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Authors

Cassels, Susan
Van Den Abbeele, Sigrid

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A call for epidemic modeling to examine historical and structural drivers of racial disparities in infectious disease

Susan Cassels[*], **Sigrid Van Den Abbeele**

Department of Geography, University of California, Santa Barbara, CA 93106-4060, United States

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Racism is a fundamental cause of health disparities (Link and Phelan, 1995; Pirtle, 2020; Williams and Collins, 2001). Fundamental causes take dynamic pathways to cause multiple disparate health outcomes. Disparities in Black and white health, specifically, are due to past and present racism and structural inequities such as hyperincarceration, segregation, and discriminatory housing and employment policies (Pirtle, 2020; Williams and Collins, 2001). The recent paper by Richardson et al. (2021) identified two mechanisms that link racism to higher risk of SARS-CoV-2 infection for Black Americans: Black workers overrepresented in front-line work, and living in higher density housing (Richardson et al., 2021). Then they used epidemic modeling to examine how reparations payments to Black Americans in Louisiana could impact variables that determine the COVID-19 reproductive ratio, R0. Rarely have epidemic models for infectious diseases incorporated structural drivers of health disparities, thus it is commendable that this paper extended their modeling approach to include such drivers. However, in order to parameterize modeling frameworks to accommodate these larger historic and structural drivers, significant assumptions regarding causal pathways that link structural drivers to explicit mediating mechanisms in the models are needed. Classically trained epidemiologists and social scientists are taught to be wary of assumptions that lack robust empirical evidence. Nonetheless, epidemic modeling is indeed the platform in which we can, and some may argue should, explore the space of imagined or "radical approaches to public health problems" (Schwartz et al., 2016). Given the urgency and critical need to combat racial disparities in health, epidemic models that evaluate large-scale, structural interventions should be a significant part of scientific discourse (Richardson et al., 2021). Thus, we hope that this paper and our response will act as a call for others to develop innovative epidemic models to further examine historical and current structural drivers of infectious disease disparities. Two important developments are needed. First, further research must clarify and parameterize the intervening mechanisms that link racism and other structural factors to health disparities. Second, as the authors state, the academic community needs to embrace creative and imaginative alternatives when objective, well-defined parameters are not available.

[*]Corresponding author. scassels@geog.ucsb.edu (S. Cassels).

Epidemic models of infectious disease have long been used to evaluate the impact of interventions on population-level health outcomes (Garnett, 2002; Heesterbeek et al., 2015). Over the past 20 years, significant progress has been made in incorporating social and behavioral determinants in epidemic models (Cassels et al., 2008), and thus modeling has been an important component in supporting societal-level interventions to reduce health disparities. For example, epidemic modeling has been critical in examining racial disparities in HIV (Goodreau et al., 2017), as well as assessing social and behavioral interventions (Jenness et al., 2019). These models have been bolstered by substantial empirical research to parameterize the proximate biological and behavioral determinants, such as selective mixing by race or serostatus (Beck et al., 2015; Birkett et al., 2019). The next wave of epidemic modeling needs to incorporate 'upstream,' distal drivers of health disparities (Shannon et al., 2015). Epidemic models should be used to examine a) how past and present structural drivers affect health disparities, and b) evaluate the potential impact of structural interventions. The key challenge is that we do not always have 'objective,' well-defined parameters to represent the complex realities and causal pathways of structural drivers of health disparities.

The first step to improve epidemic modeling frameworks so that they can integrate historical and structural determinants of health disparities is to improve parameterization. Capturing the multitude of mechanisms through which hyper-incarceration influences contact rates in one parameter is an example of the challenges posed by the inclusion of structural forces in epidemic modeling. Hyper-incarceration may affect race-specific contact rates differently by age, or by the age composition of households. For instance, patterns of age-mixing and risk of SARS-CoV2 transmission are quite different in multi-generational households (Dowd et al., 2020). We also must understand the effects of timing and sequence of interventions. How long before the pandemic would the reparations needed to have been in place to have the effects on health proposed by the authors? Because the housing supply is relatively inelastic and housing prices typically increase in response to positive income shocks (Harter-Dreiman, 2004), the implications of reparations on housing quality and location may be lagged. What is the ideal sequence in which individuals and families receive reparations? How might inequities in implementation influence the efficacy of the intervention? With improved empirical data, we can examine these additional questions with current models.

Systematically approaching epidemic modeling to assess potential impacts of racial-justice and other higher-order interventions should be the gold standard. However, this work must be carried out, and more importantly, openly received in the scientific community, even if the parameterization process is less well-defined. The authors called this an imaginative modeling exercise, and we would like to support and amplify this concept. The demand for health equity and racial-justice interventions is great, but empirical evidence of racial-justice interventions is lacking. (Richardson et al., 2021) claim that racial-justice interventions being inadequately explored could be considered a form of symbolic violence. Due to the lack of empirical evidence, systematic parameterization of this type of structural intervention is not yet available, and thus this process continues to suppress further research. Breaking this chain of oppression by using epidemic models as imaginative exercises can have long lasting impacts. Albeit a different topic and disease, one can point to another imaginative modeling exercise that had positive impacts. Published in the Lancet in 2008 was an

epidemic model assessing universal HIV testing and treatment as a way to end the HIV epidemic (Granich et al., 2009). To many, this model was unrealistic and seemed like a radical idea at the time (Dodd et al., 2010). Regardless of whether that model was precise with well-defined parameters, it instigated debate and additional research, and pushed the field forward. Similar to the Granich et al. article, we consider [this paper] as a conversation starter. At best, the model is correct, and provides a precise estimate of how a racial-justice intervention can reduce Black-white disparities in SARS-CoV-2 transmission rates. At worst, the model sparks conversation, debate, and inspires additional research that could result in creative interventions to reduce health disparities. As long as model assumptions and uncertainties are presented clearly, imaginative modeling exercises will have an important role in advancing science.

As an example, we discuss how epidemic modeling could be employed to explore the efficacy of various interventions for another group disproportionately impacted by COVID-19: people experiencing homelessness. Racial and ethnic minorities are overrepresented in the US homeless population; nearly 40% of people experiencing homelessness are Black (HUD, 2020). The homeless population has a high median age (Culhane et al., 2019) and high rates of communicable and non-communicable diseases (Fazel et al., 2014). Many of these diseases are comorbidities for COVID-19 and could increase vulnerability to infection and complications (Perri et al., 2020). Additionally, the homeless population is more likely to be transient and live in congregate settings, factors which pose obstacles for compliance with public health orders and disease prevention and treatment (Hsu et al., 2020; Perri et al., 2020). The CDC is currently advocating for reduced shelter capacity to adhere to social distancing guidelines and the maintenance of encampments unless individual housing units are available (California Department of Public Health, 2020; Centers for Disease Control and Prevention, 2020). An early estimate demonstrated high risk among the homeless population for infection, hospitalization, and death from COVID-19, and the authors calculated the cost of meeting the CDC requirements for the existing homeless population at roughly $11.5 billion (Culhane et al., 2020). However, this study only addresses the existing homeless population in a time when economic crisis will likely increase homelessness, and it uses a homogenous infection rate (Culhane et al., 2020). An epidemic modeling approach is needed to capture differential risk for COVID-19 and consider the efficacy of large-scale interventions such as near-universal rapid rehousing (an intervention that prioritizes returning a household to permanent housing and minimizing time spent in congregate settings (HUD, 2014)). Due to structural inequities and stigma, compliance with public health measures like sheltering in place and social distancing require a level of privilege that is denied to people experiencing homelessness (Perri et al., 2020).

The crisis of COVID-19 among the homeless population and other at-risk populations presents “a moral imperative to act” (Coughlin et al., 2020), and an opportunity to start conversations about making substantive change in the future through new approaches to epidemic modeling. The presence and impact of structural and institutional inequities and pervasive health inequalities necessitate change. One way in which academics can contribute to change is by using epidemic models to creatively examine fundamental solutions to public health problems.

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