Pregnancy in a Pandemic:

Fertility, Fecundity, and Infant Health During COVID-19

Jenna Nobles, UW-Madison Florencia Torche, Stanford

Berkeley Formal Demography Workshop
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Deirdre Lyell, Obstetrics & Gynecology, Stanford

Suzanne Tamang, Biomedical Data Science, Stanford

Jasmine Zapata, Neonatology, UW-Madison & Wisconsin DHS

Fiona Weeks, Population Health Sciences, Title V Director, Wisconsin DHS

Sungsik Hwang, Sociology, UW-Madison

Alison Gemmill, Public Health, Johns Hopkins

Disaster as a window into human behavior

- We can learn about social systems by introducing *stress* into those systems

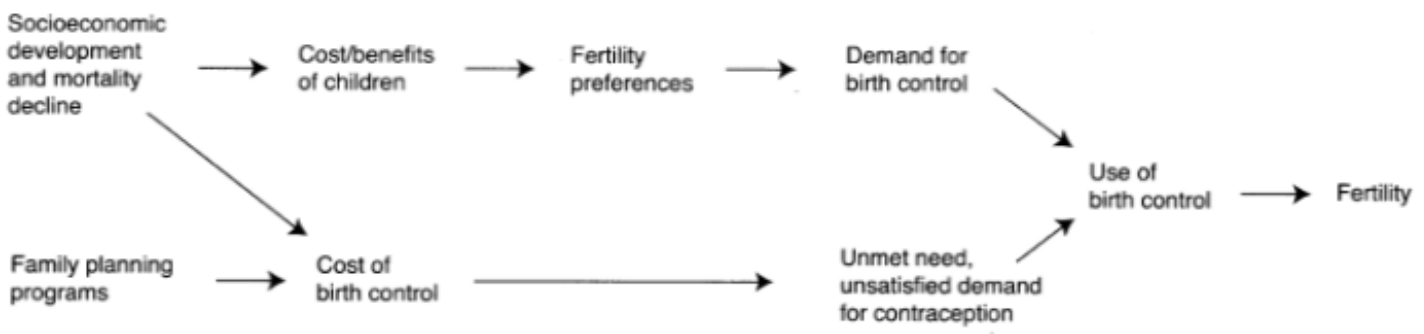
- We can learn about human behavior by observing it in a context that **changes rapidly around people,** a context with interrupted features of social organization and social function

Henry 1920, Fritz 1961, Erikson 1974, 2006, Browning et al. 2006

Fertility specifically:

Why do people have children? How and why do people time fertility?
Who adjusts timing under which circumstances?

Figure 1 Analytic framework for the determinants of fertility



Bongaarts 2006

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How are populations (re)built in the aftermath of mortality crises?

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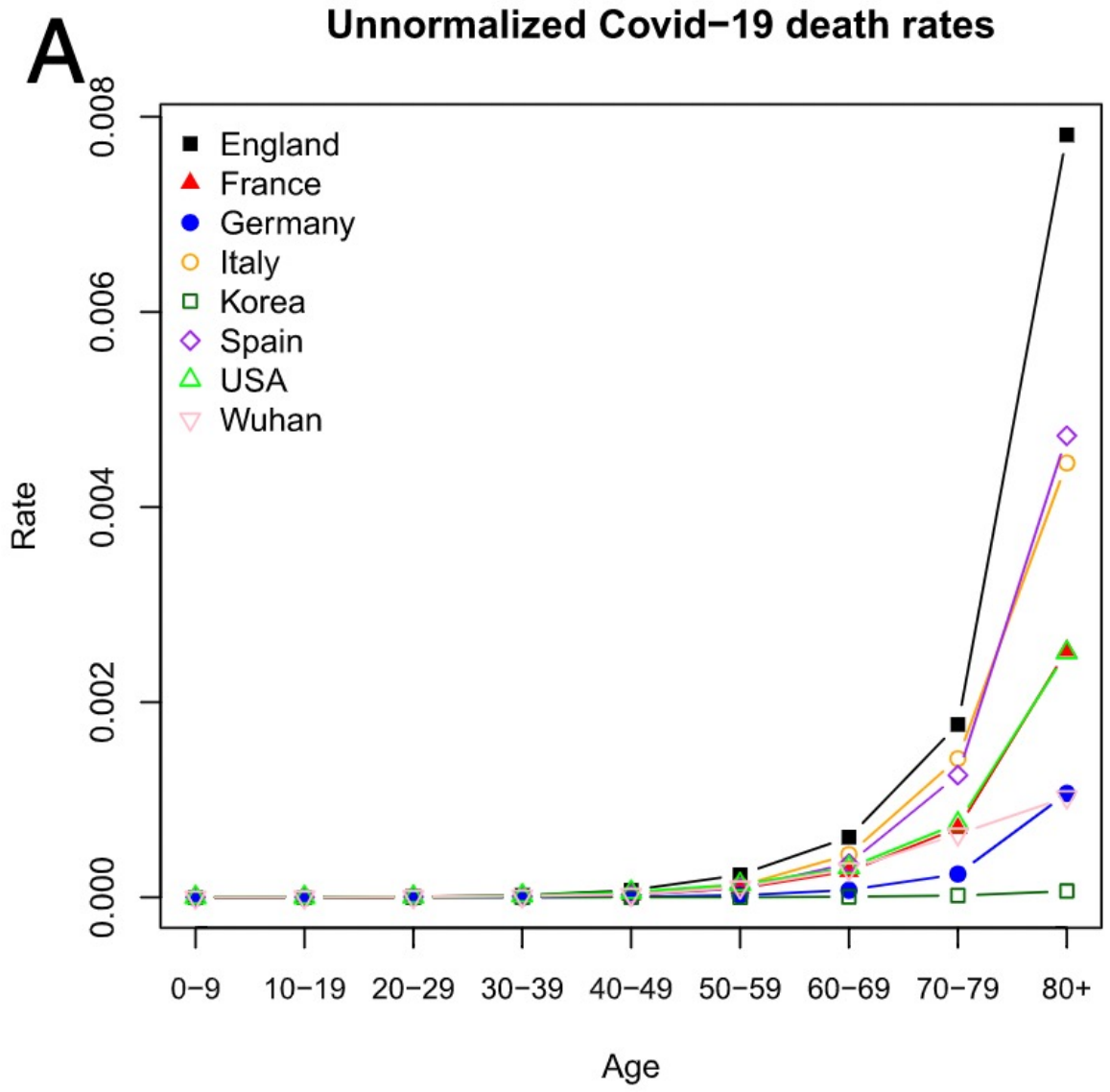
Opportunities to differentiate biological and behavioral mechanisms



Goldstein and Lee 2020 (link)

By mid-2020, Congress provided 3.6 billion to NIH for COVID-related programs.

Maternal health received < **1% of COVID-related NIH funding** in 2020.

Pediatrics received < **3% of COVID-related NIH funding** in 2020.

Balaguru et al. 2022 (link)

March 8, 2022

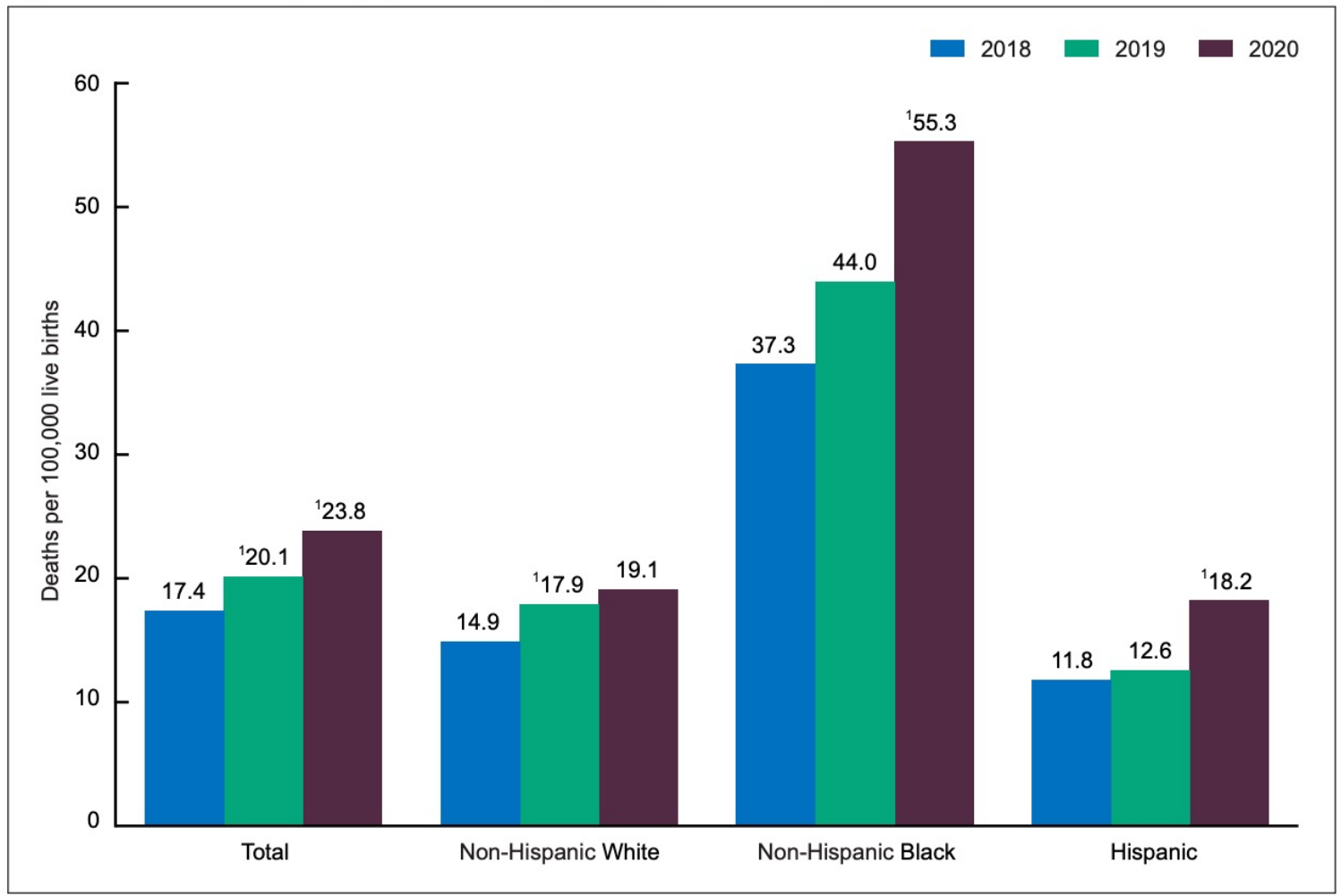
US Maternal Mortality Rate Rose Sharply During COVID-19 Pandemic's First Year

Joan Stephenson, PhD[1]

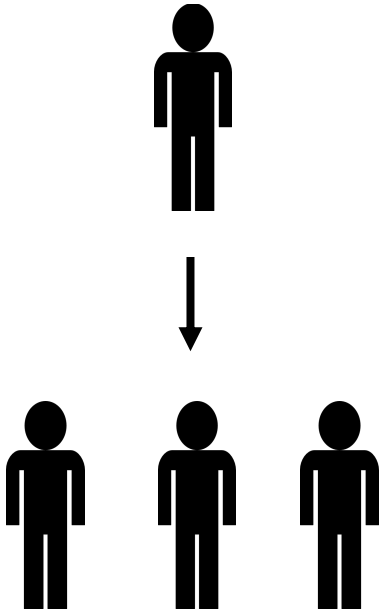
» Author Affiliations | Article Informa

JAMA Health Forum. 2022;3(3):e22068

Figure 1. Maternal mortality rates, by race and Hispanic origin: United States, 2018–2020



Exposures *in utero* and early childhood have enduring effects on health and welfare



To study the effects of pandemics on health,
need to understand attendant change
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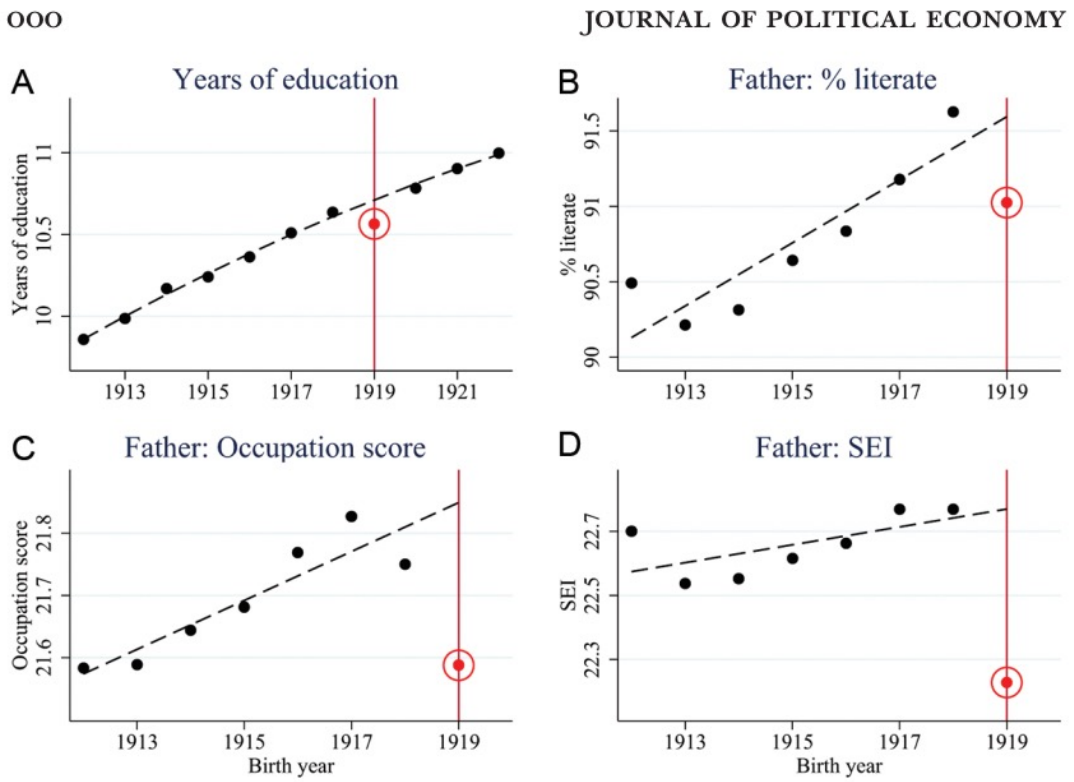


FIG. 2.—Own years of education and paternal characteristics by birth cohort. *A* uses a 1% sample of native-born US males in the 1960 census. *B–D* use fathers of children born in the United States in 1912–19, as reported in the 1920 full-count census. Estimated cohort trends are quadratic in birth year in *A* and linear in *B–D*.

Beach, Brown, Ferrie, Saavedra, & Thomas, forthcoming *JPE*: (link)

Almond's well-known findings on the long-term health effects of the 1918 flu pandemic on cohorts exposed *in utero* are not correct. Cohort patterns in health are explained by changes in who gave birth in 1919

Studying fertility and fecundity during COVID

- Fertility: birth record data from California (+ NJ, FL, WI, AL)
- Fecundity: backend data from mobile devices, people across the US

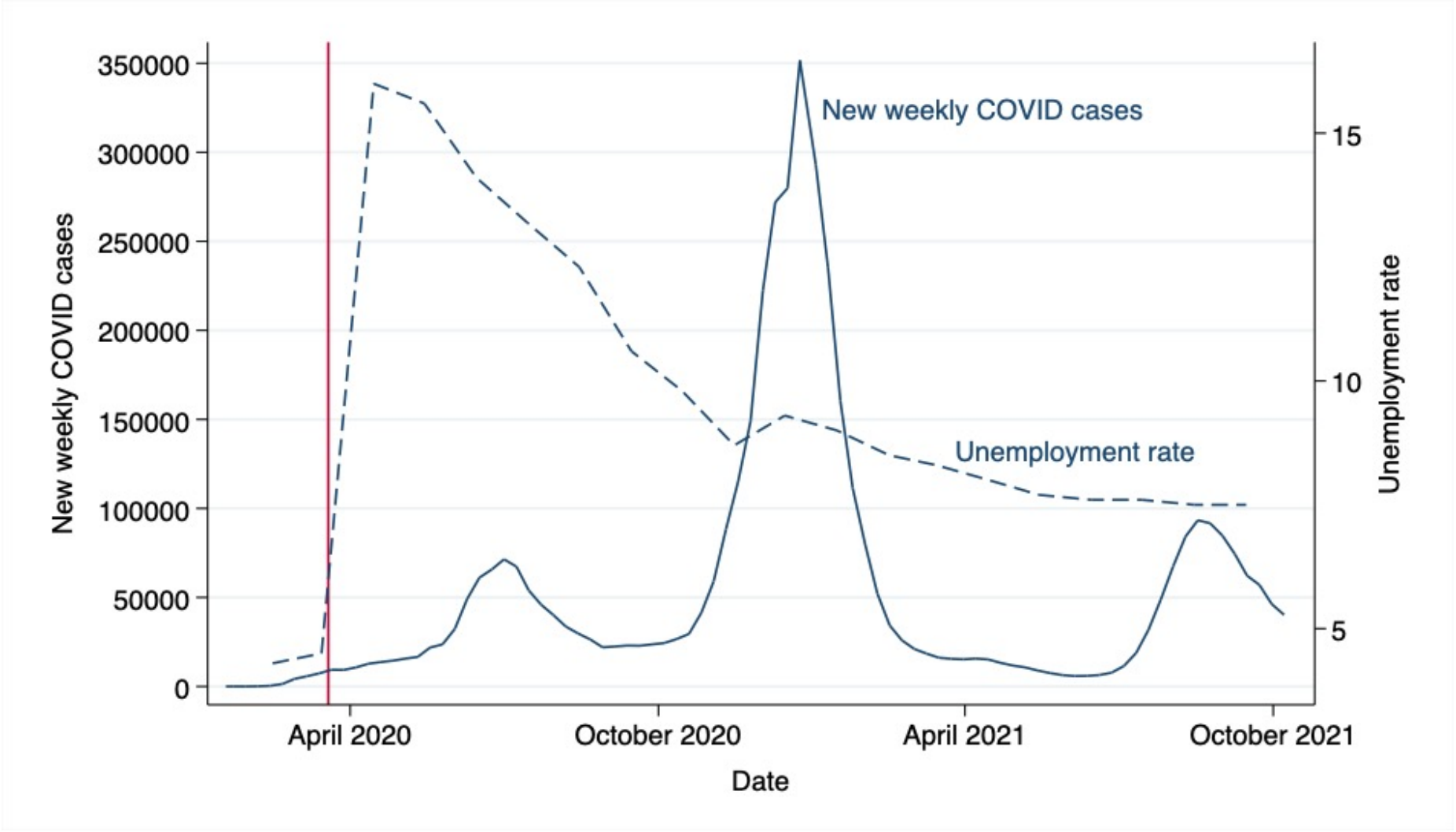
California: 40 million people & 12% of all U.S. births

(or: Norway, Denmark, Finland, Sweden, and Netherlands combined in size)

Early response to the pandemic:

shelter-in-place began on March 19, 2020

Case spike January 2021



Birth certificates

Established validity on many of the key markers of
relevance to the study of fertility, such as parental sociodemographic measures

Critical: >99% of births in the state are included

Fertility and macroeconomic cycles tend to be procyclical

Concerns about safety may have led to fertility delay

Assisted reproductive technology closed entirely March / April 2020

Unemployment, illness, caregiving stress may have made it harder to conceive & carry to term

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U.S. amidst 10+ years of fertility decline when the pandemic began

Abortion and contraceptive access disrupted

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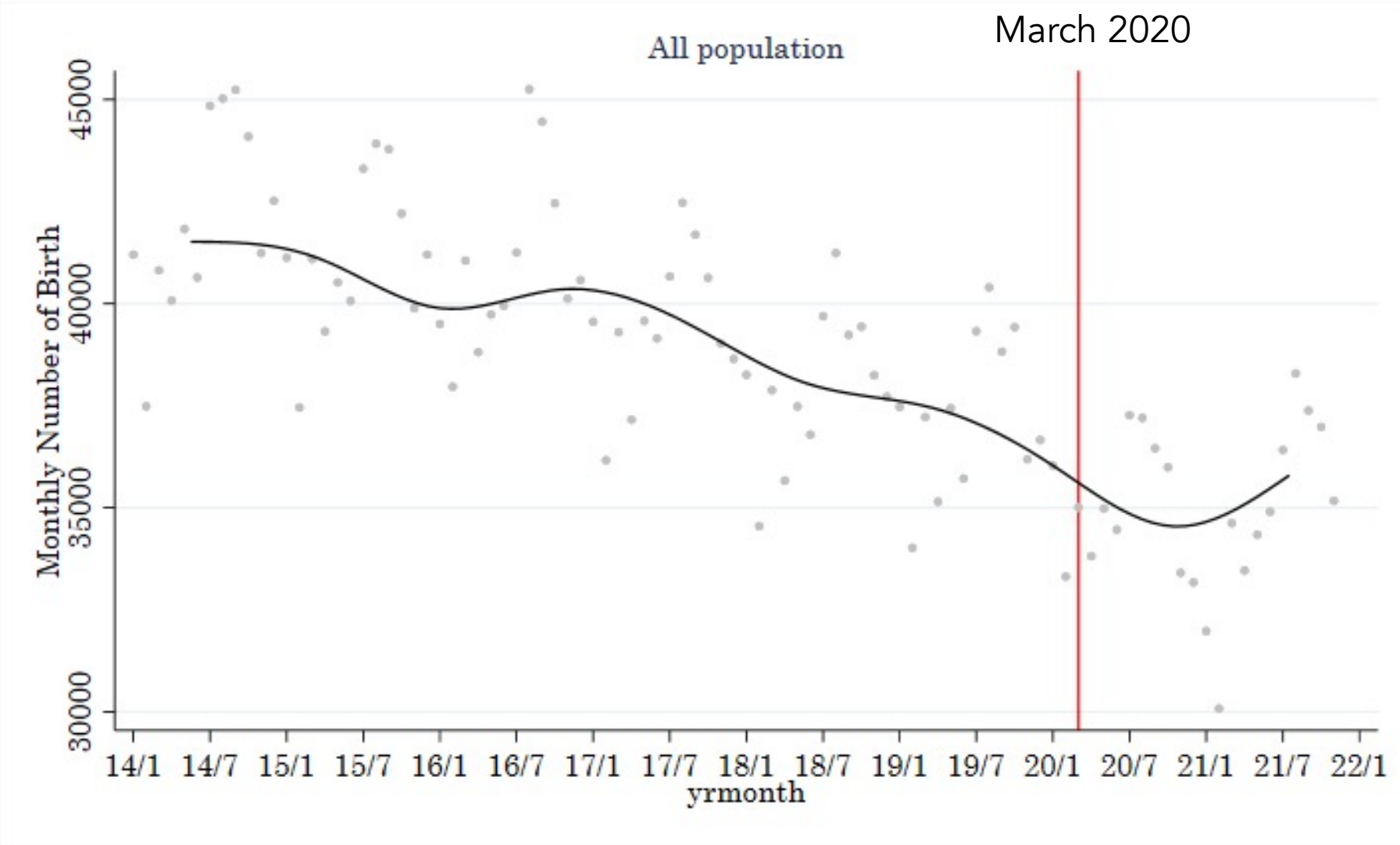
Each of these processes has implications that may vary by background characteristics like education

Birth counts, California by year and month



What we need to know:

What would have happened to population fertility
had COVID-19 (and accompanying social and economic change)
not occurred?

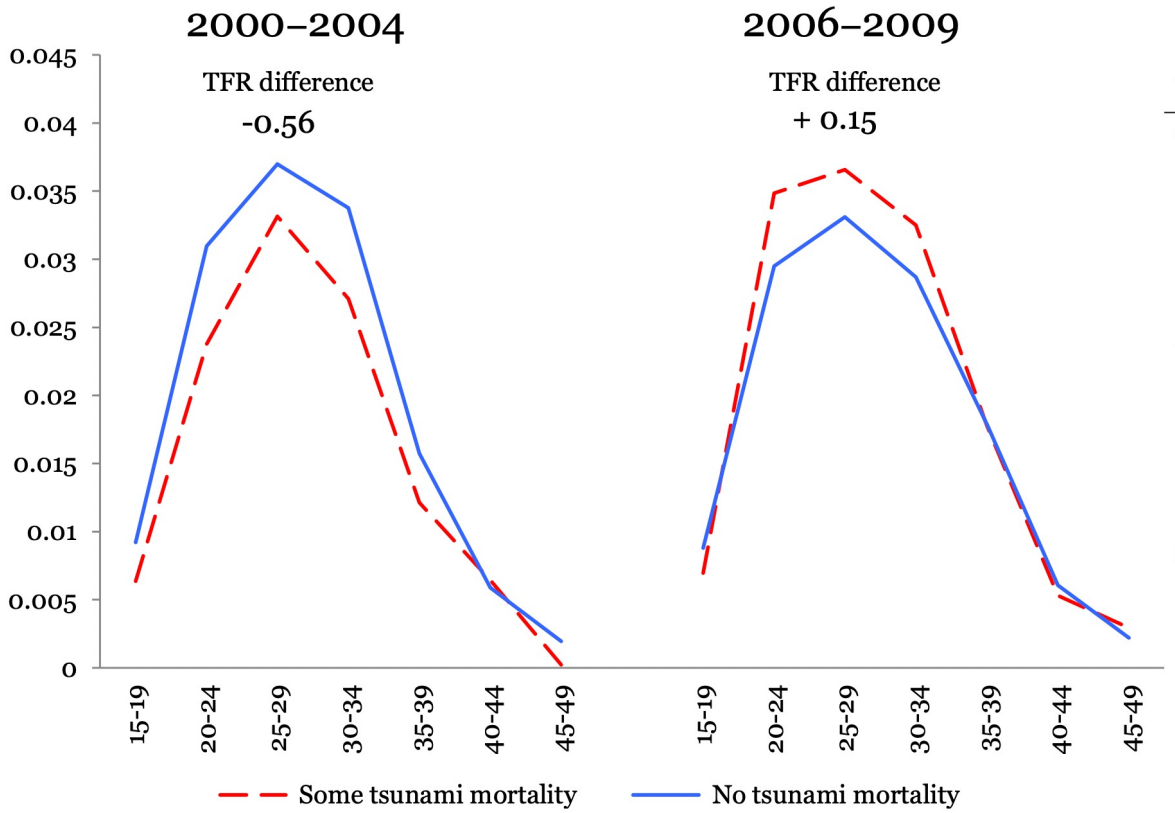
Predicting the counterfactual

Predicting the counterfactual

When we have information on unexposed places, it is possible to generate predictions that leverage the period change witnessed in those locations

Difference-in-difference – Angrist & Pischke 2009 (Cunningham link)

D-in-D example: 2004 tsunami in Aceh, Indonesia



Mortality in community:	Some	None	Difference
TFR			
2000–2004	2.18	2.74	-0.56
2006–2009	2.67	2.52	0.15
Difference	0.49	-0.22	0.71
ASFR (post- minus pre-tsunami)			
15–19	0.001	0.000	0.001
20–24	0.011	-0.001	0.013
25–34	0.004	-0.004	0.009
35–49	0.002	0.001	0.002
No. of communities	92	191	

Fig. 1 Age-specific fertility rate (ASFR) and total fertility rate (TFR) differences by period and presence of tsunami mortality in the community. Average quarter-year age-specific probabilities of live birth presented for the pre-tsunami period (January 1, 2000–December 31, 2004) and the post-tsunami period (January 1, 2006–December 31, 2009) for women in 283 communities. In each quarter-year, women from the baseline survey who are alive and aged 15–49 contribute an observation. Pooled data contain 176,862 observations for 6,363 women. Average annual TFR estimated as $TFR = 5 \times 4 \times \Sigma_i(ASFR_i)$, where i indexes five-year age intervals

Nobles, Frankenberg, Thomas 2015 (link)

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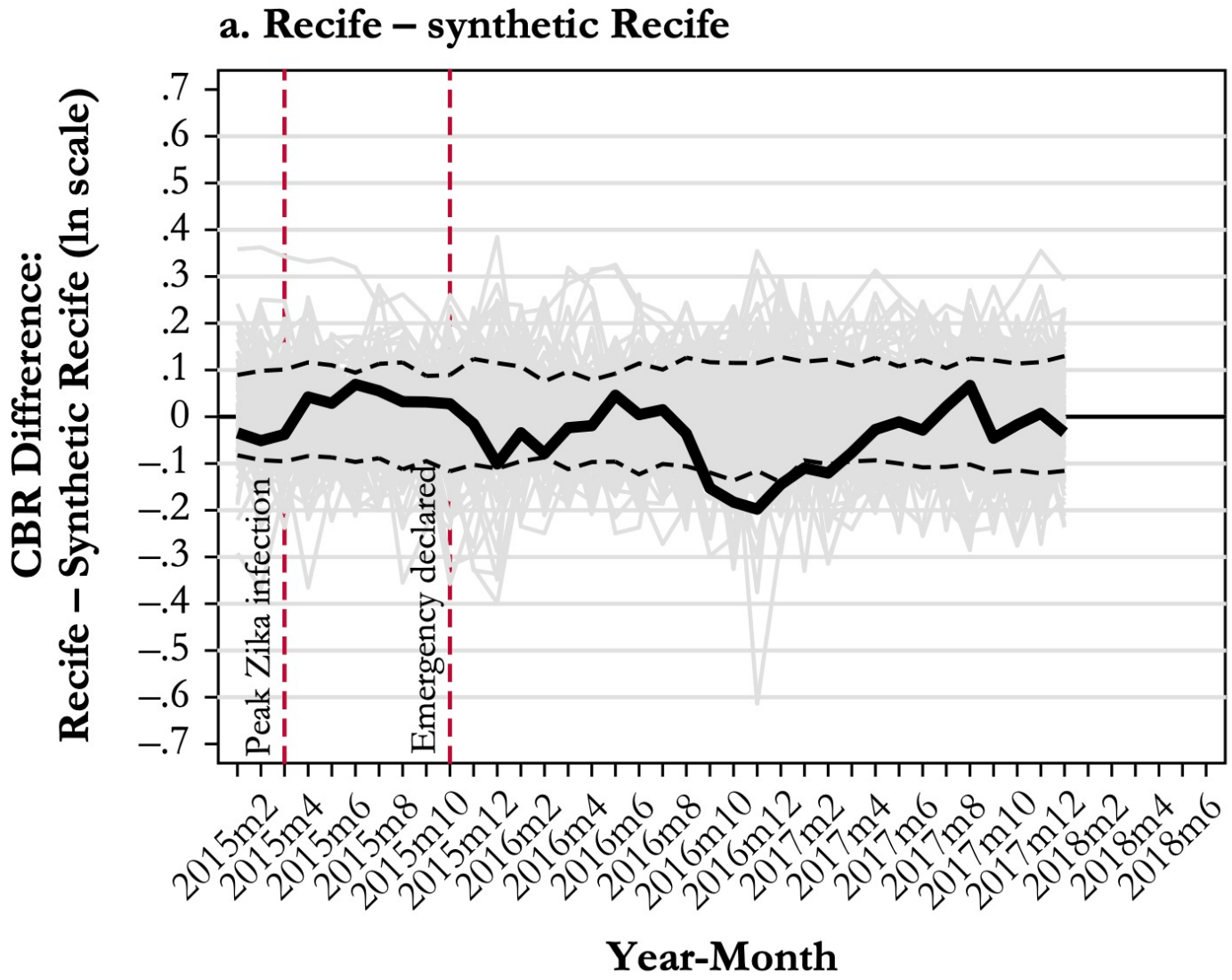
Synthetic cohort – Abadie JEL 2021 (link)

Synthetic cohort example: arrival of Zika in Recife, Brazil



Grey lines:

Placebo tests in which each donor municipality is swapped in as the "treated" municipality, one-by-one, and the procedure re-estimated.

Distribution of placebo values can be used to generate confidence intervals (dashed black lines)

Rangel, Nobles, Hamoudi 2020 (link)

Predicting the counterfactual

When we have information on unexposed places, it is possible to generate predictions that leverage the period change witnessed in those locations

COVID-19: Arguably no one is “unexposed” to the array of social and economic changes that accompanied the pandemic’s arrival

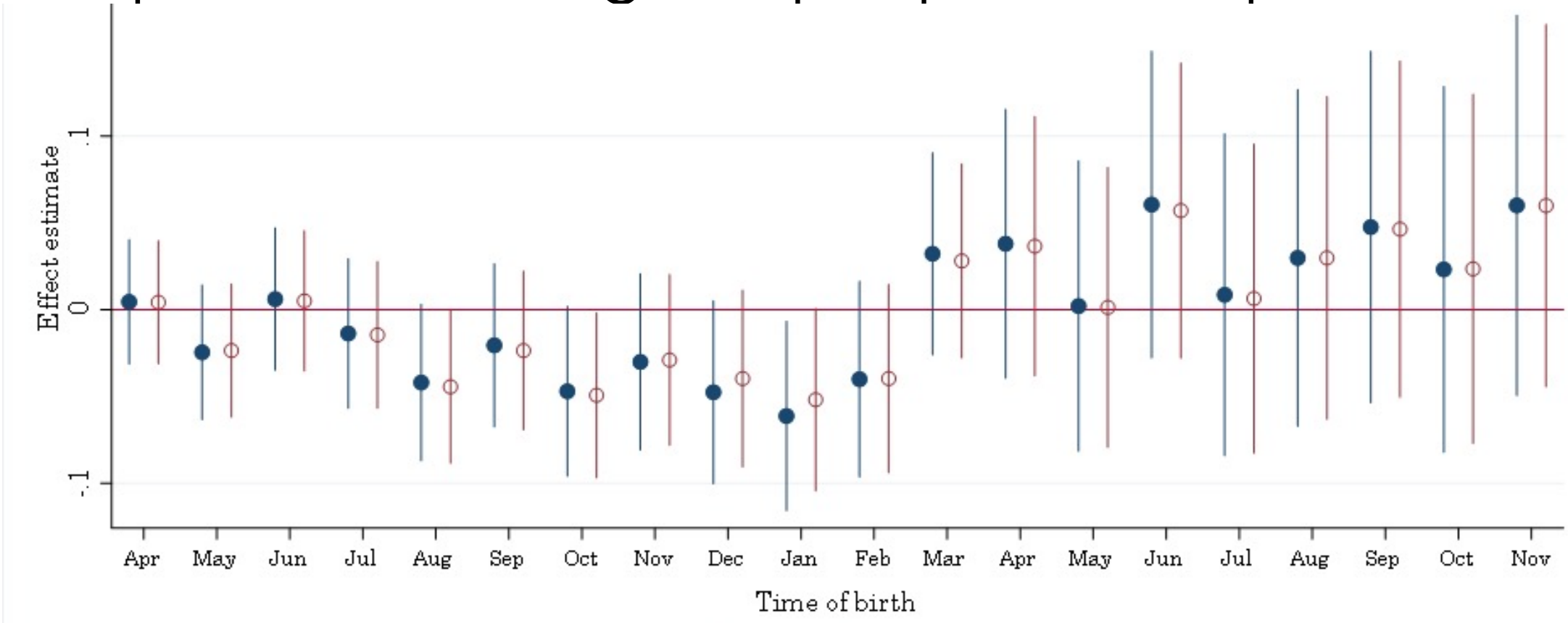
Forecasting

Time series analysis – Hausman & Rapson 2018 (link)

Demographic forecasting – Myrskylä, Goldstein, Cheng 2014 (link)

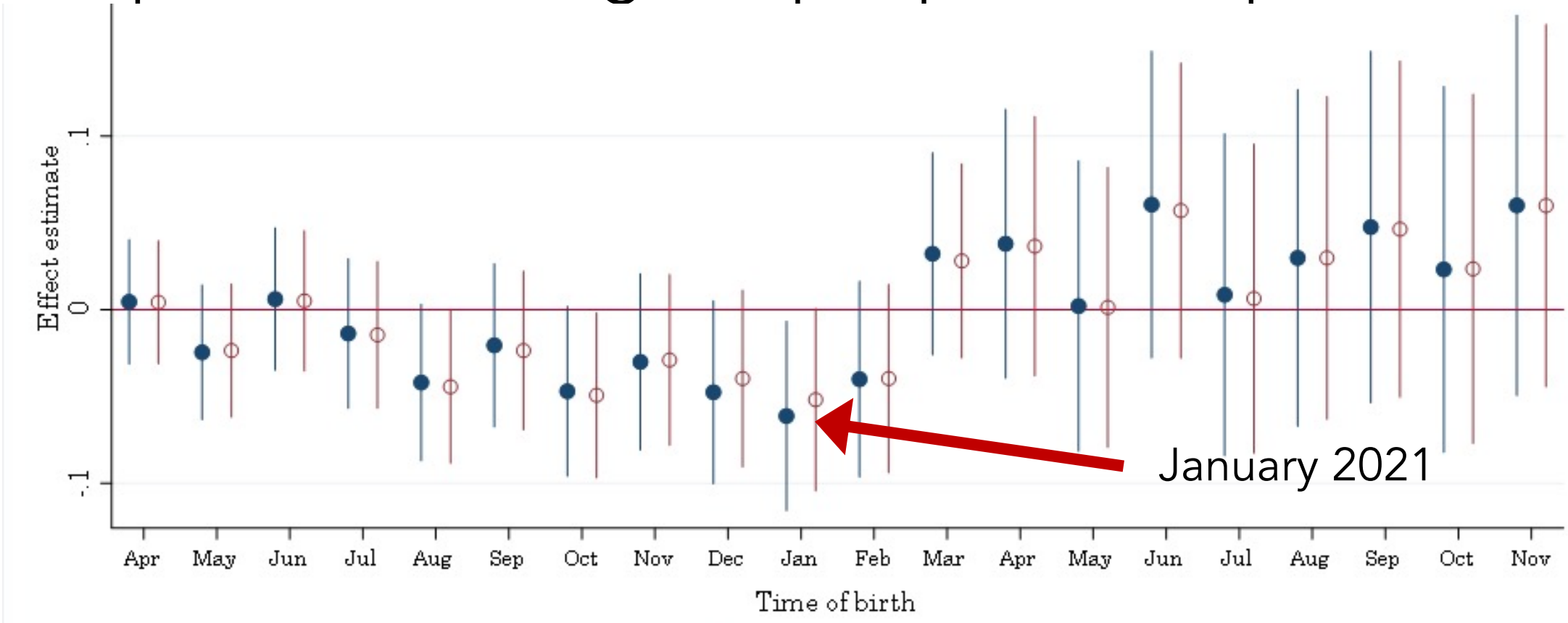
Estimate time-series analysis of aggregate monthly counts of birth data based on ARIMA models that account for trend, seasonality and other sources of temporal autocorrelation

Proportional deviation of birth counts from expected values, given pre-pandemic patterns



Note: ARIMA estimates: the proportional deviation of birth counts in each month relative to the predicted value for the month based on trend, and seasonal patterns, and other sources of temporal autocorrelation observed pre-pandemic. Navy closed circles denote estimates for all births; red open circles denote estimates for births not supported by ART. 95% confidence intervals.

Proportional deviation of birth counts from expected values, given pre-pandemic patterns



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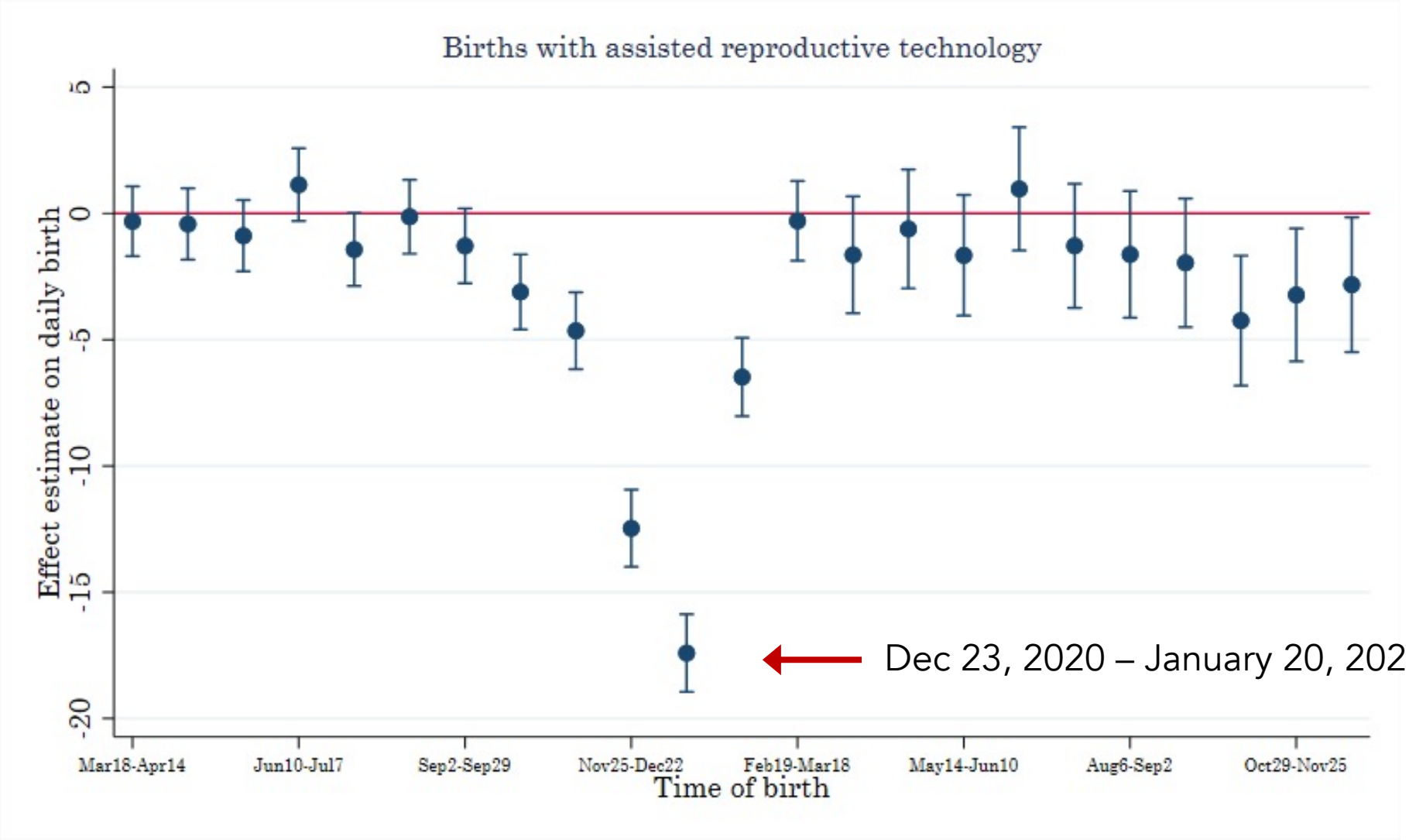
Expected ART availability to contribute significantly to reductions



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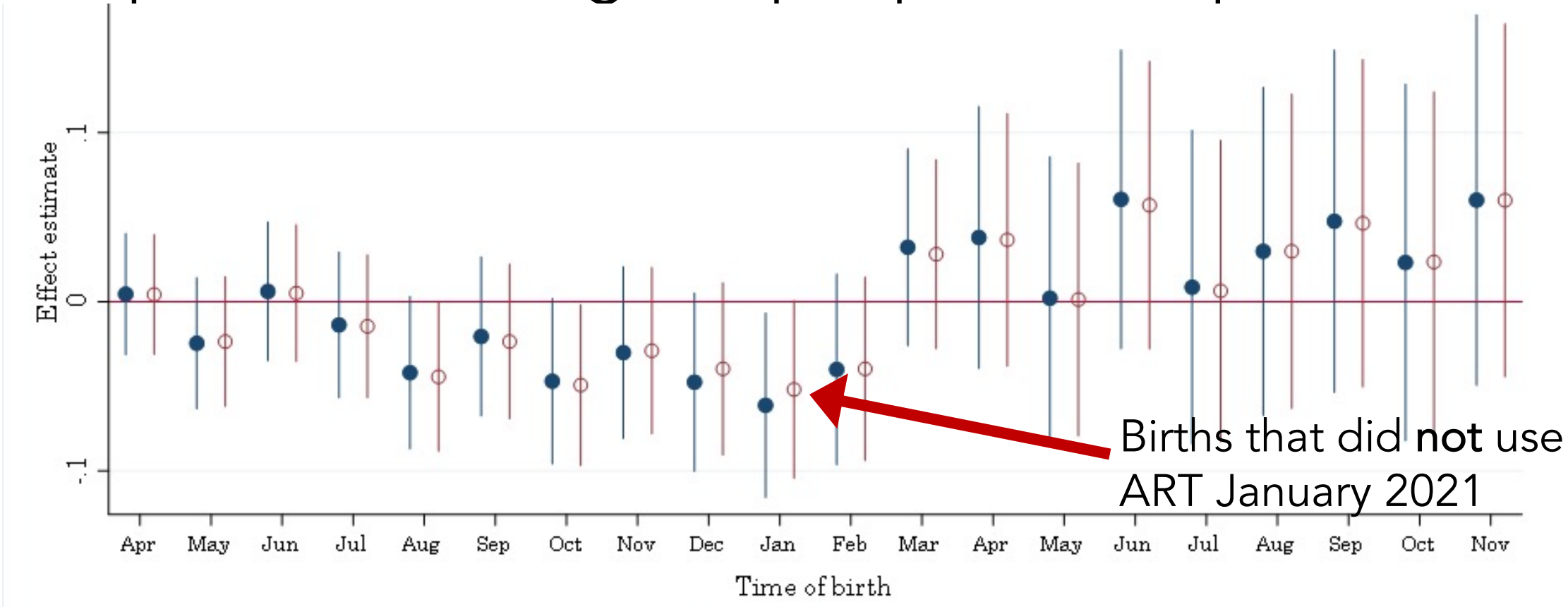

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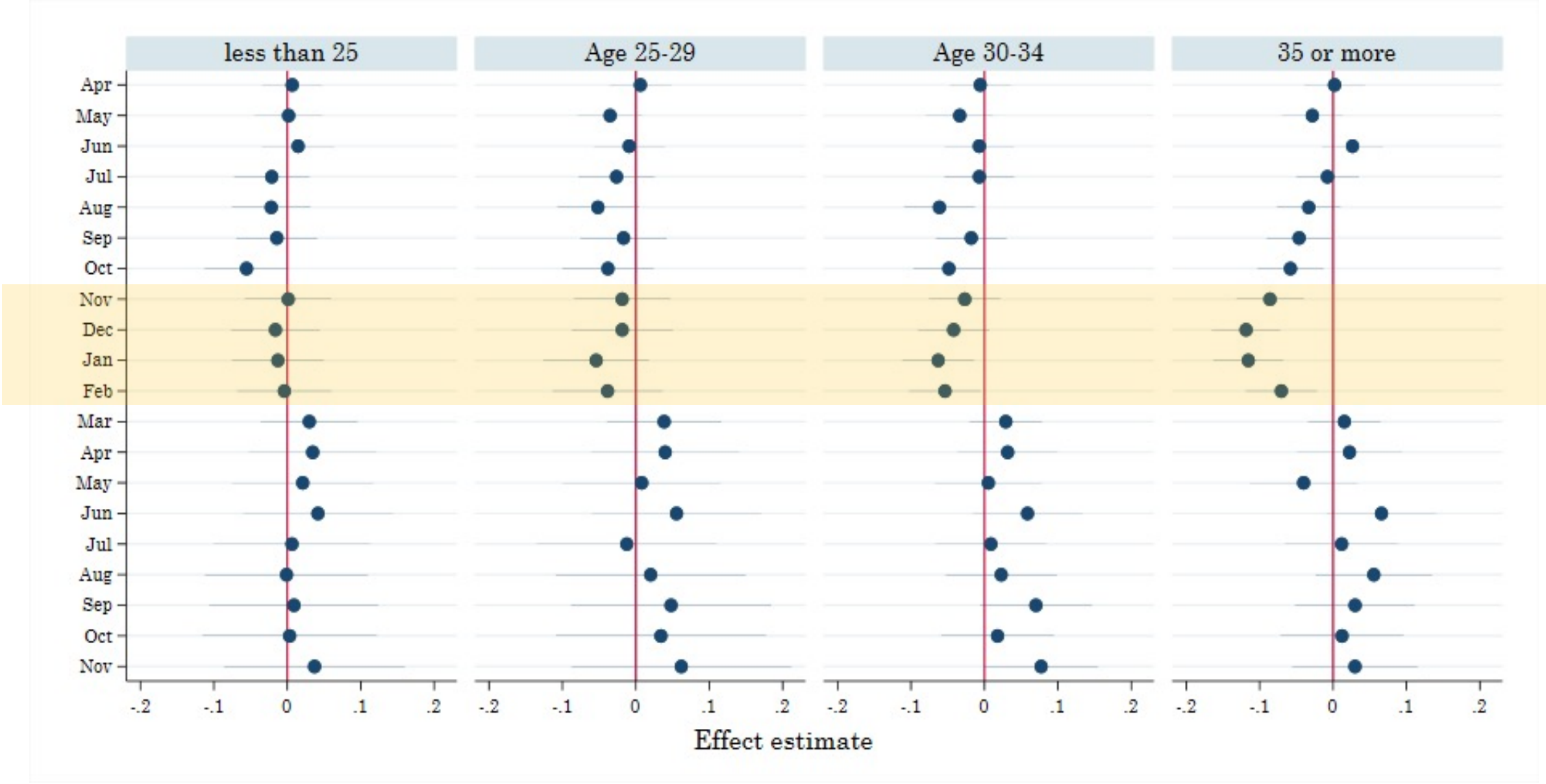
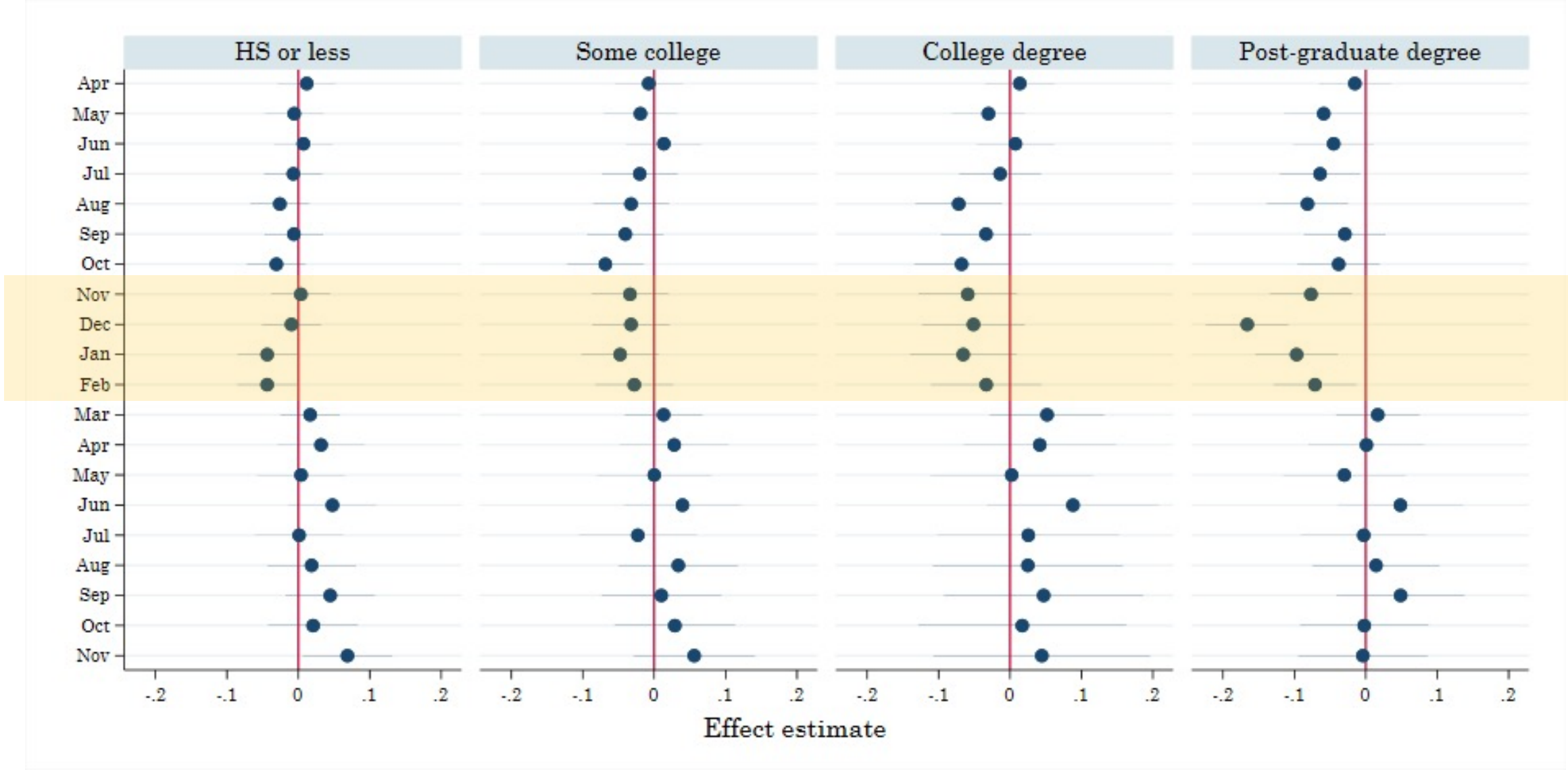
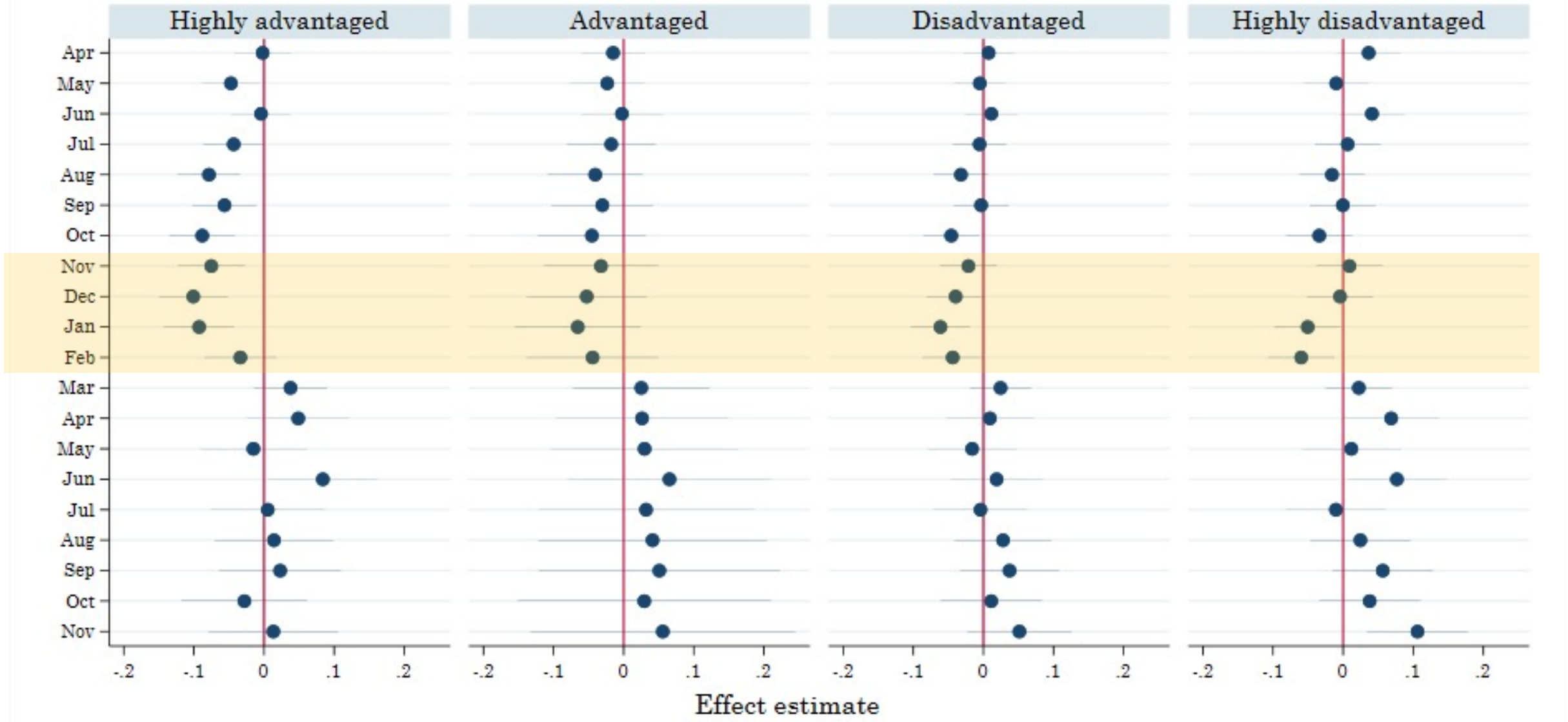
Largest reductions among older people



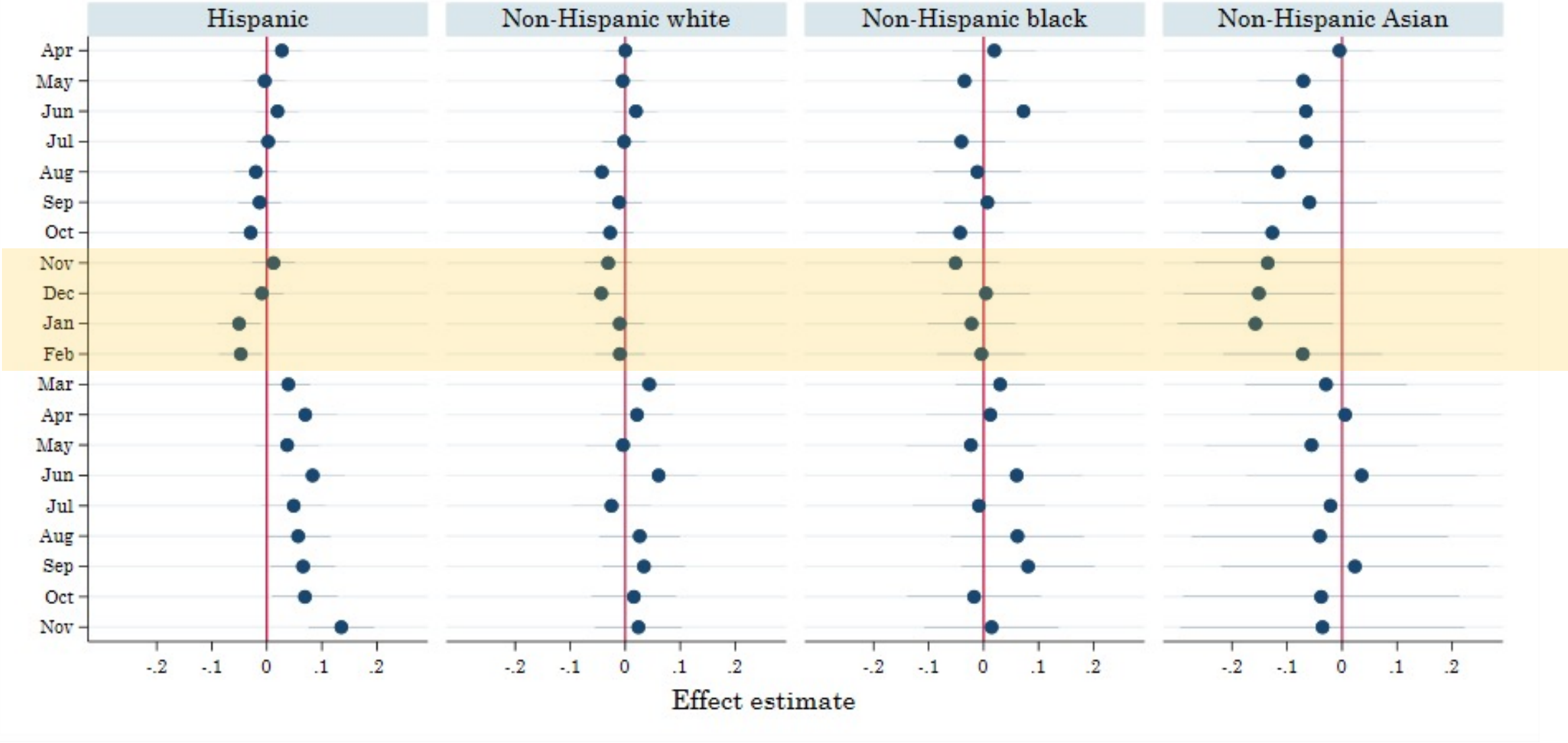
Largest reductions among highly-educated people



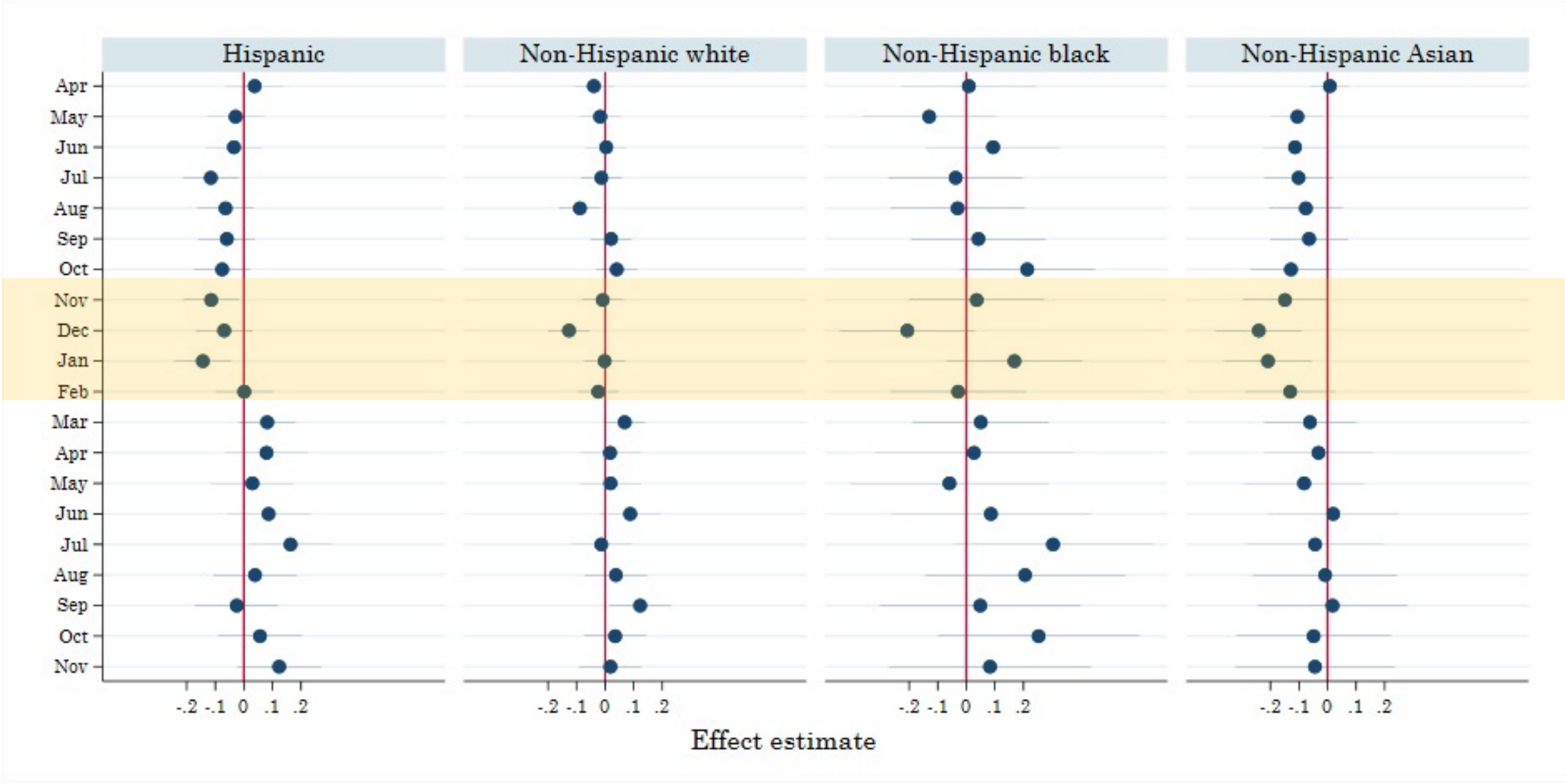
And people living in highly-resourced zip codes



Some differences by racial categorization



But among people with graduate education, reductions across race and ethnic categories



"Pandemic baby bust" short-lived. Births continue to decline into the first half of 2021 but this decline unlikely attributable to the pandemic alone.

COVID-related fertility declines may reflect

intentional fertility delays differentially available to better-resourced people.

As a result: birth cohorts in late 2020 and early 2021 shift marginally in composition. Increased % of births to younger people and people with fewer socioeconomic resources.

Birth certificates cannot tell us about

(a) time to conception or

(b) early miscarriage

Two major concerns of reproductive age people.

To do this: we would ideally follow multiple preconception birth cohorts, a costly endeavor.

Major U.S. preconception studies

Study	Recruited Sample	Number of Women/Couples
Wilcox et al. 1988	Women in Research Triangle Park, North Carolina	221
Sweeney 1988	University of Pittsburgh employees	88
Taylor et al. 1992	Women undergoing artificial insemination at a fertility clinic	92
Eskenazi 1995	Women working at seven silicon wafer fabrication sites	481
Hakim et al. 1995	Women employed at two semiconductor manufactures	148
Ellish 1996	Women renewing drivers licenses in Albany County, NY	227
Zinaman et al. 1996	A university-based obstetrics and gynecology center	200
Brown 1997	Members of Group Health HMO in Twin Cities, Minnesota	1,072
Buck 2002	Members of the New York State Angler Cohort Study	102
Buck Louis et al. 2013	16 counties in Michigan & Texas with chemical exposures	501
Wise et al. 2015; Willis et al. 2018	North American women in stable relationships recruited via internet advertisements, flyers, and word-of-mouth	2,421 6,873
Porucznik et al. 2016	Couples within one-hour of the University of Utah	183
Messerlian et al. 2018	Fertility center of academic hospital in Boston, MA	799

Source: Buck et al. 2004, authors' search

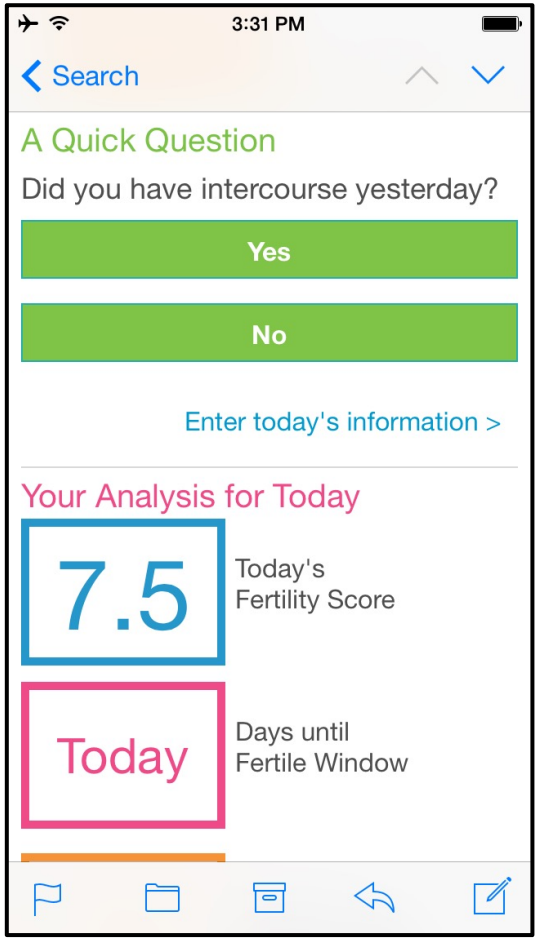
Innovations in data collection that

seek daily data from large, not-representative samples

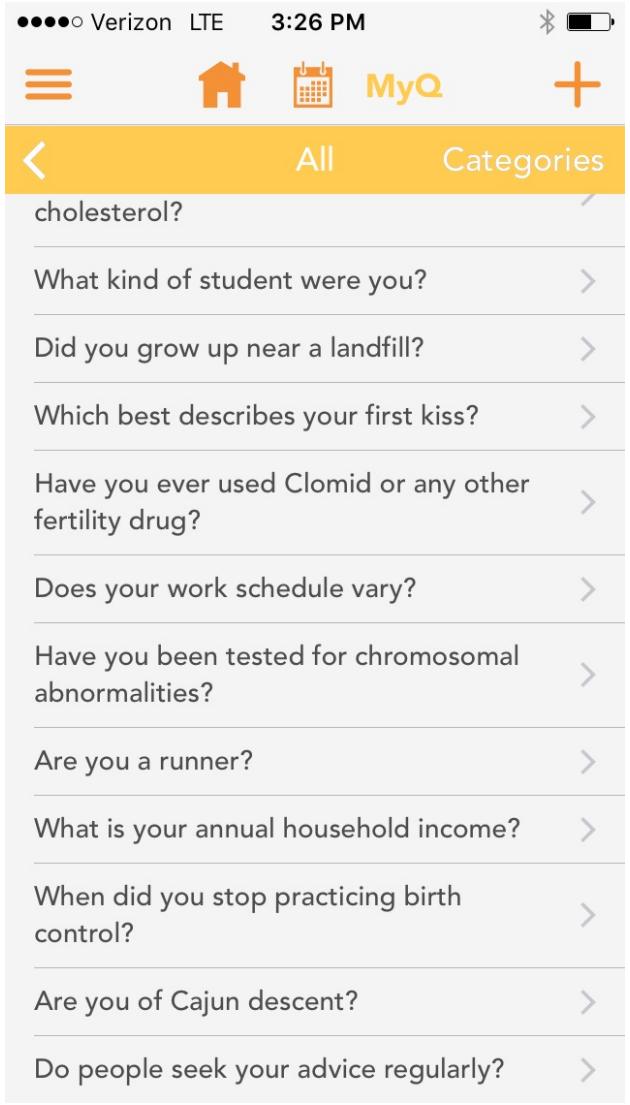
Several million active users

- zip codes
- periods
- intercourse
- contraception
- ovulation
- pregnancy

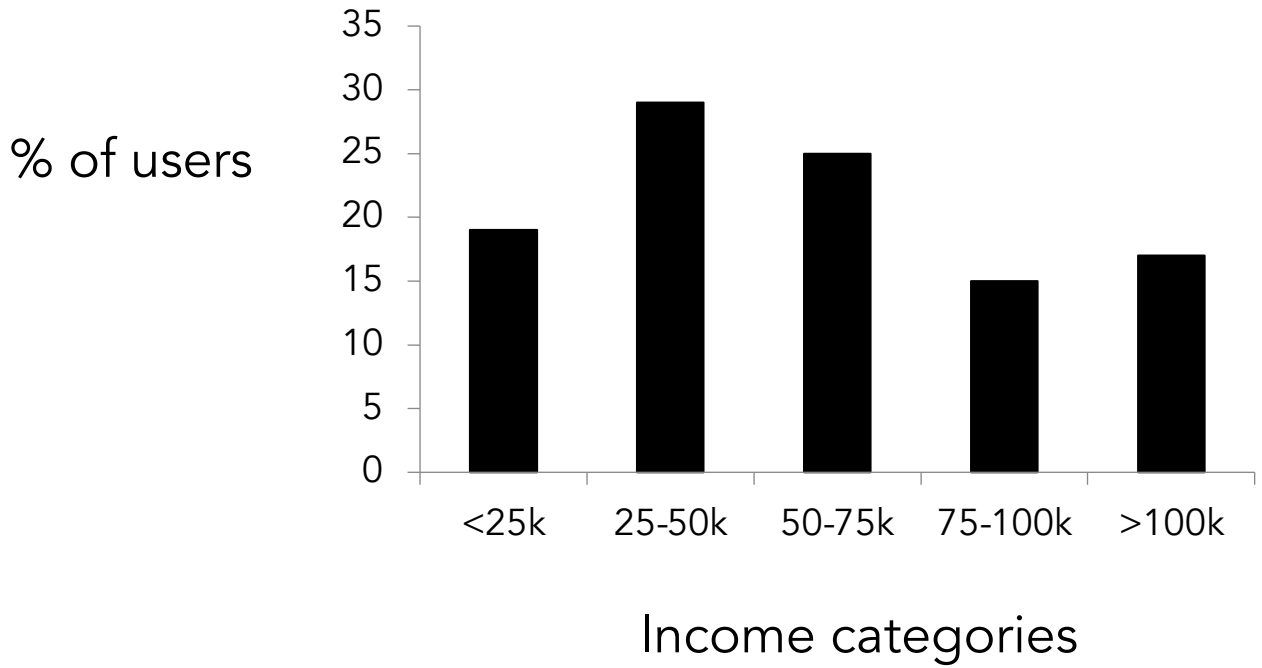
Daily support to reduce missing data

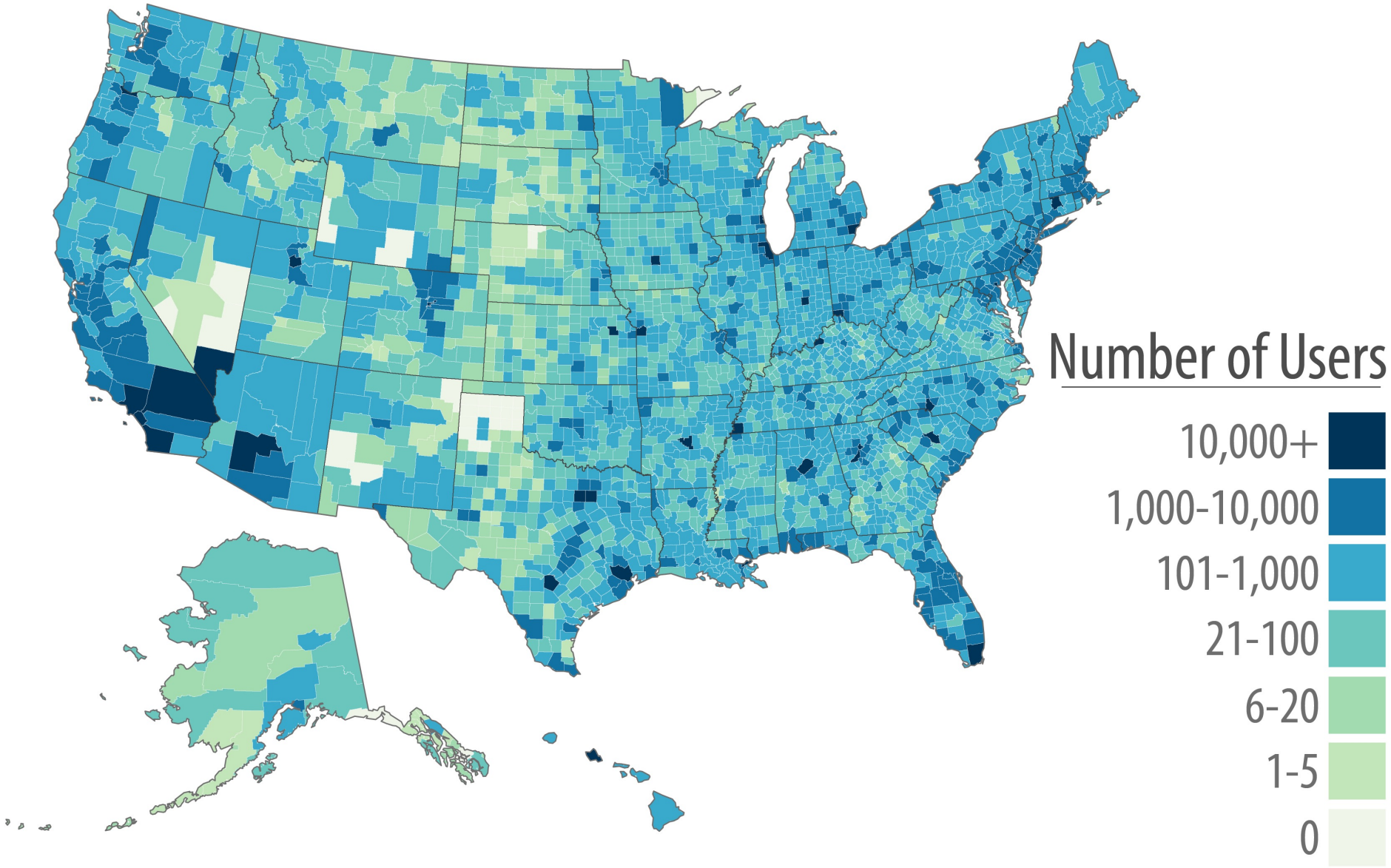


Large amount of information to characterize individuals

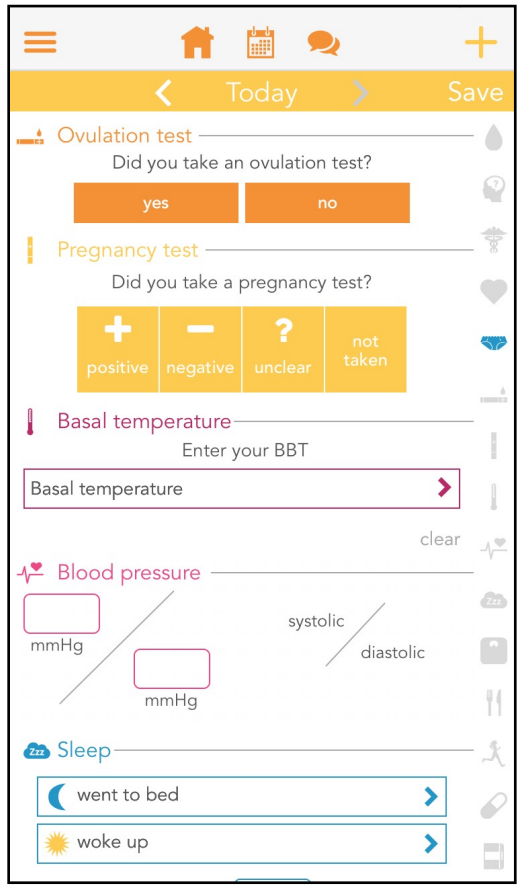


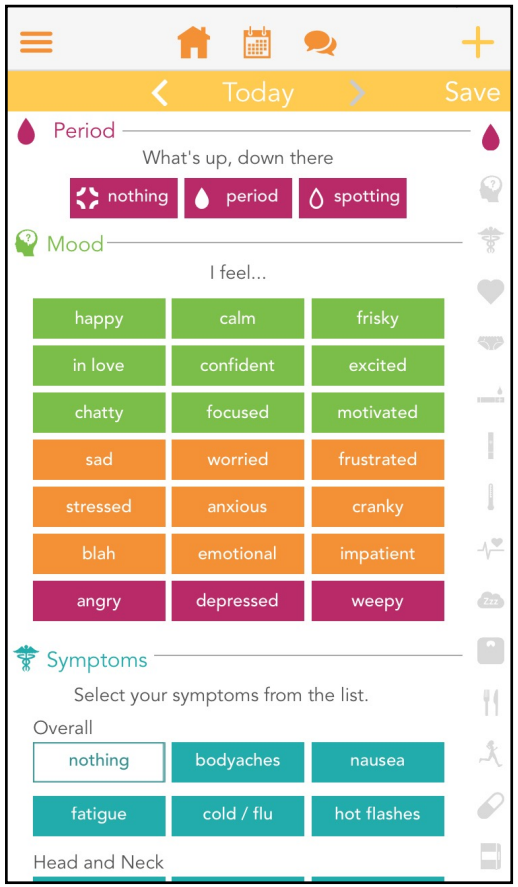
Users are diverse in many ways

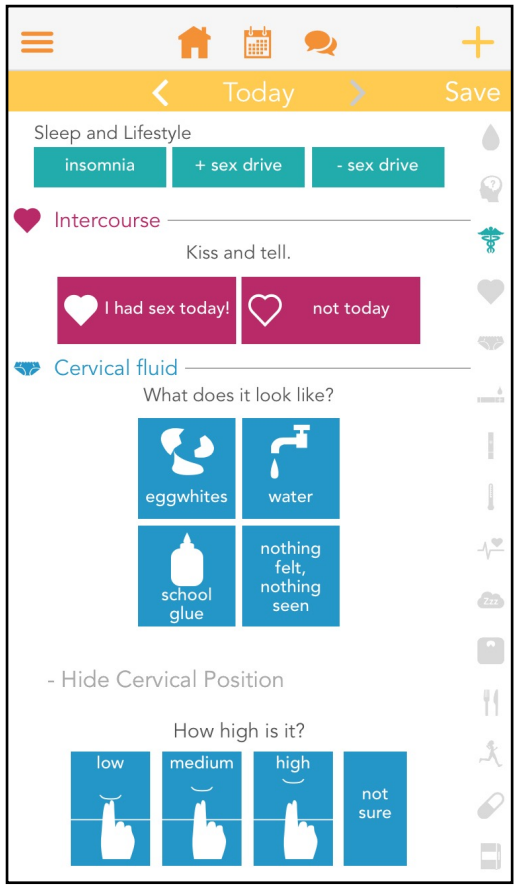



Number of Users
10,000+
1,000-10,000
101-1,000
21-100
6-20
1-5
0

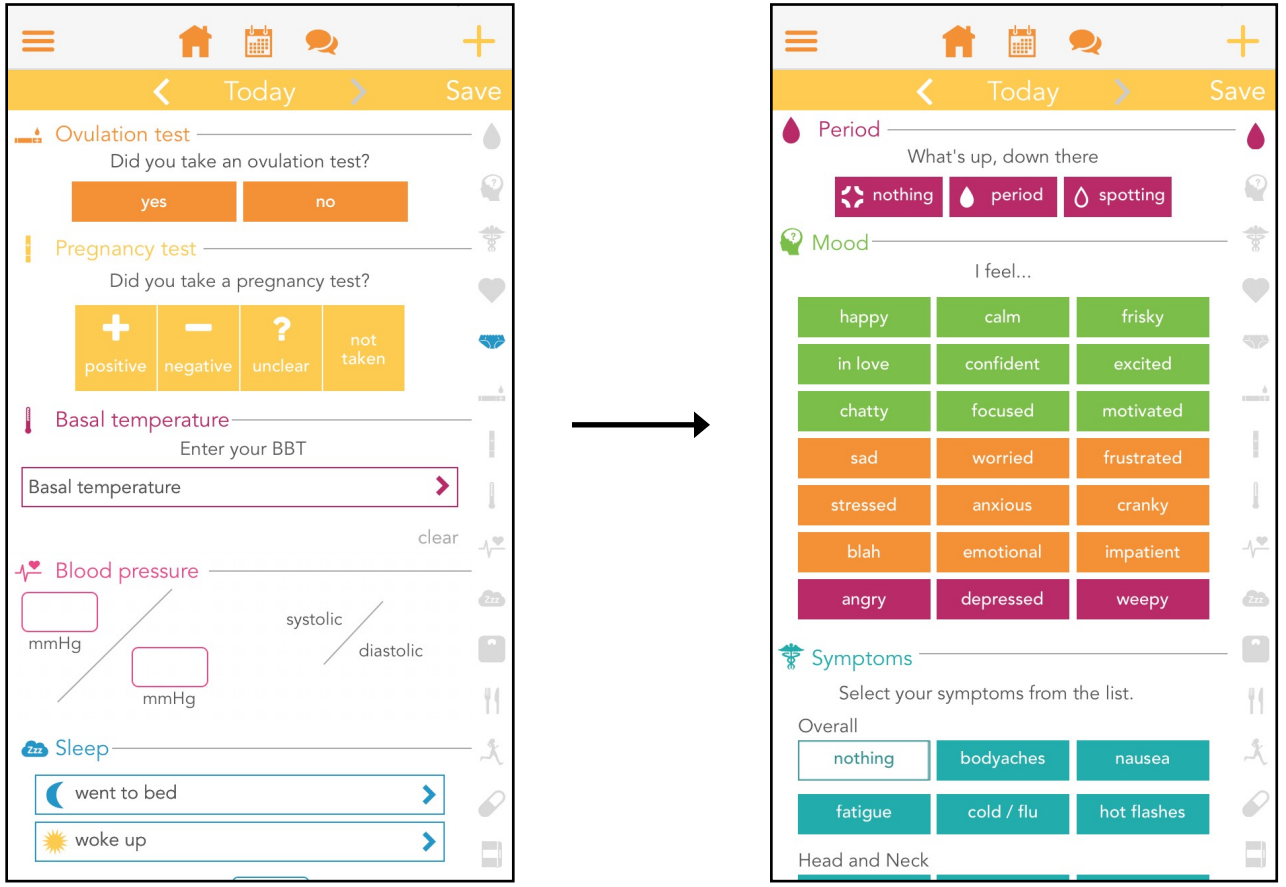
Use features of monitoring data





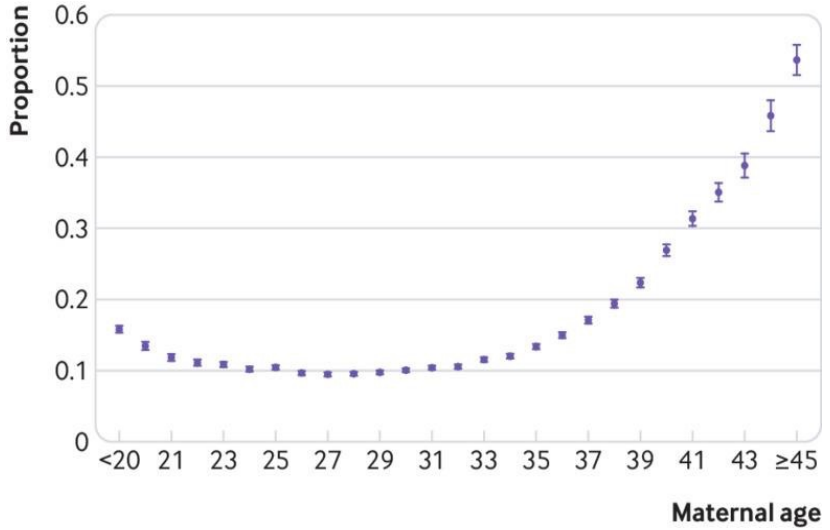


We can learn from people's experiences even without direct miscarriage report



Validation

Norwegian registry data: women attending health care appointment (~7 weeks gestation)



Magnus et al. 2019

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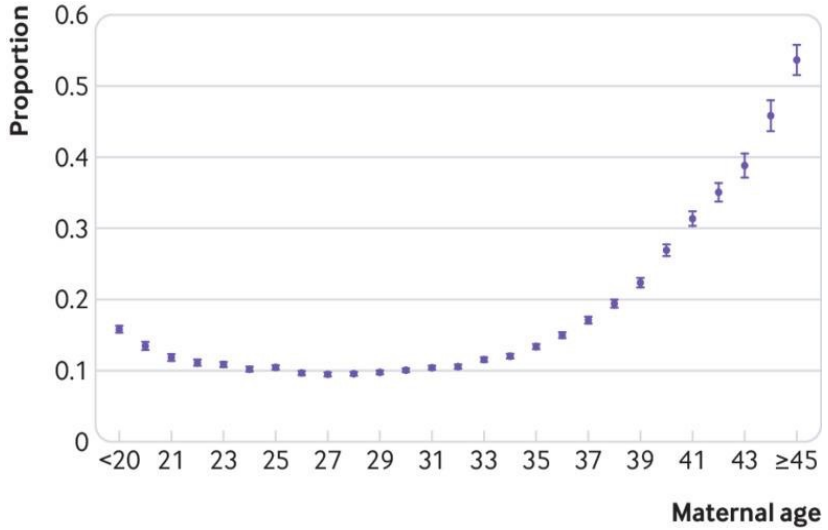
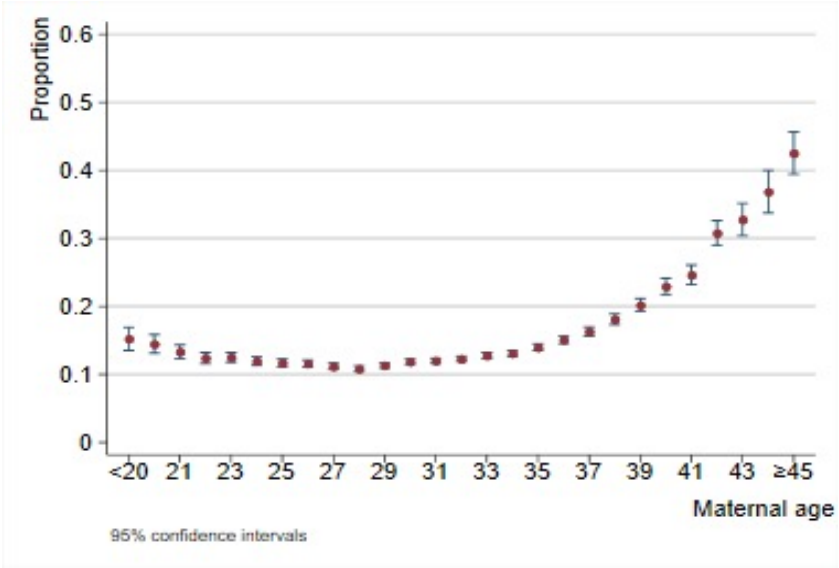


Magnus et al. 2019

User data limited to pregnancies that survive to 7 weeks



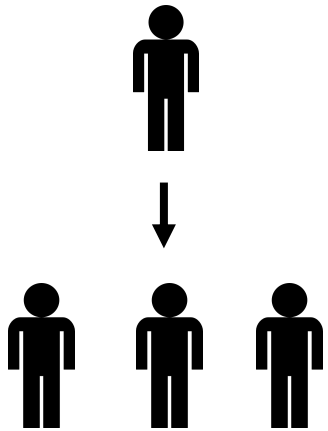
Generate conception cohorts by place (zip, county, PUMA)

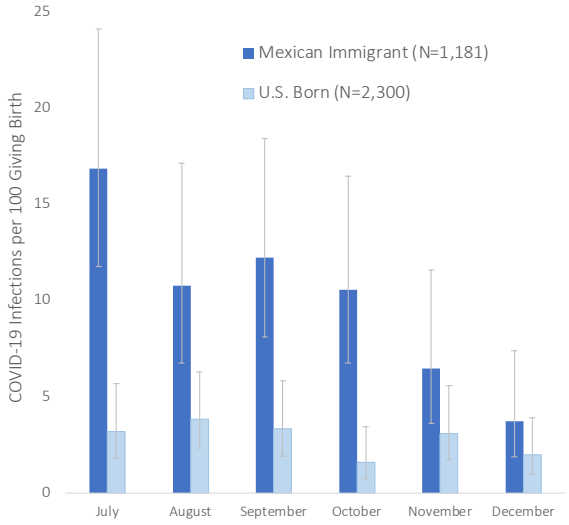
Use discrete-time event history models to estimate the within-place change in monthly probability of

- conception | trying to conceive
- spontaneous termination | positive home pregnancy test

Before and after March 2020, and then, roll-out of vaccination

Use location-level post-stratification weights to weight the data





Jenna Nobles: jnobles@ssc.wisc.edu
Florencia Torche: torche@stanford.edu

NIH *Eunice Kennedy Shriver* National Institute of Child Health and Human Development
Healthy pregnancies. Healthy children. Healthy and optimal lives.

NSF