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PERSPECTIVE

Modeling to inform economy-wide pandemic policy: Bringing epidemiologists and economists together

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Throughout the COVID-19 pandemic, policymakers have been tasked with designing and implementing policies in the face of extraordinary uncertainty (Manski, 1999) and stark trade-offs between public health and other measures of human well-being. Policies designed to "flatten the curve" through social distancing often have negative economic consequences, such as unemployment, food insecurity, and business and school closures. The downstream consequences can also extend to outcomes more directly related to health, including intimate partner violence, addiction, depression, anxiety, suicide, and delays in medical treatments. Thus, efforts to mitigate the direct public health consequences of COVID-19 may not only have negative effects along other (e.g., economic) dimensions, but can have adverse indirect public health consequences as well. By the same token, however, choosing not to aggressively address the immediate public health crisis posed by COVID-19—a choice that has often been justified as a means of avoiding calamitous economic consequences—has driven repeated waves of exponential disease spread. These waves have not only driven morbidity and mortality; they also have had negative indirect effects on the economy, necessitating prolonged shutdowns and delaying resumption of economic activity. In summary, policies designed to promote public health or to preserve the economy can have the opposite effect on both dimensions.

This paper represents a collaborative effort. All authors contributed equally and are thus listed in alphabetical order.

Both epidemiologists and economists have been called upon to analyze and forecast the complex ways that public policy during a pandemic affects the interplay between health and other measures of well-being (sometimes called "health-wealth tradeoffs," a shorthand we adopt). Unfortunately, the perspectives provided from these two fields have often appeared to be in conflict. This need not be the case. Economists and epidemiologists each use mathematical models to make ex ante policy recommendations. This means that a model of people, a pathogen, and their interaction is built and then used to predict outcomes under different policies *before they are chosen and implemented*.[1] While the tools employed to formulate these models are similar, which should enable communication across disciplines about respective approaches to pandemic policy, in fact, differences between these disciplines emerge because epidemiology and economics have traditionally tailored their models and techniques toward different questions and objectives. These different emphases often translate, in practice, into different modeling assumptions that, in turn, can produce diverging policy prescriptions.

A key difference is that epidemiologists and economists often think differently about human behavior during a pandemic. Both groups recognize that there are feedback mechanisms between the pathogen, the population, and individual choices. Models from both disciplines incorporate how behavior may shift during different phases of the epidemic. Thus, for example, it is not controversial in either group that, as a pandemic wave subsides, individuals are more likely to engage in behavior that is conducive to transmission. Key differences lie, however, in how much emphasis is placed on (a) understanding the degree to which behavior shifts occur (and the corresponding impacts on infection transmission), (b) the primary factors considered that might drive that behavior, and (c) balancing health outcomes with non-health outcomes. Epidemiologic models generally emphasize understanding of health outcomes; thus, behavior shifts, and drivers thereof, are considered important largely to the extent that they affect public health. Economic models, by contrast, generally emphasize health-wealth tradeoffs; thus, understanding economic implications and drivers of behavior change is often seen as a primary goal of the model rather than as a "means to an end" of understanding health outcomes.[2]

These differences in emphasis open both disciplines to critique. A reasonable critique of most economic models is that they impose strong and unrealistic assumptions on disease and transmission dynamics and ignore important heterogeneity in individual disease susceptibility, infectiousness, and/or severity. For example, the canonical Grossman model of health capital takes an extremely simplified, unidimensional view of health and health risk—agents want health largely to be productive in other dimensions. In contrast, a reasonable critique of most epidemiological models is that they fail to explicitly model the preferences and constraints that drive individual decision-making, leading to poor predictions of how individuals respond to evolving disease risk and fundamental health-wealth trade-offs. For example, in the standard epidemiological Susceptible, Exposed, Infectious, Recovered (SEIR) model, individual susceptibility is given by an identity rather than by a flexible function from a model of decision-making capturing heterogeneous endogenous behavior change.

Conflicting policy recommendations arising from the two disciplines, while an understandable outcome of their different approaches, are costly. They contribute to uncertainty, help to perpetuate a general lack of trust in science, and undermine the role of science in guiding policy. In today's highly polarized environment, when even scientifically grounded ways out of the crisis (such as scale-up of highly effective vaccines) are called into question, lack of consensus leads to confusion at best and exploitation of scientific findings at worst. A policymaker attempting to "follow the science" can be left to sift through two different sets of modeling results—one from an epidemiological perspective that lacks explicit consideration of economic outcomes or individual health-wealth tradeoffs, and one with an economic framing that omits important features of disease dynamics and linkage of policy to health outcomes.

In response to this "crisis of communication," we convened a group of scholars from epidemiology, economics, and related fields (e.g., statistics, engineering, and health policy) to discuss modeling economy-wide pandemics, which we define as infectious disease epidemics that are large enough to affect the aggregate economy (e.g., economic growth, GDP, or employment) so that economic and public health impacts must be addressed simultaneously.[3] The goal of these discussions was to chart a path forward for more effective synergy between disciplines. The spirit of this conversation was to foster communication between economists and epidemiologists—who are methodologically capable of critiquing each other's models but often unaware of the historical reasons or theoretical grounds for selecting certain approaches. Such communication would enable experts from each field to: (a) better understand the conceptual underpinnings of models from the other discipline; (b) obtain input as to the potential weaknesses of their own models from the perspective of the other discipline; (c) develop consensus about how to balance results from potentially divergent models from the two fields; (d) agree on the data that might be most important to collect; and (e) discuss which methodological or theoretical aspects of each discipline might be most important to consider incorporating to improve future pandemic models.

Our discussion centers on the idea that the best path forward is to recognize differences across disciplines and to address them as directly as we can through policy built upon collaborative science. Of course, consensus is not always possible. But if epidemiologists and economists jointly tackle pandemic policy analyses, we believe they are likely to come to a more fully

informed view, and to arrive at a set of conclusions that both groups can comfortably accept and communicate to policymakers. Serious efforts to collaborate and to build consensus across disciplines can help to avoid dangerous pitfalls, such as the proliferation of extreme viewpoints with little scientific support, which feed facile—and often political—narratives. To highlight two extremes, consider Murray (2020) and Herby et al. (2022). While Murray (2020) suggests the need for collaboration across disciplines, she concludes that "we need not choose between a healthy public and a healthy economy!" which downplays that a pandemic presents policymakers with difficult tradeoffs between population health and other forms of well-being. At the opposite extreme, Herby et al. (2022) claim that lockdowns are ineffective at reducing virus spread. Neither position is supported by an overwhelming preponderance of evidence suggesting that lockdowns (along with other extraordinary measures designed to protect public health) entail both massive social benefits and massive social costs—and should be analyzed as such.

To provide an anchoring example of the differences in approach commonly taken by epidemiological and economic pandemic models, our group of scholars considered a hypothetical context in which a model might inform policy decisions related to COVID-19. We settled on restaurant capacity restrictions as a tangible scenario in which both epidemiological and economic data and approaches could be brought to bear. In suggesting models to evaluate restaurant capacity constraints during a pandemic, experts in each discipline considered both individual behavior and the spread of infection, but neglected elements that the other discipline would consider to be essential. Members of both disciplines agreed on the importance of: (a) considering health and economic outcomes together; (b) using data to inform differential disease transmission (i.e., mixing patterns, infection progression) and endogenous behavioral responses; and (c) making the model realistic in terms of disease burden and human behavior. However, the relative prioritization of these different elements differed dramatically. Epidemiologists were willing to accept strong simplifying assumptions in the realm of economic outcomes, data on endogenous behavior, and the mechanisms by which individual people might respond to policies; whereas economists were willing to accept equally strong assumptions regarding outcomes of disease spread, data on heterogeneous mixing patterns, and realism in terms of calibrating the model to population-level disease burden.

The example above illustrates the potential benefits of closer collaboration between economists and epidemiologists in economy-wide pandemic modeling (and, indeed, other economy-wide public health crises). First, experts in both fields have the capacity to improve models from the other discipline, not least by simply identifying critical omissions and explaining their importance. For example, as economists were describing their proposed modeling approach, epidemiologists in our group described how such models could do a better job of incorporating key features of the underlying transmission dynamics and calibrating to population-level epidemiological indicators. Similarly, when epidemiologists described their model, economists noted how richer heterogeneity in endogenous behavioral responses could be included. Thus, it is not that either discipline's modeling approach was incapable of accounting for the priorities of the other; rather, the "fatal flaws" identified in each discipline's model largely reflected a failure to prioritize elements that experts from the other discipline considered crucial. Second, through closer communication, the intrinsic biases of each field may be partially mitigated. Epidemiological models could, for example, be constructed that place more emphasis on individual behavior and preferences—while economic models could similarly be developed that incorporate greater consideration not only of disease spread itself, but also of specific health-related constraints (e.g., ICU beds, medical personnel, and ventilators). Third, bringing epidemiologists and economists together could result in recommendations that might be better trusted by decision-makers—and by extension, the general public. Rather than having to decide between models with disjointed (or even competing) results, policymakers could instead be presented with a more holistic and balanced picture, with both disciplines (and their potential disagreements) represented in the same set of results, recommendations, and considerations. In a setting of unconstrained time, resources, and data, the ideal model for informing economy-wide pandemic policy would likely be a highly detailed framework including multiple representative populations, with that framework built by a multidisciplinary team including epidemiologists and economists and incorporating granular detail on biology, disease transmission, and individual behavior. However, this longer-term work requires a foundation of mutual trust and understanding, which must first be built.

During a rapidly evolving pandemic, quick decisions are necessary, modeling resources are limited, data sources are never complete, uncertainty abounds, unexpected circumstances arise, new information emerges, and the ideal infrastructure cannot be built overnight. It is therefore unlikely that the full modeling infrastructure necessary to plan for any given pandemic can be fully operationalized in advance. A pragmatic path forward, therefore, might address the question, "How can epidemiologists, economists, and other experts start working together to produce a coherent evidence base for pandemic policymaking in the context of known constraints?" We propose a six-step approach in response.

Figure 1 depicts six steps toward bringing epidemiologists and economists together for improved decision-making. The initial step is to learn each other's language and priorities. If economists learn why epidemiologists value model components such as unbiased population-level data, calibration to time-dependent disease burden, and secondary transmission, and epidemiologists begin to understand why economists use utility functions, tradeoffs, and endogenous behavior, then experts from

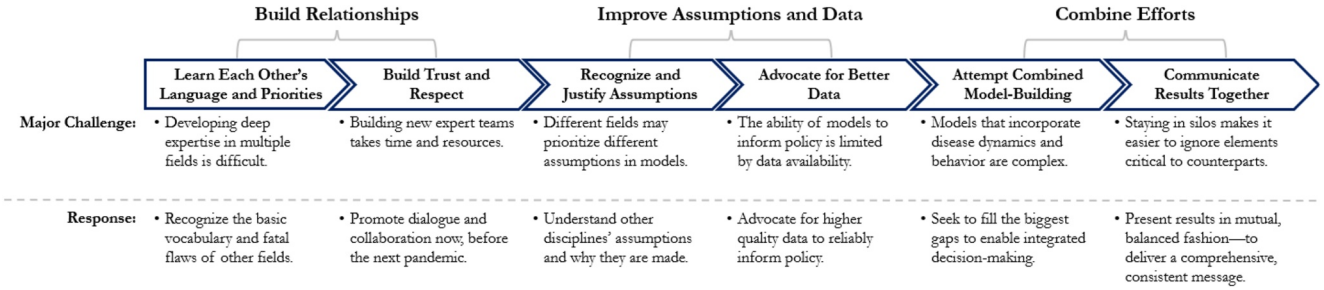

FIGURE 1 Six steps toward bringing epidemiologists and economists together for evidence-based pandemic decision-making

both fields can be more careful in constructing their own models. After developing something of a shared vocabulary, economists and epidemiologists could begin to form teams (before the next pandemic occurs) where they could not only continue to learn each other's language but also observe how those priorities play out in practice. Such collaboration need not (at this stage) involve developing a suite of consensus models to be fruitful. Rather, experts from both disciplines might still work in their own domains, but by observing how members of the other discipline think and act, mutual trust and respect would likely emerge.

Beyond the experience of language-learning and trust-building, epidemiologists and economists can also work together to achieve common goals. In a third step, for example, experts from each discipline tasked with guiding specific policy could come together with their potentially competing models to explicitly discuss their assumptions, thus subjecting them to challenge from experts in the other field. It is likely that such an exercise would expose assumptions not thought in one discipline to be particularly strong or limiting—but perceived by the other discipline to be fatal. With sufficient dialog, experts in both fields could potentially agree on the model modifications and data collection priorities that would be most critical to further modeling efforts.

Once a rough consensus is developed between economists and epidemiologists with respect to critical assumptions and data gaps, a sufficient foundation should exist for useful combined model-building exercises between the disciplines. In building a consensus model, experts from both fields would be explicitly forced to make compromises and thus come to terms with their own underlying disciplinary philosophical biases—and potentially overcome them. Finally, whether or not epidemiologists and economists can succeed in building combined models, we must learn to provide consistent and harmonious messaging (or clearly articulated reasons for discrepancies) to decision-makers. Only in this fashion can decision-makers receive expert advice as to how they can appropriately balance the priorities of epidemiology and economics—rather than simply receiving siloead advice from each side and being forced to make decisions between the two on their own.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

No data were used in preparation of this manuscript.

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ENDNOTES

[1] We distinguish this approach from program evaluation, sometimes called ex post policy evaluation, which refers to analyses that examine the impacts of policies that have been implemented in the past.

[2] We recognize the challenge of doing justice to the vast modeling and COVID-19 literature in epidemiology and economics. James et al. (2021), Haber et al. (2021), and Lemaitre et al. (2021) discuss modeling considerations from epidemiology, while reviews in Brodeur et al. (2020) and Papageorge (Forthcoming) highlight economic perspectives to these questions.

[3] A complete summary of our discussions, along with a wider literature review, may be found in Darden et al. (2021).

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