence of 5% after 10 years

PESSIMISTIC
1. Excess mortality risk of e-cigarettes at 40% that of cigarettes
2. Cessation from cigarettes and e-cigarettes at the 50% the rate of cigarette cessation pre-strategy
3. Initiation at the 150% the rate of cigarette initiation pre-strategy
4. Residual cigarette prevalence of 10% after 10 years
### Status Quo and E-Cigarette Substitution, Premature Deaths and Life Years Lost For All US Cohorts, Males and Females Combined

<table>
<thead>
<tr>
<th>OUTCOME</th>
<th>Year 2016</th>
<th>2026</th>
<th>2060</th>
<th>2080</th>
<th>2100</th>
<th>Cumulative (2016-2100)</th>
<th>Deaths Prevented/ Life Years Gained*</th>
<th>% Change relative to status quo</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Premature Deaths</strong></td>
<td>461,588</td>
<td>470,743</td>
<td>316,556</td>
<td>167,037</td>
<td>2,905</td>
<td>26,065,448</td>
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<tr>
<td><strong>Life Years Lost</strong></td>
<td>5,689,458</td>
<td>5,625,286</td>
<td>2,626,503</td>
<td>685,593</td>
<td>1,852</td>
<td>248,639,532</td>
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</tbody>
</table>

**Status Quo Scenario**

<table>
<thead>
<tr>
<th>OUTCOME</th>
<th>Year 2016</th>
<th>2026</th>
<th>2060</th>
<th>2080</th>
<th>2100</th>
<th>Cumulative (2016-2100)</th>
<th>Deaths Prevented/ Life Years Gained*</th>
<th>% Change relative to status quo</th>
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</thead>
<tbody>
<tr>
<td><strong>Premature Deaths</strong></td>
<td>461,588</td>
<td>380,832</td>
<td>233,243</td>
<td>56,399</td>
<td>459</td>
<td>19,484,289</td>
<td>6,581,159</td>
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<td><strong>Life Years Lost</strong></td>
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<td>3,839,765</td>
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<td>183,297</td>
<td>294</td>
<td>161,905,579</td>
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**Optimistic Scenario**

<table>
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<th>2026</th>
<th>2060</th>
<th>2080</th>
<th>2100</th>
<th>Cumulative (2016-2100)</th>
<th>Deaths Prevented/ Life Years Gained*</th>
<th>% Change relative to status quo</th>
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</thead>
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<tr>
<td><strong>Premature Deaths</strong></td>
<td>461,588</td>
<td>456,297</td>
<td>298,689</td>
<td>127,706</td>
<td>2,188</td>
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<td><strong>Life Years Lost</strong></td>
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<td>5,261,398</td>
<td>2,319,388</td>
<td>528,926</td>
<td>1,396</td>
<td>227,835,203</td>
<td>20,804,329</td>
<td>-8.4%</td>
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*Life Years gained = Life years lost in Status Quo - Life years lost in E-cigarette Substitution Scenario*
Results and Implications

• Even under pessimistic (worst case scenario), there are gains from a strategy of encouraging switching from cigarettes to e-cigarettes

• Potential for major gains in optimistic scenario
Unlike other models, focuses on a representative single cohort: age 15 in 2012

Applies a decision-theoretic framework (Levy et al. 2017, Addiction) grounded in a public health approach to examine the effect of transitions to final states of established use.

Distinguishes trial use from established e-cigarette use

With trial use, individuals may transition to: 1) exclusive e-cigarette use, 2) dual (cig and e-cig) use, 3) exclusive cigarette use, or 4) no use (e-cigarettes as transition to quitting both).

Public health implications depend on the counterfactual of what would have happened in the absence of e-cigarette use
<table>
<thead>
<tr>
<th>Scenario</th>
<th>Measure</th>
<th>Age</th>
<th>15</th>
<th>25</th>
<th>45</th>
<th>65</th>
<th>85</th>
<th>Cumulative Ages 15-85</th>
<th>Difference from Status Quo</th>
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<tr>
<td></td>
<td>Prevalence</td>
<td>Smoker</td>
<td>4.6%</td>
<td>20.4%</td>
<td>12.7%</td>
<td>5.6%</td>
<td>1.1%</td>
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<td>SADs</td>
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<td>581</td>
<td>2,116</td>
<td>2,816</td>
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<td>23,573</td>
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<tr>
<td></td>
<td>Prevalence</td>
<td>Smoker</td>
<td>2.8%</td>
<td>12.4%</td>
<td>7.7%</td>
<td>3.4%</td>
<td>0.6%</td>
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<td>E-cigarette</td>
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<td>1.3%</td>
<td>5.9%</td>
<td>3.7%</td>
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<td>0.3%</td>
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<td></td>
<td>Dual</td>
<td></td>
<td>1.3%</td>
<td>5.9%</td>
<td>3.7%</td>
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<td>0.3%</td>
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<td>2,401</td>
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<td></td>
<td>22,898</td>
<td>42,564</td>
<td>14,243</td>
<td>1,421,000</td>
<td>118,242</td>
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</table>
Predictive, But Heuristic: The Public Health Impact of E-cigarette Use Among Never Smokers

**Never Smoker**
- Would have become a smoker in the absence of e-cigarettes
- Would NOT have become a smoker absent e-cigarettes

**TRANSITIONAL E-CIGARETTE USE**
- Does not try e-cigarettes
  - Quit e-cigarette use
  - Continue to use e-cigarettes
- Try e-cigarettes
  - Does not try e-cigarettes
  - Try e-cigarettes
  - Continue to use e-cigarettes

**LONG-TERM USE**
- Long-term cigarette smoker
- Does use cigarettes or e-cigarettes
- Long-term dual user
- Long-term e-cigarette use
- Does not smoke or use e-cigarettes
- Long-term dual user
- Long-term e-cigarette use
- Does not smoke or use e-cigarettes

*Green indicates public health benefit*  
*Red indicates public health harm*
In Examining Past Behavior, Need to Focus on Useful Measures

- Need to determine useful measures of experimental and long-term use
- Measures may need to vary by cohort as well as age, i.e., Circumstances at early ages affect later ages (past experiences)
  - Awareness and perceived risk
  - Previous experience: Available products with differing appeal, ability to satisfy cravings
  - Differing policies, especially price of e-cigs relative to cigarettes
Current Smoker

Would have quit in the absence of e-cigarettes

Would not have quit in the absence of e-cigarettes

TRANSITIONAL E-CIGARETTE USE

Does not try e-cigarettes

Tries e-cigarettes*

Tries e-cigarettes

Does not try e-cigarettes

Quit e-cigarettes

Quits e-cigarettes

Continues to use e-cigarettes

Continues to use e-cigarettes*

LONG-TERM use

Former smoker

Continue smoking

Former smoker

Dual user*

Former smoker, e-cigarette user

Continue smoking

Former smoker*

Dual user

Former smoker, e-cigarette user

Long-term Smoker

---

Green indicates public health benefit
Red indicates public health harm
Heuristic: Need to Consider the Structure of the E-Cigarette Industry

Stage One: Components
- Devices
  - Disposables
  - Reusables:
    - Closed systems
    - Open systems

Stage Two: Device Marketing
- Cigarette Manufacturers
  - Mostly disposables and refillables

Stage Three: Consumer Channels
- Conventional Retail Markets
- Other retail: tobacconists, kiosks
- Vape Shops
- Internet

INDEPENDENTS
- All kinds of devices, including tanks and mods

LIQUIDS
Market Structure (Based on Antitrust Guidelines)

Horizontal (competition at product level):
- E-cigarettes- many different types and more product variety than cigarettes (disposables and close and open system reusables) with much innovation
- Markets less distinct- increasingly closer substitute to cigarettes.
- New products which are potential close substitutes, e.g. heat-not-burn

Vertical (different stages of production):
- Manufacture of devices and liquids- much produced in China
- Sellers of devices, mostly US: responsible for pricing and marketing of products
- Distribution channels: retail stores (mass market and kiosks), vape shops, internet

Conglomeration (firms producing different final products)
- Cigarette manufacturers producing e-cigarettes (also smokeless and cigars
- Independents = largely independent firms, many technology-oriented
### US Market Consumer Channels and Industry Shares

<table>
<thead>
<tr>
<th>Channel</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>MARKET SHARES</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-cigarettes (Disposables and Closed system)</td>
<td>1,000</td>
<td>1,400</td>
<td>1,600</td>
<td>1,400</td>
<td>31.8%</td>
</tr>
<tr>
<td>Mass Market (Retail convenience store, Food, Drug stores)</td>
<td>600</td>
<td>600</td>
<td>700</td>
<td>700</td>
<td>15.9%</td>
</tr>
<tr>
<td>Online</td>
<td>200</td>
<td>400</td>
<td>500</td>
<td>400</td>
<td>9.1%</td>
</tr>
<tr>
<td>Other Retail (including kiosks)</td>
<td>200</td>
<td>400</td>
<td>400</td>
<td>300</td>
<td>6.8%</td>
</tr>
<tr>
<td>Vapors/Tanks/Mods &amp; Personal Vaporizers (Open System)</td>
<td>1,500</td>
<td>1,900</td>
<td>2,500</td>
<td>3,000</td>
<td>68.2%</td>
</tr>
<tr>
<td>Convenience Store, Food, Drug and Mass Retail</td>
<td>300</td>
<td>300</td>
<td>500</td>
<td>500</td>
<td>11.4%</td>
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<tr>
<td>Online and other retail outlets</td>
<td>300</td>
<td>400</td>
<td>600</td>
<td>700</td>
<td>15.9%</td>
</tr>
<tr>
<td>Vape Shops</td>
<td>900</td>
<td>1,200</td>
<td>1,400</td>
<td>1,800</td>
<td>40.9%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>2,500</td>
<td>3,300</td>
<td>4,100</td>
<td>4,400</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

**Market shares:**
- Type: Open Systems 68%, Closed Systems and Disposables 32%
- Consumer sectors: Mass market retail 27%, Other retail 7%-20%, Online 15%-20%, Vape shops 41%
- Cigarette Manufacturers: mostly mass market retail (27%) where they are 65% (Vuse, MarkTen, Blu and Logic) => total market share of approximately 18%-25%

Source: Wells Fargo Securities
Economic Framework: Entry Barriers

**Horizontal:**

Production - appears to be minimal economies of scale and can purchase from other China, vape shops appear to require minimal investment (and franchised)

Marketing - internet and word of mouth are important, does not appear to be require large expenditures for mass media

**Vertical:**

Entry barriers foreclosure of market downstream, e.g., through retail shelf-space

Limit supplies of essential inputs upstream - not likely for e-cigarettes, unless proprietary or patents or regulatory hurdles to product devices or e-liquids (can be produced in China)

Government regulations: before deeming was small, but now unclear, some at state level
US Market Conduct

- Competitive: With minimal concentration and low entry barriers (subject to government regulation)
- Prices of specific products have been falling over time
- New products through innovation: recent growth in sales of Juul
- Demand may to have flattened for some products, but growth in others (e.g., Juul)
- Future growth likely to depend on regulations, information dissemination about risks and new products, smoke-free air laws and taxes

The market structure and conduct of firms in this industry is very different from the prior (pre-2005) experience in the cigarette market
Heuristic: Government Regulation and Market Structure: Further complexity

**GOVERNMENT REGULATION**
- Content: toxicity, flavors
- Marketing restrictions, incl. retail point of sale
- Messaging regarding sole and dual use risks: media, packaging, news and websites
- Taxes: e-cigarette & cigarette
- Smoke-free air laws

**INDUSTRY**: Cigarette

**INDUSTRY**: Independent

Consumers via Retail, Internet, Vape shops

*Independent firms have different interests than cigarette firms, i.e., protecting profits of cigarettes, but compete with each other*
Modeling policies to encourage switching

Two pronged approach being considered in the US

• **Stronger policies discouraging cigarettes:**
  – Traditional Policies- increase cigarette taxes, extend smoke-free air laws, greater retail compliance with minimum purchase
  – New policies- implement strong graphic warnings, raise minimum purchase age, ban retail displays (ban slotting allowances?). Nicotine reduction?

• **Policies encouraging switching to e-cigarettes:**
  • Content unrestricted: toxicity, flavors
  • Marketing restrictions, incl. retail point of sale, but geared toward youth
  • Taxes: e-cigarette low relative to cigarettes
  • Smoke-free air laws
  • Messaging regarding risks: media, packaging, news and websites
Modeling the Impact of Policies

• Policies: need to distinguish the effects of cigarette-oriented and e-cigarette oriented policies

• Impacts
  – Direct on product toxicity, flavorings, types, costs, where used and consumer knowledge
  – Interactive effects, i.e., cigarette policies may have greater effects with non-restrictive e-cigarette policies
  – Indirect through market structure: Independents have different incentives than cigarette firms (protecting profitability of cigarettes)
Conclusions

• E-cigarette use has beneficial public health impact over a wide range of plausible values

• To model actual trends:
  – Cohort analysis is central, will need to examine age patterns over time by cohort
  – Will need better measures of use, especially established use (exclusive and dual)
  – Much will depend on products available (esp HNB)

• Government regulation and industry structure are likely to play an important role
It's tough to make predictions, especially about the future.

Yogi Berra

In theory, there is no difference between theory and practice. In practice, there is.

Yogi Berra

If you don't know where you are going, you will wind up somewhere else!

Yogi Berra

Yogi Berra's wife asked, "Yogi, when you die, where do you want to be buried, in Montclair, New York or in St. Louis?“
Yogi: "I don't know, Carmen, why don't you surprise me?“