What can epidemiological models tell us about infection inequality?

Jon Zelner

March 9, 2021

University of Michigan School of Public Health
jzelner@umich.edu
epibayes.io

Agenda

- Case Study: Racial disparities in COVID-19 incidence and mortality in Michigan.

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- Interactive thought experiment: What mechanisms can explain these disparities?

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- Interactive thought experiment: What mechanisms can explain these disparities?
- What does any of this mean for 2021 and beyond?

Was exciting to see this

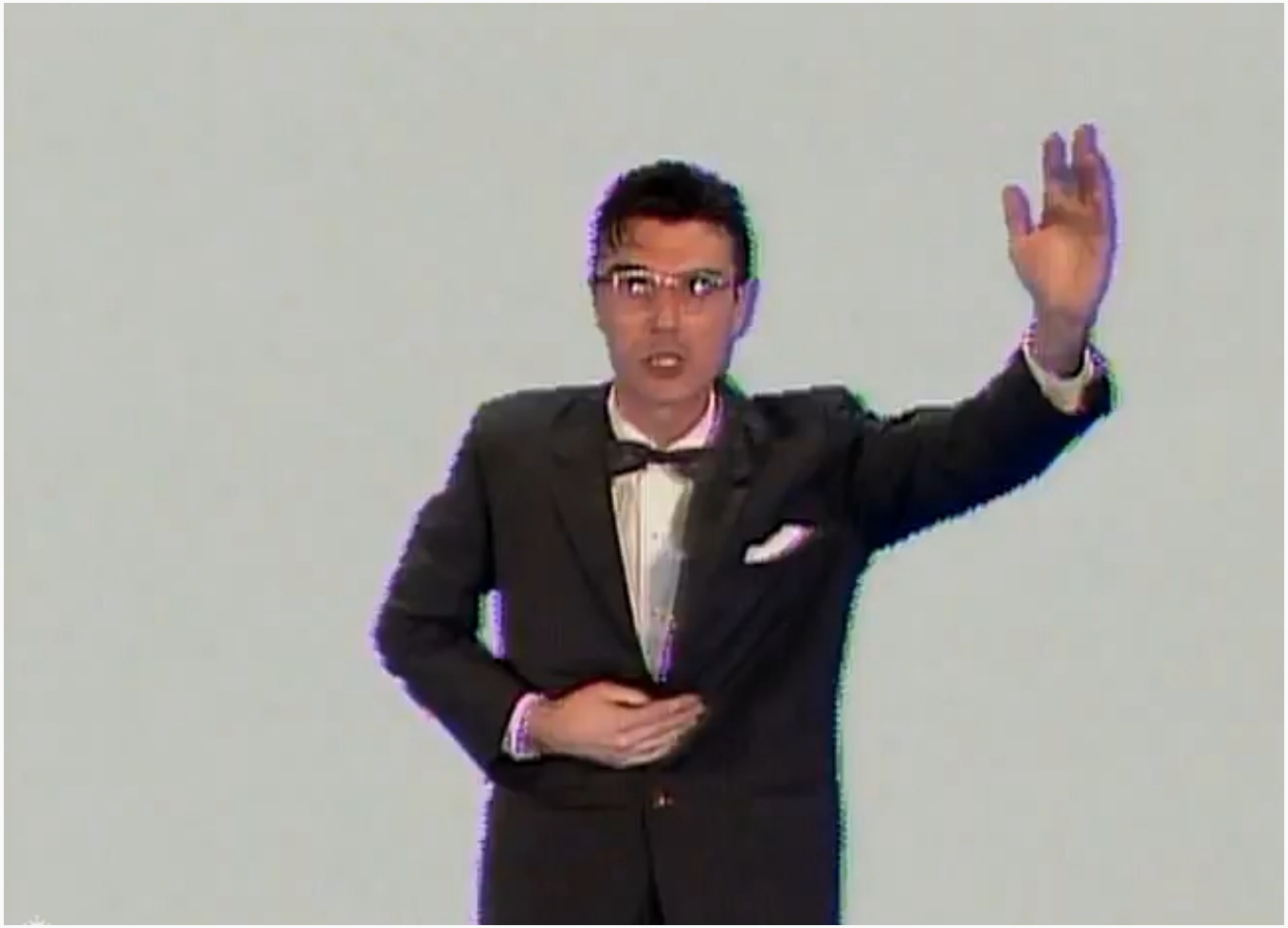
Where models meet morality: What role should complexity science play in addressing racial and socioeconomic disparities in the COVID-19 crisis?

A Virtual Complex Systems Seminar

Jon Zelner
School of Public Health
University of Michigan
(and Complex Systems Alum!)

Tuesday, March 9, 2021
11:30AM EST

How did I get here?



My god, what have I done???

How did I get here?

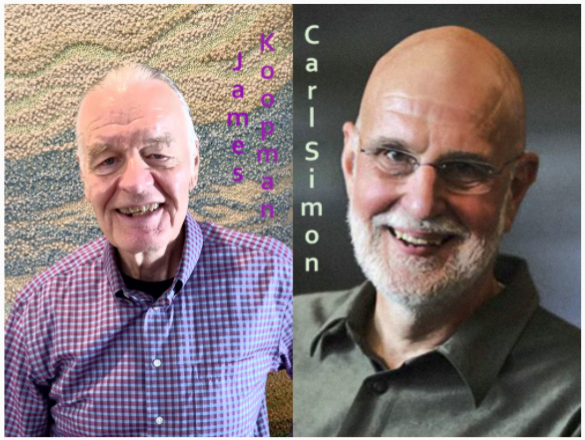
New data, models, and methods to guide SARS-CoV-2 vaccine design and vaccination programs that counter escape mutations

A Virtual Complex Systems Seminar

James Koopman
Epidemiology, School of Public Health, University of Michigan

Carl P. Simon
Complex Systems, Math and Ford School of Public Policy, University of Michigan

Tuesday, March 2, 2021
11:30AM EST



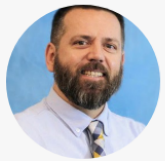
EpiBayes Group

Team

Joey Dickens
Postdoctoral Fellow

Kelly Broen
Doctoral Student

Nina Masters
PhD Candidate



Paul Delamater
Assistant Professor, UNC

Ramya Naraharisetti
Doctoral Student

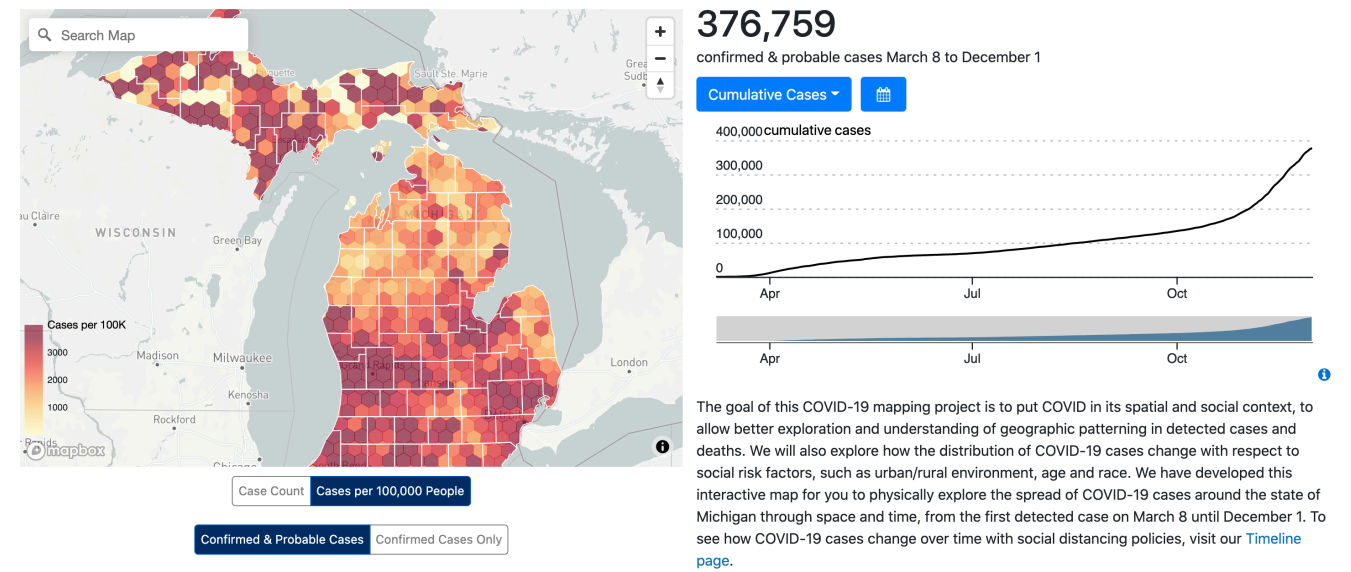
Rob Trangucci
PhD Candidate

Ryan Malosh
Assistant Research Scientist

Stephanie Choi
UI/UX designer

Not Pictured: Alex Cao, Krzysztof Sakrejda

COVID-19 risk has been characterized by spatial heterogeneity and inequality



Geographic loci of transmission in Michigan has shifted multiple times over the course of COVID-19 pandemic. (Image from covidmapping.org)

These patterns reflect enormous race/ethnic disparities

Race	Incidence/100K	IRR	Mortality/100K	MRR
Black	1644 (1621,1668)	5.6 (5.5,5.7)	251 (242,262)	6.9 (6.5,7.3)
Latino	1113 (1074,1152)	3.8 (3.7,3.9)	79 (66,94)	2.2 (1.8,2.6)
Other	1520 (1442,1605)	5.2 (4.9,5.5)	152 (124,185)	4.2 (3.4,5.1)
Asian/Pacific Islander	695 (654,738)	2.4 (2.2,2.5)	79 (61,99)	2.2 (1.7,2.7)
White	293 (289,296)	Ref	36 (35,38)	Ref
Native American	254 (209,303)	0.9 (0.7,1)	26 (12,49)	0.7 (0.3,1.3)

Table 2: Age and sex-standardized incidence and mortality rates and corresponding rate ratios. The table shows incidence rates and mortality rates and 95 percent posterior credible inervals, as well as corresponding standardized incidence rate ratios (IRRs) and mortality rate ratios (MRRs). For all comparisons, the incidence and mortality rate among Whites is used as the reference group.

COVID-19 incidence and mortality rates 3/2020-7/2020 (From Zelner et al., CID 2020 [4])

A focus on racial disparities without understanding mechanisms is dangerous

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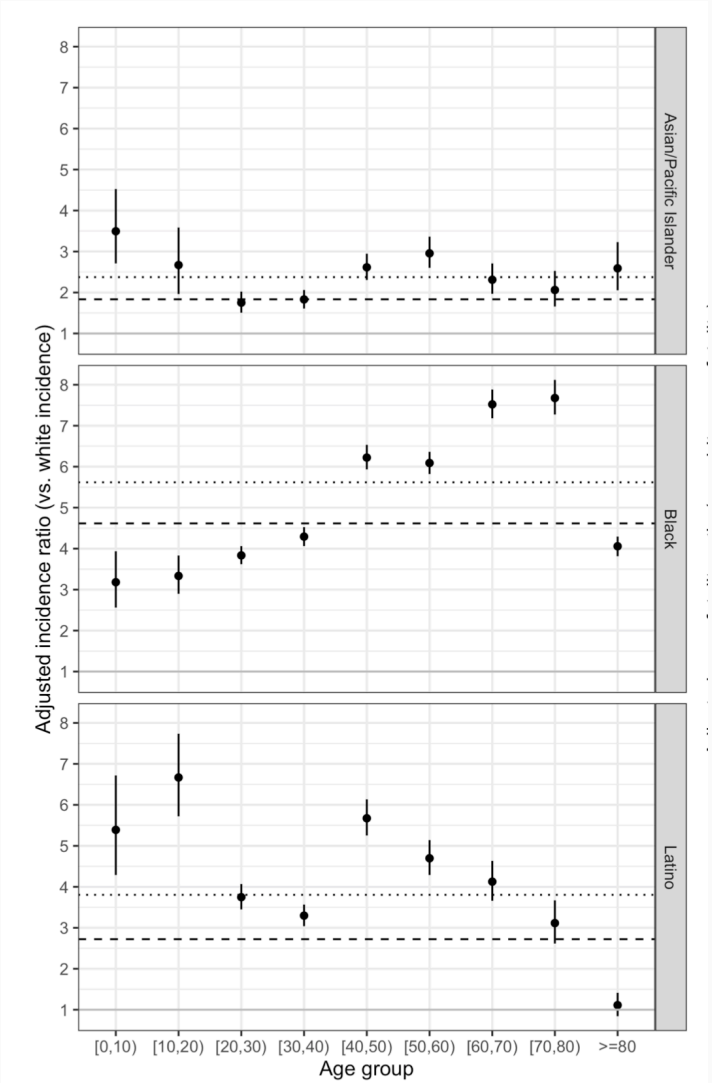
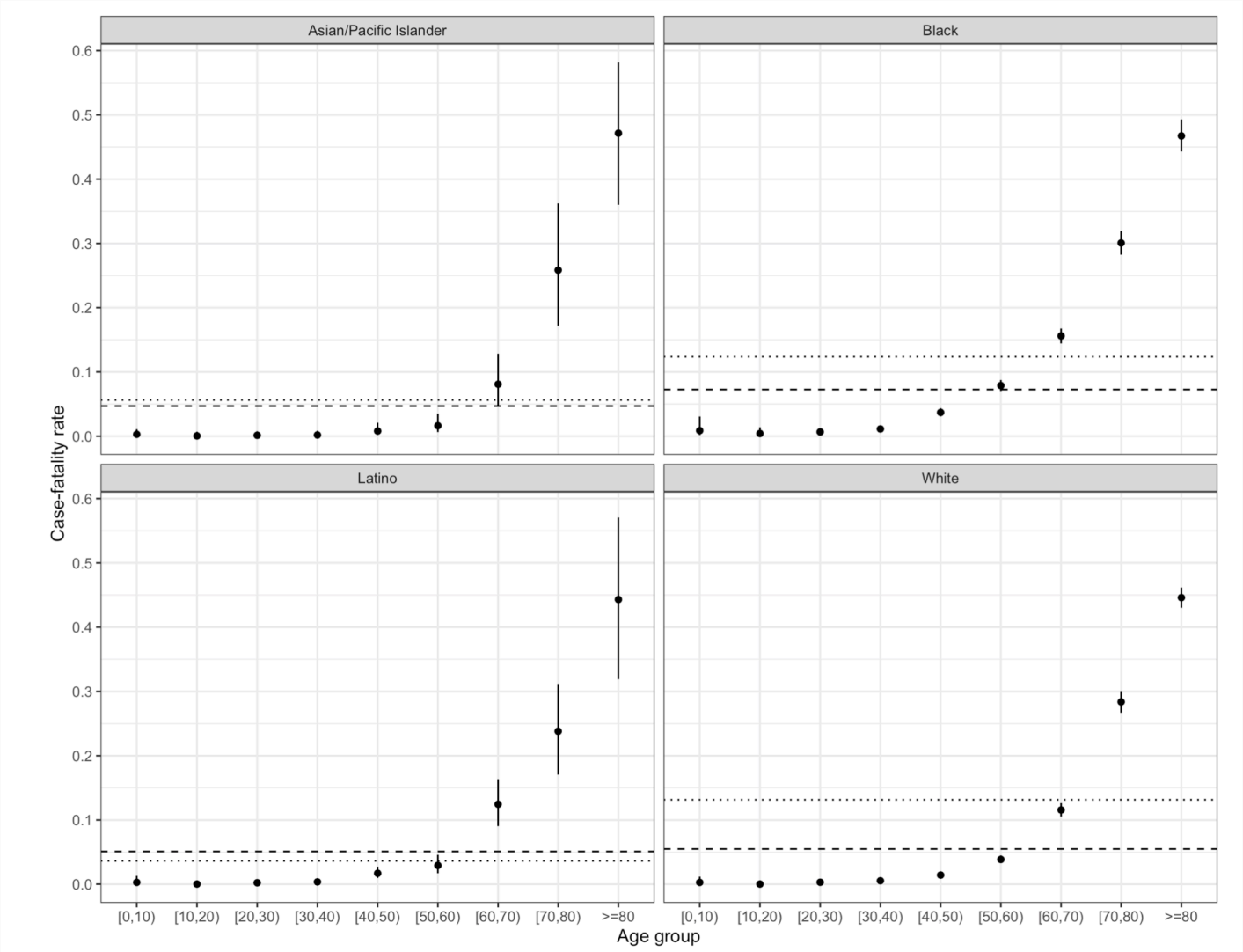
- Racializing risk can be stigmatizing and may lead to further neglect [1].
- Obscures underlying mechanisms such as residential and occupational segregation.

Early on, incidence disparities most extreme in oldest age groups



But: Age-specific case-fatality rates did not vary much.



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- Substituting White case-fatality rates for Black case-fatality rates, would result in ~29% decrease in mortality for African-Americans.
- Suggests that exposure is a key driver of inequality rather than ‘pre-existing conditions’ and other group-individual-level explanations.

What might explain these disparities in exposure?

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- Multigenerational households/household crowding
- Mass incarceration
- Racial residential segregation encompasses these and other factors.

So, what does segregation *do*?

Access interactive R tutorial here:

https://sph-umich.shinyapps.io/segregation-transmission/

Equity challenges for 2021 and beyond

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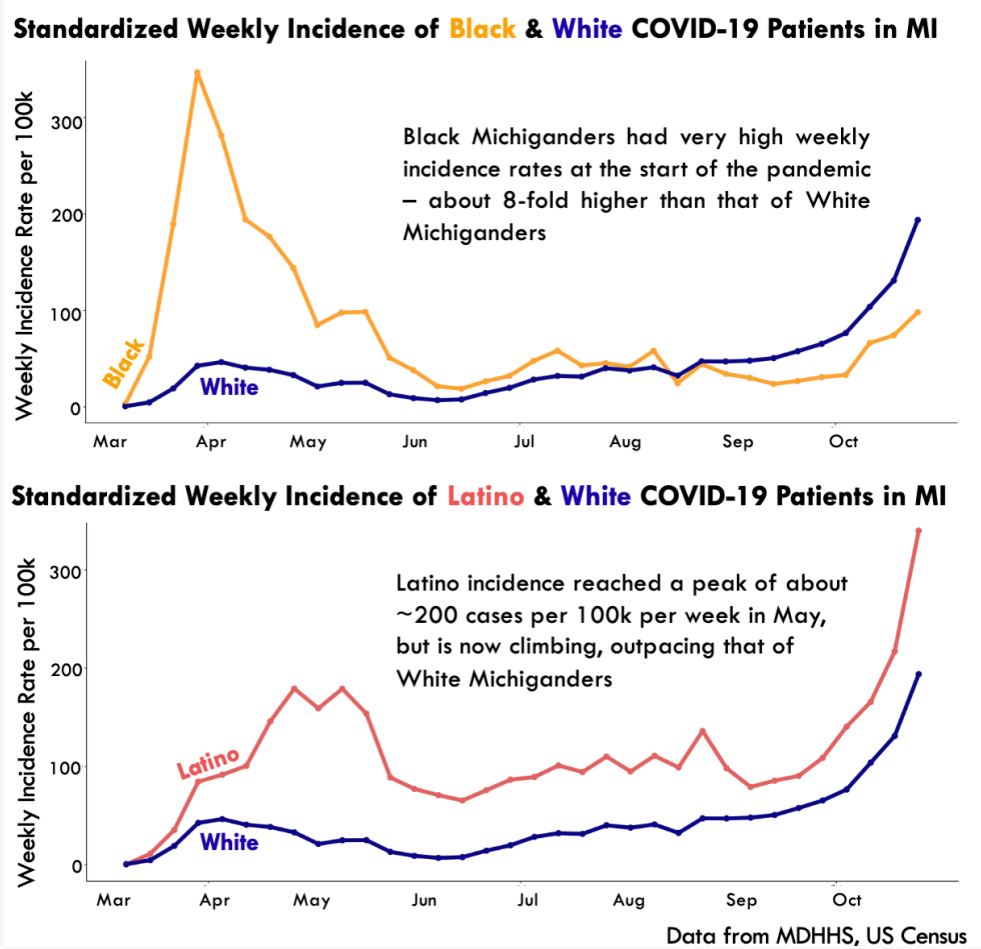
- Achieve sustained reductions in race/ethnic disparities in incidence/mortality.
- Ensure equitable distribution and uptake of vaccination.
- Prepare for inequity long-term sequelae of SARS-CoV-2 infection
- Start closing other gaps in global and domestic health equity that have been widened by the pandemic.

Race/ethnic disparities in COVID-19 incidence and mortality appear to have decreased

As coronavirus spreads in Michigan, racial and age disparities shrink

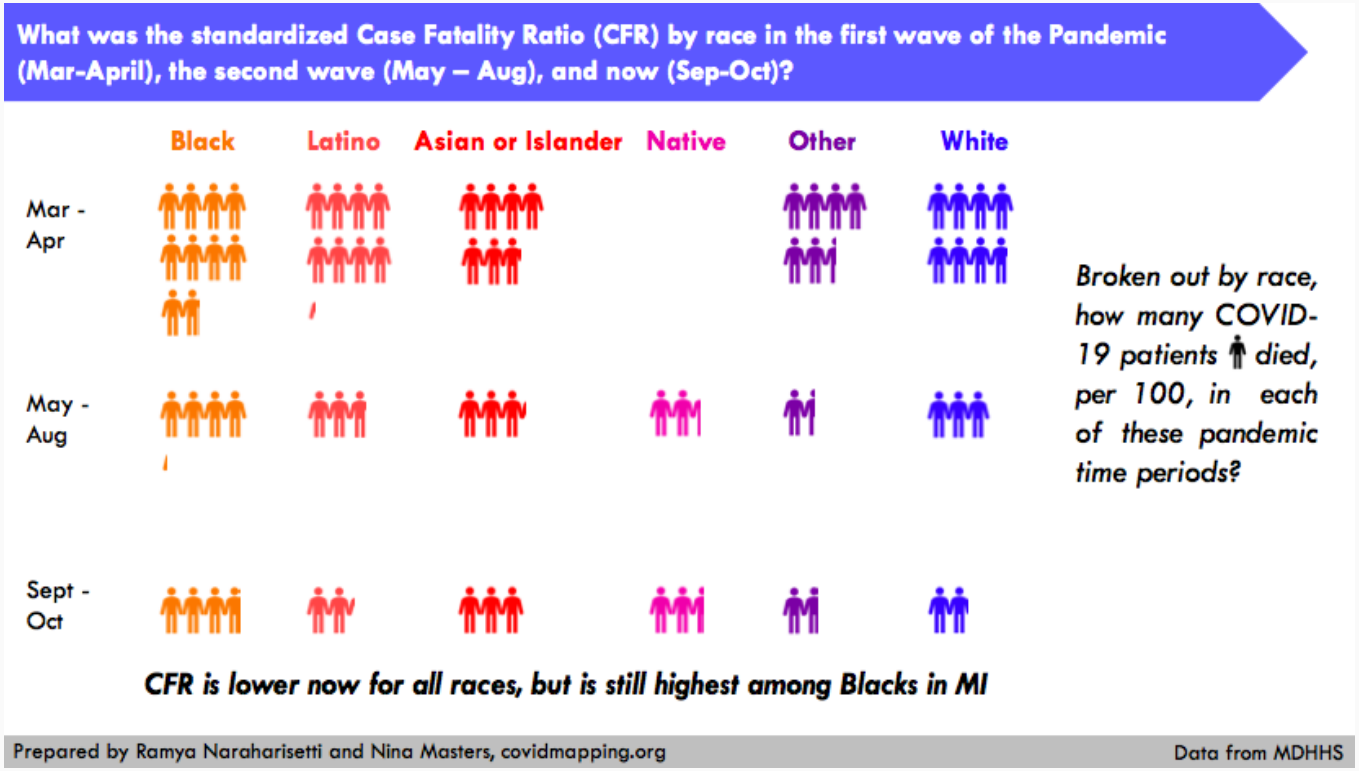
What does this really show us?

But: Rates in all groups went up over the summer



Not clear that this represents significant progress. (Figure from Naraharisetti et al., *In Prep*)

Disparities in overall case-fatality are more impactful now because the average age of infection has decreased



Disparities may increase as case rates plummet if vaccine access and uptake remain inequitable

KFF Filling the need for trusted information on national health issues

New Analysis: Updated State Data Continues To Show Wide Disparities in COVID-19 Vaccination Rates by Race/Ethnicity

Published: Feb 18, 2021

High population-level coverage of vaccination may allow outbreaks to occur if vulnerability remains spatially/socially clustered

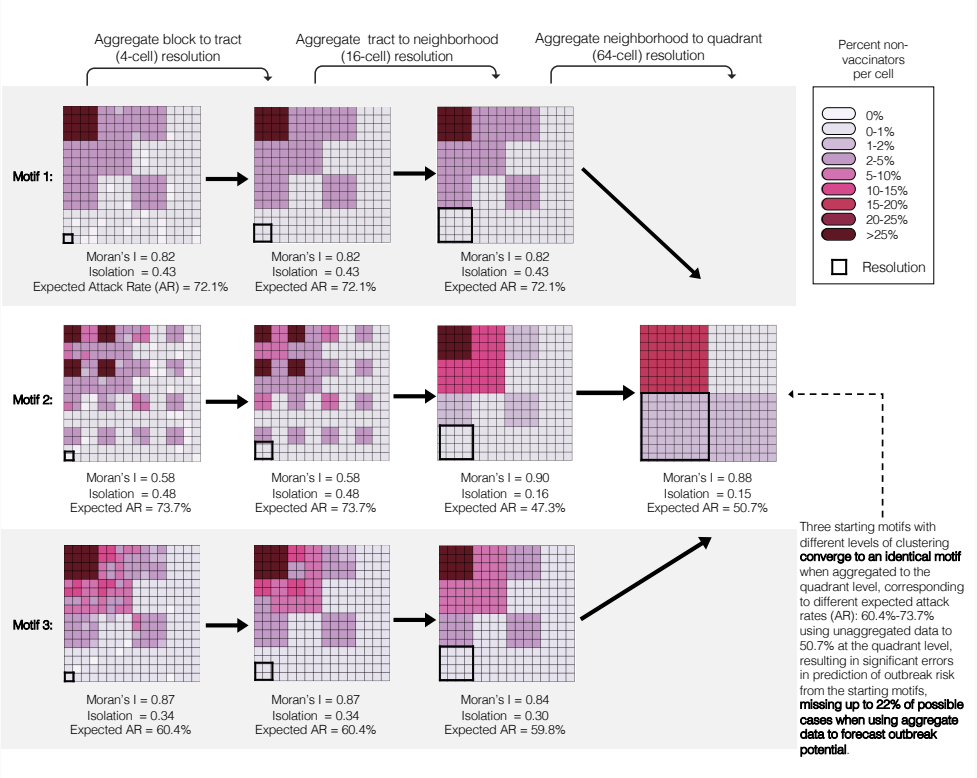


Figure from Masters et al., PNAS 2020 [3]

Equity can't be an afterthought in the epidemiological modeling toolkit

- Mechanisms driving inequality - such as segregation - need to be thought of as integral rather than ancillary to transmission.

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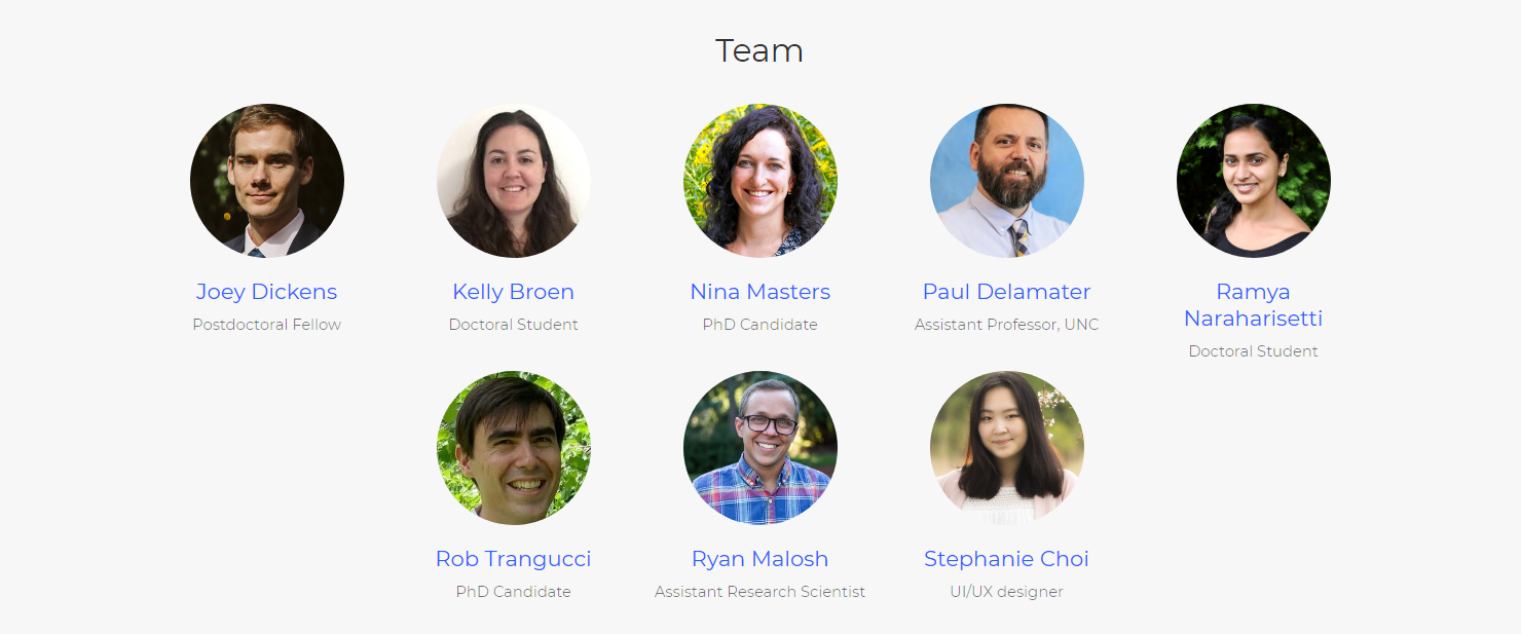
- Ultimately reflect the type of heterogeneity [2] that has been a significant focus of research around COVID-19.

Equity can't be an afterthought in the epidemiological modeling toolkit

- Mechanisms driving inequality - such as segregation - need to be thought of as integral rather than ancillary to transmission.
- Ultimately reflect the type of heterogeneity [2] that has been a significant focus of research around COVID-19.
- But they provide more causal explanations for heterogeneity and may potentially lead to more effective solutions.

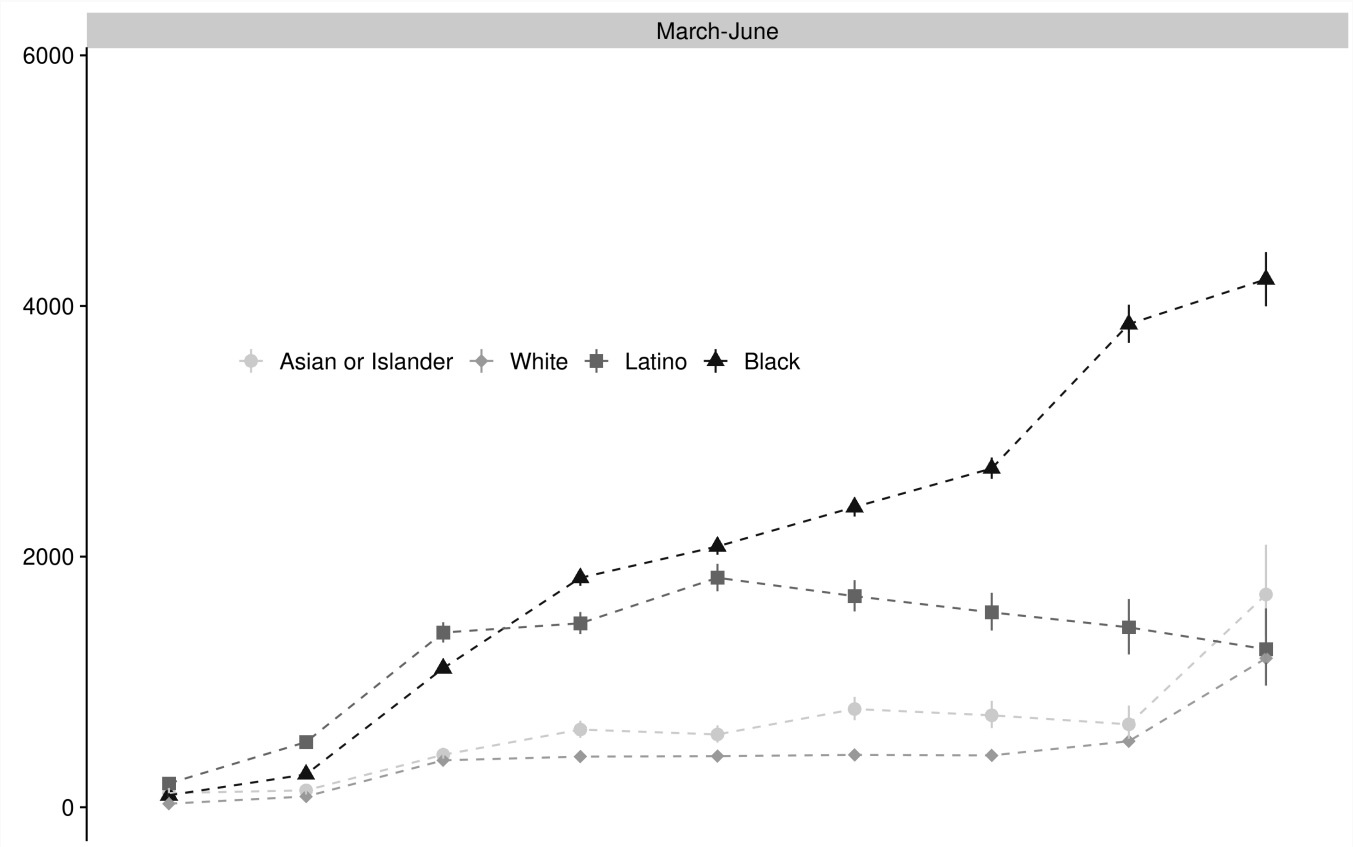
Thanks!



Not Pictured: Alex Cao, Krzysztof Sakrejda

Appendix

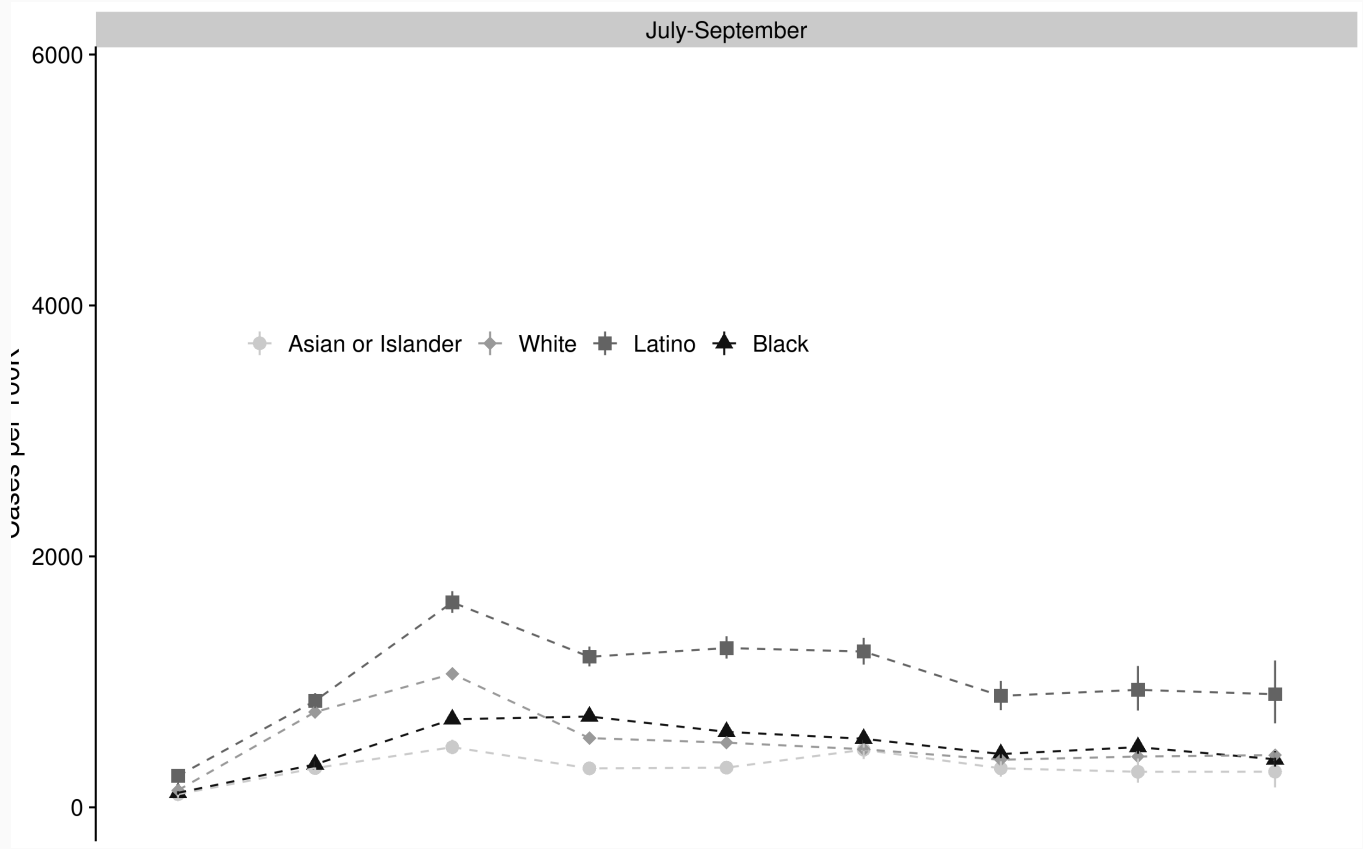
COVID-19 inequalities are a moving target



Age-specific incidence rates by race/ethnicity in MI - March-June 2020

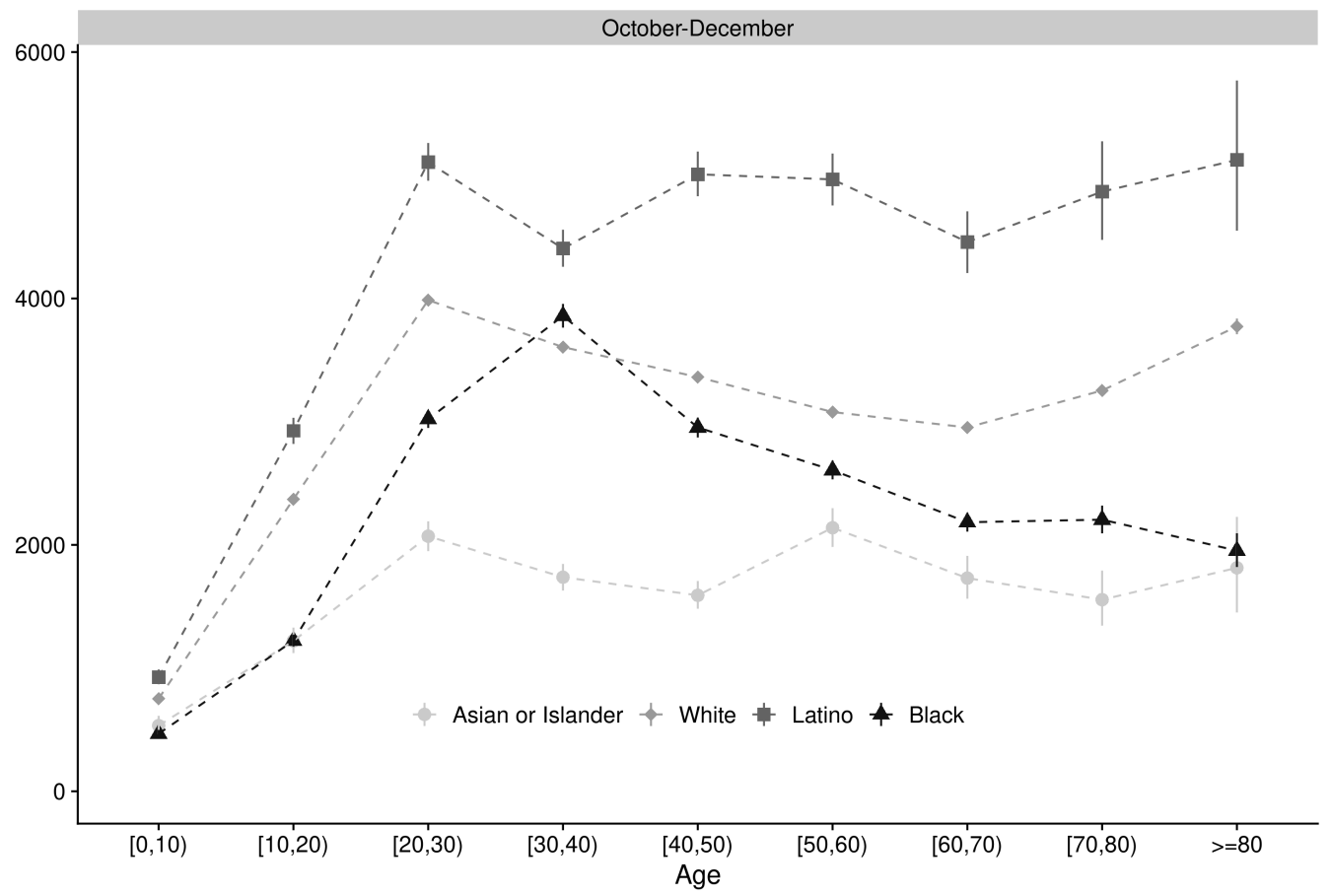
(Figure from Naraharisetti et al., *In Prep*)

As the pandemic has progressed, risk has shifted



Age-specific incidence rates by race/ethnicity in MI - July-September 2020

Different Inequities ≠ No Inequities



Age-specific incidence rates by race/ethnicity in MI - October-December 2020

References i

[1] Merlin Chowkwanyun and Adolph L. Reed. “Racial Health Disparities and Covid-19 — Caution and Context”. In: *New England Journal of Medicine* 383.3 (July 2020), pp. 201–203. ISSN: 0028-4793. DOI: 10.1056/NEJMp2012910.

[2] J. O. Lloyd-Smith et al. “Superspreading and the Effect of Individual Variation on Disease Emergence”. en. In: *Nature* 438.7066 (Nov. 2005), pp. 355–359. ISSN: 0028-0836, 1476-4687. DOI: 10.1038/nature04153.

References ii

[3] Nina B. Masters et al. “Fine-Scale Spatial Clustering of Measles Nonvaccination That Increases Outbreak Potential Is Obscured by Aggregated Reporting Data”. en. In: *PNAS* (Oct. 2020). ISSN: 0027-8424, 1091-6490. DOI: 10.1073/pnas.2011529117.

[4] Jon Zelner et al. “Racial Disparities in COVID-19 Mortality Are Driven by Unequal Infection Risks”. en. In: *Clin Infect Dis* (2020). DOI: 10.1093/cid/ciaa1723.