Complexity and the Health-Wealth Relationship: Politics, Public Policy, and the Joint Inheritance of Wealth and Health

Gregory Robinson
Assistant Professor
Department of Political Science
Binghamton University (SUNY)

ABSTRACT

This paper addresses a puzzle in the literature on the social determinants of health—why are wealthier people healthier? The answers seem obvious, from childhood nutrition to lifestyle advantages to the ability to afford better health care. The puzzle arises, though, from the empirical finding that, controlling for lifestyle and resources, *wealth is still a significant predictor of health outcomes*. While some plausible causal mechanisms have been identified for this phenomenon, this proposal seeks to augment those explanations with an argument about how wealth and other resource endowments influence the selection of sexual partners.

Put another way, the principal argument of this paper is that if wealthier individuals are advantaged in the selection of healthier mates, and if endowments of health and wealth are inheritable by progeny, then the wealth-health relationship within any particular generation is necessarily attenuated. That is, wealth's relationship to behavioral factors, environmental factors, resource factors, and even physiological factors must be viewed in the context of how wealth in previous generations can influence inherited traits in the current generation.

More generally, however, the paper puts forward a model of the relationship between wealth and health outcomes that takes seriously notions of "financial" and genetic inheritance. Using an agent based modeling (ABM) approach, I can then move toward a model that allows the simulation of different policies and their subsequent effect on the wealth-health relationship over time. In this way, I can show how the decisions governments make about health policy, and the political constraints on their decisionmaking, affect the fundamental causal process that underlies the joint (or potentially *independent*) inheritance of wealth and health.

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The Argument

This paper deals with a fundamental process affecting health outcomes that governments cannot (or will not) regulate and the implications of that process for policy makers. It is about the persistence of the wealth-health relationship, a term that characterizes the *independent* effect of higher wealth on health outcomes. And it is about bringing agent based modeling to the debate over the design and implementation of public policy.

The principal argument in this paper is that if wealthier individuals are advantaged in the selection of healthier mates, and if endowments of health and wealth are inheritable by progeny, then the wealth-health relationship within any particular generation is necessarily attenuated. That is, wealth's relationship to behavioral factors, environmental factors, resource factors, and even physiological factors must be viewed in the context of how wealth in previous generations can influence inherited traits in the current generation.

This argument does not, however, set aside these other crucial factors in explaining the persistent wealth-health relationship. Health outcomes are the result of a complex, dynamic process driven by behavioral factors, inheritable factors, and essentially stochastic processes. Recognizing this, but wishing to highlight the role of inheritance, I propose an agent based model (ABM) of health outcomes that can capture the complexity and the dynamic processes that drive health outcomes. Most importantly for this proposal, the model has obvious import for questions of public policy because of the ease with which somewhat simplified health policy programs (and their political determinants) can be introduced into the model. The behavior of the posited agents, following simple decision rules, and their response to these policy interventions can then provide lessons to scholars and policymakers with an interest in shaping effective solutions to social disparities in health outcomes, as well as showing political scientists a valuable way of modeling how citizens' evaluations of the impact of policy on their lives in turn produce demands for new policies and for reform.

The Literature

The current state of the literature on the social determinants of health owes much to studies of the United Kingdom that began to be published in the 1980s. The so-called Black Report (Working Group on Inequalities in Health 1980; Black et al. 1988) and Whitehall Studies (Marmot et al. 1984, 1991) brought a curious result to the attention of public health scholars, sociologists, political scientists, economists, and beyond. This result is that wealth/social status has an *independent* effect on health outcomes. Others, notably McDonough et al. (1997) and Pappas et al. (1993) found evidence of the same phenomenon in the United States. Moving from identifying the pattern, otherwise known as the social gradient, to explaining the pattern has proven difficult. The difficulty has been largely driven by the inability of scholars to work past the obvious correlates of wealth (see Working Group on Inequalities in Health 1980) to explanations of wealth's independent effect.

Probably the best explanation so far offered is found in Marmot et al. (1997, 1998), with the argument that wealth, resources, and work environment are related to "perceptions of control and self-efficacy" (1998, 405), which in turn have significant physiological consequences that effect morbidity, mortality, and general wellness. While not discounting this argument, I argue that it needs to be augmented with a consideration of wealth's capacity to bias health-based selection of mates, which therefore leads to persistent inequalities in the wealth *and* health being handed down, in tandem, to future generations.

The argument presented here, then, relies heavily on the notion of *selection*. This is a term used in the literature on the socio-economic determinants of health, but which is used to describe a phenomenon that could better be called endogeneity. As Marmot et al. (1998) describe selection in this context, "people in worse health end up in a lower socioeconomic position and... this accounts for the relation between socioeconomic status (SES) and health" (438). This is not the way the term selection is intended to be read in this proposal, but it does represent an important factor influencing health that I will work to include in extensions to the model I outline below.

My hope is that the argument being presented here will have an impact both in the literatures on public health, health policy, health economics, etc. and in the literature advancing agent based models of complex social phenomena.

The Modeling Strategy

Whether we are curious about something as banal as the origin of traffic jams or the incidence of standing ovations at public performances (Miller and Page 2007), or something as serious as the incidence of ethnic violence (Bhavnani 2006), agent based modeling is a powerful tool for scholars of social and political phenomena . Agent based modeling is an approach well-suited to the analysis of less-than-rational behavior and, perhaps more importantly, of phenomena whose analysis with traditional game theoretic techniques is intractable. As discussed above, my argument does not exclude existing explanations, but instead embeds its contribution in the complex set of factors other scholars have identified as driving health outcomes, which necessarily leads to an analytically intractable model. Moreover, the basic argument of this paper views the wealth-health relationship as an emergent phenomenon, which an agent based model is uniquely suited to analyze (Bonabeau 2002).

Emergent here refers to macro-level phenomena that arise (often counterintuitively) from micro-level behavior. Whether the empirical regularity of wealth-driven health disparities is observed at the level of social classes, employment ranks, neighborhoods/communities, it is crucial to base one's explanation of these observations on micro-level behavior, which is one clearly important parallel between agent based modeling and more traditional classical game theory.

As Bonabeau (2002) points out, agent based modeling is well-suited to the description and analysis of systems. While health outcomes are fundamentally driven by individual

factors, policy solutions must necessarily address health outcomes at the system-level. So while we still want to build on an individual-level foundation, if we want to be of use to policymakers in this context, the challenge is to create a model that demonstrates how *the system* responds to policy interventions. Agent based models in general, and specifically the model I outline below, can do just that.

The method of solving complex agent based models is to use computationally-intensive simulations of the phenomenon of interest, starting with agents endowed with information, resources, and decision rules that allow them to interact with each other and with their environment. The model below is not particularly complex, and so is computationally simple.

The Model

I begin with a simplified version of the model. Imagine a generation[1] of agents[2] i_g (one can conceive of them either as males or females, or some of both) who begin with randomly assigned endowments of wealth ($W_{i_g} \in [0,1]$) and health ($H_{i_g} \in [0,1]$). Crucially, there is no statistical relationship between wealth and health at the initial stage of the model. Next, there is a set of mates m_g randomly assigned only health endowments ($H_{m_g} \in [0,1]$). Agents in the set i_g then choose mates in turn from wealthiest to poorest, and produce offspring i_{g+1} with wealth endowment W_{i_g} and health endowment:

$$H_{i_{g+1}} = \frac{H_{i_g} + H_{m_g}}{2}$$

Agents i_g are replaced by their offspring,[3] a new population of mates is generated with randomly assigned health endowments, and the scenario plays out again. Running this scenario for 2000 individuals, the correlation between wealth and health endowments goes from -0.028 to 0.949 by the third generation.

This version of the model is rather deterministic and does little to show the value-added of an agent based model. What it does do at this point, though, is provide the foundation for more complex models that better approximate reality. There are obvious extensions to the model to make it more realistic and, crucially, to facilitate the simulation of policy programs on a population, and more generally, the introduction of politics into the story.

In this version of the model, the mates are not agents *per se*. Future versions of the

[1] *Generation* is used here in the common, genealogical sense.

[2] *Agent* here is part of the jargon of agent based modeling (ABM), referring to imagined individuals whose behavior is modeled by giving them simple decision rules and subjecting them to an imagined decisonmaking environment that the analyst believes captures important characteristics of some real world situation or phenomenon.

[3] They are replaced one-to-one, so the size of the population of individuals remains fixed across generations. This is an assumption that will be relaxed as the project moves forward, but this version functions to illustrate the general outline of the inheritance argument.

model will of course include decision rules for this set of individuals, and will endow them with wealth as well. Wealth does, in fact, produce better health outcomes within generations, and this notion will be an important building block for the model, as it is often the translation of wealth inequality into health inequalities that drives policy interventions. As it stands, the model posits homogenous individuals who are interested only in selecting healthy (as opposed to wealthy, or healthy *and* wealthy) mates. An obvious extension would be to allow the agents in the model to vary according to how they weight consideration of the different endowments of their mates. Agents in the model described above identify the health endowments of potential mates with no error, which is a strong, unrealistic assumption that will be weakened as the project progresses. Perhaps most obviously, the vagaries of reproduction and of the durability of couples are absent from this version of the model. Families vary in the number of children produced, childhood mortality is at least a possibility *and in part a function of inherited health*, and not all couples stay together.

There are dozens of other complications that can be introduced to the model. But one of the core insights of the project is, again, found in the simplest of models—biased selection of mates and inheritability can drive *an important portion* of the empirical relationship between wealth and health.

Bringing Politics and Policy into the Model

Here, I briefly outline extensions to the model that can help simulate broad health policies. First is wealth-based health care system, which can be thought of as a system in which health care is managed by private insurers who provide better coverage to those with the resources to afford it. Fundamentally, then, we move from a model in which wealth and health are, by construction, unrelated within any particular generation to a model in which they *are* related. Here, individuals i_g start with health endowments ($H_{i_g} \in [0,1]$) and wealth endowments ($W_{i_g} \in [0,1]$) but receive an augmented health endowment:

$$H'_{i_g} = \begin{cases} 1 & \text{if } H_{i_g} + W_{i_g}(H_{i_g}) \geq 1 \\ H_{i_g} + W_{i_g}(H_{i_g}) & \text{if } H_{i_g} + W_{i_g}(H_{i_g}) < 1. \end{cases}$$

Wealth is not 'spent' in this process, so the only change to the rest of the model is to substitute H'_{i_g} for H_{i_g} in calculating the health endowment for the next generation of individuals.

Another extension would be to simulate a redistributive health care system. In a very simple tax and transfer system, we have a flat fee F that is incurred where W_{i_g} is greater than some threshold T. In this case, before mates are selected, both W_{i_g} and H_{i_g} are adjusted as follows:

$$W'_{i_g} = W_{i_g} - F \text{ if } W_{i_g} > T$$

and

$$H'_{i_g} = \begin{cases} 1 & \text{if } H_{i_g} + \frac{\sum_{i=1}^{n} F}{n} \geq 1 \\ H_{i_g} + \frac{\sum_{i=1}^{n} F}{n} & \text{if } H_{i_g} + \frac{\sum_{i=1}^{n} F}{n} < 1. \end{cases}$$

Here, wealth has been redistributed in the form of socialized medicine, and health outcomes within generations and across generations begin to converge irrespective of wealth, though wealth-biased sexual selection can still continue to operate at the margin.

Again, neither of these extensions adds much complexity to the model, yet they point to the potential utility the approach has for policymakers. More nuanced policy interventions, like a national catastrophic insurance pool, could certainly be simulated. Indeed, the potential for catastrophic, exogenous shocks to individual health is another element that will be introduced to the model as it grows, and a catastrophic insurance pool is obvious policy whose effects can be simulated.

Beyond these more policy-oriented extensions to the project, there are clear political extensions to the model as well. The very process of choosing an approach to health policy points to Harold Lasswell's (1936) famous definition of politics as "Who gets what, when, how" or David Easton's (1953) definition of politics as "the authoritative allocation of values." Health care is a contentious political issue that has real allocative consequences for citizens and for the leaders who want to win their votes (or at least retain their acquiescence to the regime). The system by which a country elects its representatives, how it organizes its parliament or legislature, and the degree to which it empowers its executive, as well as the ideologies and attitudes of its political elites and individual citizens all help shape health policy, as a casual survey of health care systems around the world demonstrates. Even something as simple as the existence of subnational jurisdictions can affect how health care is provided, and can in turn be modeled using my approach.

The argument I make also has important normative political consequences, suggesting that policy choice can, with time, reshape the most fundamental processes of human interaction. Political elites, in choosing whether or not to intervene in the 'market', can alter the nature of inequality in wealth *and* in health outcomes, and thus the potential for unintended consequences, both beneficial and detrimental, is great.

Concluding Remarks

At this stage of the project, I see many possibilities for the way forward. The first step is to build an architecture for increasingly complex models of health outcomes using an agent based modeling approach. In the future, though, I intend to move from this model toward the testing of its predictions and the evaluation of its assumptions using empirical data.

ABM and computational modeling (or, more generally, complexity science) are of growing interest in various disciplines, fields and subfields. The study of public policy, though, is one area where these methods have so far had little impact. This is unfortunate, because the tools of complexity have important implications for public policy. The ability to simulate the effects of policy interventions on (admittedly) simplified and abstracted versions of the public can help guide policymaking without the need for trial and error in the field. Beyond the substance of my research, I hope that scholars in health policy, health economics, and even health professionals—people with whom political scientists too rarely interact—will be convinced that complexity science offers a useful set of tools for answering all manner of substantive questions. Beyond that, I hope my work going forward helps to address a rather apt criticism leveled at scholars of political institutions—that we too often stop paying attention to policy once it becomes law and leaves the deliberative parts of government and enters the real world where it actually affects the lives of ordinary citizens.

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