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Unpacking the Drop in COVID-19 Case Fatality Rates: A Study of National and Florida Line-Level Data

From Phenotyping to Risk Prediction

Session 61

Helen Zhou

Co-authors: Cheng Cheng, Jeremy Weiss, Zachary Lipton

Carnegie Mellon University

Twitter: @helenz1235

#AMIA2021

Disclosure

Our research team has no relevant relationships with commercial interests to disclose.

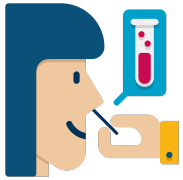
Learning Objectives

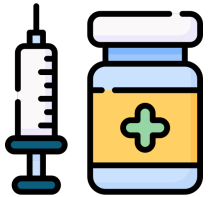
After participating in this session the learner should be better able to:

- Understand the **limitations of using the aggregate case fatality rate** when assessing the efficacy of treatment improvements
- **Account for confounding factors** such as shifting age distributions, increased testing, and lags between detection and death
- Understand how to use and interpret our publicly released web tool to **apply our analyses to any demographic** of interest.

Motivation

Over the past 1.5 years, **the coronavirus pandemic has continually evolved**

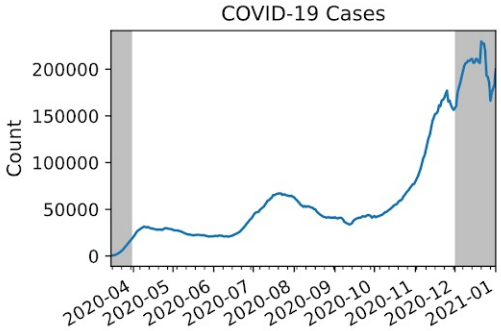


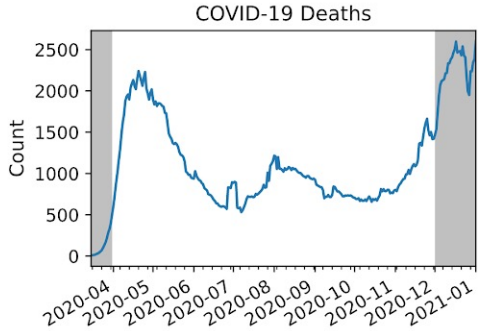


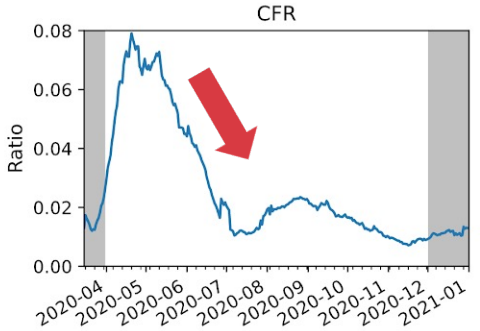
Decision makers face key questions:

- Has treatment **improved outcomes?**
- Is **fatality** decreasing?
- **Infection rate** at current vs. previous dates? **Artifacts** of expanded testing?

Background







- CFR = # of deaths due to covid / # of covid cases
- Between the first and second peaks, >70% drop in CFR
- Focus of this study: **April 2020 – December 2020**
- **Driving Question:** What explains the movement (& apparent overall decline) in the CFR over the course of the COVID-19 pandemic?

Importance to policy

Press briefing by former President Donald Trump (July 27):

*"**Due to the medical advances** we've already achieved and our increased knowledge in how to treat the virus, the **mortality rate** for patients over the age of 18 is **85 percent lower** than it was in April."*

This statement was about the **aggregate CFR**.

Can we really say that **treatment** caused the 85% drop in CFR?
→ According to our analysis, no.

What explains the drop in CFR?

Academic & public discourse has centered around the following hypotheses:

could misinform policy decisions

(H1) Shifting **age distribution**

(H2) Increasing **testing capacity**

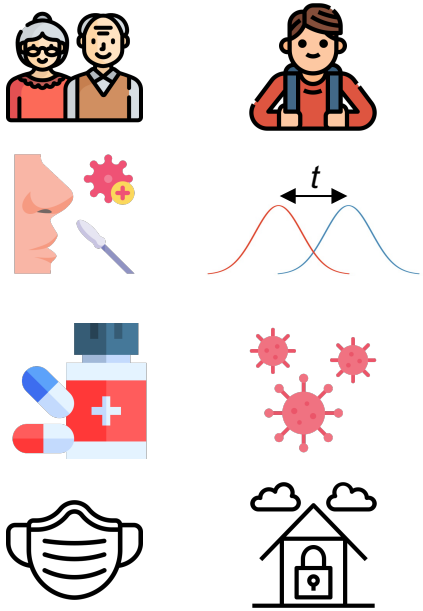
(H3) **Delay** between detection and fatality

(H4) **Treatment improvements**

(H5) Disease **mutation**

(H6) Reduced viral load due to **precautions**

reasonable grounds for policy (e.g. re-opening)



Contributions

- Demonstrate how H1, H2, and H3 (“artifacts”) can be accounted for when attempting to quantify improvements in treatment (H4)
- **Age-stratified hospitalization data** is key
- Analyze data over a **longer time range** and **larger scale** than prior work
  - 9-month time period (April 2020 – December 2020)
  - **State-level** data from the FDOH (1 million cases, 57K hospitalizations)
  - **National** data from the CDC (10.3 million cases, 588K hospitalizations)
  - Data characteristics: line-level, date of detection, age, gender, hospitalized or died
- Publish a **web tool** for users to apply our analyses to selected demographics, regions, and dates of interest

Methods – Accounting for "Artifacts"

We use 7-day lagged averages to reduce noise in time series.

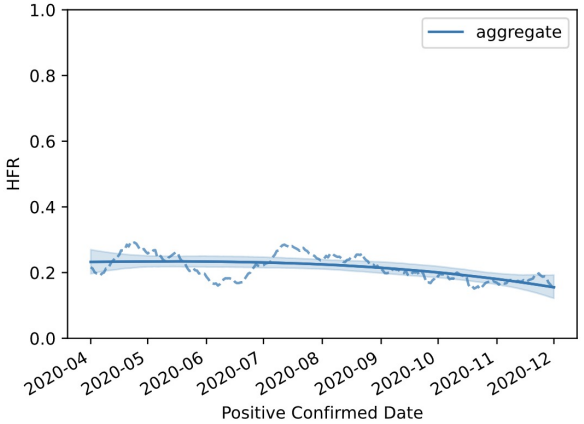
We establish and account for:

- **Increased testing (H1):** examine *hospitalization fatality rates (HFR)*
- **Age distribution shifts (H2):** *stratify* by age groups 0-9, 10-19, ..., 80+
- **Delays between detection and fatality (H3):** use line-level data for a *cohort-based analysis*, so fatality matches up with the right individual
  - Cohort-based fatality rate definition:

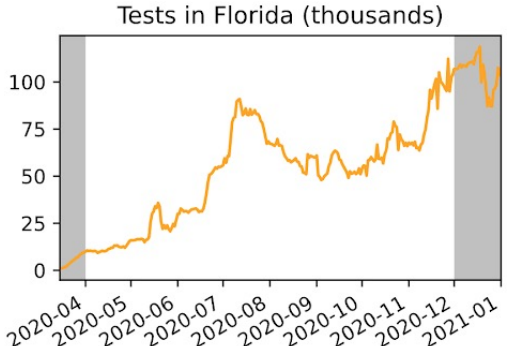
$$\text{HFR}_t = \frac{\text{cases confirmed (or reported) at day } t \text{ that eventually get hospitalized and die}}{\text{cases confirmed (or reported) at day } t \text{ that eventually get hospitalized}}$$

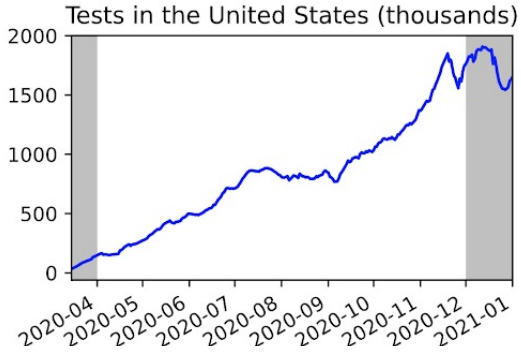
Methods – Quantifying True Improvements

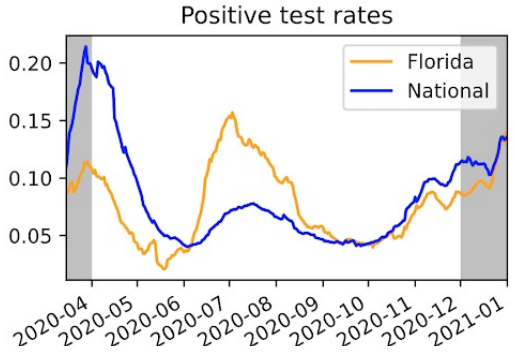
- Quantify the change in **age-stratified HFR**
- **Cubic splines**: estimate the underlying trend
- **Block-bootstrapping with post-blackening** (Davison and Hinkley 1997): estimate uncertainty around this trend
- Rather than fitting a predictive model for forecasting, we **estimate** the existing trends in HFR at all points in time



Results – Increased Testing (H2)



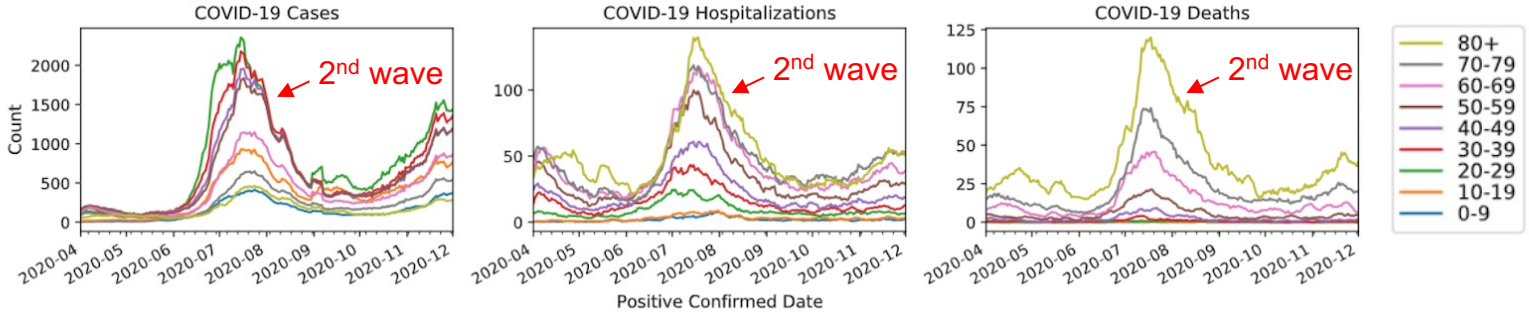




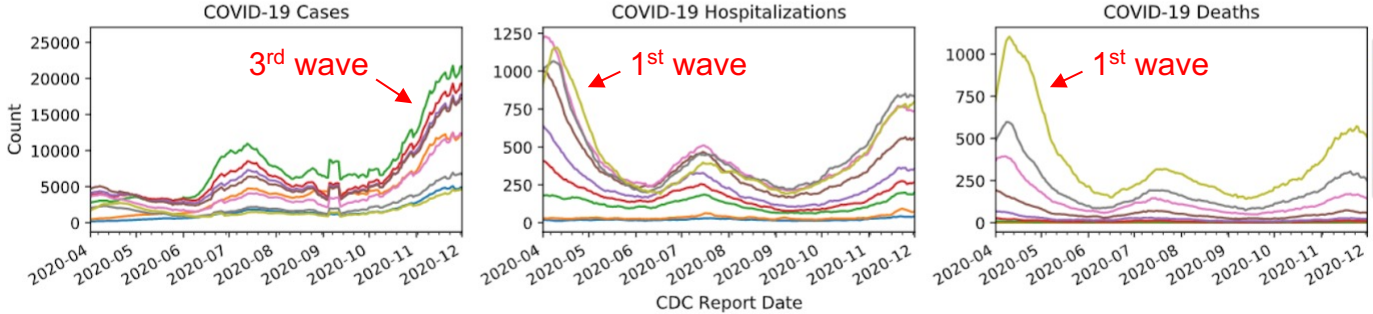
- April to December: testing increases significantly
- Positive test rates spike in April, July, and December
- Although spikes in tests could inflate case counts, there are also large spikes in positive test rates

Results - Cases, Hospitalizations, Deaths

Florida FDOH Data



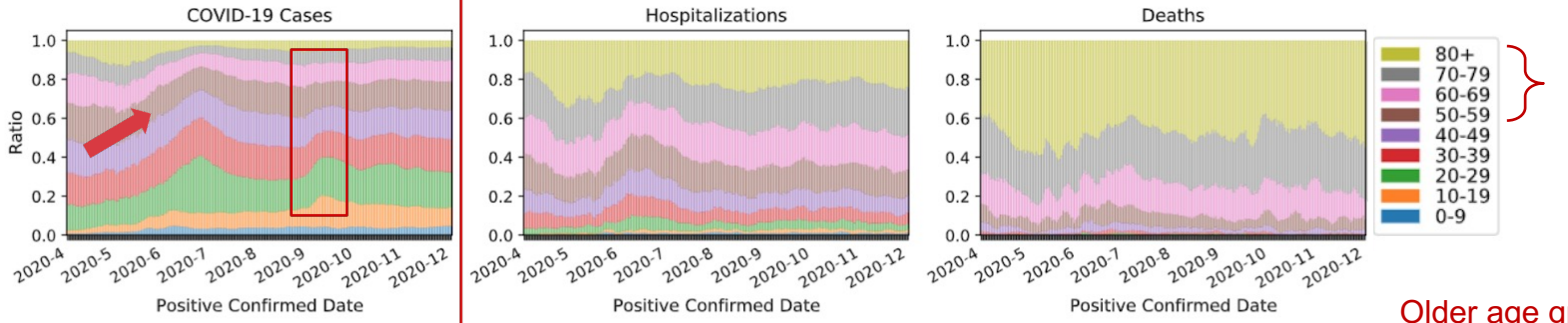
U.S. CDC Data



Results – Demographic Shift (H1)

Florida FDOH Data

uptick in younger
shift towards younger



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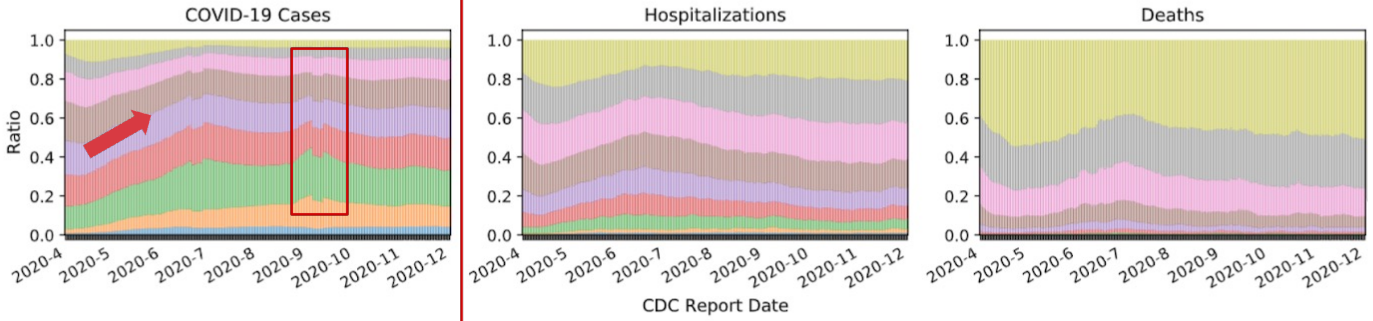


Older age groups comprise more hospitalizations and deaths

Results – Avg. Change in Estimated HFR

1st & 2nd Peak dates
(April 15th – July 15th)

Age	Florida	National
aggregate	–2.3%	–41%
20-29	-	–34%
30-39	-	–37%
40-49	-	–29%
50-59	+12%	–31%
60-69	+13%	–30%
70-79	+3.4%	–34%
80+	+2.9%	–27%

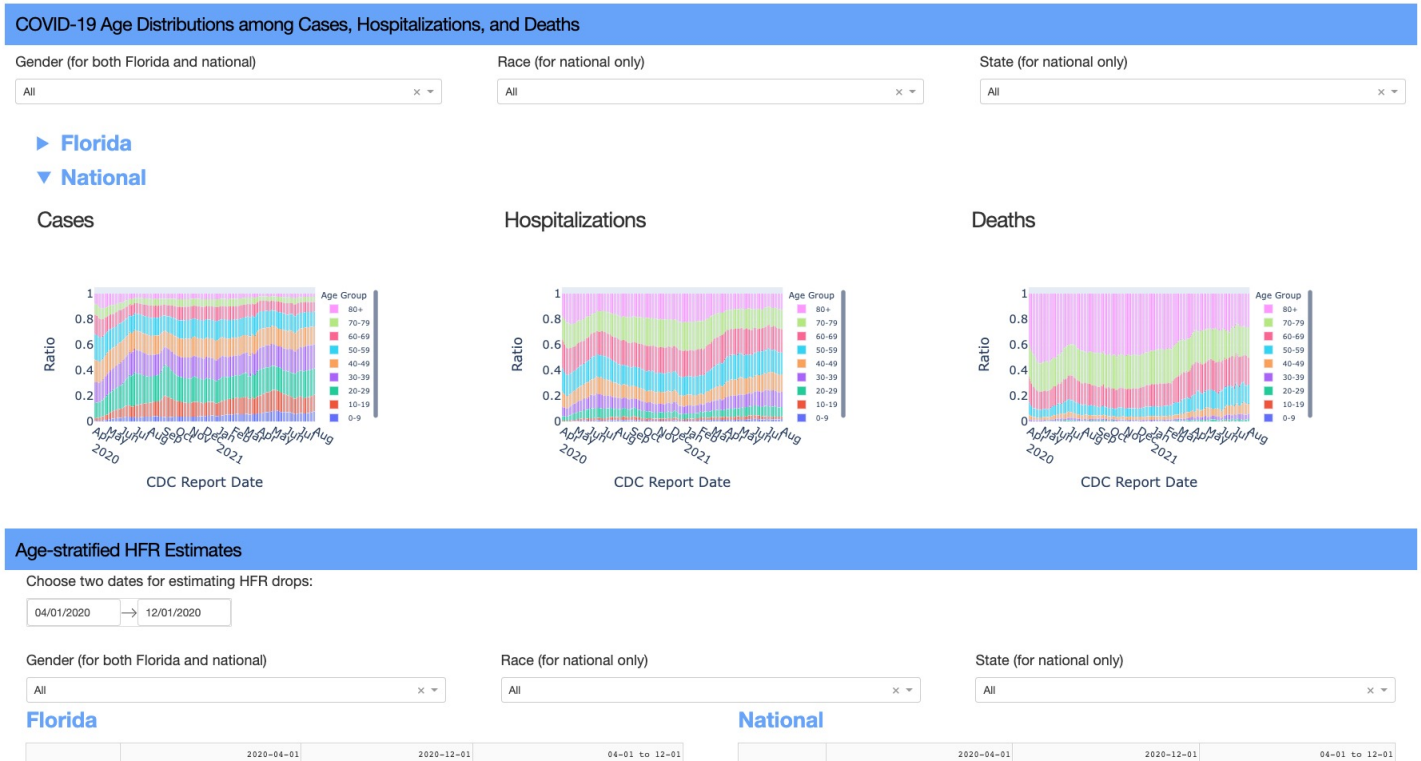
Entire study time range
(April 1st – December 1st)

Age	Florida	National
aggregate	–33%	–61%
20-29	-	–73%
30-39	-	–61%
40-49	-	–65%
50-59	-	–63%
60-69	–42%	–61%
70-79	–38%	–60%
80+	–17%	–55%

Conclusions

- Unpacked the "improvement" in CFR, honing in on improvements reasonably attributable to advances in treatment
- Account for:
  - shifting age distributions → by **age-stratifying**
  - increased testing capacity → by focusing on the **hospitalized**
  - delay between detection & fatality → by doing **cohort-based** analysis
- **We recommend policy-makers account for at least these three factors**
- Coming back to Trump's statement in July…
  - age-stratified HFR had actually *increased* in Florida
  - nationally, the drop in HFR was at most 41%
- Customizable web tool

Web Tool


COVID-19 Age Distributions among Cases, Hospitalizations, and Deaths
Gender (for both Florida and national)
All
Race (for national only)
All
State (for national only)
All
Florida
National
Cases
Hospitalizations
Deaths
Ratio
Age Group
80+
70-79
60-69
50-59
40-49
30-39
20-29
10-19
0-9
CDC Report Date
Age-stratified HFR Estimates
Choose two dates for estimating HFR drops:
04/01/2020
12/01/2020
Gender (for both Florida and national)
All
Race (for national only)
All
State (for national only)
All
Florida
National
2020-04-01
2020-12-01
04-01 to 12-01

Thank you!

Email me at:
hlzhou@andrew.cmu.edu