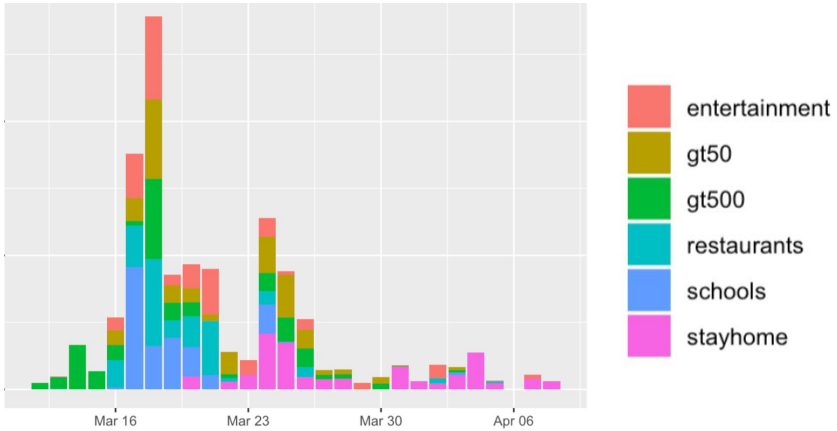
Disentangling the Immediate Effect of Timing of Stay-home Orders and Mobility Decrease in US Counties

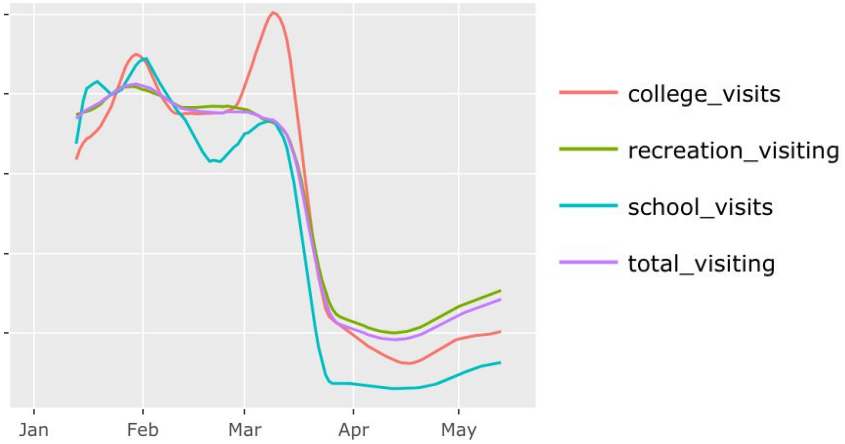
Major obstacles in answering **which policy intervention had the greatest effect in reducing Rt?**:

- Close spacing of policy interventions in time
- Strong correlation between the onset of interventions and reductions in mobility
- State-level analysis mask county-level heterogeneity

Policy interventions



Mobility reductions

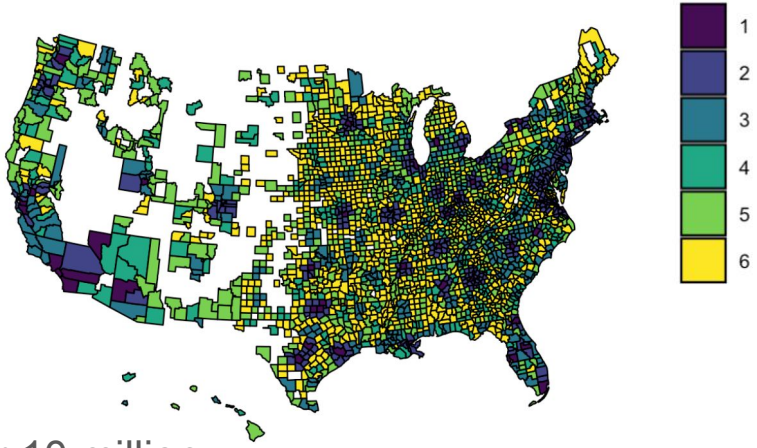


County-level data set

- Mid-March to early May
- Policy-intervention -> stay-at-home orders
- Mobility-intervention -> 50% decrease in total visits

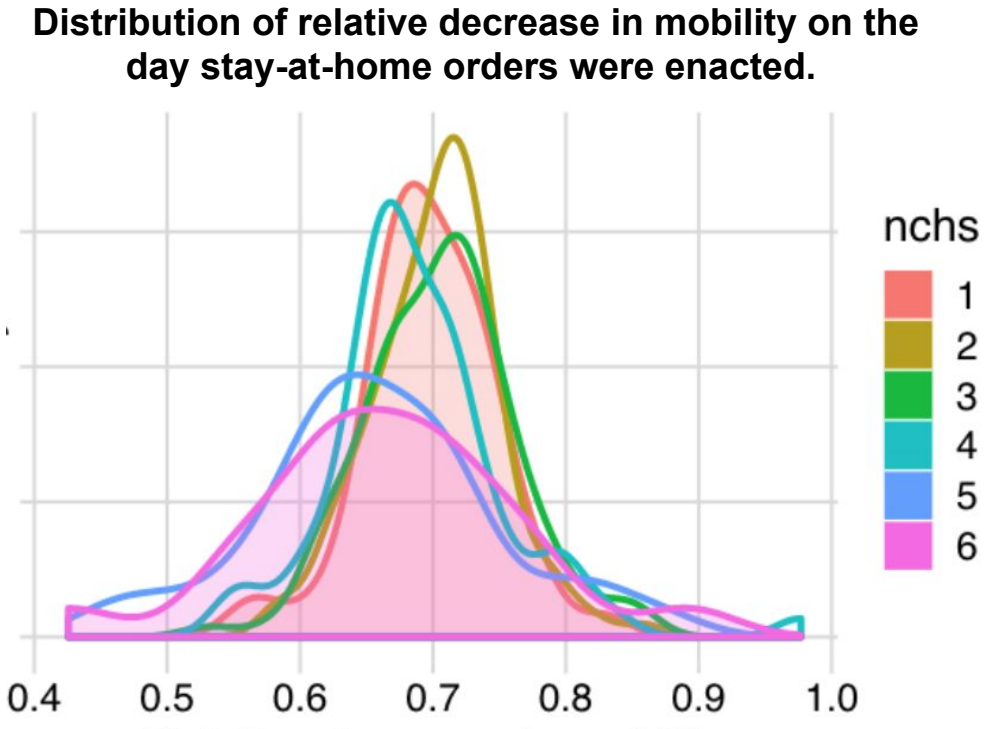
	Mobility-intervention		
Policy-intervention	Yes	No	Total
Yes	336	84	420
No	20	0	20
Total	356	84	440

NCHS classification



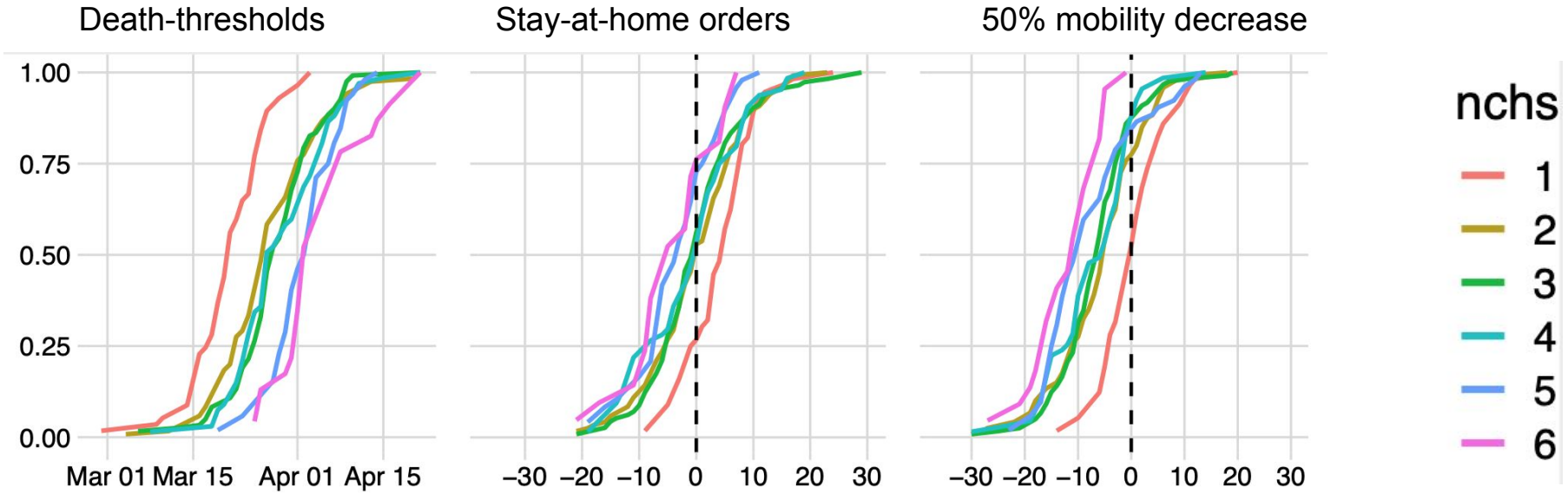
- Counties that reached a threshold of 3 deaths per 10 million
- NCHS classification captures rural/urban factors:
  - population density, modes of travel, distance to major airports
- Other county demographics:
  - percentage of black residents, hispanic residents, college students, age 65+

- Total visits declined significantly prior to stay-home



County-level timing of interventions

- Varying distribution of dates at which counties in each NCHS reached death thresholds
- Date distributions of policy implementation and mobility reductions across NCHS
  - Uniform in calendar time
  - Heterogeneous in epidemic time



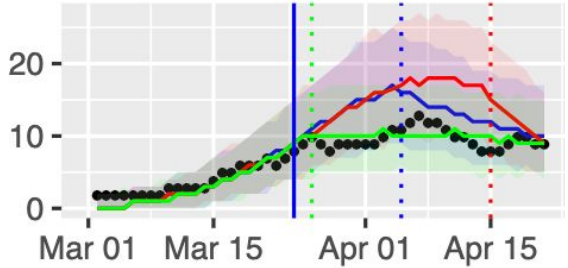
Methodology

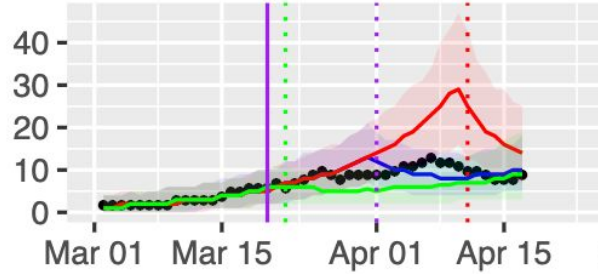
- County death trajectories
  - Interval: death threshold, 30 days after intervention onset
  - 7 day moving averages
- Curve fitting
  - Log-deaths per capita, quadratic polynomials, Bayesian hierarchical model
  - Pre- and post-intervention time counters (Hockey-stick) capture changes in shape after introduction of the intervention + intervention lag
- Three models
  - Policy intervention
  - Mobility intervention
  - Two hockey-stick

Stay-home intervention timing effects

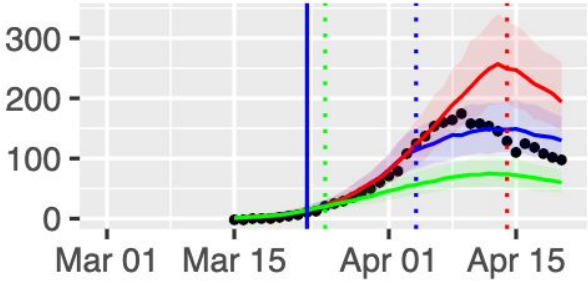
Mobility reduction timing effects

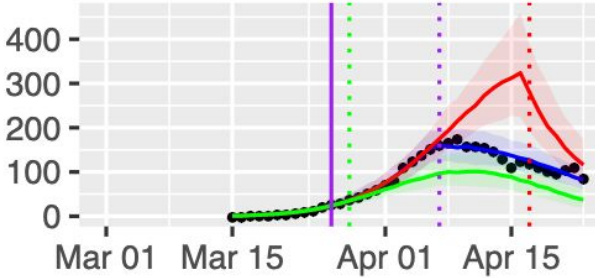
Washington, King
mobility-decrease 3 days before stay-home



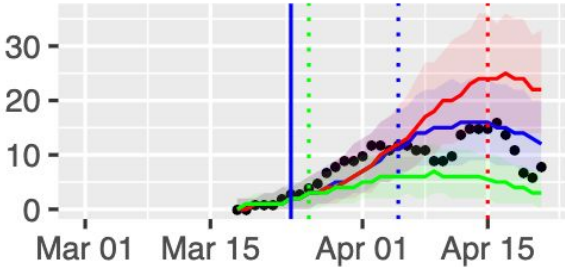


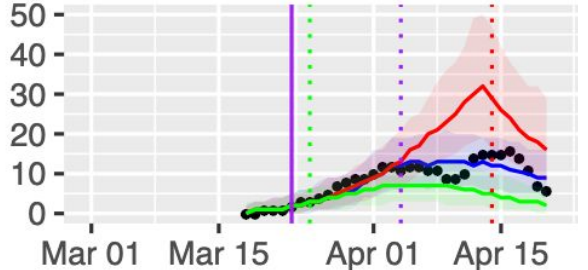
New York, Kings County
mobility-decrease 3 days after stay-home





Louisiana, Jefferson
mobility-decrease same day as stay-home

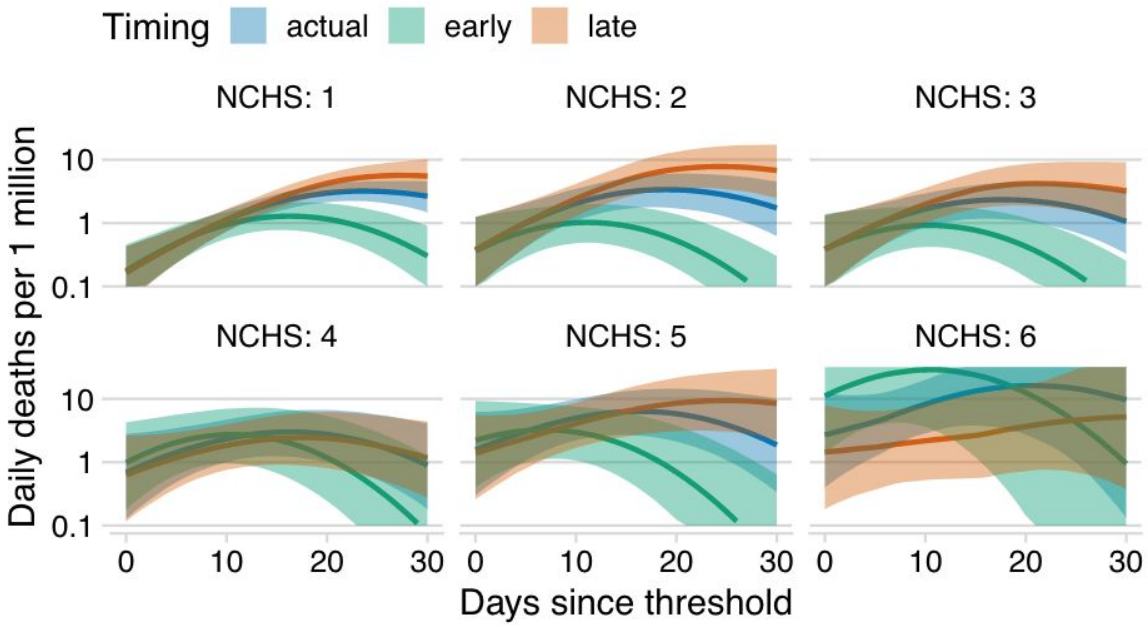




Mobility Intervention Timing

Average curve for each NCHS had the intervention been enacted on the observed date +-10 days:

- Average random effects are zero
- Diverging average main effects for each NCHS



Days since threshold at peak

NCHS	Early	Actual	Late
1	16	24	27
2	11	19	24
3	10	18	21
4	11	16	18
5	7	16	25
6	11	21	33

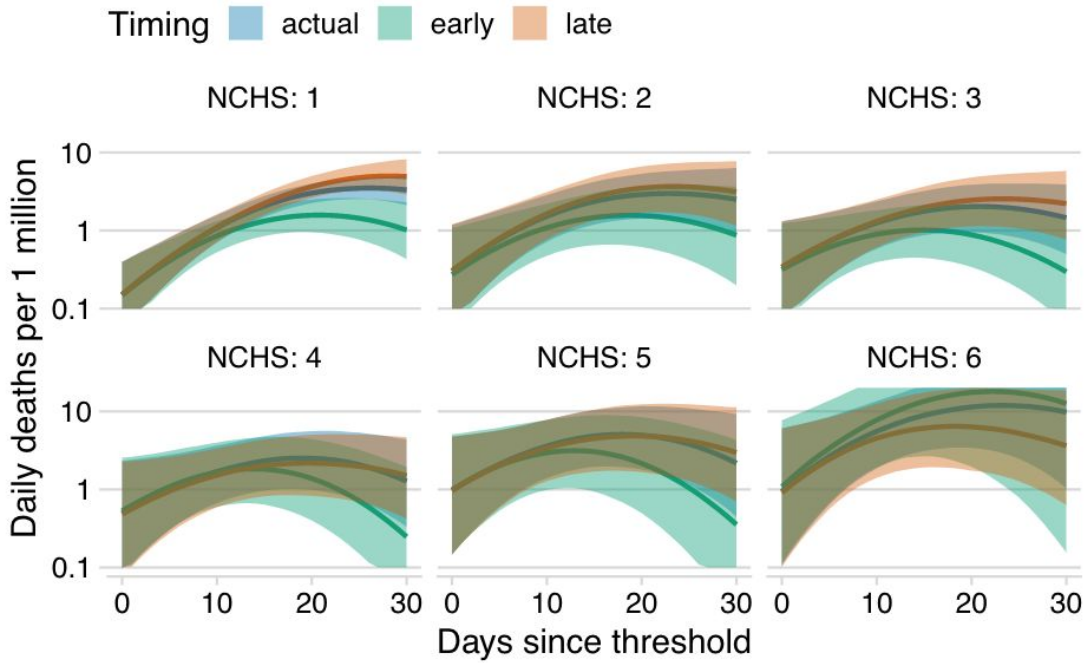
Deaths per 1 million at peak

NCHS	Early	Actual	Late
1	1.34	3.20	5.49
2	1.03	3.33	7.59
3	0.92	2.31	4.14
4	2.74	2.92	2.37
5	3.30	6.23	9.19
6	27.79	16.57	5.82

Policy Intervention Timing

Average curve for each NCHS had the intervention been enacted on the observed date +-10 days:

- Average random effects are zero
- Diverging average main effects for each NCHS



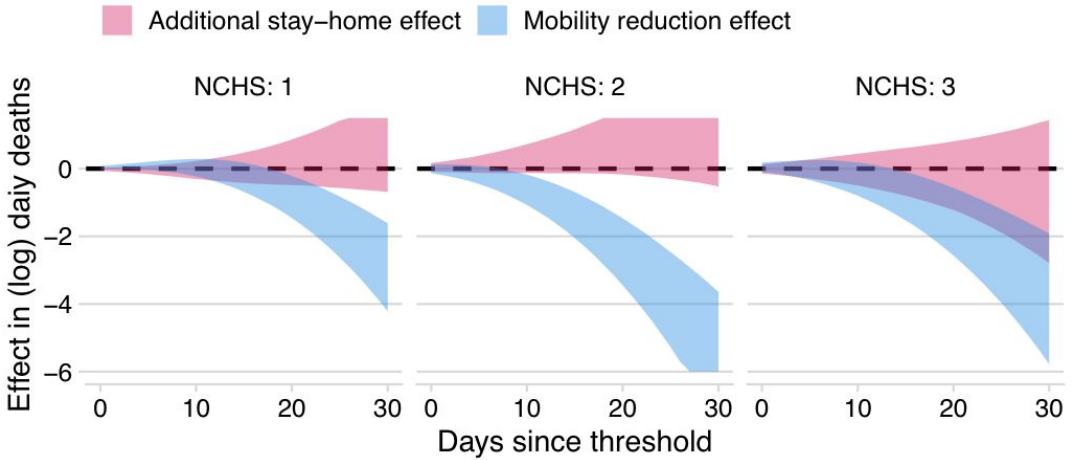
Days since threshold at peak

NCHS	Early	Actual	Late
1	21	26	28
2	19	23	23
3	15	21	23
4	14	19	20
5	13	18	19
6	22	23	18

Deaths per 1 million at peak

NCHS	Early	Actual	Late
1	1.56	3.49	4.97
2	1.54	2.93	3.60
3	1.00	1.99	2.50
4	1.80	2.46	2.12
5	3.08	4.91	4.73
6	17.59	11.54	6.30

Discussion Points



- **Results**: Stay-home orders did not preceded significant reductions in total visits
- In metropolitan areas, mobility reduction timing more heavily influenced the bending death curves relative to timing of stay-home orders, corroborated by the double intervention model
- In the rural areas, both stay-home orders and mobility reductions were adopted significantly early, making it hard to estimate their timing effect with our method
- **Open questions**: Total visits is mostly comprised of schools, colleges, restaurants and bars visits, its reductions are a direct consequence of school and business closures? Other drivers?
- Stay-home orders increased the actual time people spent at home state level(Abouk 2020) and might have a larger role in maintaining low activity for longer periods
- **Limitations**: measure relative effectiveness of intervention timing, not the overall effectiveness nor the absolute lack of them. Rely on quadratic forms and not in epi engines

Backup

- Except for +65 age group all features are statistically significant
- Mean estimates are relative stable across different intervention models

Parameter	Stay-home only		Mobility only		Double intervention	
	Mean	*[5%, 95%]*	*Mean*	*[5%, 95%]*	*Mean*	*[5%, 95%]*
Degree=0						
(Intercept)	-11.3*	[-15.8, -6.79]	-9.71*	[-14.4, -5.42]	-10*	[-14.6, -5.38]
NCHS-2	0.27	[-0.11, 0.67]	0.87*	[0.44, 1.26]	1*	[0.54, 1.43]
NCHS-3	0.01	[-0.42, 0.5]	0.55*	[0.11, 0.99]	0.65*	[0.2, 1.09]
NCHS-4	-0.17	[-0.74, 0.4]	0.03	[-0.63, 0.65]	0.25	[-0.37, 0.9]
NCHS-5	0.4	[-0.34, 1.08]	0.9*	[0.29, 1.54]	1.04*	[0.28, 1.74]
NCHS-6	0.12	[-0.96, 1.18]	-0.64	[-2.48, 1.09]	0.22	[-1.77, 2.2]
% in college	-0.09*	[-0.12, -0.07]	-0.08*	[-0.11, -0.06]	-0.08*	[-0.11, -0.06]
% black	0.07	[-0.03, 0.16]	0.07	[-0.02, 0.18]	0.11*	[0.01, 0.21]
% hispanic	-0.29*	[-0.45, -0.15]	-0.36*	[-0.5, -0.22]	-0.34*	[-0.47, -0.2]
% +65 age	0.28	[-0.26, 0.82]	0.07	[-0.47, 0.57]	0.04	[-0.54, 0.62]
Degree=1						
(Linear)	-19.7	[-313, 274]	20.7	[-217, 266]	-46.8	[-287, 168]
NCHS-2	-37.6*	[-70.6, -3.77]	8.29	[-19.6, 35.1]	11.5	[-18.7, 42.7]
NCHS-3	-50*	[-84.3, -18]	-15.5	[-44.3, 14]	-14.8	[-49.5, 15.3]
NCHS-4	-102*	[-148, -61.4]	-91.2*	[-134, -49]	-86.3*	[-130, -42.5]
NCHS-5	-98.5*	[-154, -41.7]	-42.7*	[-81.4, -2.42]	-63.3*	[-116, -13.1]
NCHS-6	-140*	[-229, -52.1]	-151*	[-252, -59.9]	-62.2	[-223, 95.7]
% in college	-2.56*	[-4.2, -0.87]	-1.89*	[-3.24, -0.43]	-1.74*	[-3.09, -0.43]
% black	7.39	[-0.14, 14.6]	1.85	[-3.64, 7.67]	5.43	[-0.38, 11.1]
% hispanic	4.62	[-4.96, 14.2]	5.4	[-1.18, 12.6]	4.6	[-2.4, 11.8]
% +65 age	15.9	[-19, 48.7]	13	[-16.3, 40.3]	19.3	[-6.67, 46.6]
Degree=2						
(Quadratic)	-172	[-407, 52.9]	-20.7	[-176, 130]	-4.05	[-176, 154]
NCHS-2	-7.46	[-28.2, 12]	0.43	[-14.5, 14.7]	0.38	[-14.3, 14.3]
NCHS-3	4.2	[-17.2, 25.5]	-2.64	[-17.3, 11.2]	0.51	[-14.7, 16]
NCHS-4	-10.4	[-38.2, 16.7]	-15.7	[-35.3, 3.34]	-15.6	[-36.5, 4.3]
NCHS-5	-13	[-45.3, 20.9]	9.42	[-9.01, 28]	-4.78	[-30, 18.8]
NCHS-6	-47.2*	[-94.3, -0.89]	-2.15	[-52, 46.9]	36.6	[-42.5, 116]
% in college	0.61	[-0.63, 1.9]	-0.04	[-0.99, 0.83]	-0.07	[-0.95, 0.85]
% black	2.65	[-3.14, 8.56]	-2.77	[-6.7, 1.12]	-1.08	[-5.09, 3.28]
% hispanic	2.32	[-4.39, 9.12]	1.37	[-3.42, 5.89]	0.93	[-3.68, 5.96]
% +65 age	9.06	[-17.2, 36.8]	1.14	[-16.6, 19.7]	-2.31	[-21.7, 17.7]