Health Beliefs and the Long Run Effect of Medical Information

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- Replication: all data is coming from public sources.

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- How successful is new medical information in changing perception and behavior in the long-run?
- Some socio-economic groups are difficult to reach
  - In the short-run, not everyone receives/understands/trusts medical information.
  - With time, this information may indirectly reach groups who are unreceptive in the first place.

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- Examples:
  - Smoking: beliefs about the product went from positive to negative over a century.
  - Vaccination: MMR, COVID
  - More broader issue: climate change, beliefs and personal engagement.

Motivation - smoking

- Smoking is the leading cause of preventable deaths in developed nations
- CDC estimates a cost of 225 billion USD in direct medical care for adults

Health information on smoking:

- 1950: first scientific results receive widespread attention
- 1964: Surgeon General Report on Smoking and Health

Beliefs about smoking:

- 1970: 30% did not believe smoking can cause lung cancer
- 2020: 90% believes smoking can cause lung cancer
  disparities by education, race, age or region

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- Dynastic/life cycle model of competing mortality risk, risk perception, information propagation and smoking.
- We allow for many sources of learning about the effect of tobacco
  - introspection, by learning from one's own experience.
  - social learning in directed network: friends sharing their experience.
  - public health information

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- Dynastic/life cycle model of competing mortality risk, risk perception, information propagation and smoking.
- We allow for many sources of learning about the effect of tobacco
- We show that such a model can rationalize many aspect of the data.
- Evaluate the importance of medical information.

Plan of talk

Introduction

Evidence on smoking and beliefs

Model

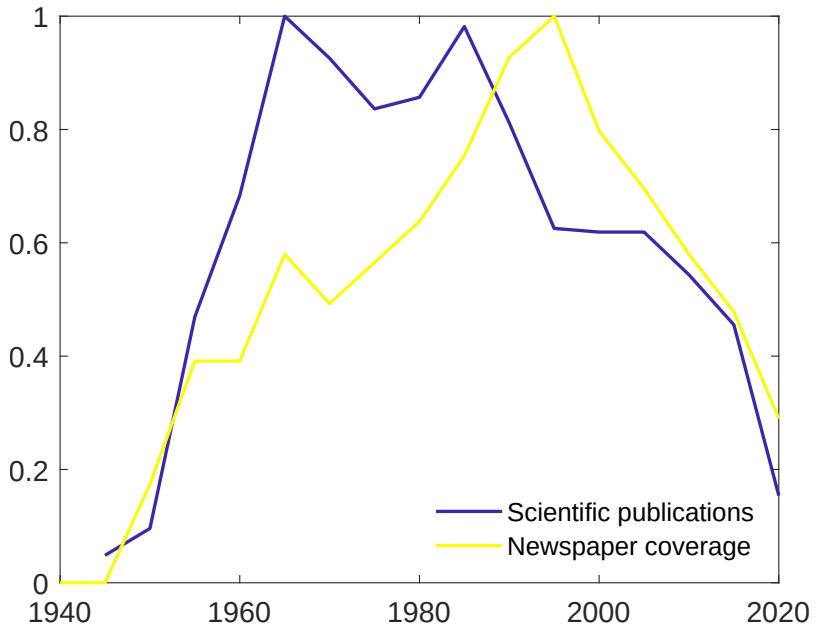
Estimation

Results and policy implications

Data sources

Outcome	Source	Period
Smoking	National Health Interview Survey (NHIS), cross-sectional data with retrospective information.	1970-2020
Health shocks	National Health and Nutrition Examination Survey (NHANES), cross-sectional data	1966-2020
	Health and Retirement Study (HRS), panel data. Includes restricted data on cancer site	1992-2020
Mortality	CDC death rates	1900-1998
	wonder CDC death rates	1999-2020
	Surgeon General Report (SGR), 2014, aggregate data on Smoking Attributable Mortality	1965-2014
Beliefs	Gallup US poll, aggregate data for given years	1954-2013
	Monitoring the Future (MTF), aggregate data on a panel of young individuals	1980-2020
	National Survey on Drug Use and Health (NSDUH) (formerly the National Household Survey on Drug Abuse - NHSDA), cross-sectional data	1985-2020
	Teenage Attitudes and Behavior Concerning Tobacco (TABT) cross-sectional data on adolescents	1992
	Annenberg Tobacco Risk Study (ATRS), cross-sectional data on adolescents	1999
	Population Assessment of Tobacco and Health (PATH), panel data	2014-2021
	Health Information National Trends Surveys (HINTS), cross-sectional data	2003, 2015, 2017
Medical information	Web of Science (scientific publications), time series	1945-2020
	Ancestry (newspaper articles), time series	1930-2020
Tobacco industry	Federal Trade Commission Report 2020 (Advertisements and Promotion), time series	1970-2020
	OpenSecrets (Lobbying), time series	1999-2020
Cigarette prices	The Tax Burden of Tobacco (TBT), time series	1955-2019
Social networks	General Social Survey (GSS), cross-sectional	1985, 2004
Demographic composition	IPUMS USA, cross-sectional data	1910-2020

Medical information incriminating smoking



Notes: Scientific publications from Web of Science, newspaper coverage from Ancestry. The series have been normalized between zero and one.

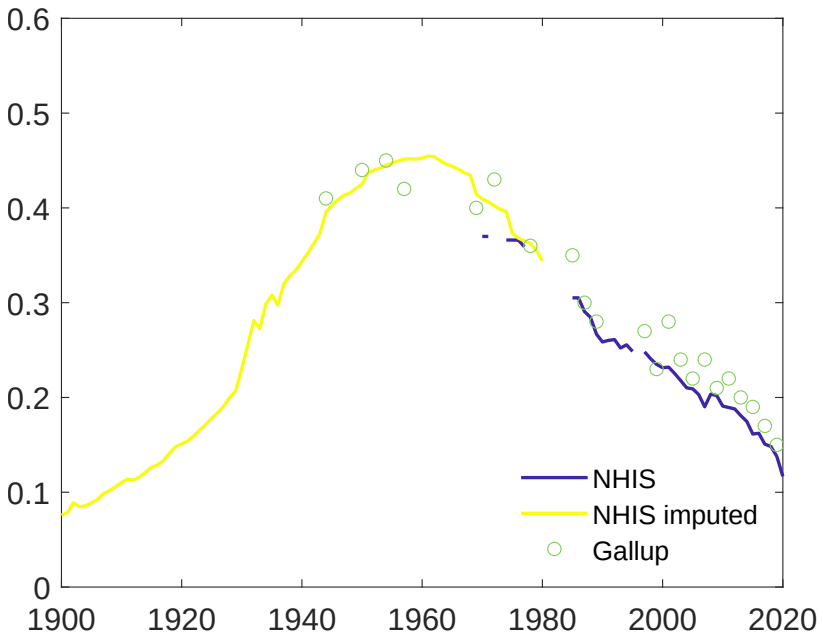
- Medical hard evidence starts in the early 1950s (Doll and Hill, 1950).
- Publicized by the Surgeon General report in 1964.

Evolution of smoking

(a) Per capita consumption of cigarettes

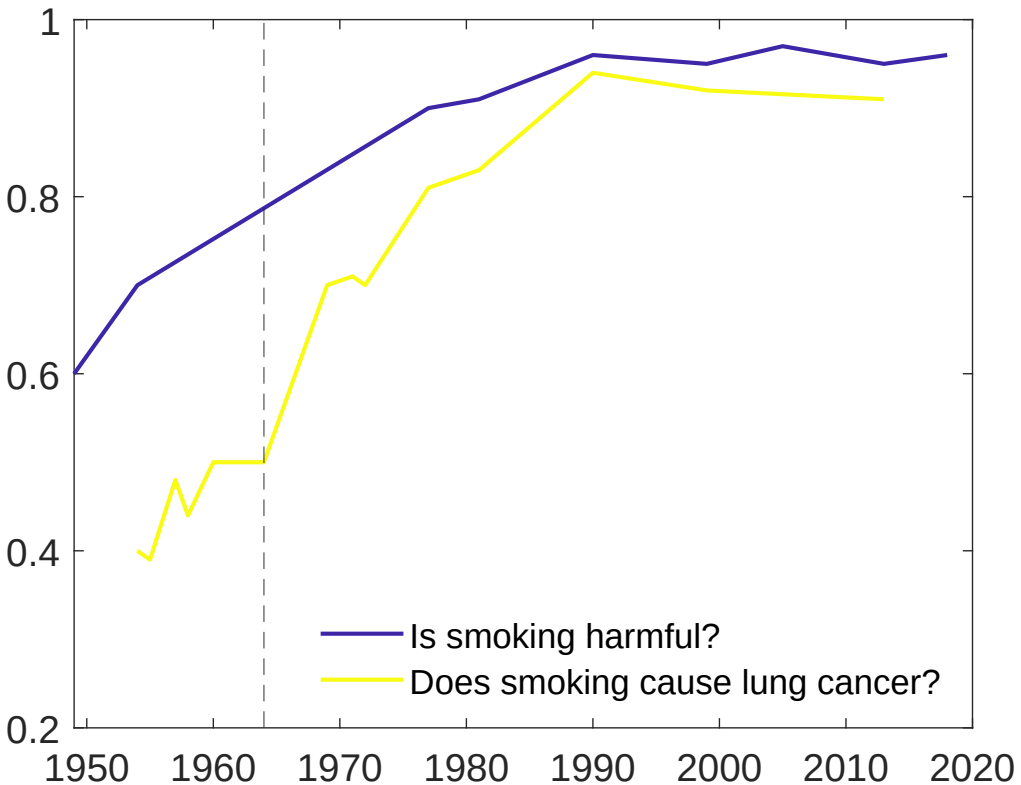
American Lung Association (2004)

(b) Percentage of Current Smokers



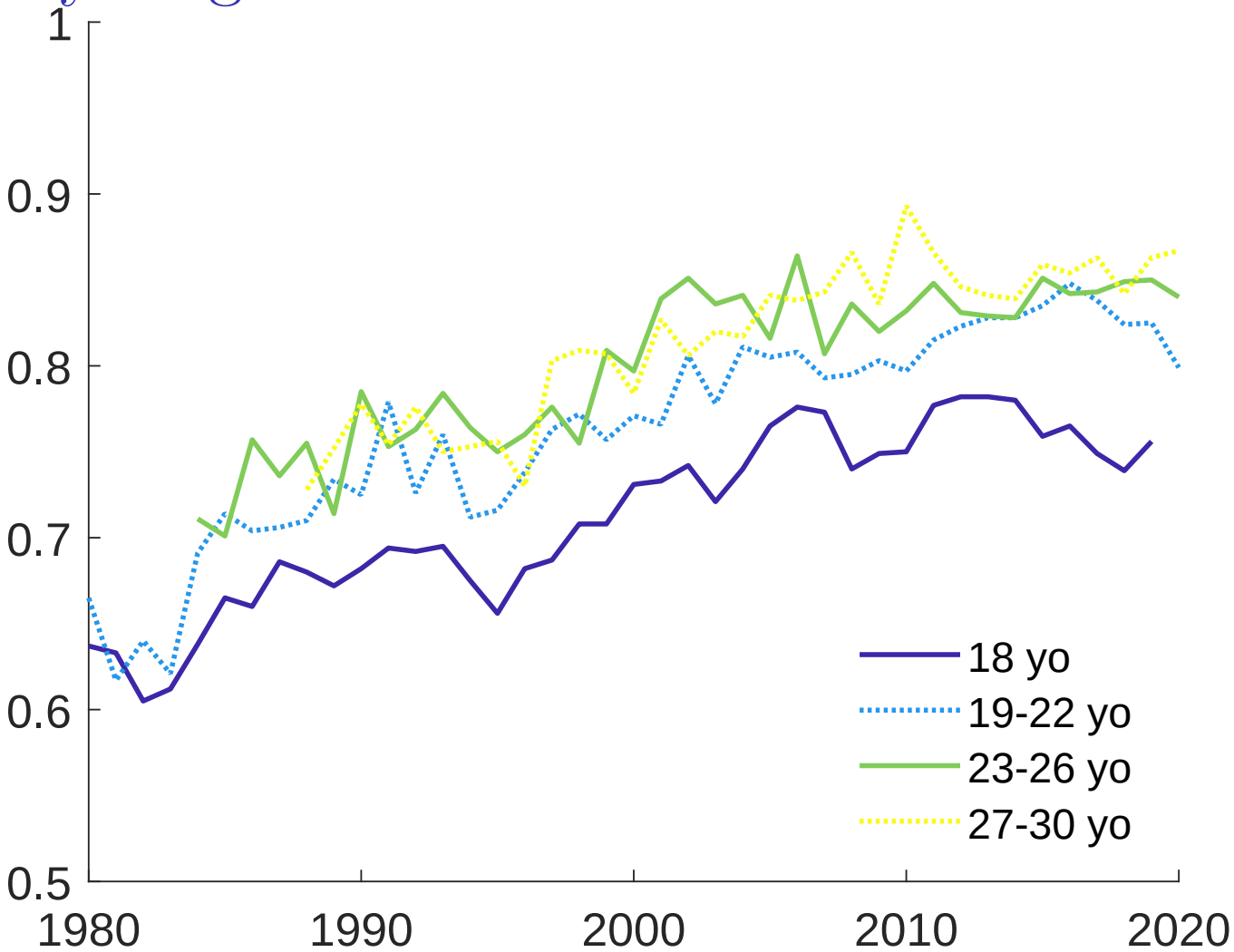
NHIS, Gallup and own estimation from NHIS start and quit date

Beliefs about the harmfulness of tobacco



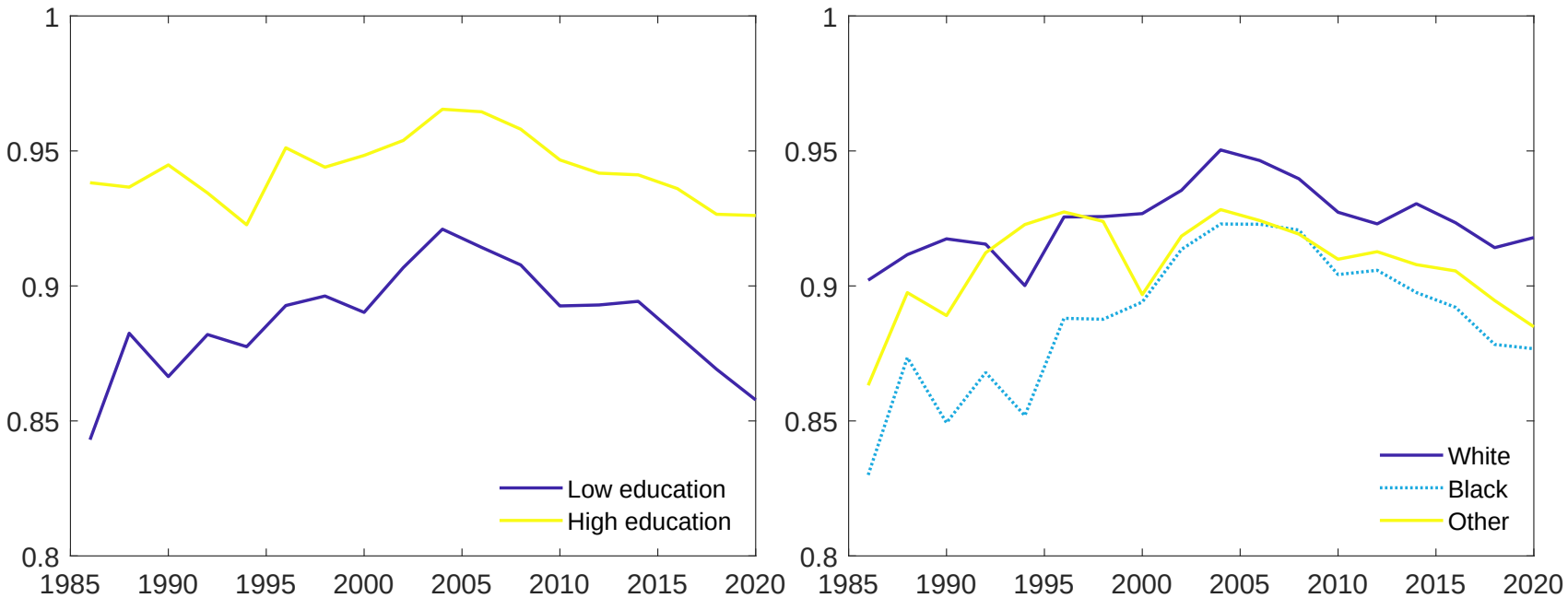
Source: Gallup Poll

Beliefs of young adults



Source: Monitoring the Future

Beliefs by Education and Race



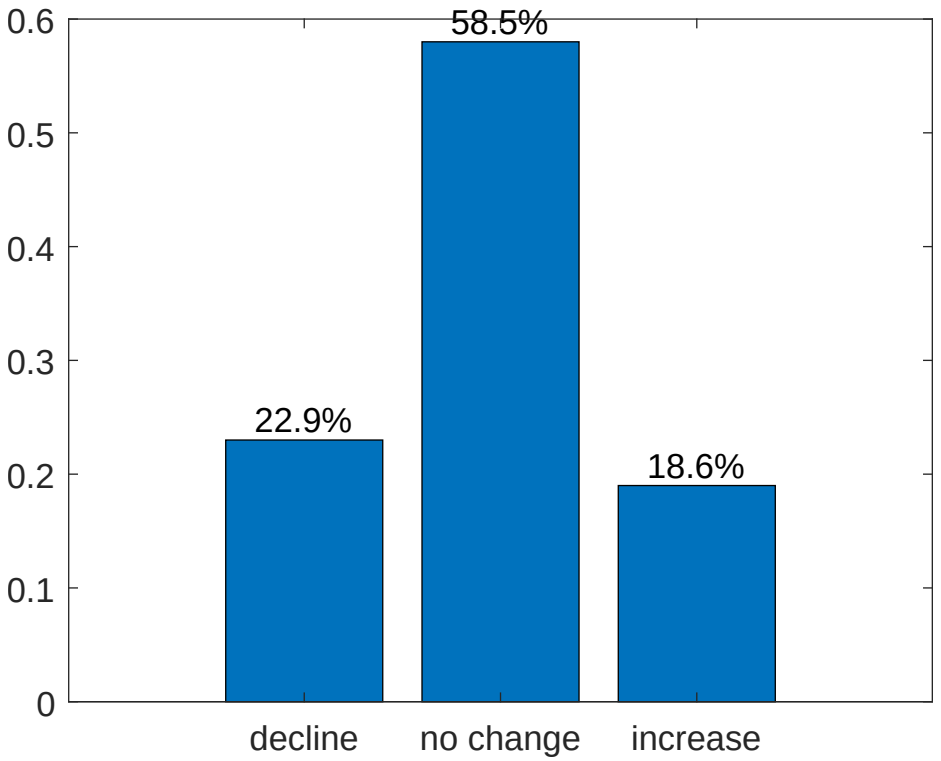
Source: NSDUH (prev. NHSDA)

How much do people risk harming themselves physically and in other ways when they smoke one or more packs of cigarettes per day?
Percentage saying moderate or great risk

Individual changes in beliefs (1)

Panel data $\sim$ 37K individuals, 5 waves in 2014-2019

Changes in individual $\times$ year observations



Source: PATH

Selected tobacco advertisement, various years

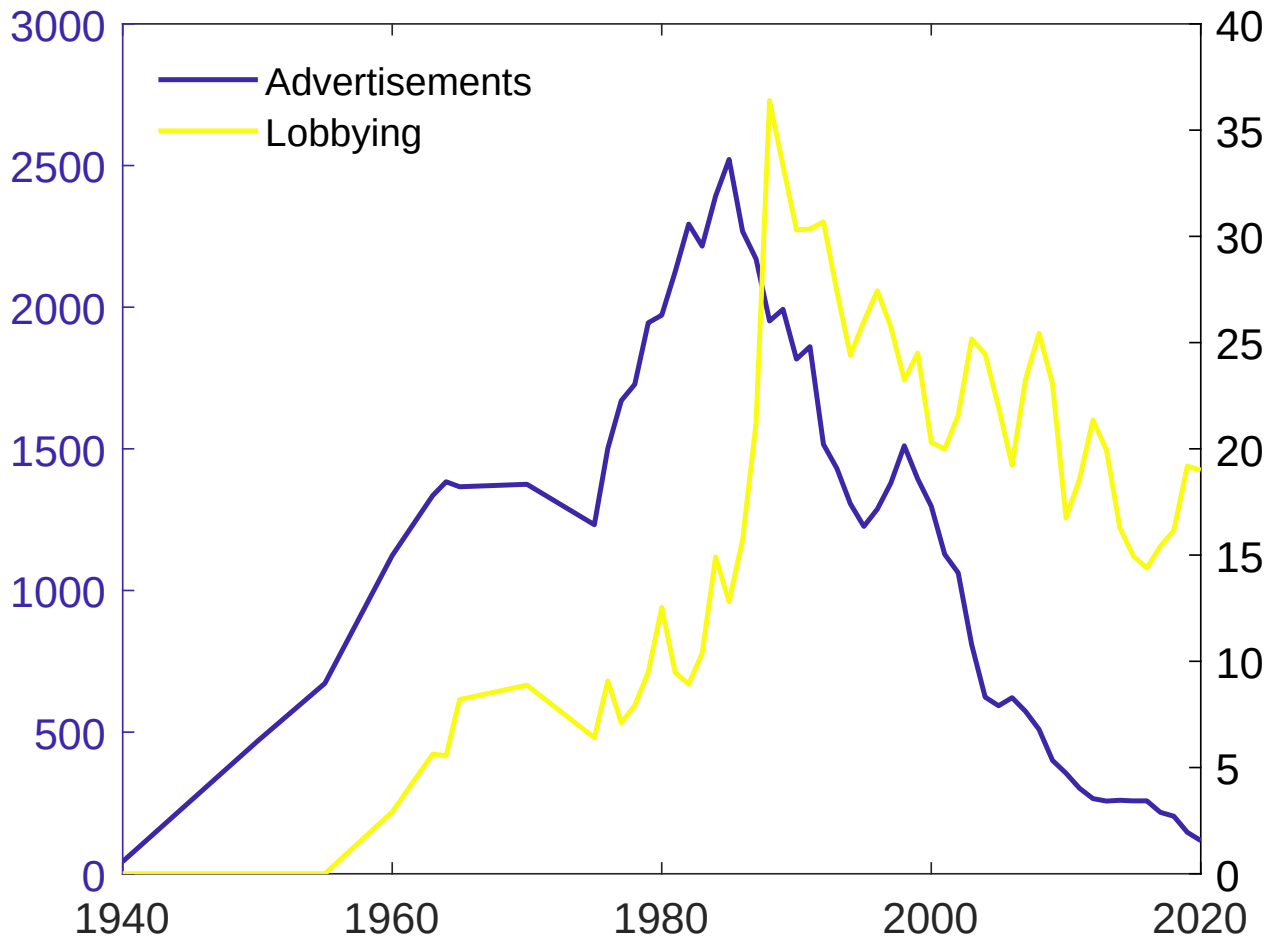
1885

1942

1951

1993

Tobacco industry efforts



Model

- Many individuals followed from birth to death

Model

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- Overlapping cohorts and dynastic model
  - First cohort born around 1885
  - A new cohort is born about every 25 years
  - Parthenogenesis reproduction: each individual produces an offspring with the same characteristics.

Model

- Many individuals followed from birth to death
- Overlapping cohorts and dynastic model
- Each individual belongs to a birth cohort c_i and a group g_i
  - education level
  - race
  - geographical location

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- Individuals decide in each period whether to smoke
- Decision depends on individual and societal factors:
  - past behavior
  - peer effects
  - health status
  - beliefs about how dangerous tobacco is
  - prices
- Heterogeneous beliefs that evolve as individuals learn

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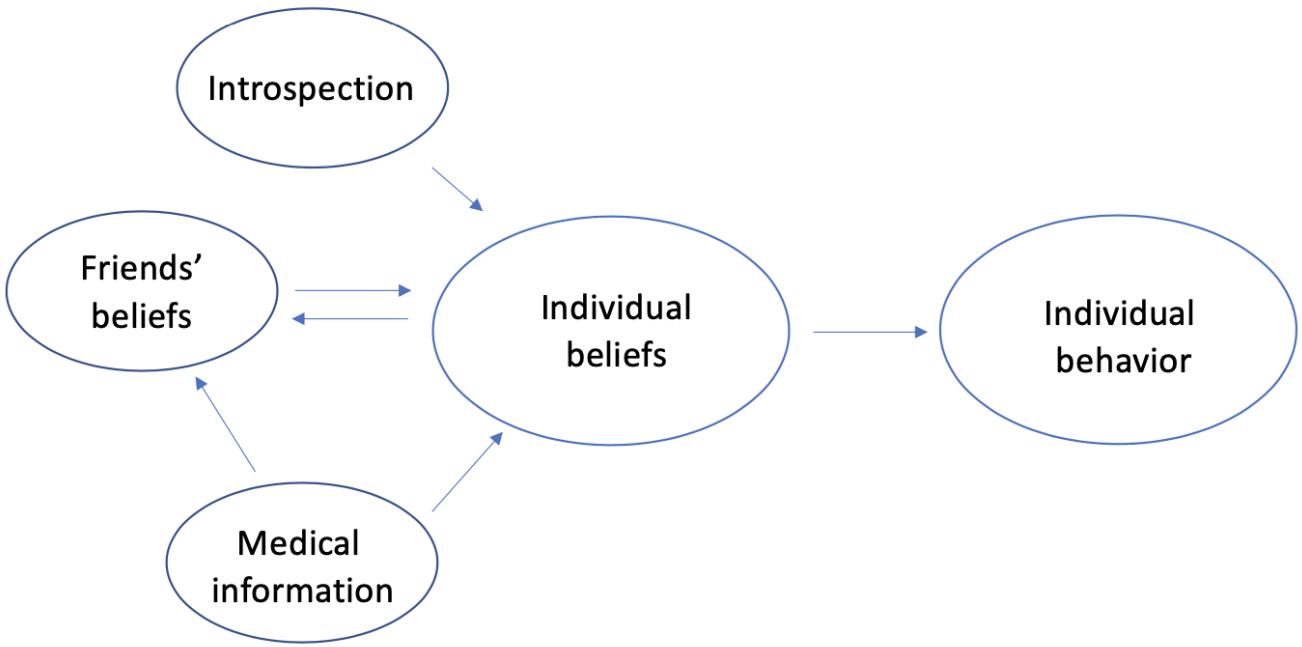
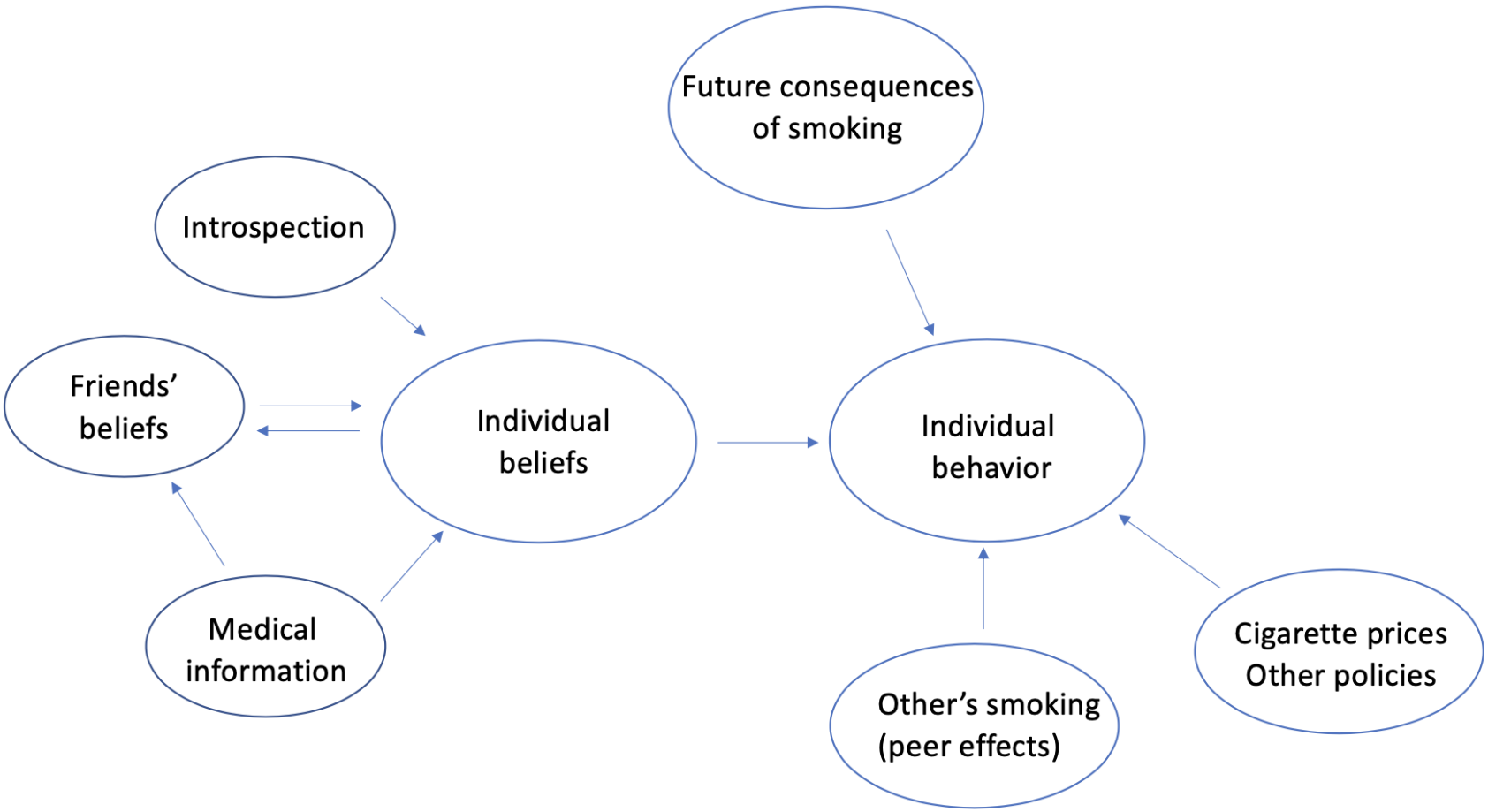
- Overlapping cohorts and dynastic model
- Each individual belongs to a birth cohort c_i and a group g_i
- Individuals decide in each period whether to smoke
- Decision depends on individual and societal factors:
- Heterogeneous beliefs that evolve as individuals learn
  - Initial beliefs passed on by the parent
  - updating of beliefs over the life-cycle by
    - introspection,
    - exchange of information among individuals
    - medical information or tobacco-firm obfuscation.

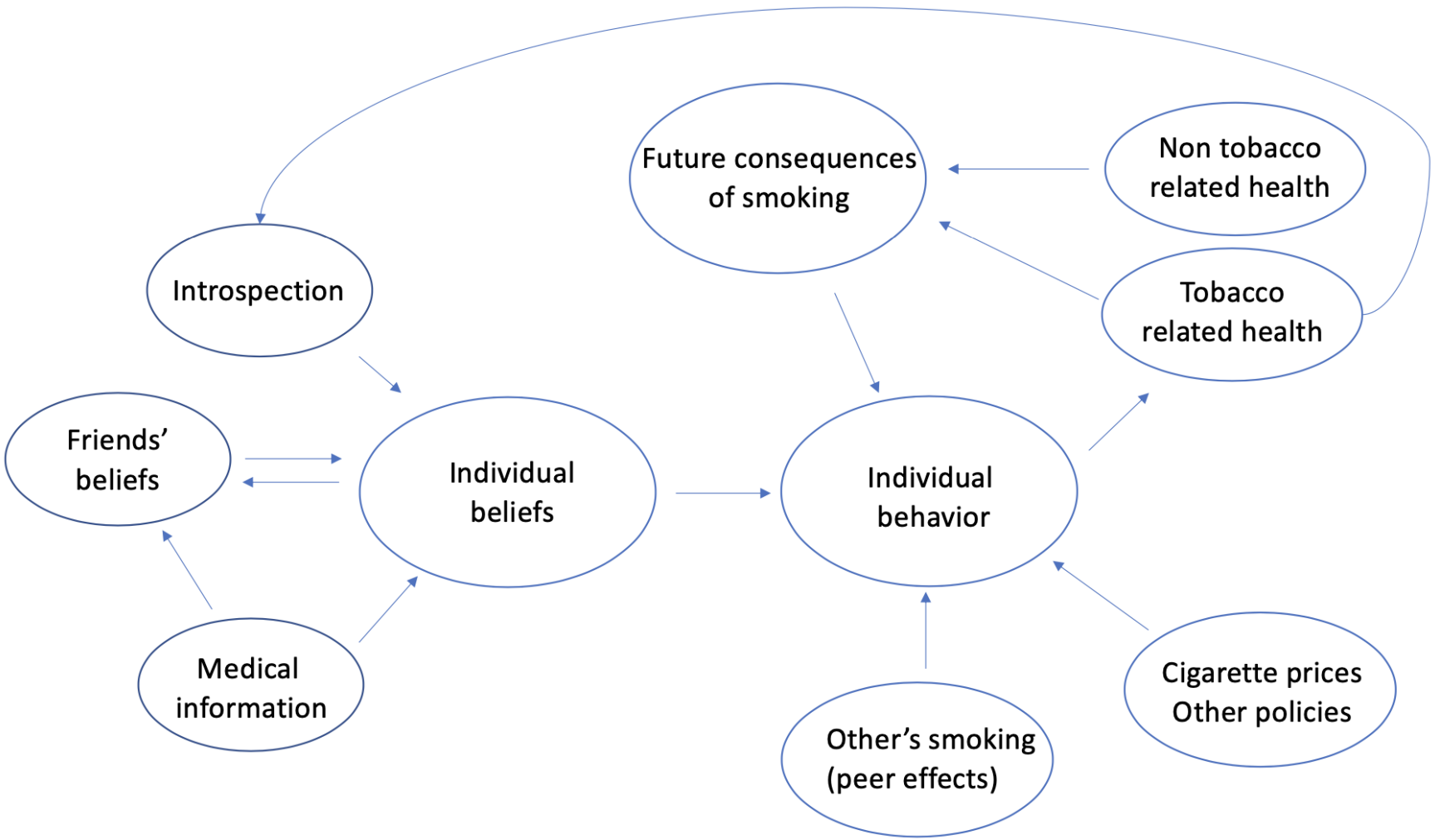
Overview of the model: beliefs and behavior



Overview: more determinants drive behavior



Overview: full model



Preferences

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- Taste for tobacco is heterogeneous and depends in part on the prevalence of smoking in the population and in the social group of the individual.

Preferences

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- Tobacco is addictive through a habit stock.
- Preferences towards smoking depends on the occurrence of tobacco-related diseases.
- Taste for tobacco is heterogeneous and depends in part on the prevalence of smoking in the population and in the social group of the individual.
- Consumption is financed by an income that varies across age, cohort and socio-economic groups.

The effect of tobacco on health

- True conditional probability of getting a smoking-related health shock (e.g. lung cancer) depending on age, the cumulative stock of smoking and demographics.

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- True conditional probability of getting a smoking-related health shock (e.g. lung cancer) depending on age, the cumulative stock of smoking and demographics.
- The agent hesitates between two states of the world:
  - H: Smoking is harmful:
    Prob(Disease$|H$) depends on age, demographics and smoking
  - NH: Smoking is not harmful:
    Prob(Disease$|NH$) depends on age, demographics but *not* smoking

Beliefs about the danger of smoking

- Log odds ratio of the prior of tobacco being harmful:

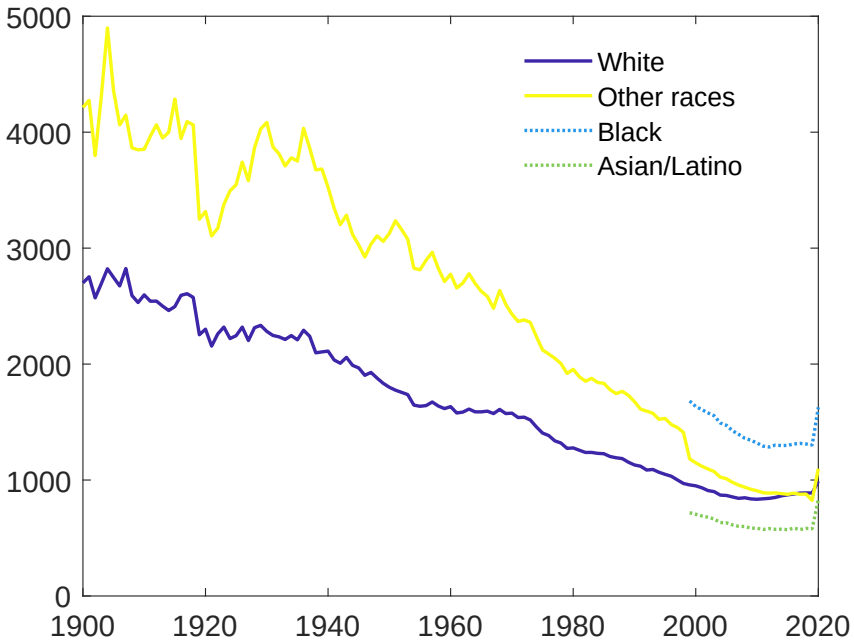
$$\lambda_{it} = \ln\left(\frac{P_{it}(H)}{P_{it}(NH)}\right)$$

- From the perspective of the individual with a given odds ratio λ_{it}:

$$P(Disease) = \frac{Prob(Disease|H)e^{\lambda_{it}}}{1+e^{\lambda_{it}}} + \frac{Prob(Disease|NH)}{1+e^{\lambda_{it}}}.$$

Mortality: competing risks framework

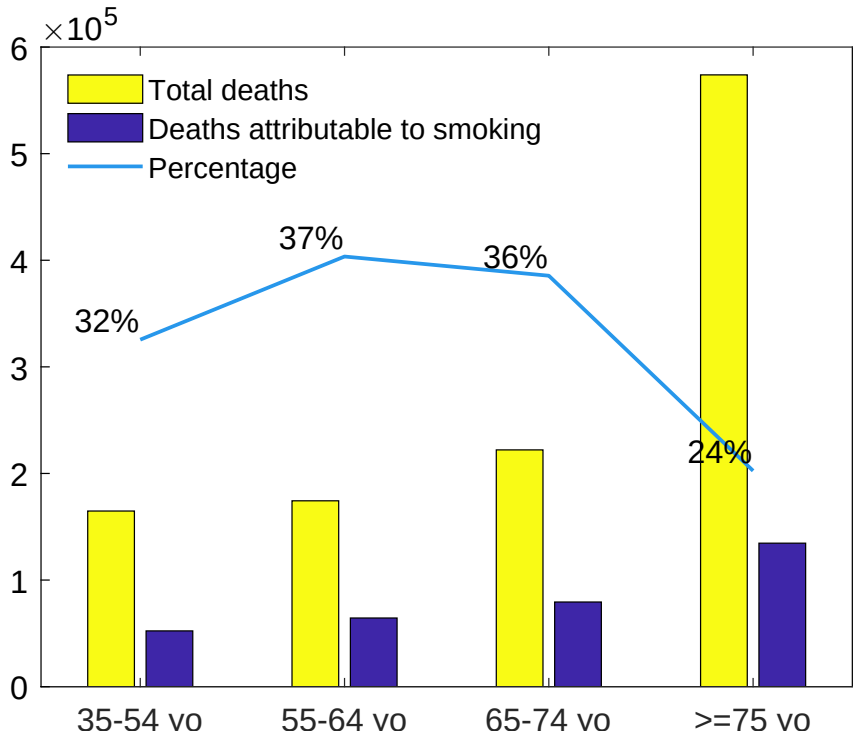
- Two causes of mortality
  - tobacco and non-tobacco related,
  - determined by two independent shocks.
  - Death occurs if either of these two shocks occur.



55-64 yo - Source: NCHS and NVSS

Mortality: competing risks framework

- Two causes of mortality
- Smoking-related mortality depends on exposure to tobacco, through tobacco related diseases and arises mostly in older age



Dynamic choice

- In each period the agent decides whether to smoke or not.
- The agent balances the current utility of smoking with future consequences.
- Future consequences depends in part on:
  - on the beliefs the agent has on how dangerous tobacco is.
  - on the agent's non-tobacco health
  - addiction
- Behavior is the solution to a Bellman equation.

Evolution of beliefs - 1^{rst} channel: introspection

- Experiencing a disease potentially related to smoking leads to Bayesian updating:

$$\begin{cases} \lambda_{it} = \lambda_{it-1} + \ln\left(\frac{Prob(Disease|H)}{Prob(Disease|NH)}\right) & \text{if disease} \\ \lambda_{it} = \lambda_{it-1} + \ln\left(\frac{1-Prob(Disease|H)}{1-Prob(Disease|NH)}\right) & \text{if not} \end{cases}$$

- In short

$$\Delta\lambda_{it} = \mathcal{BL}_{it}(\text{Onset of disease})$$

- At young ages, observing no tobacco health signal is uninformative as no-one expects to be sick in any case.

Evolution of beliefs - 2^{nd} channel: external information

- Scientific publications provide new information on the health consequences of smoking. This information may reach the public directly
- Denote by $MedPub_{t-k} \in [0,1]$ an index of the number of medical publications in year $t-k$ that associate smoking with poor health.
- Denote by $\delta^M_{g_i}$ the weight an individual in the group g_i places on that information and by $\bar{\lambda}$ the highest log-odds ratio, corresponding to a near certainty that tobacco is harmful

$$\mathcal{EI}^M_{it} = \bar{\lambda}\delta^M_{g_i}\ MedPub_{t-k}$$

Evolution of beliefs - 2^{nd} channel: external information

- Denote by $TobObf_t \in [0,1]$ an index of the intensity of the tobacco industry spending on information. Denote by $\underline{\lambda}$, the log-odds ratio corresponding to a near certainty that tobacco is not harmful:

$$\mathcal{EI}_{it}^{Tob} = \underline{\lambda}\delta_{g_i}^{Tob} TobObf_t$$

- Absent other channels, the log-odds ratio evolves as:

$$\lambda_{it} = \lambda_{it-1} + \mathcal{EI}_{it}^{M} + \mathcal{EI}_{it}^{Tob}$$

Evolution of beliefs - 3^{rd} channel: social learning

- Learning from others: DeGroot agents

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- Individuals belong to a network of friends and relatives, denoted $\mathcal{F}_i$, with whom they exchange views on the state of the world and incorporate it into their beliefs.

Evolution of beliefs - 3^{rd} channel: social learning

- Learning from others: DeGroot agents
- Individuals belong to a network of friends and relatives, denoted $\mathcal{F}_i$, with whom they exchange views on the state of the world and incorporate it into their beliefs.
- The structure of the network is specific to a socioeconomic group: homophily along education, race, region and birth cohort

	Low educated			High educated		
	White	Black	Other	White	Black	Other
% Contacts low-edu	71	74	75	32	45	40
% Contacts high-edu	29	26	25	68	55	60
% Contacts white	95	9	16	96	12	20
% Contacts black	0	87	7	1	88	6
% Contacts other race	4	5	77	3	0	74

Evolution of beliefs - 3^{rd} channel: social learning

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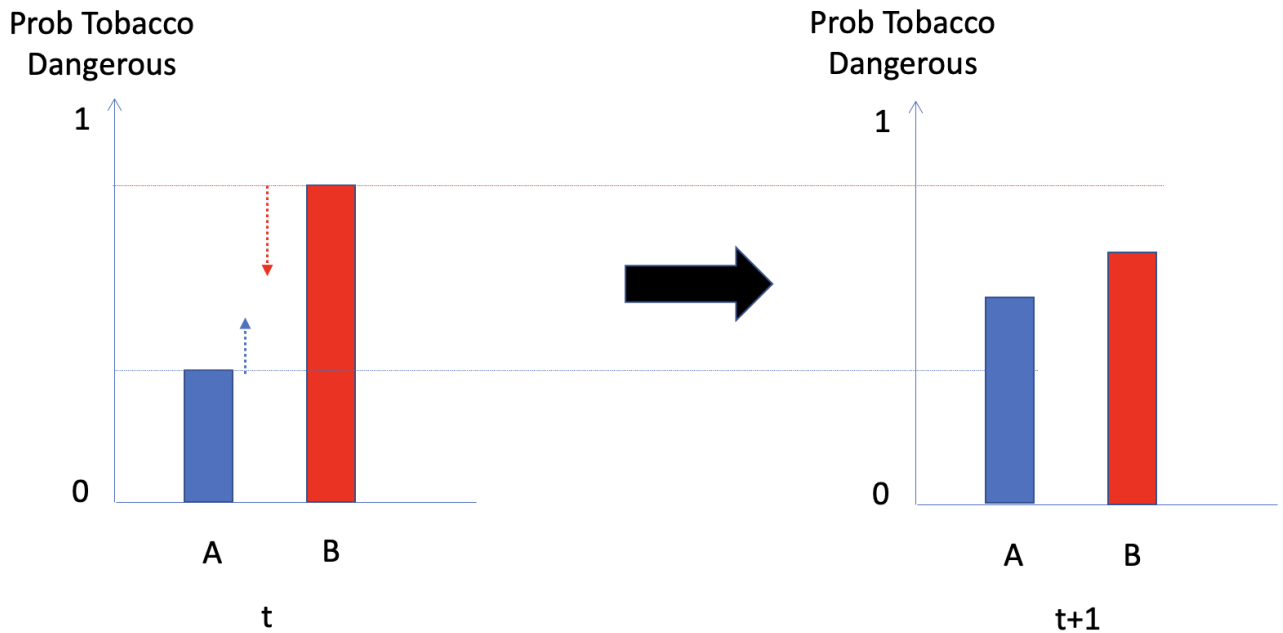
- The structure of the network is specific to a socioeconomic group: homophily along education, race, region and birth cohort
- The members of the network are fixed over the life-cycle

When two people meet...

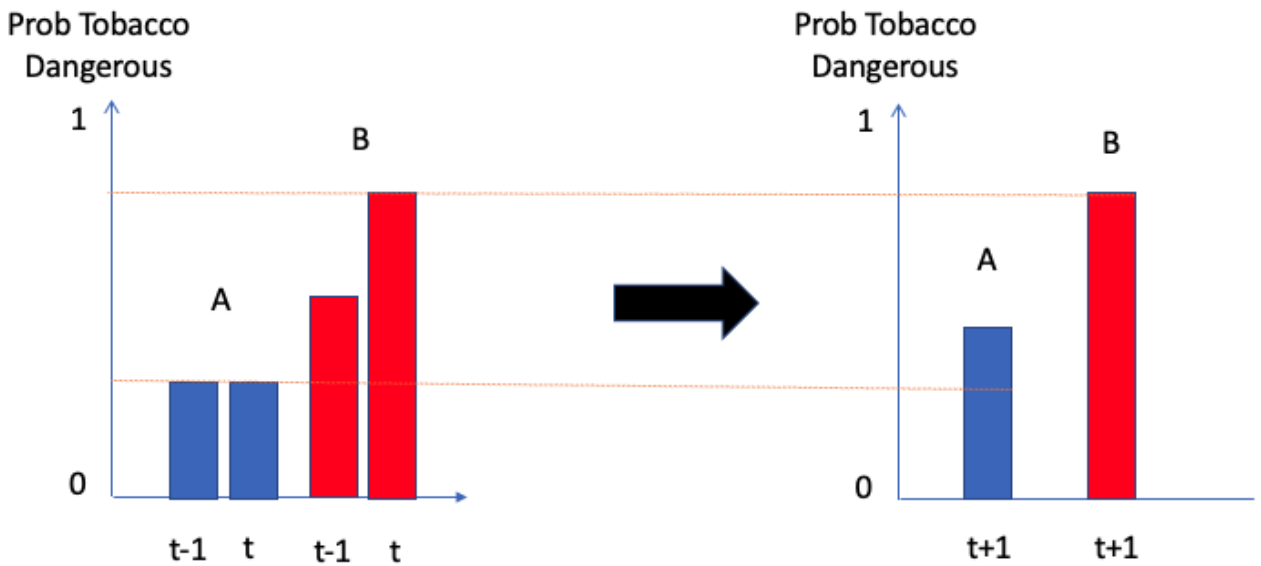
- Belief averaging



$$\lambda_{it} = (1-\delta^{\lambda}_{g_i})\lambda_{it-1} + \delta^{\lambda}_{g_i}\mu_i \sum_{j \in \mathcal{F}_i, j \neq i} \lambda_{j,t-1} \qquad \mu_i = 1/(card(\mathcal{F}_i)-1)$$

When two people meet...

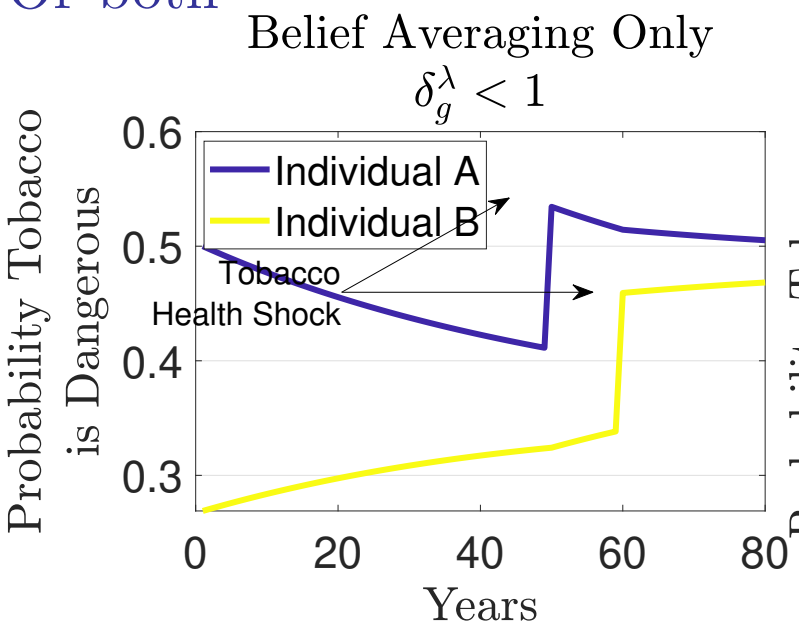
- Belief averaging
- New information averaging

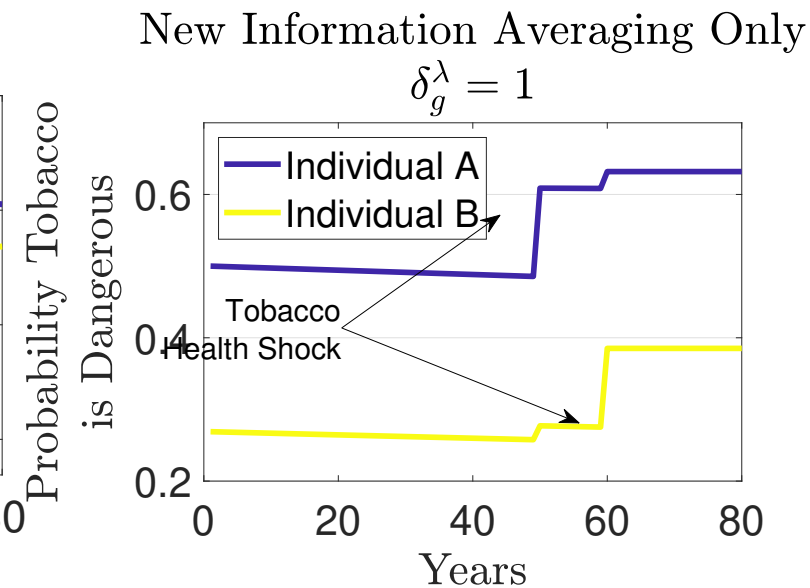


$$\lambda_{it} = \lambda_{it-1} + \mu_i \sum_{j \in \mathcal{F}_i, j \neq i} (\delta^{BL}_{g_i} \mathcal{BL}_{j,t} + \delta^{EI}_{g_i} \mathcal{EI}_{j,t})$$

When two people meet...

- Belief averaging
- New information averaging
- Or both





Evolution of beliefs

- Putting everything together, introspection, direct and indirect information through social learning:

$$\lambda_{it} = \overbrace{\overbrace{\mathcal{BL}_{it}}^{\text{Own}} + \overbrace{\delta^{BL}_{g_i}\mu_i \sum_{j\in\mathcal{F}_i, j\neq i} \mathcal{BL}_{jt}}^{\text{Social learning}}}^{\text{Introspection}} + \overbrace{\overbrace{\mathcal{EI}_{it}}^{\text{Own}} + \overbrace{\delta^{EI}_{g_i}\mu_i \sum_{j\in\mathcal{F}_i} \mathcal{EI}_{jt}}^{\text{Social learning}}}^{\text{External information}}$$

$$+ \overbrace{\overbrace{(1-\delta^{\lambda}_{g_i})\lambda_{it-1}}^{\text{Own}} + \overbrace{\delta^{\lambda}_{g_i}\mu_i \sum_{j\in\mathcal{F}_i, j\neq i} \lambda_{jt-1}}^{\text{Social learning}}}^{\text{Belief averaging}}$$

Initial conditions

- An agent starts life at age 15 in period t_0:
  - with the same demographics as the parent
  - stock of addiction set to zero.
  - beliefs are inherited from the parent with a discount δ^F.
- The model starts in 1885 and the first cohort is born 1866-1874. Those individuals start with a log-odds belief drawn from a normal distribution:

$$\lambda_{i0} \sim \mathcal{N}(\mu_\lambda, \sigma_\lambda)$$

- Over the period 1885 to 2020, we consider six cohorts, coming of age around 1910, 1935, 1960, 1985, and 2010.
- We reweigh each group annually to match observed demographic patterns.

Beliefs evolution: how the model works

- Up to about 1920: little evolution
  - Smoking is expensive, more likely in high SES groups
  - No clear medical information
  - Competing risk feature of mortality and short life expectancy means that few smokers experience smoking related diseases: limited learning through introspection
  - Not much to learn from friends and relatives.

Beliefs evolution: how the model works

- Up to about 1920: little evolution
- Between about 1920-1960: unequal and slow diffusion
  - Smoking becomes cheaper and spreads to lower classes
  - Life expectancy increases, especially for educated whites: larger scope for learning, more to lose.
  - Diffusion of beliefs in more affluent segment of the society

Beliefs evolution: how the model works

- Up to about 1920: little evolution
- Between about 1920-1960: unequal and slow diffusion
- Between 1960-2004: (slow) convergence
  - Medical information: reaches the more affluent and educated part of society directly.
  - More scope for individual learning as life expectancy increases further
  - Large role for the diffusion of beliefs across individuals as more smokers
  - Less affluent groups indirectly benefit from this diffusion but with a lag
  - Price increases also curb smoking

Beliefs evolution: how the model works

- Up to about 1920: little evolution
- Between about 1920-1960: unequal and slow diffusion
- Between 1960-2004: (slow) convergence
- After 2004: slight divergence
  - Reduced Medical information
  - Persistent role of tobacco industry
  - Reduced role of diffusion of beliefs as less smokers
  - Unlearning in young smokers through introspection

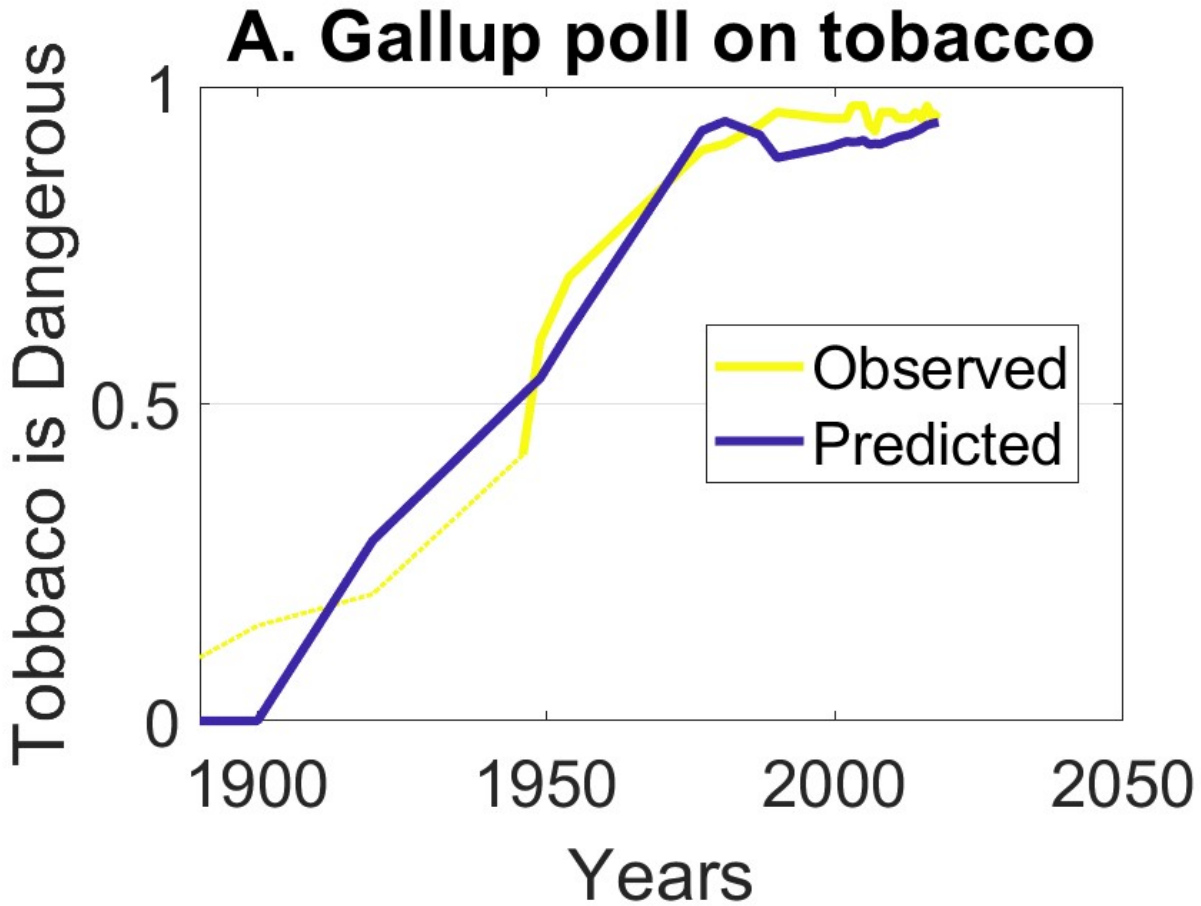
Estimation

- Estimation based on simulated method of moments
- Model is solved and simulated for a given set of parameters
- Minimize the distance between simulated and observed moments
- We initialize the simulation with a cohort born in 1875, which is discarded in the estimation.

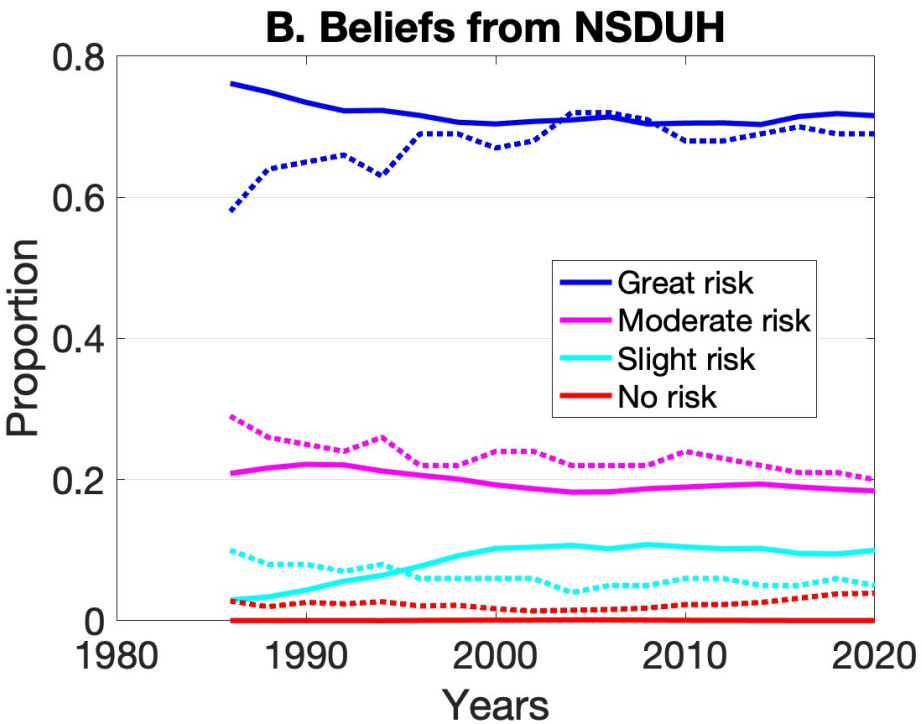
Moments used in estimation

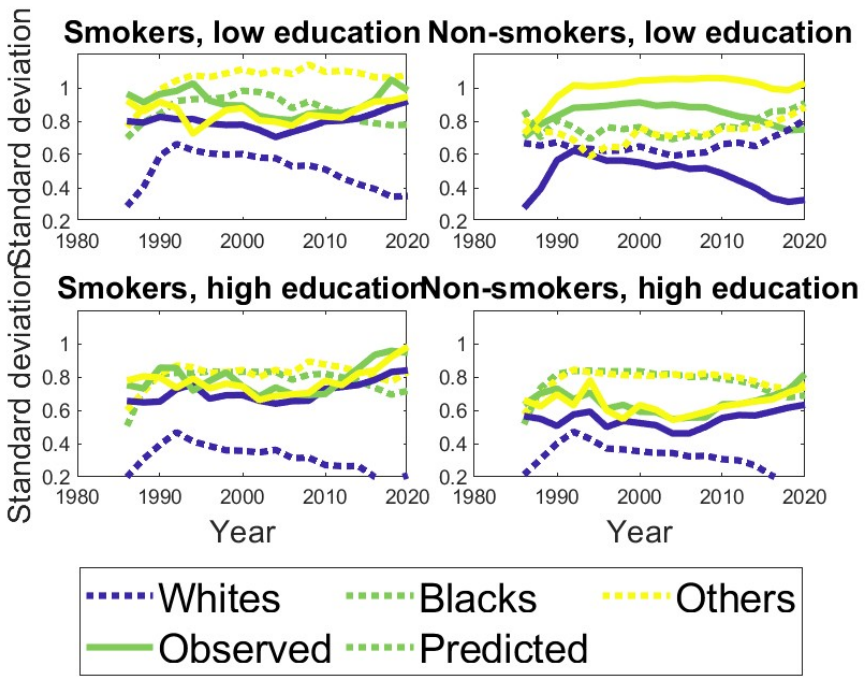
	Moment	Source	Number of moment
Beliefs	Proportion who believe smoking is harmful, time trend	Gallup	14
	Proportion who believe smoking is harmful in the life cycle, by cohort	MTF	24
	OLS regression of beliefs on demographics, year and smoking status	NSDUH, PATH, HINTS, ATRS, TABT	30
	OLS regression of beliefs on demographics, region and smoking status	NSDUH	11
	OLS regression of individual changes in beliefs on demographics and smoking status	PATH	7
	Distribution of beliefs in Likert scale	NSDUH	216
	Standard deviation of beliefs in Likert scale, by demographics and smoking status	NSDUH	
Smoking	Proportion of ever smokers, by socioeconomic group and birth cohort	NHIS	28
	Proportion of current smokers, by socioeconomic group and age	NHIS	576
Quitting	RE panel regression of quitting on demographics and	HRS	10

Model fit: beliefs over time



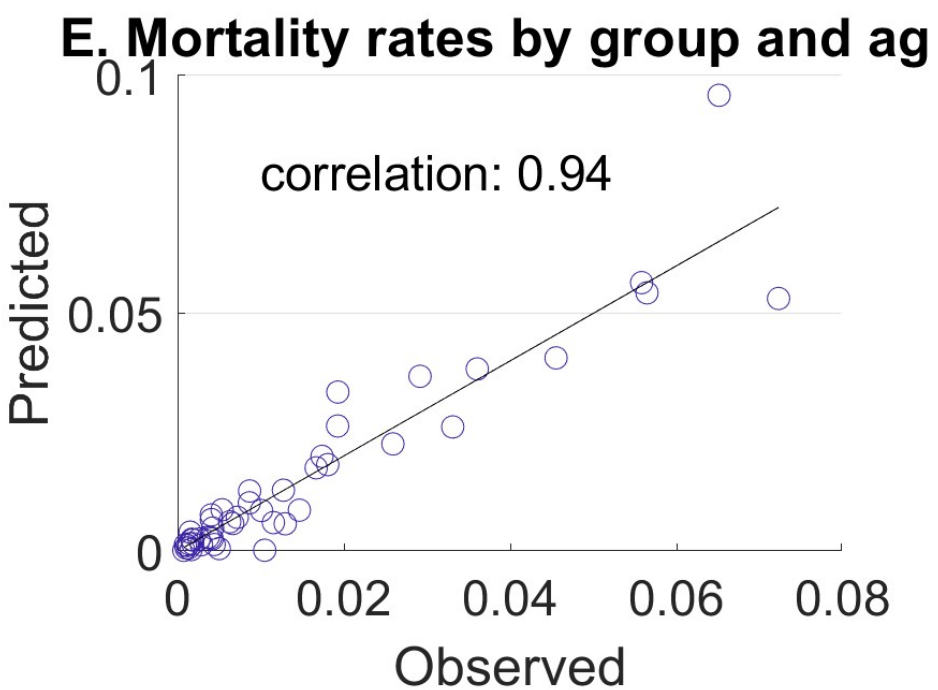
Model fit: intensity and heterogeneity in beliefs

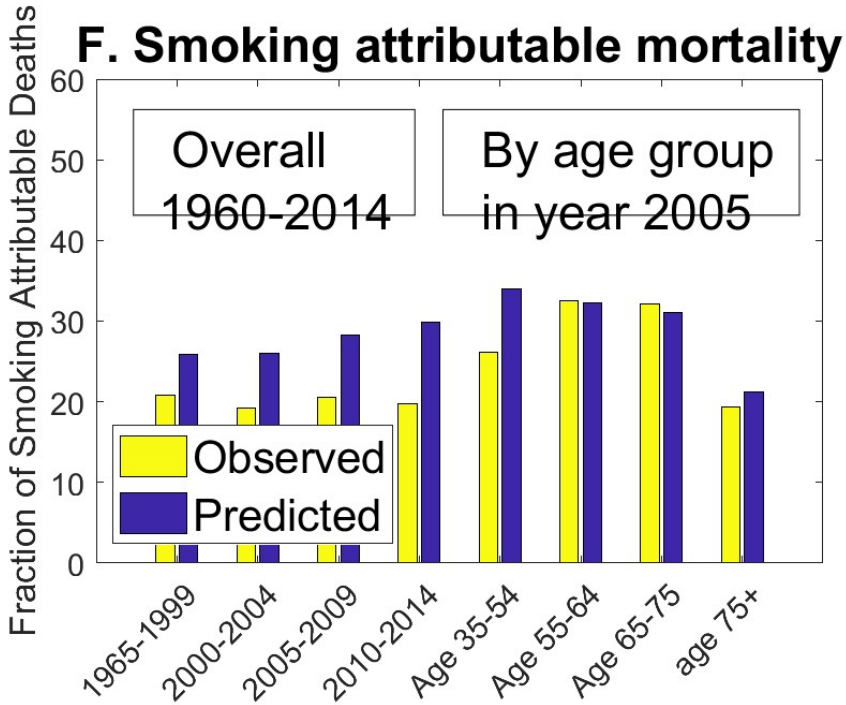




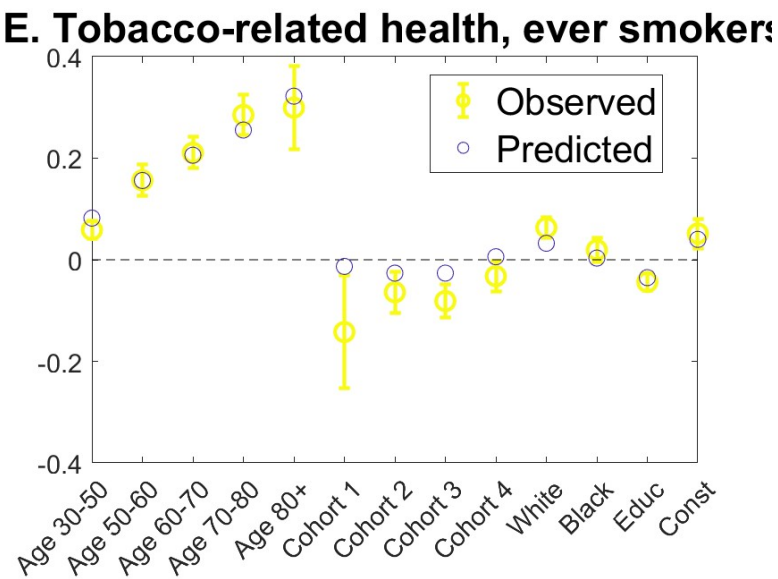
Note: observed data from NSDUH.

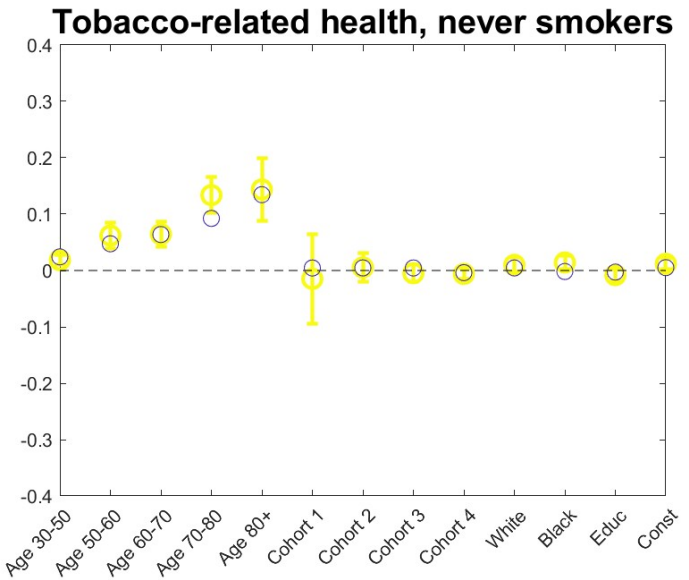
Model fit: mortality and smoking-attributable mortality



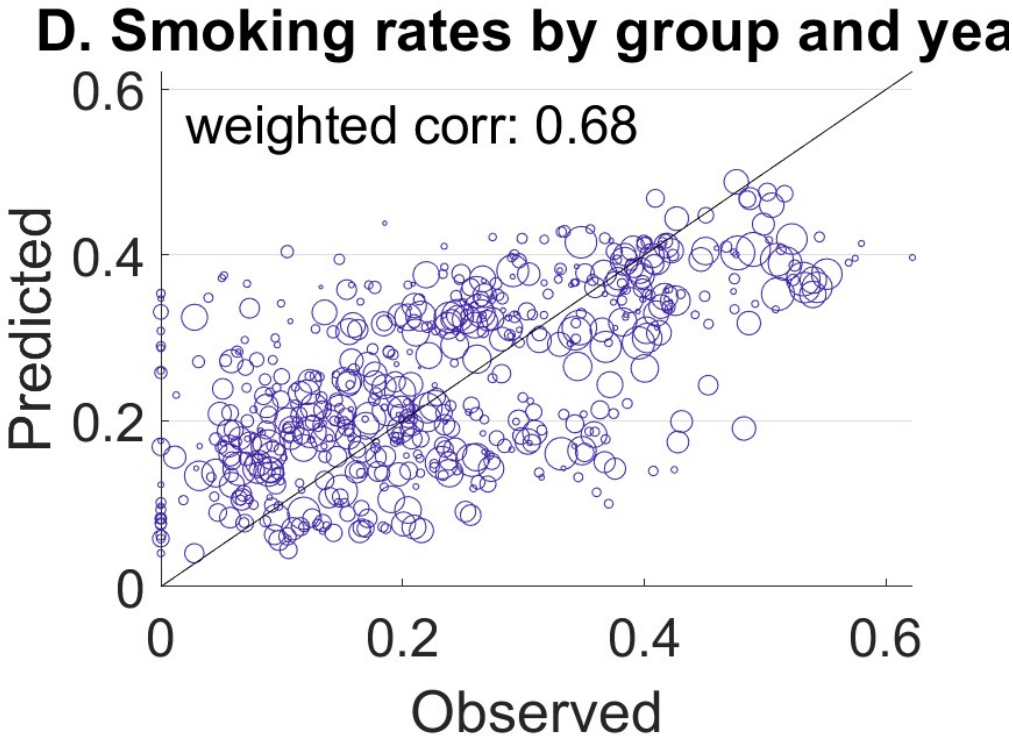


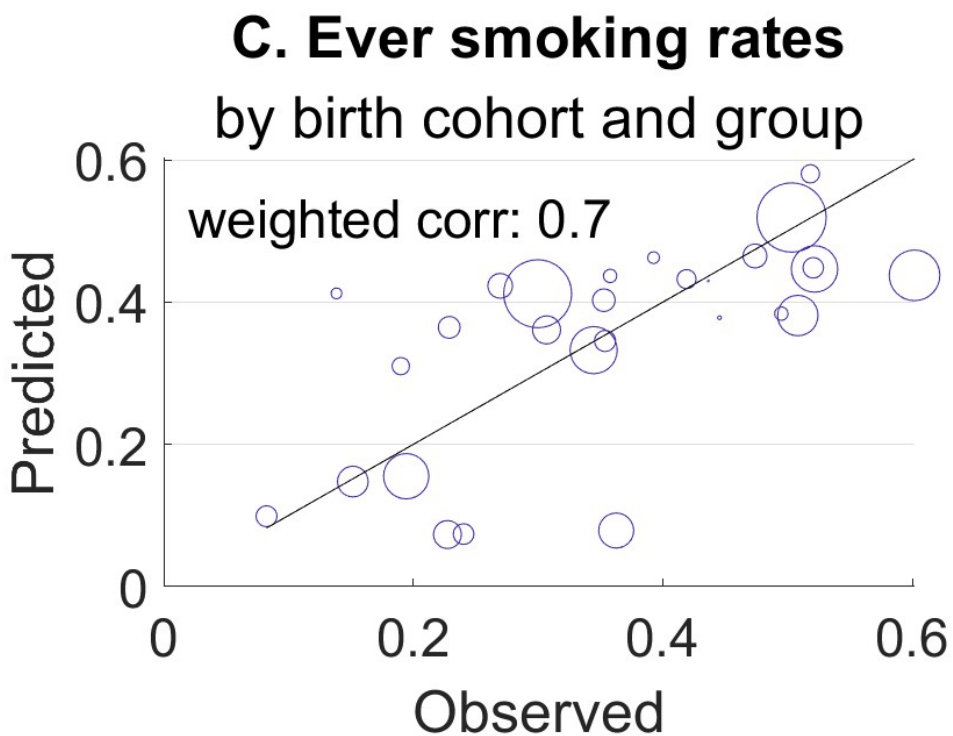
Model fit: cancer rates ever smokers / never smokers





Model fit: current and ever smoking

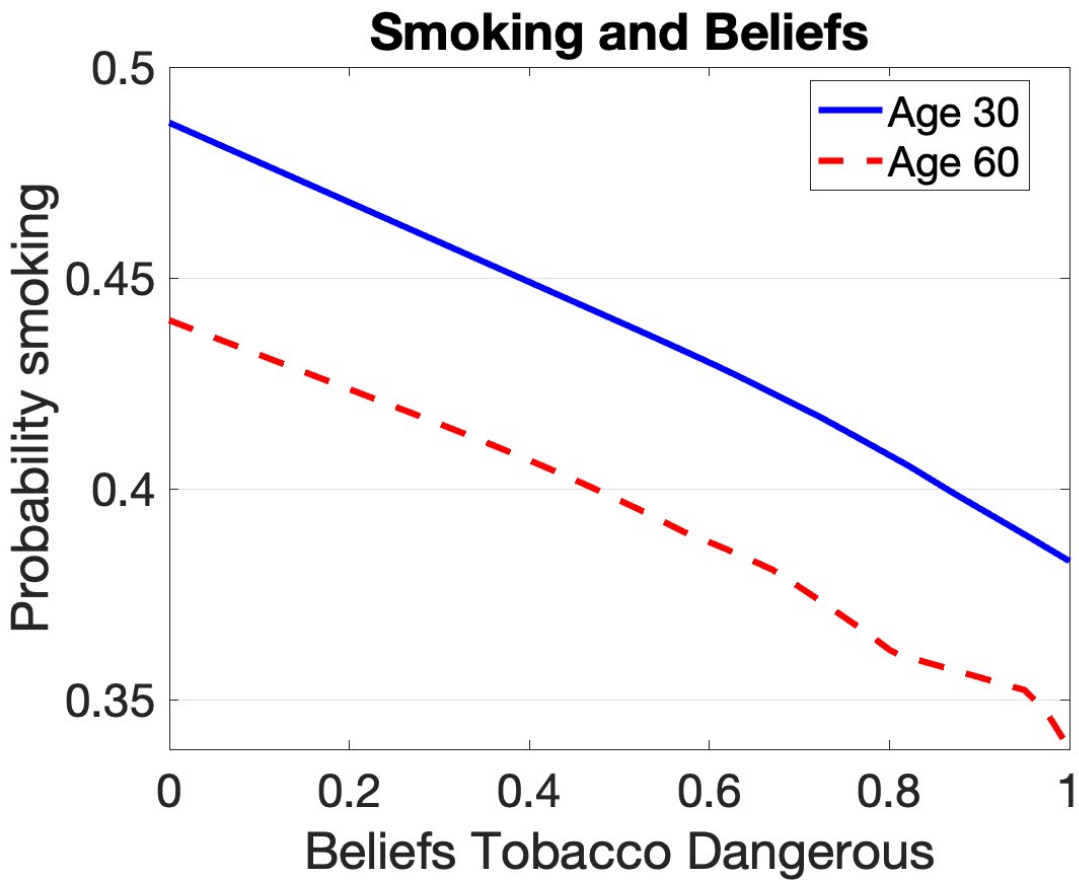




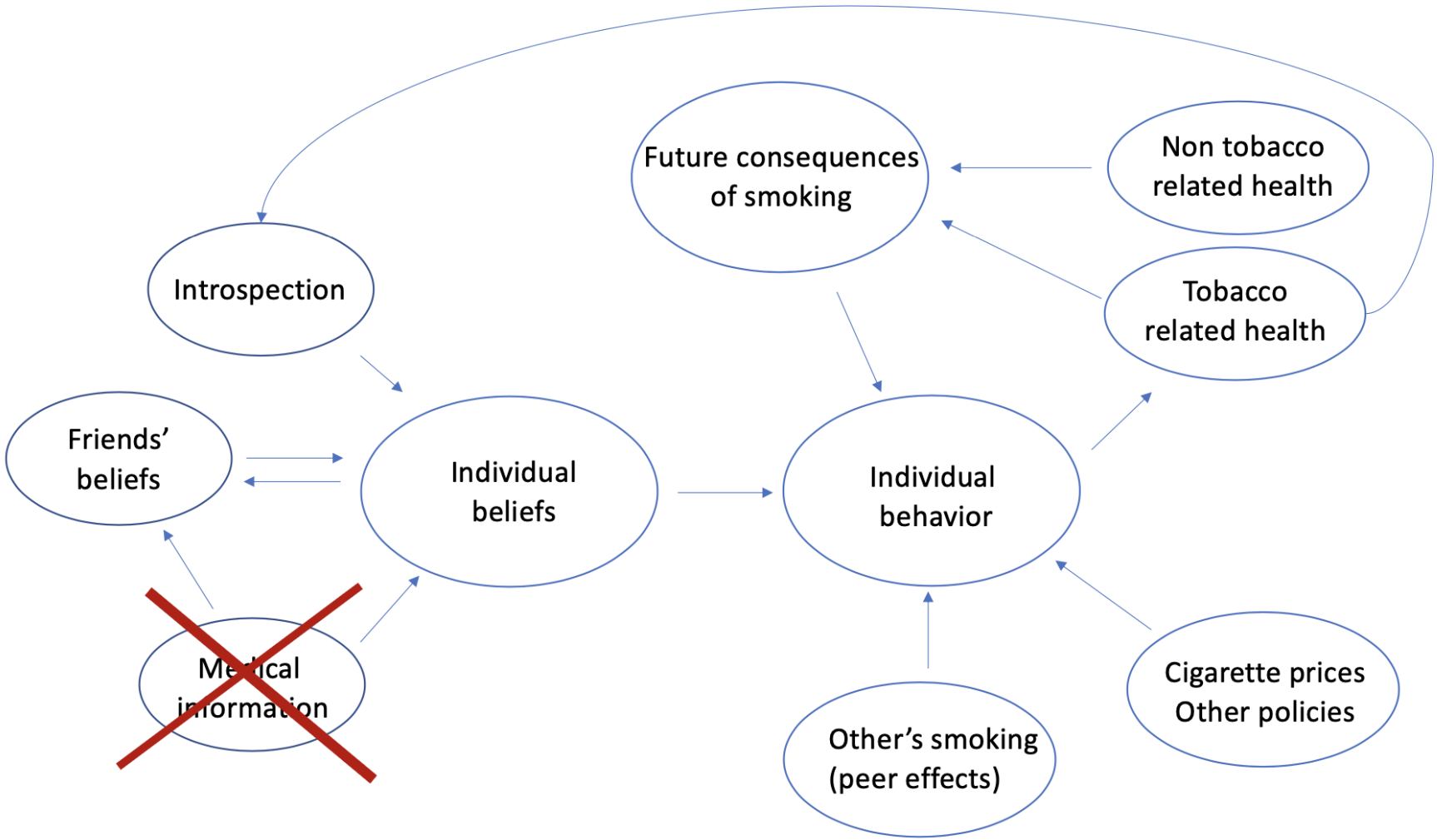
Parameter estimates, beliefs formation

A. Initial conditions			
Average initial beliefs, first cohort, μ_λ	0.134		
Std dev of initial beliefs, first cohort, σ_λ	0.23		
Parent-child shifter, δ^F	0.723		
B. Own weight			
Medical information ($\delta^{BL}_{g_i}$)		Own health shock ($\delta^{BL}_{g_i}$)	
Average effect	0.0331	Average effect	1
High educated	7.05%		
Blacks	-6.13%		
Other races	-3.4%		
Midwest	-21.95%		
South	32.11%		
West	13.55%		
Tobacco spending on advert	0.07		
Tobacco spending on lobbying	0.11		
C. Social learning			
Others' medical information ($\delta^{EI}_{g_i}$)		Others' health shocks ($\delta^{EI}_{g_i}$)	
Average effect	0.254	Average effect	0.222
High educated	-1.78%	High educated	10.78%
Blacks	9.48%	Blacks	13.52%
Other races	-8.94%	Other races	7.74%
Midwest	-1.33%		
South	4.18%		
West	-2.21%		
D. Belief averaging ($\delta^{\lambda}_{g_i}$)			
Low educated, white	0.0238	High educated, white	0.087
Low educated, blacks	0.0112	High educated, blacks	0.0683
Low educated, others	0.00639	High educated, others	0.0184

Beliefs and probability of smoking



Policy counterfactuals

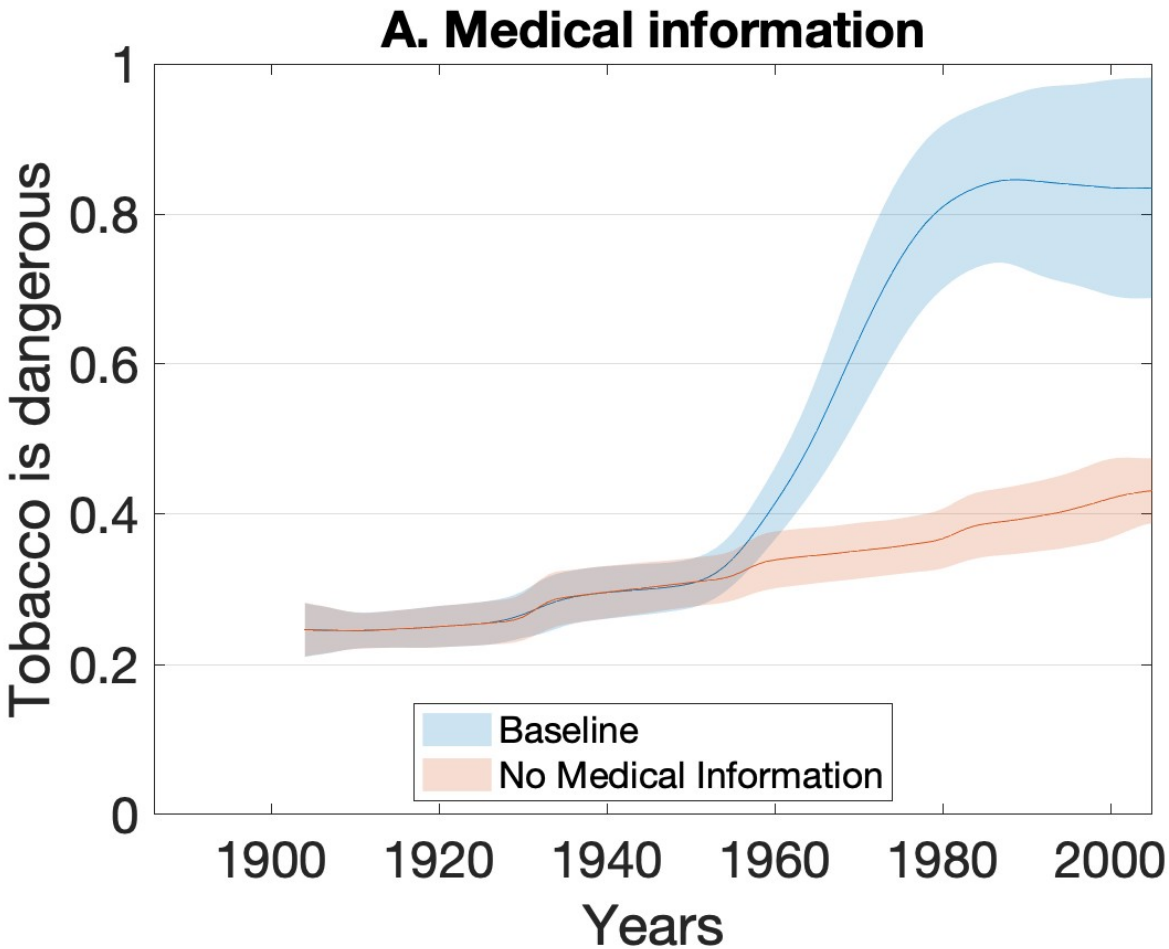


Policy counterfactuals

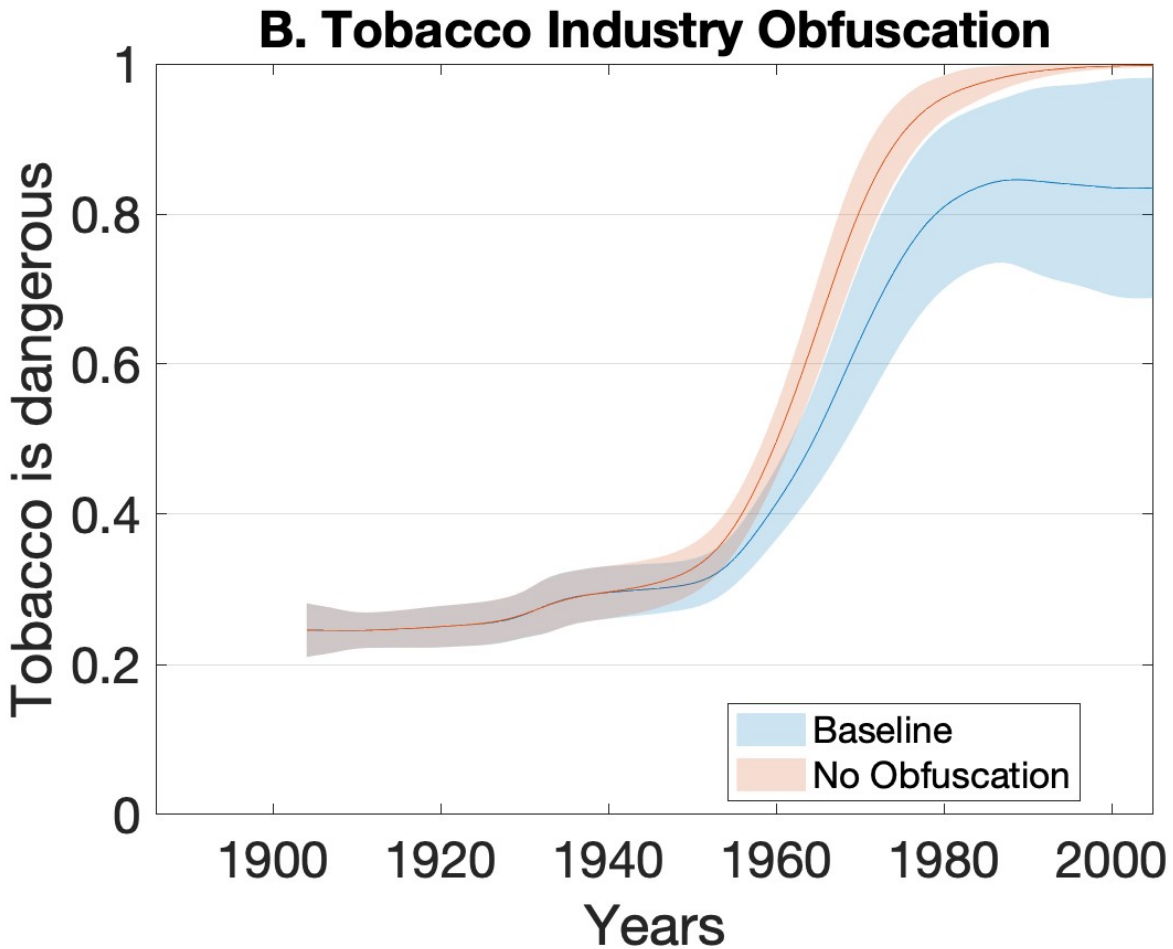
We use our model to quantify the long term effects of medical information. We consider:

1) No medical information: publication of scientific articles on the harms of smoking and newspaper coverage set to zero
2) No obfuscation: advertisement and lobbying set to zero
3) Only introspection: all other information channels set to zero

Policy counterfactual: beliefs- no medical info

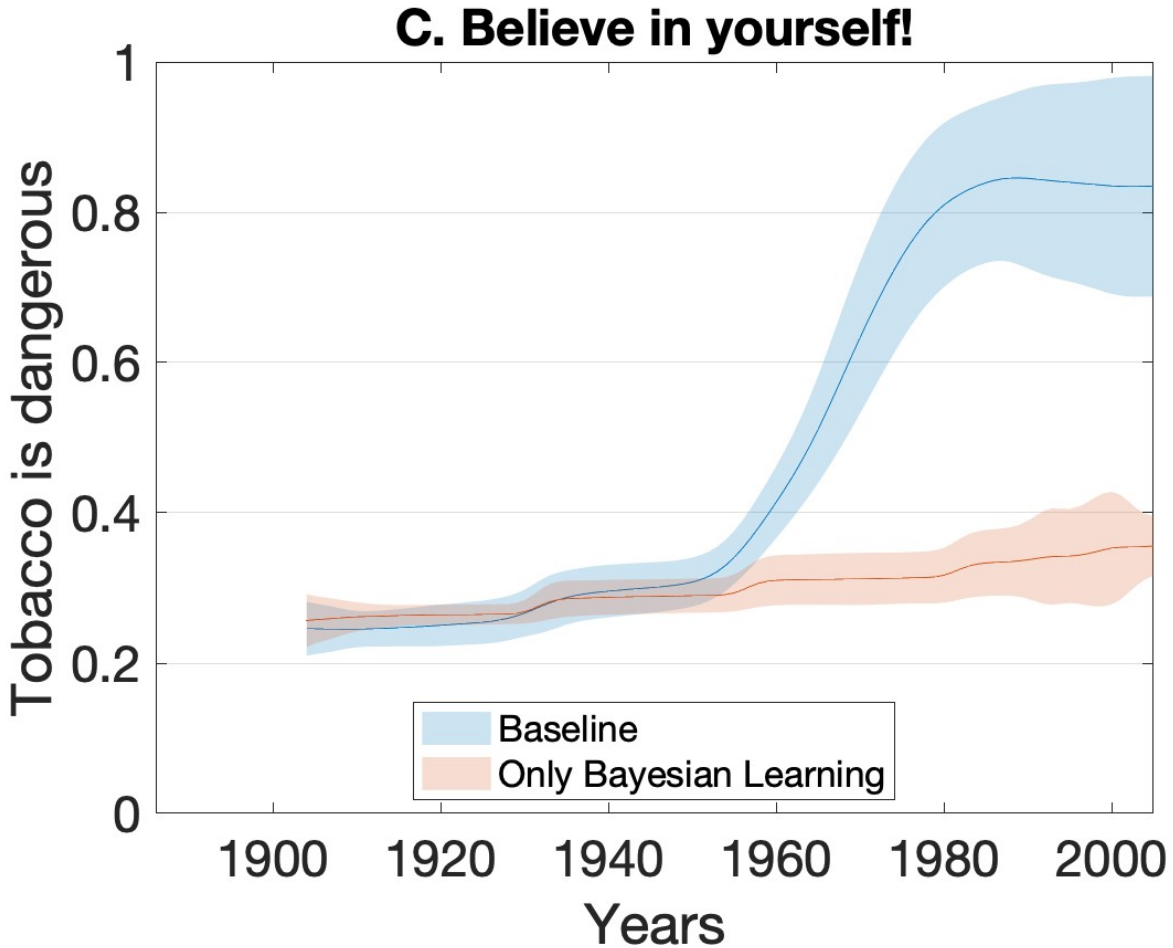


Policy counterfactual: beliefs- no obfuscation

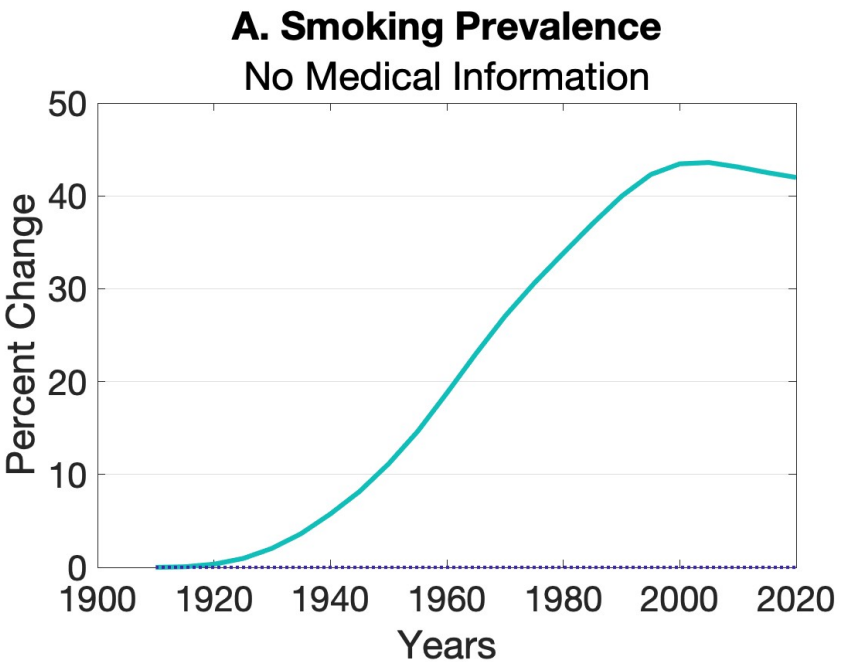


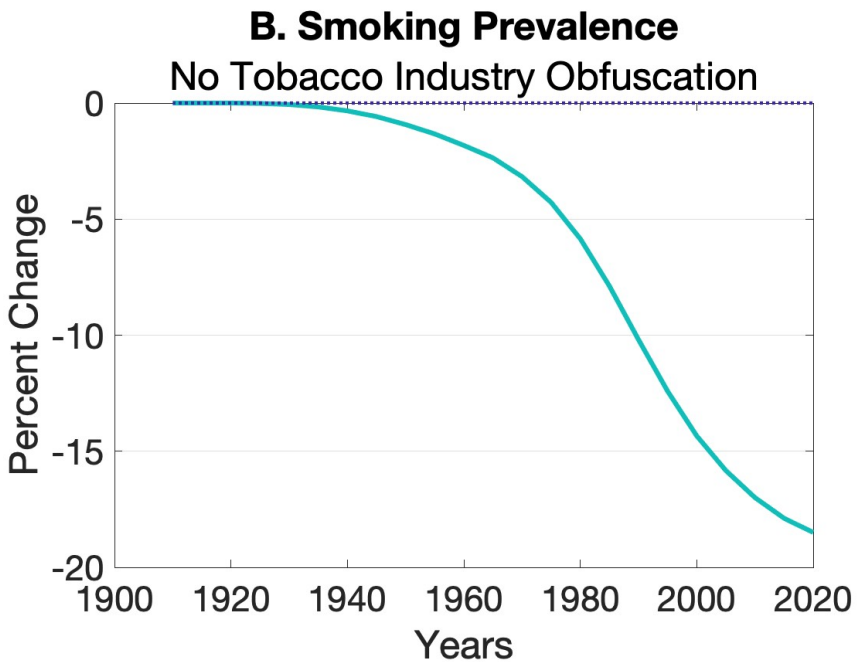
Policy counterfactual: believe in yourself?

Only Bayesian updating

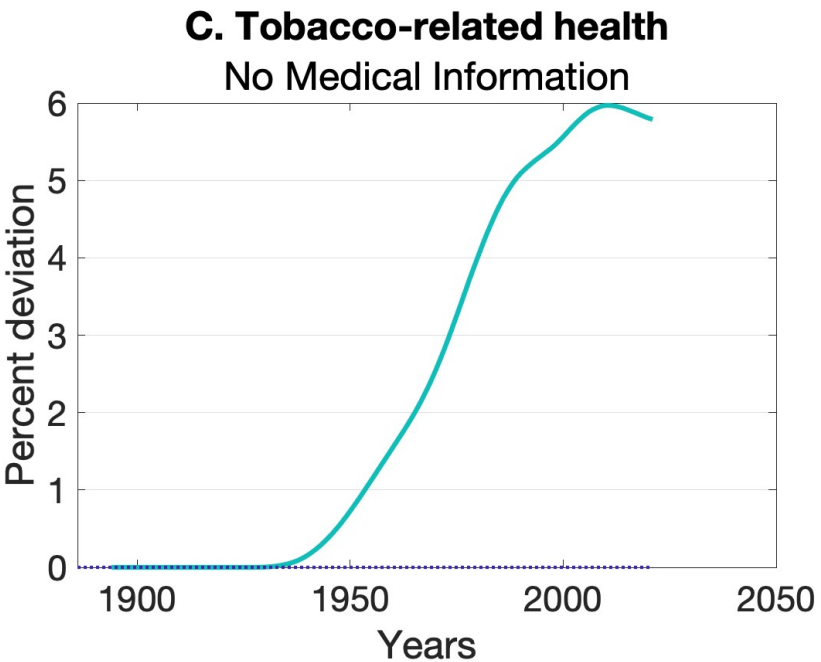


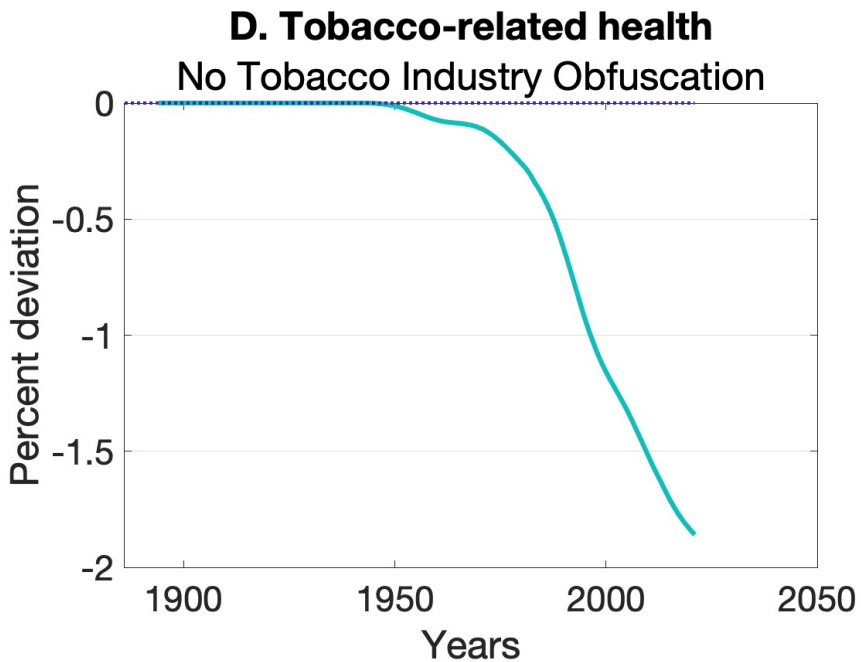
Policy counterfactual: smoking





Policy counterfactual: cancer





Conclusion

- First paper to look at the evolution of beliefs about health behavior over an extended period
- Proposes a framework to endogenize beliefs and health behavior
- Long-run perspective and focus on the role of heterogeneity
- Role of different socio-economic groups in mediating diffusion
- Important to target influential groups, rather than trying to convince hard to reach groups.
- Medical information is slow to have an effect at first, but substantial in the long run.