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

- 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
- 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
- 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 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

Hypothetic Impacts: Two Scenarios

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

OUTCOME	Year 2016	2026	2060	2080	2100	Cumulative (2016-2100)	Deaths Prevented/ Life Years Gained*	% Change relative to status quo
Status Quo Scenario								
Premature Deaths	461,588	470,743	316,556	167,037	2,905	26,065,448		
Life Years Lost	5,689,458	5,625,286	2,626,503	685,593	1,852	248,639,532		
Optimistic Scenario								
Premature Deaths	461,588	380,832	233,243	56,399	459	19,484,289	**6,581,159**	**-25.2%**
Life Years Lost	5,689,458	3,839,765	1,345,385	183,297	294	161,905,579	**86,733,953**	**-34.9%**
Pessimistic Scenario								
Premature Deaths	461,588	456,297	298,689	127,706	2,188	24,432,065	**1,633,383**	**-6.3%**
Life Years Lost	5,689,458	5,261,398	2,319,388	528,926	1,396	227,835,203	**20,804,329**	**-8.4%**

*** Life Years gained = Life years lost in Status Quo - Life years lost in E-cigarette Substitution Scenario**

Results and Implications

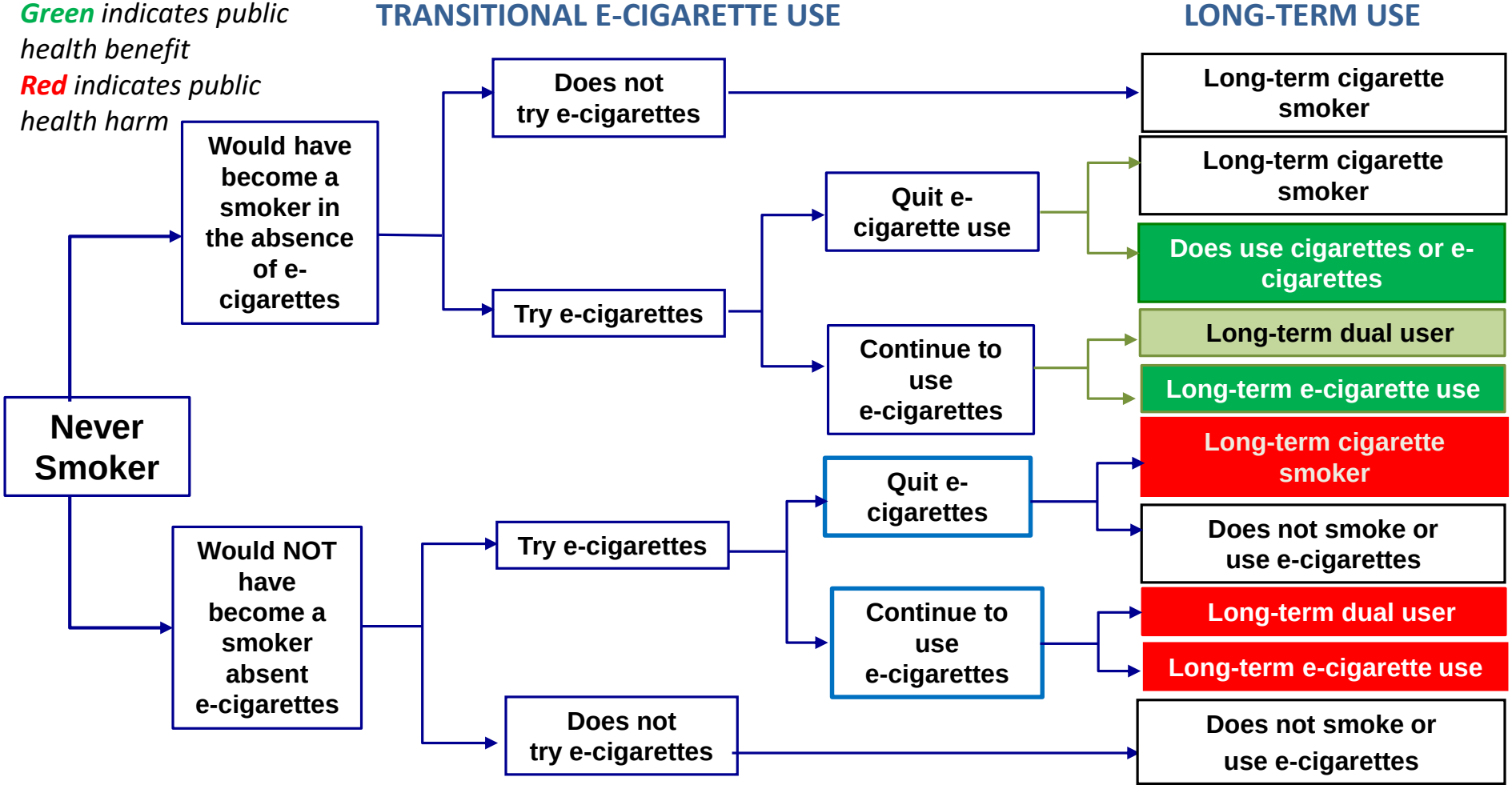
- Potential for major gains in optimistic scenario
- Even under pessimistic (worst case scenario), there are gains from a strategy of encouraging switching from cigarettes to e-cigarettes
- Can compare parameters, including how use rates and risks vary over time

Predictive: Levy et al. Initiation Model (2017, Nicotine & Tob Res)

- 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



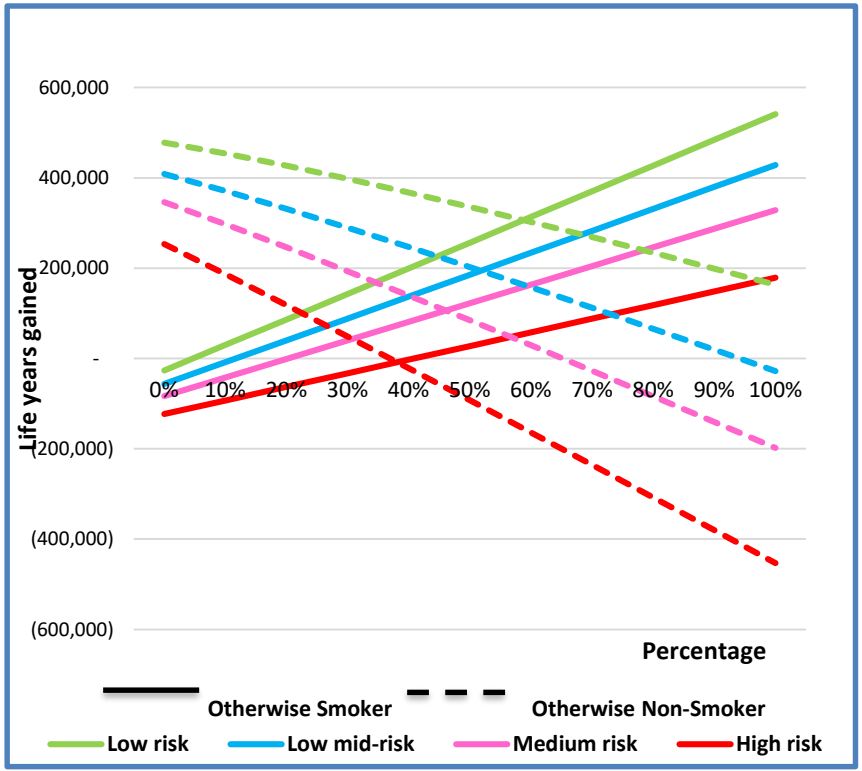
In Examining Past Behavior, Need to Focus on Useful Measures

- **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

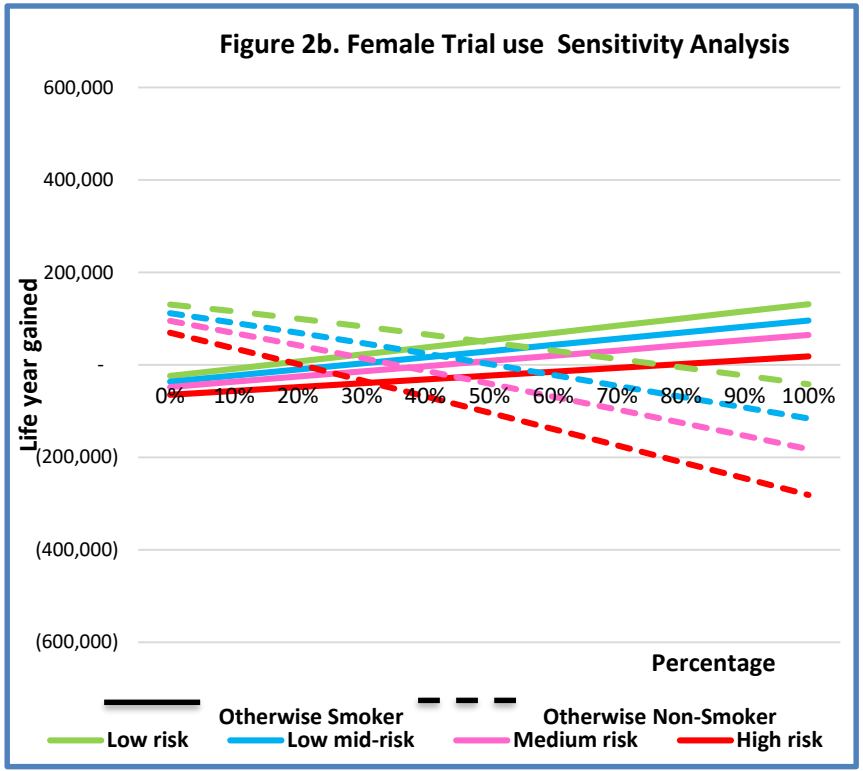
Results: US Males for 1997 cohort

Scenario	Measure	Age	15	25	45	65	85	Cumulative Ages 15-85	Difference from Status Quo
Status quo	**Prevalence**	**Smoker**	4.6%	20.4%	12.7%	5.6%	1.1%		
	SADs		-	-	581	2,116	2,816	79,322	
	LYL		-	-	23,573	46,335	16,706	1,539,242	
Best	**Prevalence**	**Smoker**	2.8%	12.4%	7.7%	3.4%	0.6%		
		E-cigarette	1.3%	5.9%	3.7%	1.6%	0.3%		
		Dual	1.3%	5.9%	3.7%	1.6%	0.3%		
Low Risk	**SADs**		-	-	442	1,522	1,879	56,213	23,109
	LYL		-	-	17,921	33,313	11,147	1,112,151	427,091
Low-mid Estimate	**SADs**		-	-	480	1,653	2,041	61,058	18,264
	LYL		-	-	19,465	36,184	12,108	1,208,000	331,242
Medium Risk	**SADs**		-	-	514	1,769	2,185	65,365	13,958
	LYL		-	-	20,838	38,736	12,962	1,293,200	246,042
High risk	**SADs**		-	-	565	1,944	2,401	71,824	7,498
	LYL		-	-	22,898	42,564	14,243	1,421,000	118,242

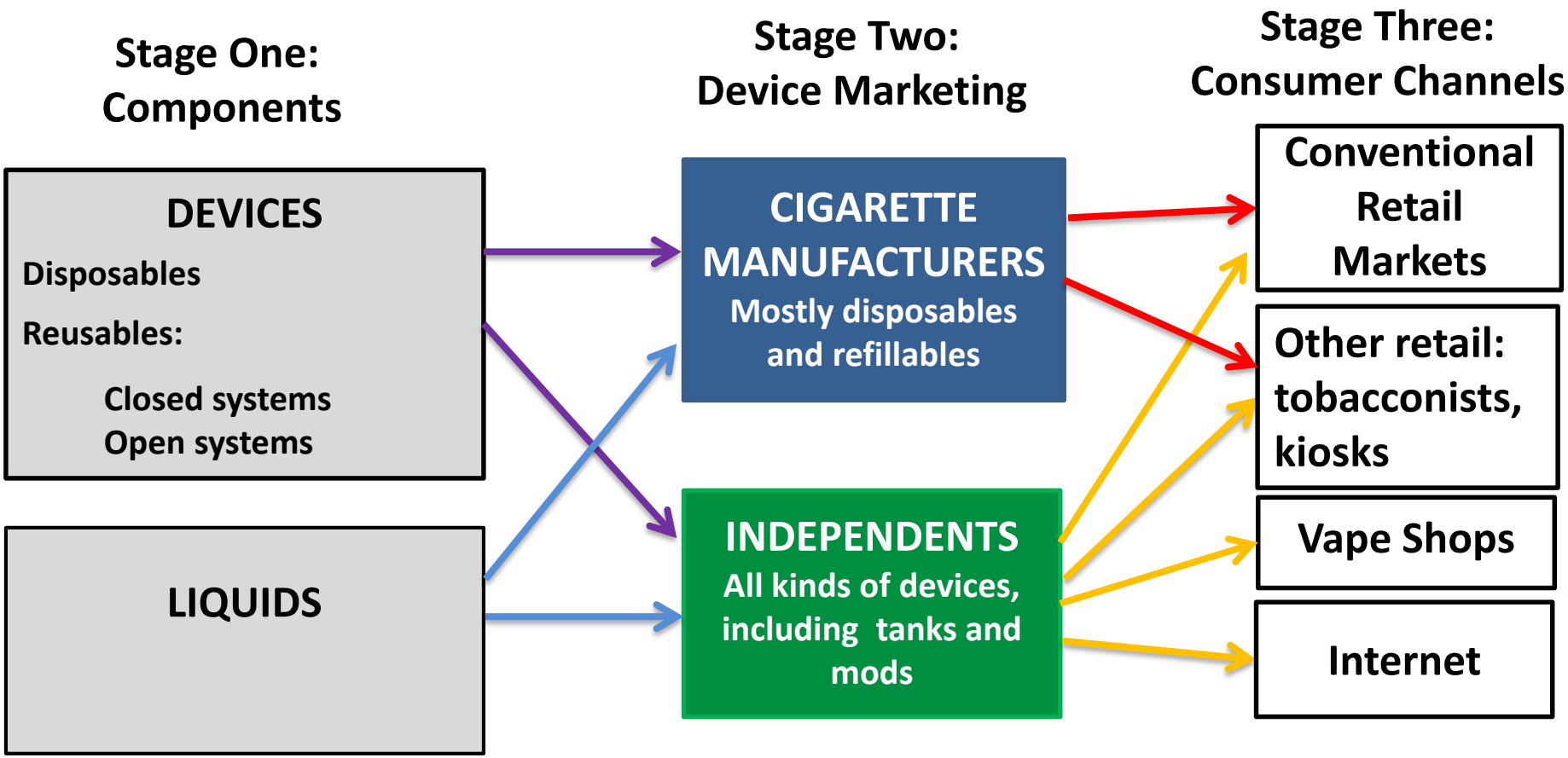
Trial Use Sensitivity Analysis: Male



Trial Use Sensitivity Analysis: Female



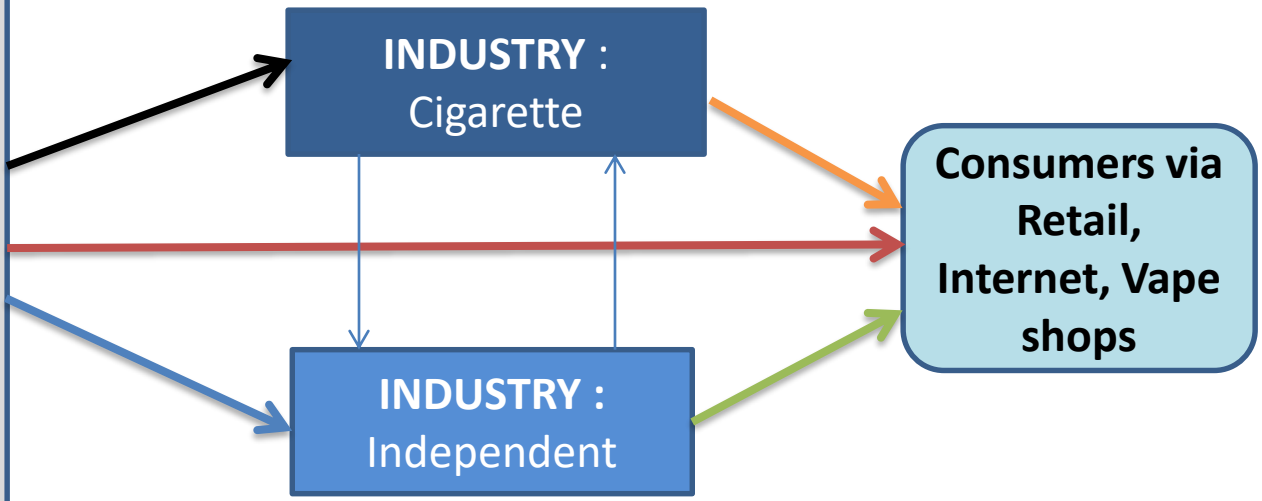
Heuristic: The Structure of the E-Cigarette Industry



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**



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