

# Introduction to Population Modeling

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# Considered This?



VS.

**Sage smoked for 23 years, and switched to JUUL in 2018.**

"I hadn't planned to switch. But after about a week of having the JUUL in my hand, I started reaching for it over my pack of cigarettes."

**Make the Switch**

A man with a beard and dark hair, wearing a dark blue t-shirt and a long gold chain necklace, is sitting at a table. He has a tattoo on his left forearm that reads "SAGE THE SMOKER". The background is a plain, light-colored wall.

# Everybody Models



# Some do it Systematically



# Why Model?

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- Analyze complex processes
- Integrate effects of multiple influences
- Identify key drivers of outcomes
- Prioritize data collection
- Predict effect of changes in policy or products

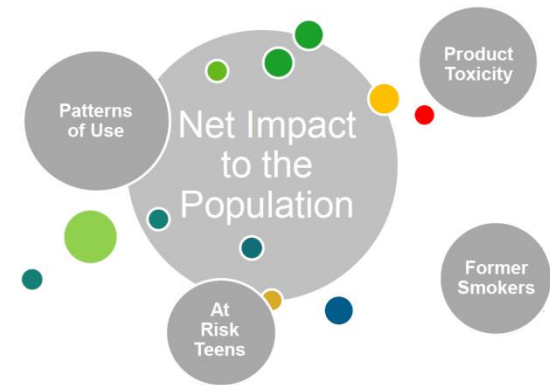
# US FDA

## Population Health Standards

ASSESSING OVERALL IMPACT TO PUBLIC HEALTH

FDA

- New products (PMTAs):  
"appropriate for the protection of the public health"  
(910(c)(4), FD&C Act)
- Modified-risk claims (MRTPAs):  
"will benefit the health of the population as a whole"  
(2(36), Tobacco Control Act)
- Inherently invoke balancing of harms and benefits
- Inherently involve considering a different world
- (Used by FDA to justify its own policy proposals, such as very-low nicotine cigarettes)

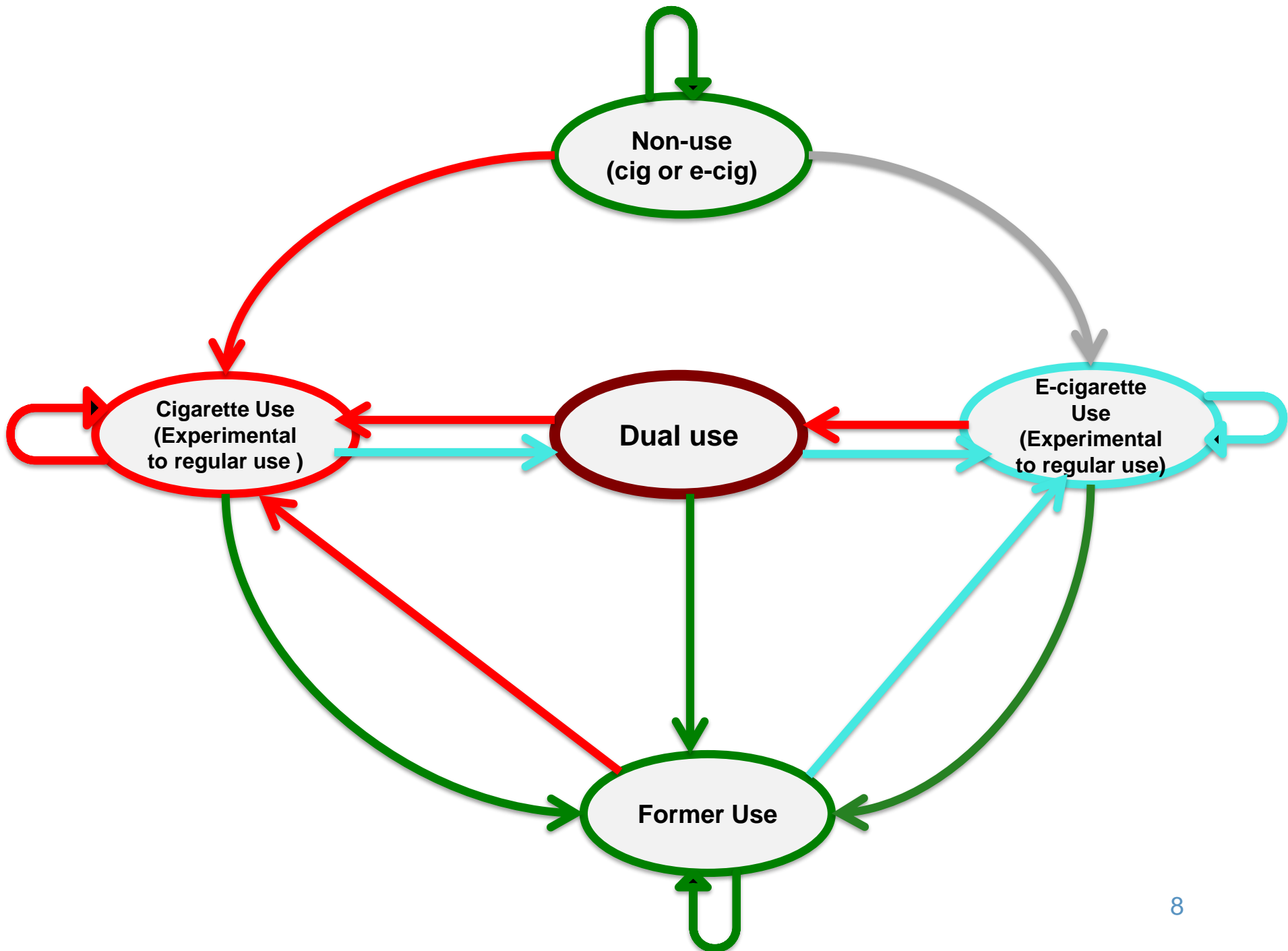


# Example:

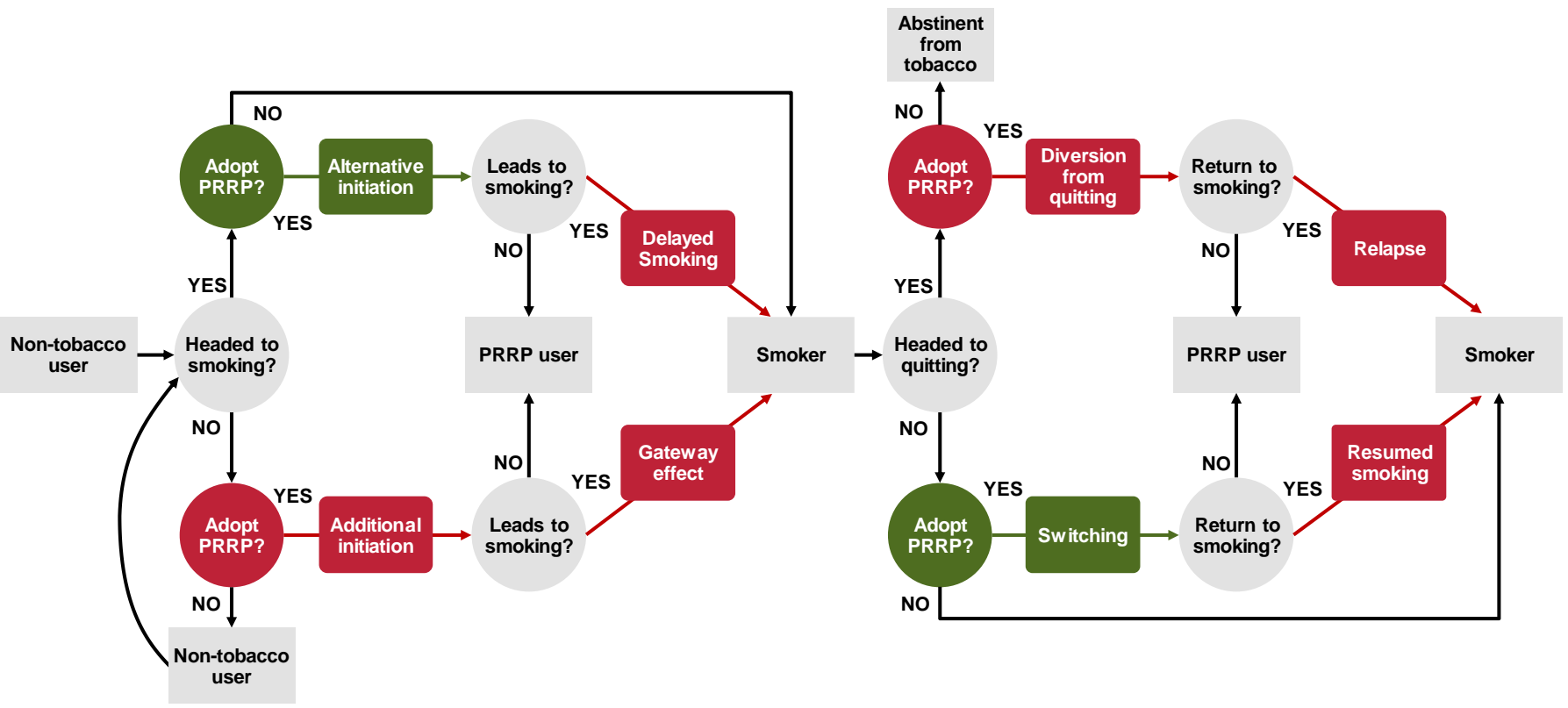
## Weighing Youth Harm and Adult Benefit

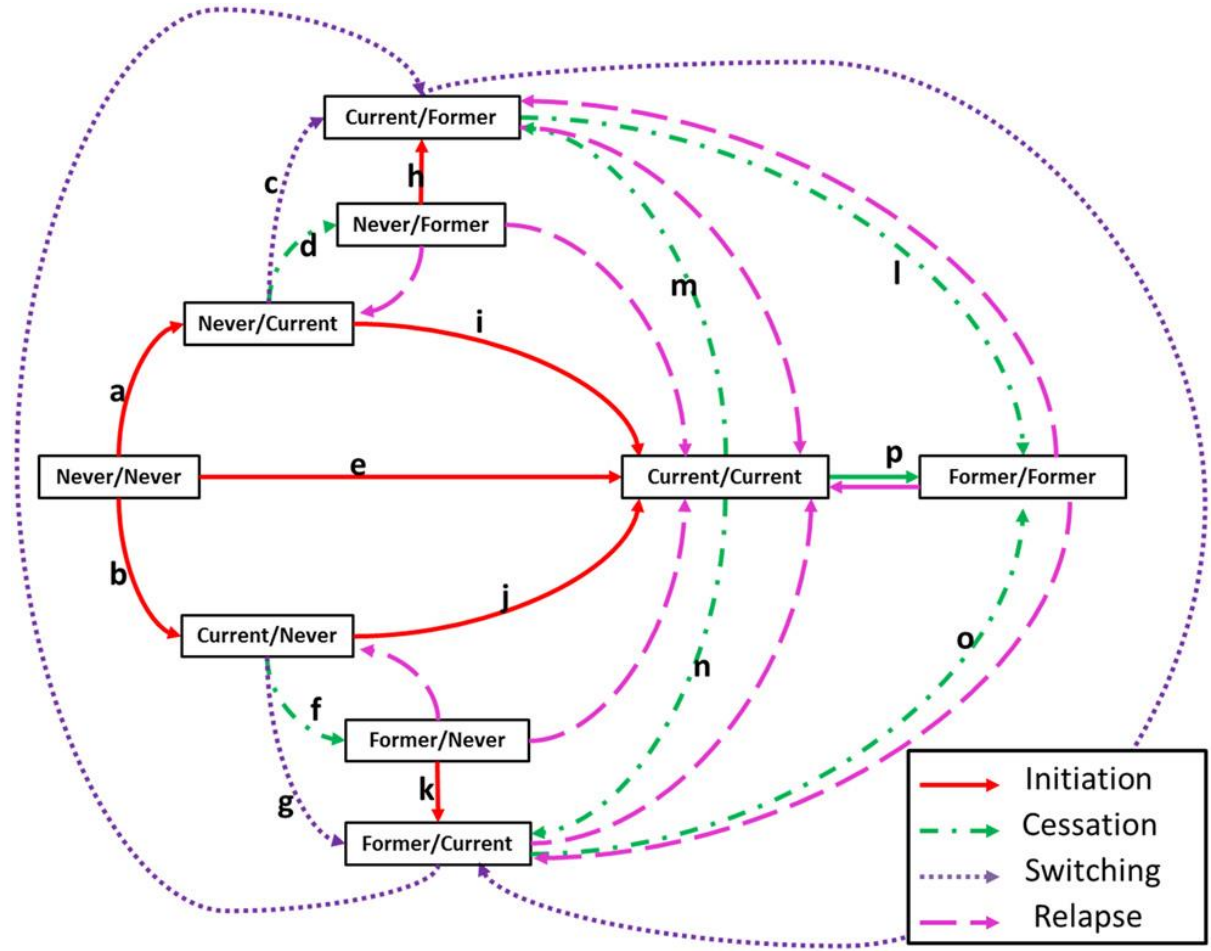
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- Some youth who would not otherwise have used tobacco may take up THR product, and some may be caused to progress to smoking
  - How many?
  - How great is the population harm?
- Some adult smokers who may not otherwise have quit may switch to a THR product instead of smoking
  - How many?
  - How great is the population benefit?
- What is the net benefit/harm?









# Outcomes

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- Ultimate outcome: Population health
  - Longevity/survival
  - Burden of disease
  - Quality-Adjusted Life-Years (QALYs)
- Intermediate outcomes
  - Prevalence
  - Initiation
  - Age distribution
  - Etc.

# Not Just Facts.... Values & Politics!

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*OK, maybe [e-cigarettes] can help five currently addicted adult smokers quit. But for every five adult smokers that quit, one kid's going to become addicted to nicotine. And we might say on balance, that's not a trade that we would be willing to make from a regulatory standpoint.*

- Scott Gottlieb, as FDA Commissioner

# Inputs Based on Observation

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- Defining the base case
- Profiles of the population
  - Including 'stocks' of smokers, ex-smokers, non-smokers
- Existing, observed transition/flow rates
- Health impact of smoking (i.e., base-case product)
- Base-case model can be validated by seeing if it 'predicts' actual observed data
- Health impact of alternative product (?)
  - Often expressed as a proportion of the risk of smoking ('Excess Relative Risk'; ERR)

# Inputs that Need to be Inferred

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- Health impact of alternative product (?)
- New transitions introduced in the counterfactual
  - Consumer research
  - Assumptions, extreme values
- Typically assume “all else being equal”

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*Prediction is very difficult...*

*Especially about the future*

- Niels Bohr, Nobel Prize Physicist

# Sensitivity Testing

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- If facts were clearly known, modeling might not be necessary
- So we typically model in a state of uncertainty
- Since assumptions, inputs, and relationships are uncertain...
- Need to test sensitivity of the outcomes to variations in assumptions, inputs, and relationships
- What are reasonably expected variations in outcomes?
- Which assumptions, inputs, and relationships most affect outcomes?



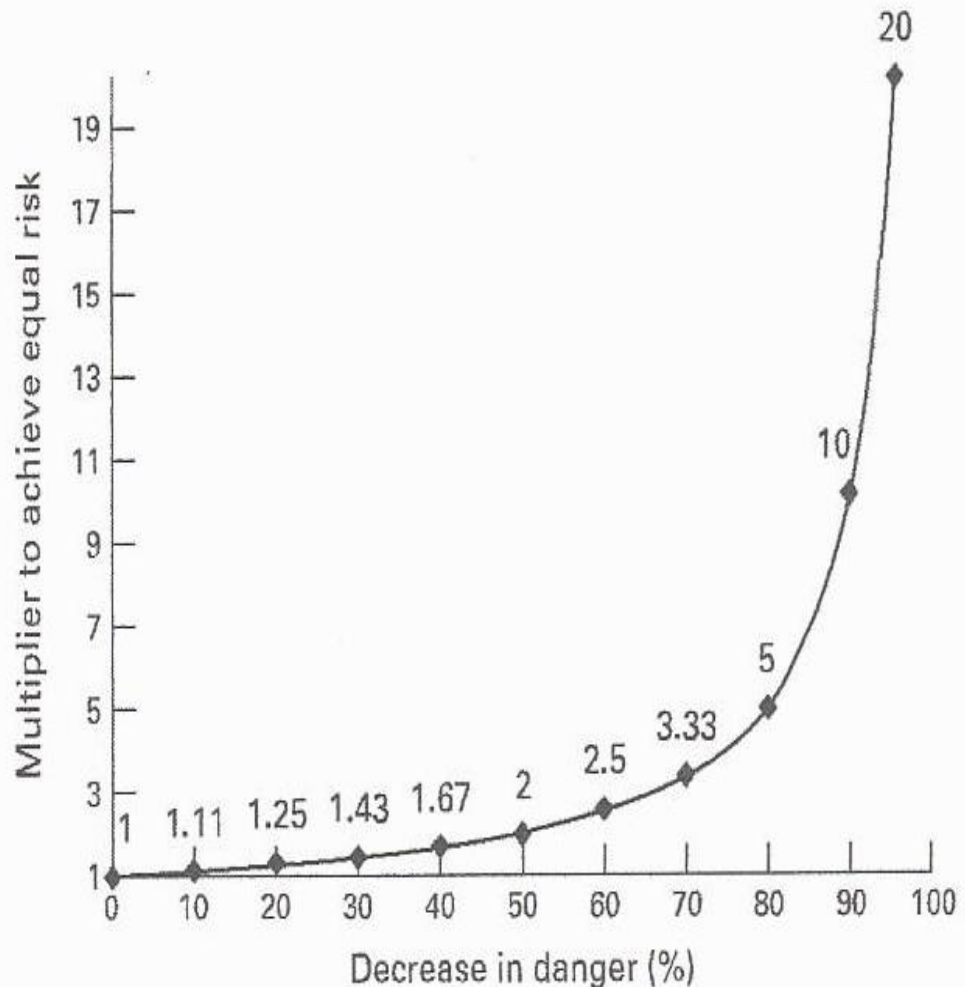
# A Specific Use of Sensitivity Analyses: Tipping Point Analyses

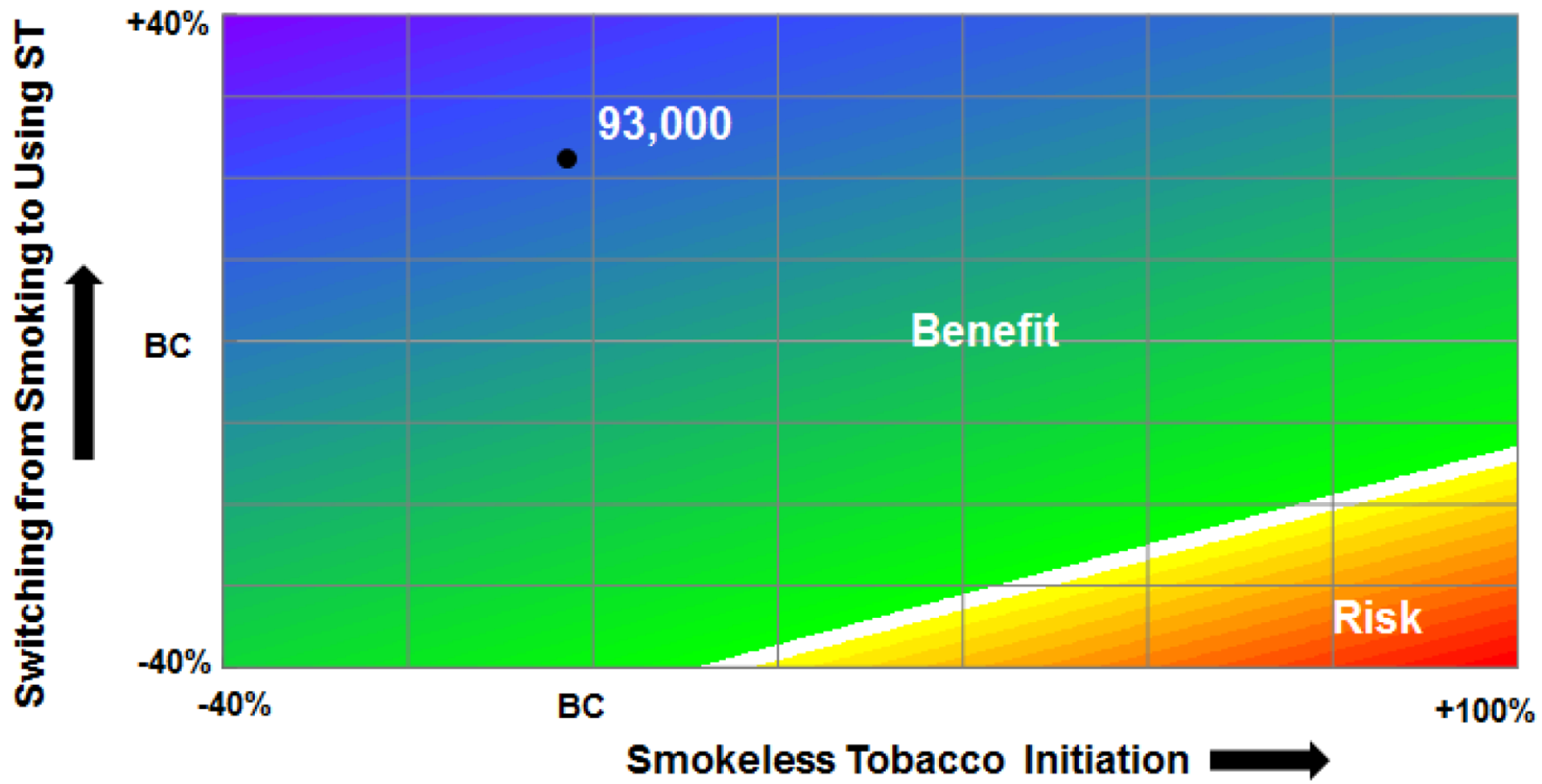
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- Interest in boundary where outcome shifts from benefit to harm (the ‘tipping point’)
- What circumstances cause the outcome to ‘tip’?
- Given assumptions about harmful transitions, what beneficial transitions would be needed to overcome the harm?
  - Are those beneficial transitions plausible?
- Given assumptions about beneficial transitions, what harmful transitions would be needed to overcome the benefit?
  - Are those harmful transitions plausible?

# Simple, Heuristic Model: The Risk/Use Equilibrium

Amount by which prevalence would need to increase to counteract benefit, based on posited product's risk-reduction





# How Models Differ

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- Inputs, sources of data, assumptions
- Cross-sectional (whole current population) vs cohort-longitudinal (following a cohort over time)
- Number of products in base case and counterfactual
- Ways of modeling uncertainty
- Purpose: Predictive vs analytical vs aspirational