Modeling of E-cigarette Use

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Computational Models

• Simulation models (macro or micro) models are used in other fields, but are increasingly common in public health, especially in the fields of tobacco control and obesity

• Models are especially useful where there are dynamic systems with many stages (e.g., policy -> environment -> behaviors -> health outcomes) and where the effects unfold over time.

• Models attempt to make the connections between stages across stages and over time explicit, focusing on the movement of whole system rather than an isolated part
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
Hypothetic Impacts of Switching to NVPs: Structure

1. Begin with a Status Quo - in this case no vaping, includes current and former smokers, developed applying age-period cohort analysis (NHIS) survey using data up until 2012 (before e-cigarettes widely used) - ignores other tobacco use.

2. Allow switching from cigarettes to e-cigarettes over a ten year period to the residual cigarette prevalence - will consider two scenarios, specifying basic parameters of risk and use rates.

3. Public health implications depend on the counterfactual of what would have happened in the absence of e-cigarette use.

*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
METHODS

• Project from 2016 to 2100 current and former cigarette prevalence, attributable deaths and life years lost by age and gender under the status quo

• Project current and former smokers and vaper prevalence and attributable deaths from 2016 to 2100 by age and gender for US under the status quo current and former cigarette prevalence and attributable death

• Compare results of each vaping scenario to the status quo
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>
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<td><strong>Status Quo Scenario</strong></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

• Potential for major gains in optimistic scenario
• Even under pessimistic (worst case scenario), there are gains from a strategy of encouraging switching from cigarettes to e-cigarettes
• Can compare parameters, including how use rates and risks vary over time

- 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).
Predictive, But Heuristic: The Public Health Impact of E-cigarette Use Among Never Smokers

**Green** indicates public health benefit

**Red** indicates public health harm

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**LONG-TERM USE**

- Long-term cigarette smoker
  - Does use cigarettes or e-cigarettes
  - Long-term dual user
  - Long-term e-cigarette use

- Long-term cigarette smoker
  - Does not smoke or use e-cigarettes
  - Long-term dual user
  - Long-term e-cigarette use

**TRANSITIONAL E-CIGARETTE USE**

- Would have become a smoker in the absence of e-cigarettes
  - Would NOT have become a smoker absent e-cigarettes

- Try e-cigarettes
  - Does not try e-cigarettes
  - Quit e-cigarette use
  - Continue to use e-cigarettes

- Does not try e-cigarettes
  - Quit e-cigarette use
  - Continue to use e-cigarettes

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**Never Smoker**

- Would have become a smoker in the absence of e-cigarettes
- Try e-cigarettes
- Does not try e-cigarettes
- Quit e-cigarette use
- Continue to use e-cigarettes
- Does not smoke or use e-cigarettes
- Long-term dual user
- Long-term e-cigarette use
- Long-term cigarette smoker
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
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<th>Scenario</th>
<th>Measure</th>
<th>Age</th>
<th>15</th>
<th>25</th>
<th>45</th>
<th>65</th>
<th>85</th>
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<td>Dual</td>
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Trial Use Sensitivity Analysis: Male

Trial Use Sensitivity Analysis: Female

Figure 2b. Female Trial use Sensitivity Analysis
Heuristic: 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

Other retail:
- tobacconists, kiosks
- Vape Shops
- Internet

 Liquids

- All kinds of devices, including tanks and mods
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*
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