

Modeling of E-cigarette Use

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Conflicts of Interest and Other Contributors

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Purposes of Modeling

- Examining Past Behavior:
Past Policies-> Smoking Behaviors ->
Health Outcomes
- Potential Future Public Health Impacts:
Potential Future Policies (given current policies) ->
E-Cigarette and Cigarette Use Patterns ->
Health Outcomes
- Heuristic: Understanding system aspects,
helping to determine the information needed
to evaluate public health impacts***

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

Previous Models: All but two* cohort-based

- Modified Risk Product:
 - Scandia model (Vugrin et al)
 - Industry model (Bachand and Sulsky)
- E-cigarettes:
 - Kalkhoran and Glantz (2016)*
 - Cobb et al. (2015)*
 - Cherng et al (2016)
 - Levy et al (2016, 2017)

** Unlike most previous models (e.g., SimSmoke), which were age-based and assumed stable trajectories by age over time (not dependent on cohort)*

Reasons to Focus on Cohort

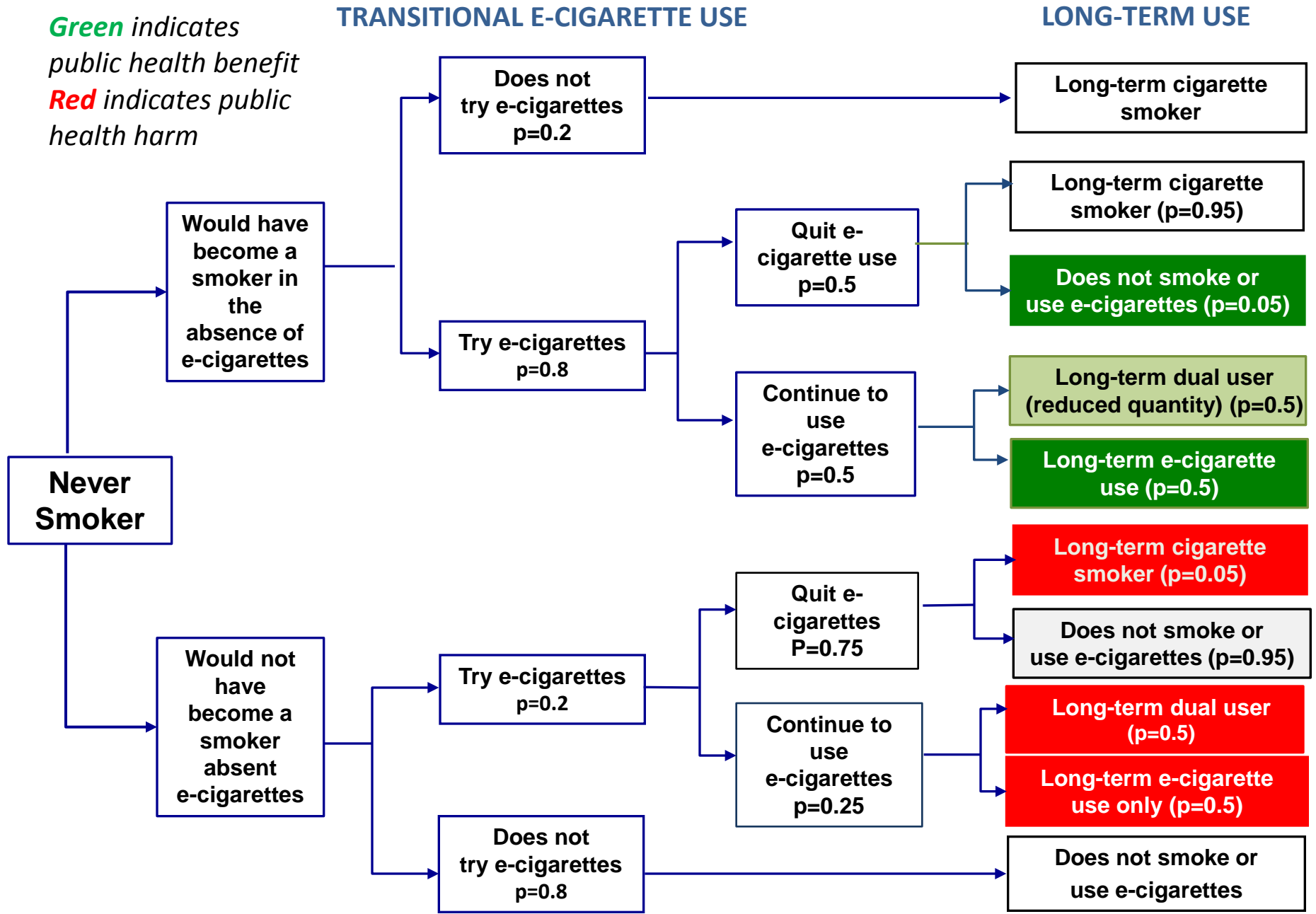
- ❖ In a changing environment, use rates and outcomes are likely to be dependent on age and environment for a given cohort
 - Awareness and perceived risk
 - Available products with differing appeal, ability to satisfy cravings
 - Differing policies with respect to e-cigarettes and cigarettes, especially price of e-cigarettes relative to cigarettes
- ❖ Experiences at previous ages affect use and outcomes at later ages (like cessation tx)

Evidence that e-cigarette use rates change considerably by age group over time is suggestive of important cohort effects

Levy et al. model (2016, NTR)

- ❖ Unlike earlier models, focuses on a representative single cohort: age 15 in 2012
- ❖ Applies a decision-theoretic framework (Levy et al. 2007, Addiction) grounded in a public health approach to examine the effect of transitions to final states of established use.
- ❖ Public health implications depend on the counterfactual of what would have happened in the absence of e-cigarette 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).

Figure 1. The public health impact of e-cigarette use among never smokers



Status Quo (smoking only)

Counterfactual

- Prevalence by current, former and never smoker using NHIS data through 2010 (Holford et al. AJPM, 2013) updated to 2012 (Holford et al, JAMA 2014). CISNET data developed using age-period-cohort model correcting for differential mortality
- Projections based on NHIS data through 2012 based on initiation and cessation rates (measured as 2 year quit = cessation net of relapse) ***before significant e-cigarette use***
- Death rates based on CPS-I and CPS-II data (recent data suggests higher risks) vary by age and gender and by current, former (reflecting years quit) and never smokers

Structure and Assumptions of the E-cigarette Initiation Model

- Separate analysis by gender for a specific cohort, age 15 in 2012, when most initiation occurs, allows for e-cigarette use consistent with the rates of smoking initiation up until age 26
- Individuals remain in their final states, subject to cessation among exclusive smokers, exclusive vapers, and dual users at the rate of cessation among smokers in the status quo scenario
- Does not consider other tobacco products (e.g., smokeless tobacco, cigars, hookah)

Attributable deaths calculated in terms of excess risks to smokers

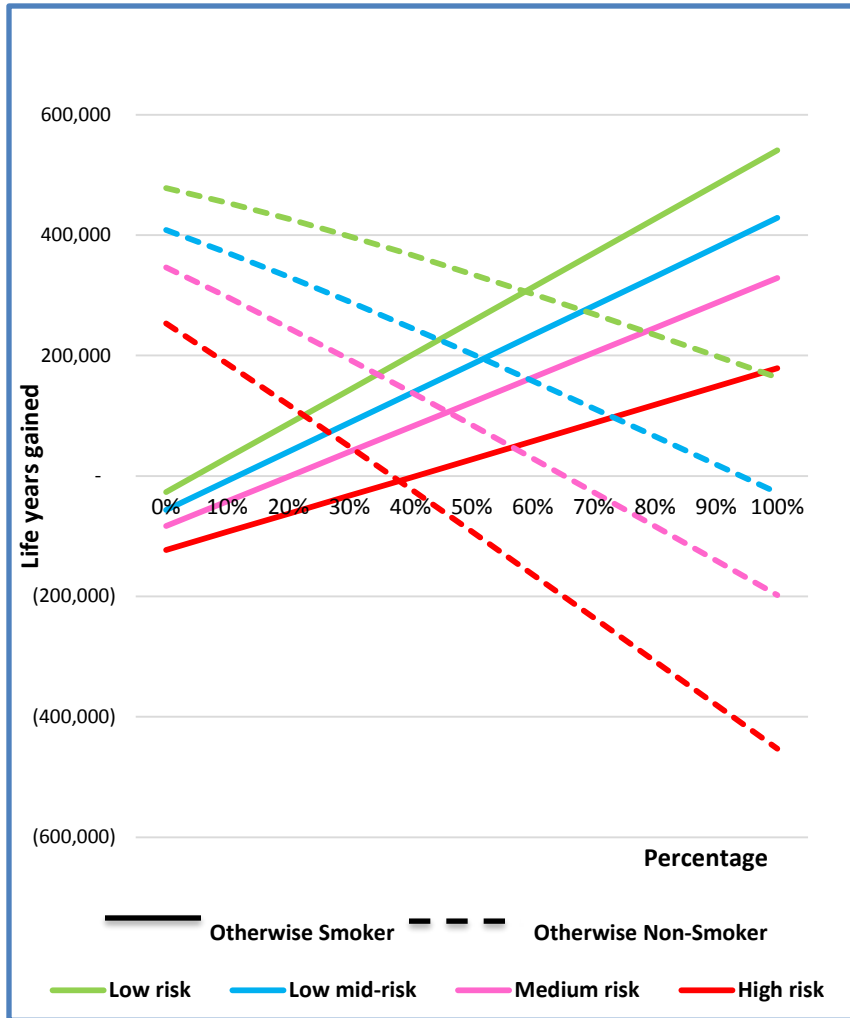
- Health effects depend on final state (established use)
- Attributable deaths calculated at each age through age 85 as excess deaths risks* number in category (prevalence* population at each age)
- Compares deaths and life years lost under different e-cigarette scenarios with status quo

	Optimistic (low risk)	Best (Mid-low)	Medium	Pessimistic (high risk)
Cigarette Smoker	100%	100%	100%	100%
Dual User	50%	70%	85%	100%
E-cigarette User	2.5%	5%	10%	25%
Former Smoker+ E-cigarette User	Former*1.025	Former*1.05	Former*1.10	Former*1.25

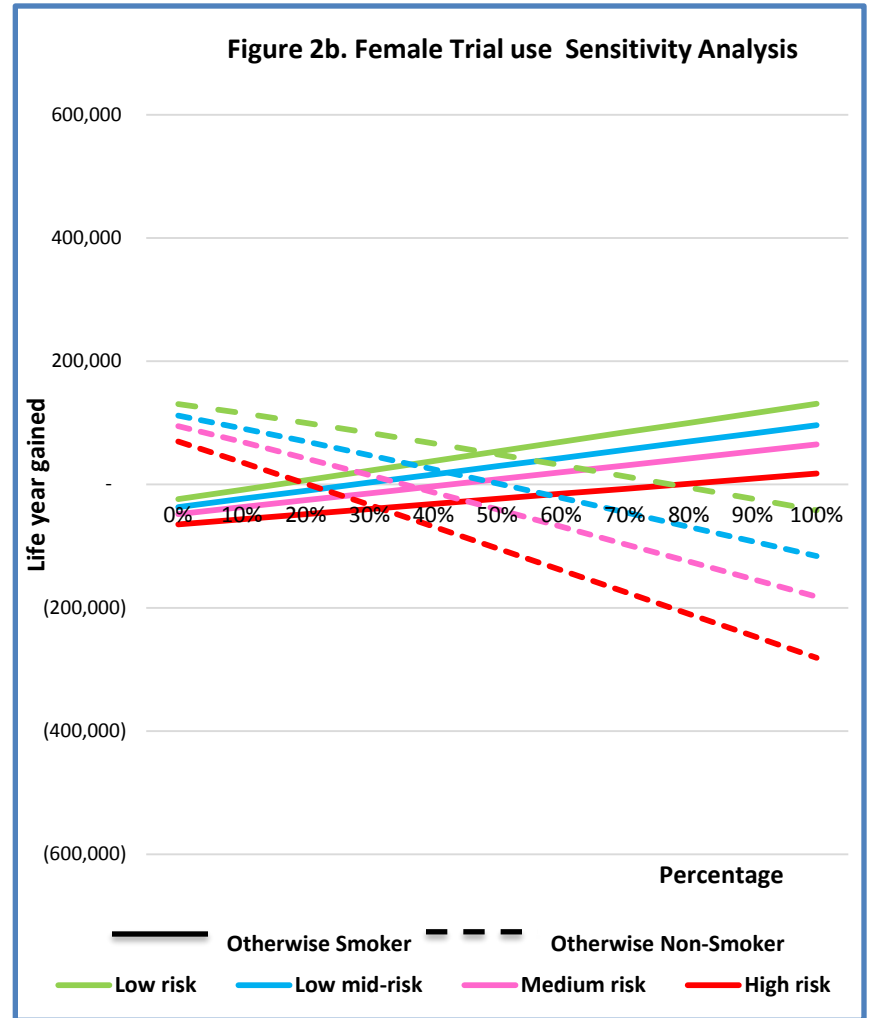
Results: Males for 1997 cohort

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

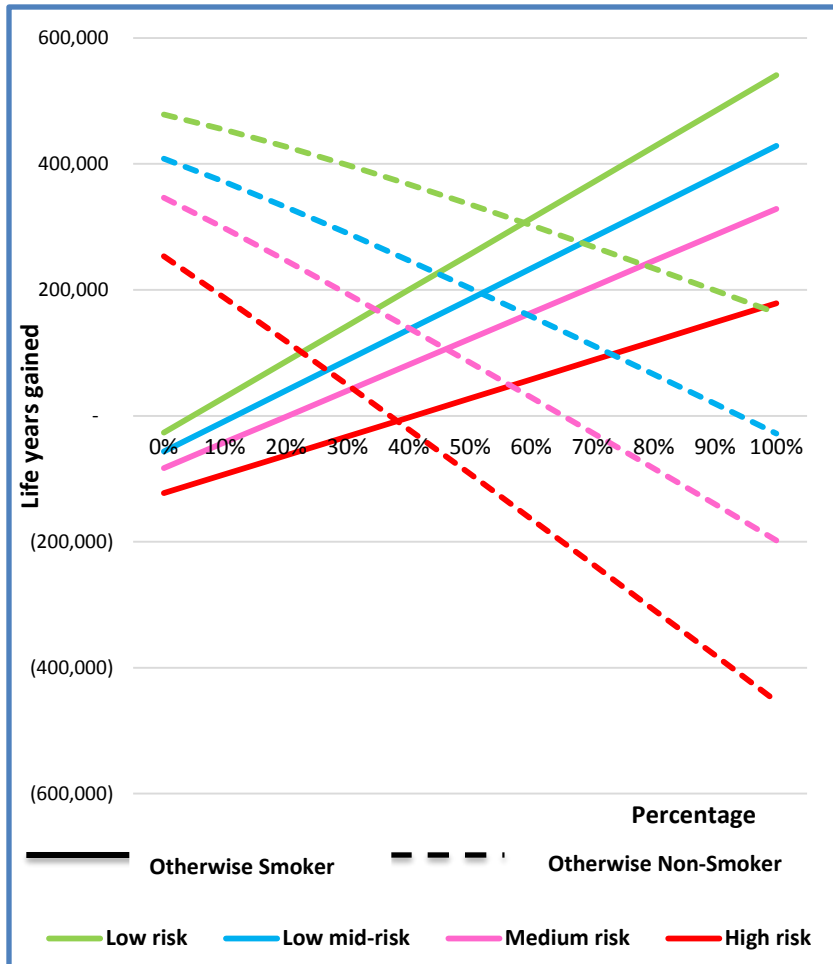
Trial Use Sensitivity Analysis: Male



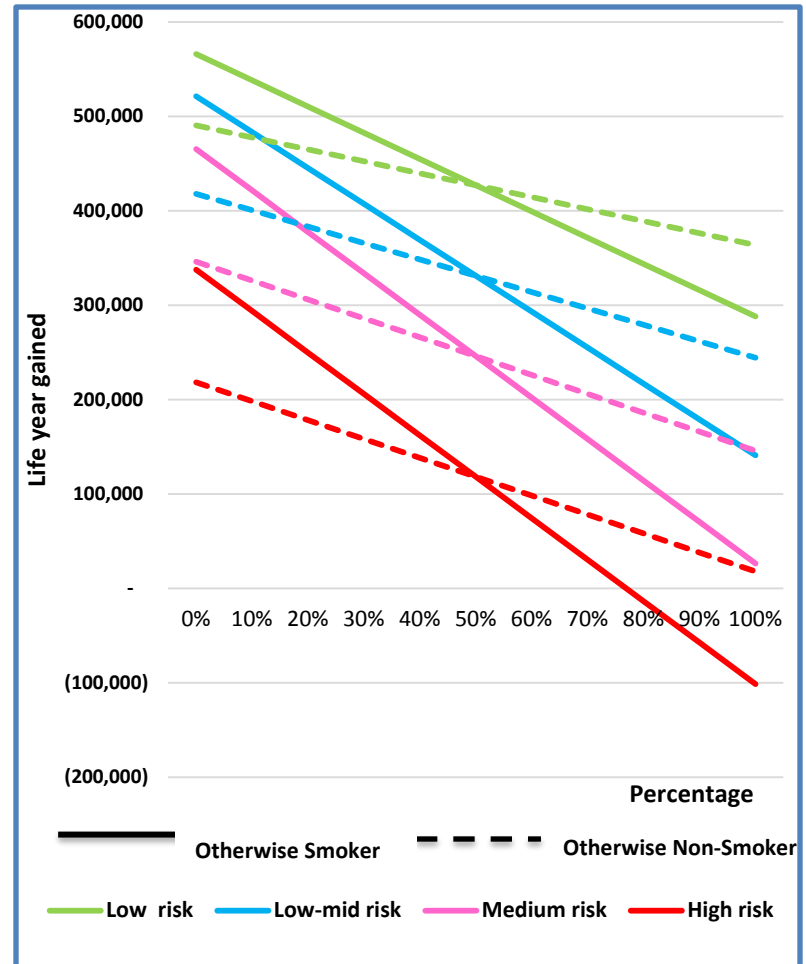
Trial Use Sensitivity Analysis: Female



Male Regular Use Sensitivity Analysis



Male Dual Use Sensitivity Analysis



Implications

- Public health benefits are projected over a wide range of parameters
- Results insensitive to future cessation (not shown)
- Model sensitive to use rates of otherwise smokers vs otherwise non-smokers especially at low risk-> need to continue making cigarettes less appealing (cig taxes, etc)
- Results depend on toxicity-> may reduce harms to users and encourage exclusive rather than dual use
- ***Results are highly sensitive to initial use and transition measures***

E-cigarette Use and Transitions

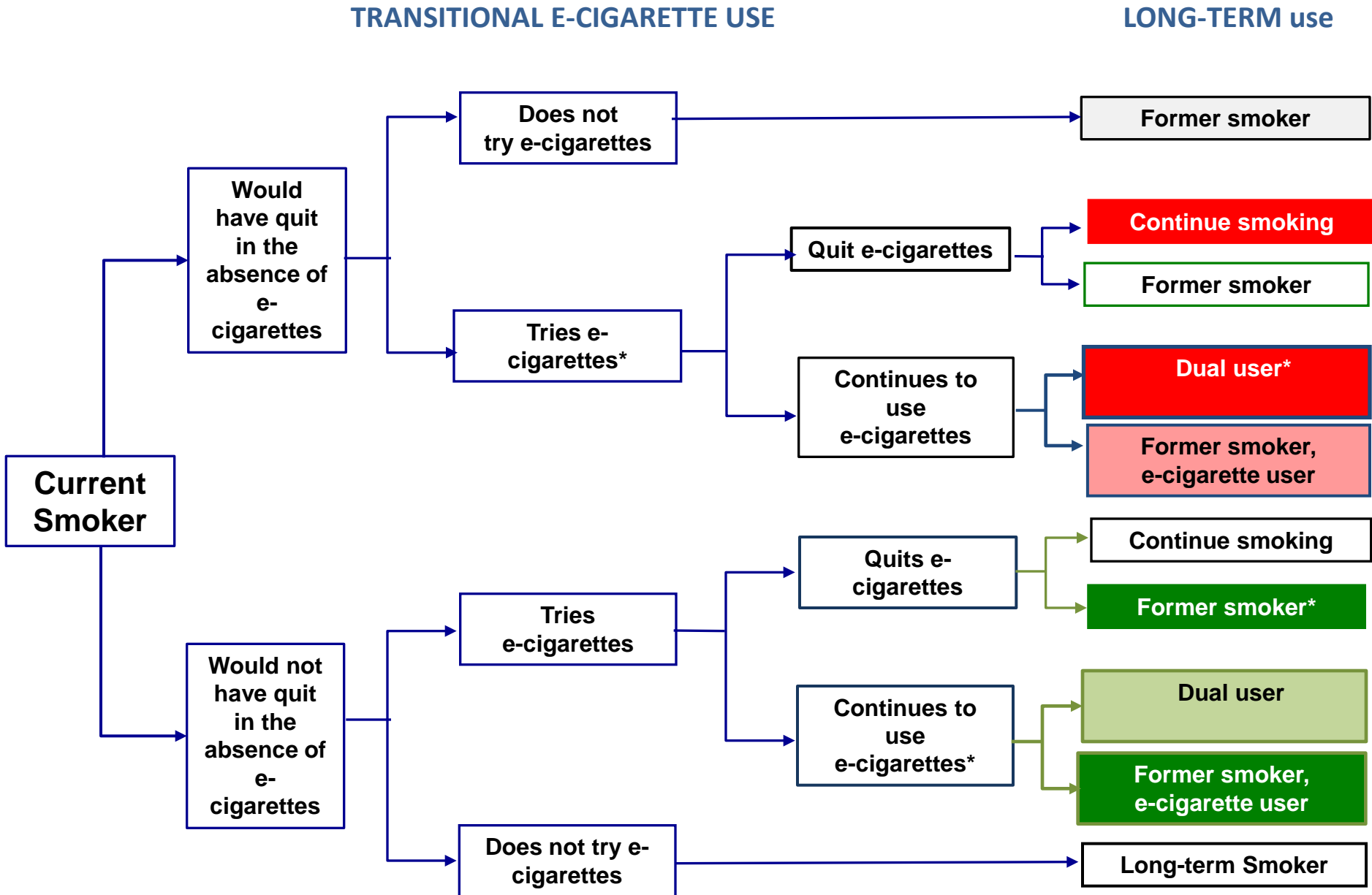
- **Potential smoker vs non-smoker:** not well defined, can use smoker susceptibility, previous smoking experience, characteristics of e-cigarette users relative to smokers. Uptake patterns variable with increasing role of other products (smokeless, cigars, etc)
- **Trial use:** ever use increasing over time but of limited meaning, last 30 day use still not serious trial use, number of times within a specified period or reason for use, see Amato et al (2016, 2017)
- **Long-term e-cigarette use:** ideally specified number of days per month over an extended period or # days lifetime. 100 cigarettes still relevant?
- **Dual vs. exclusive e-cigarette use:** same problems as for long-term use with patterns again variable and increasing use of other products

Current oft-used measures, e.g., ever use and last 30 day use, are probably not useful predictors, need to validate measures

Further Analysis: Cessation Model

- Focus is on smokers: relevant public health distinction is whether the individual would have quit and at what age in the absence of VNP
- Separate analysis by gender for specific cohort after smoking rates established (patterns different for the those that experienced e-cigarettes at an earlier age)
 - 1983 cohort (age 26 in 2012) when smoking reaches its peak, cessation is low, but tobacco use patterns are still likely forming
 - 1964 cohort (age 45 in 2010) when smoking cessation normally begins to pick up, e-cigarettes may deter that cessation

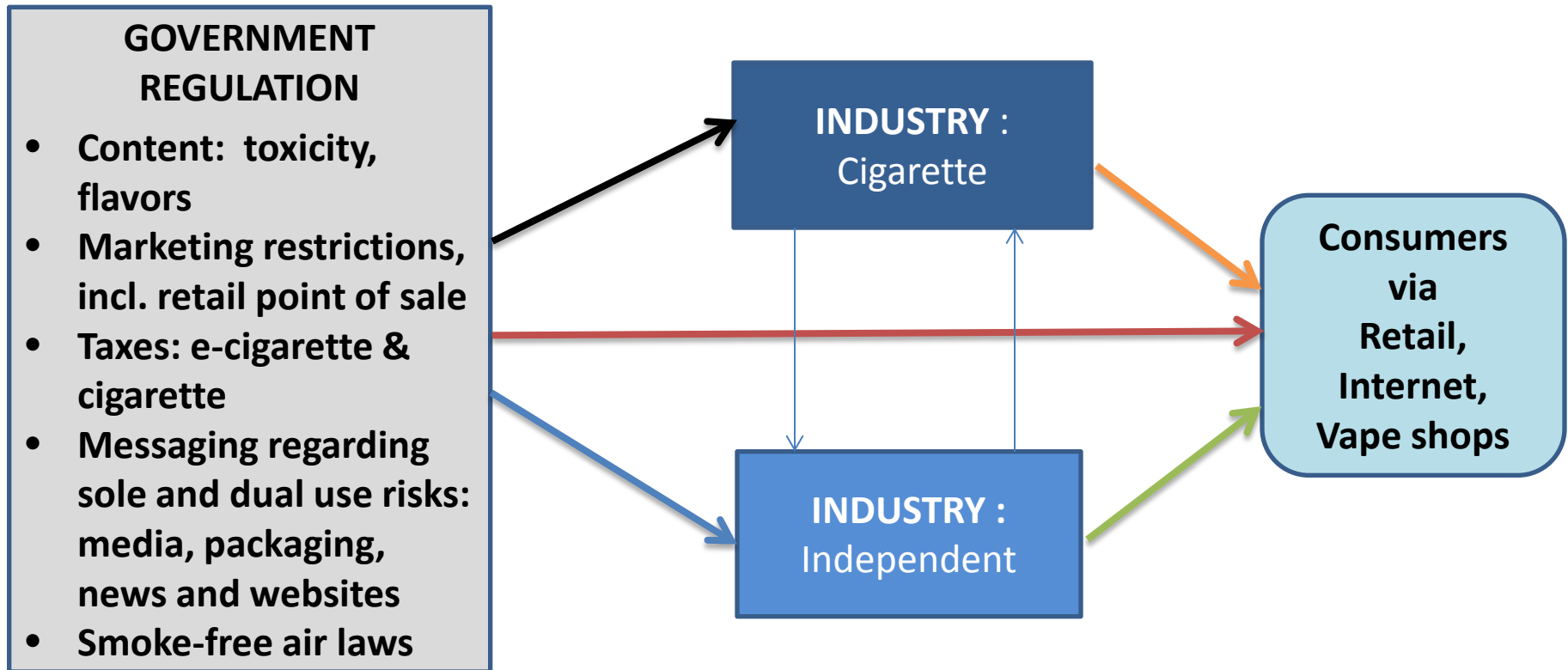
Figure 2. The public health impact of e-cigarette use among smokers



Implications

- Results again tend to confirm public health benefit
- Model most sensitive to changing rates of otherwise smokers. Want to encourage their use-> making cigarettes less appealing (cig taxes, etc) and making e-cigs more appealing to smokers
- Public health implications depend on the hypothetical, would otherwise quit; can look to susceptibility, characteristics of users relative to those who would quit, and if new quit attempts
- Measures of short-term and long-term use are still poor and not well defined or validated, especially distinguishing dual use as a temporary or final state

Government Regulation and Market Structure: Further complexity



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
- 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)
- Government regulation and industry structure are likely to play an important role

You can observe a lot by just watching. Yogi Berra

Yogi Berra's wife recently 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?"