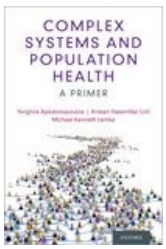

Complex Systems and Population Health

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CHAPTER

19 C19 Making the Global Complexity Turn in Population Health

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Abstract

While the story of population health in the 20th century is one of tremendous success, at the global level (and across various countries) it presently faces a crisis of complexity, due in large measure to the forces of globalization. In response, a growing network of researchers have called for the field of population health to make the "complexity turn" to the complexity sciences. To do so, however, a list of challenges need to be addressed. In this chapter, the author uses a complex systems perspective to critically review how the current conventions of population health—from policy and interventions to research design and methods to accepted standards of practice and education—can be advanced to more effectively deal with its crisis of complexity. The review takes the form of a "top 10" list of critiques.

Keywords: global complexity, globalization, global health, complexity turn, crisis of complexity, global civil society, computational modeling, case-based methods, big data

Subject: Public Health, Epidemiology

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19.1. Population Health: A Story of Success? C19.S1

Nuances aside, the intertwined histories of population and public health throughout the world are ultimately a story of significant accomplishment.[1,2] As proof, a short list is sufficient: clean drinking water, sanitation, food safety, air quality, vaccines and preventable diseases, tobacco control, family planning and so forth.[1,2] And these accomplishments have extended themselves well into the globalized era in which we presently live.[3] C19.P1

Still, despite these accomplishments, population health in the 21st century faces a "crisis of complexity."[4] And the major culprits, it appears (in addition to more localized factors) are the same economic, political, cultural, and technological forces of globalization that have, in many ways, purportedly made the world a better place.[5,6,7] In short, the crisis is one of global complexity.[5,6,7] For example, while our collective well- C19.P2

being, as a planet, has improved overall,[8,9] the more nuanced reality is that population health—broken down by country or region or community—is far too complex, nonlinear, and multiple in its path dependencies to be evolving along a singular path of "getting better" or "getting worse." Also, "getting better" is not the same as "doing great!" As such, claims of improvement need to be modified such that they are more context-dependent, trend-specific, temporally sensitive, and short-term predictive.[10]

Relative to this point, as Szreter[11] outlined in *The Population Health Approach in Historical Perspective*, it appears that, as with most major socioeconomic and scientific-technical advances—albeit with certain exceptions—globalization's economic growth often produces as much harm as good, particularly amongst the ↳ poor and most vulnerable. It is for this reason that Szreter[11,p421] states, "The origin of the population health approach is a historic debate over the relationship between economic growth and human development." And, more to the point, it is not, therefore, simply the neoliberal view of growing the economy that leads to a concomitant linear increase in health and well-being.[10,11,12] Nor is such a "constant growth" solution to health, circa 2020, sustainable.[4,5,6,7] Consider, for example, if India or China, to obtain higher levels of health, lived at the consumption level of the United States.

C19.P3

p. 272

In short, we need more complex ways of thinking to handle the current complex "globalized" problems of population health. We need the *complexity sciences*.[13,14,15,16]

C19.P4

19.2. Adopting a Complex Population Health Perspective

C19.S2

As outlined by a growing network of complexity scholars, it is mainly through the complex, corrective actions of civil society—of which public health is a major part—that the deleterious and corrosive effects of globalization on population health can be assuaged.[2,5,13,17,18] Or, alternatively, it is through global civil society that the positive dimensions of globalization can be harnessed to improve population health the world over. Either way, the point is the same: Improving population health involves a civil society-based array of complex ecological, geographical, socioeconomic, political, psychological, and medical-technical factors, all of which combine to form the complex systems in which population health is situated and with which the health of populations is interdependent.

C19.P5

As illustration of this difference, consider, for example, the distinction between the following two research questions. The first is reductionist and ignores the complex systems in which population health is situated. Here the question is, How do we help poor people deal with their health vulnerabilities? In contrast is the complex systems question, which asks, How do we fix the communities and social institutions and socio-ecological systems in which people live (of which the economy is a part) so that poverty is not a vulnerability to population health?

C19.P6

Still, adopting a complex-systems view of population health, while both necessary and useful, is not always a guarantee for success—no matter what the approach, everything has its limitations. Nor is it true that the current methodological, theoretical, and practical conventions of population health are not still incredibly important—because they are. The better question, then, is how can a *complex systems view* be used to improve how we engage in the science and practice of population health sufficient to better manage the crisis of complexity it currently faces, particularly vis-à-vis the challenges of globalization and global health? All of which brings us to the purpose of the current chapter. We will use a *complex systems perspective* to critically review how the current conventions of population health—from policy and interventions to research design and methods to accepted standards of practice and education—can be advanced to ↳ more effectively deal with its crisis of complexity. Our review will take the form of a "top 10" list of critiques.

C19.P7

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19.3. Making the Global Complexity Turn: A "Top 10" List C19.S3

19.3.1. Theorizing Global Health as Complex C19.S4

Of the various conventions that need to be overcome, the first—which we have already suggested—is probably the most important: Population health needs to accelerate its current trend toward a complex global health framework, from research and practice to policy and academic training.[17,18] More specifically, the field needs to theoretically embrace, as a basis for its models, a *complex global systems* view of population health—that is, one grounded in the understanding that population health, the world over, is self-organizing, emergent, nonlinear, dynamic, path dependent, network-like in structure, and so forth, resulting in a world-wide system of interdependent and interconnected systems—albeit even if these systems are only partially connected in fragmented ways.[7] C19.P8

Getting population health to embrace this view, however, will most likely prove difficult. Part of the problem is the larger socio-political context in which such a *complex global systems* view approach is situated, including populist debates over the value of science and expertise in policy[3]; as well as the neoliberal tendency—as discussed earlier—of international policy to focus too narrowly on growing the economy of "developing" countries to improve population health.[6] C19.P9

Relative to this point is the mindset amongst many western societies that global health is a foreign problem. As Frenk, et al.[18,p94] state, "in the media, in lay and scientific literature, and in major initiatives, global health is still identified with problems supposedly characteristic of developing countries, and global cooperation in health with a sort of paternalistic philanthropy that is armed with the technological developments of developed countries." What is ironic about this approach is that the real essence of globalization, in truth, is that the health of any given population, including western countries, is often tied in highly complex and nuanced ways to the well-being of others. Which we have recently seen, for example, with the coronavirus pandemic. Frenk et al.[18,p94] ask, "How should global health be understood in an era marked by the rising burden of non-communicable diseases (NCDs), climate change and other environmental crises, integrated chains of production and consumption, a power shift towards emerging economies, intensified migration, and instant information transmission?" Their answer: "Global health should be reconceptualized as the health of the global population, with a focus on the dense relationships of interdependence across nations and sectors that have arisen with globalization."[18,p94] And the reason for doing so, they argue, is that it will help to ensure that the health of any one population is "duly protected and promoted, not only in the post-2015 development agenda but ↳ also in the many other global governance processes—such as trade, investment, environment, and security—that can profoundly affect health."[18p94] C19.P10

p. 274

19.3.2. Definitional Struggles C19.S5

In addition to embracing a *complex global systems* view, scholars and practitioners alike need to resist the temptation to reduce population health to the purview of cost control or bureaucratic management. The first, as outlined by Sharfstein,[19] is the extent to which controlling costs should ultimately dictate the goals of population health. For example, seeing air pollution prevention in strictly economic terms often pushes policies to be more reactive and policy-cycle focused. Such an approach also tends to devalue, reduce, or remove more long-term but important services, particularly large-scale population-based preventive measures, which are in a better position to embrace a complex-systems view of the problem being addressed. An example would be reducing exposure to $PM_{2.5}$ by improving the built environment for vulnerable groups in urban environments. C19.P11

The second mindset (which is more of a western society issue among globally northern countries) is the degree to which a population should be limited to the patients, employees, or members of an insurance plan or, in turn, the degree to which a population is confined to a specific health issue or a clinical group.[19,20,21] The result, as Diez Roux[12] explains, is one of the current challenges for the population health movement: Despite its best attempts to treat populations across scientific and bureaucratic categories, the complexity of this concept is regularly appropriated in the service of the more focused goals of health finance, healthcare management or research.[1,2,4,12] Examples include such neologisms as *population health strategy* (i.e., enrolling as many people as possible in a healthcare plan) and *population health solutions* (i.e., offering healthcare members and providers such options as wellness programs and surgical device management).[19,20,21] C19.P12

19.3.3. The Methodological Problem of Organized Complexity C19.S6

The third is the need for a *complex global systems* view of population health to see complexity as organized.[22] In 1948, Warren Weaver[23] published an article titled, *Science and Complexity*, that addressed what he saw as the future problem of all research, including the burgeoning fields of population health and policy evaluation. According to Weaver, the basic problems of science can be organized, historically speaking, into three main phases. The first phase focused on *simple systems*, comprised of a few variables and amenable to near-complete mathematical descriptions. The second phase, which was the birth of statistical mechanics, focused on *disorganized complex systems*, where the unpredictable microscopic behavior of a very large number of variables makes them highly resistant to simple formulas. Hence, this phase was the golden age of statistics. C19.P13

p. 275 Finally, there was the forthcoming third phase (*ca.* 1948), based on the challenges of *organized complex systems*. Here, the focus is on how the qualitative interactions amongst a profile of variables and the (equally important) emergent, self-organizing, aggregate system they create come together to determine their complexity. For Weaver, examples of such systems cut across the health and social sciences, including population health.[10,13,14,15,24,26] The problem, however, is that such systems cannot be effectively modelled using the conventional statistics of disorganized complexity. Needed, therefore, was a methodological revolution, grounded in the forthcoming age of the computer, which Weaver presciently saw on the horizon. C19.P14

So that was 1948. What has happened since then? As we know, the computational modeling revolution took place, along with the sweeping development of the complexity sciences, all of which changed (and are presently changing) the world.[22] Meanwhile, public health has basically kept calm and carried on, continuing to develop the same repertoire of conventional quantitative methods and treating populations as disorganized complex systems of aggregate individuals and households. The result, circa 2020, is that most population health experts are woefully unequipped to effectively model the global complexity that has thrown the field into crisis. C19.P15

19.3.4. Data Mining Big Health Data

C19.S7

C19.P16 Related to the crisis of complexity is that of big data. As outlined elsewhere,[24,25,26,27] the globalized world(s) in which we now live, including the complex health systems in which population health is grounded, have become massively digital—from diagnostic software and geospatial disease-tracking systems to nudgewear and the big-data health-informatics databases upon which population health increasingly depends. In terms of big health data, the challenges revolve around what are called the Six Vs. First, there is *volume*: Big health data often exceed current capacity for storage. Second is *variety*: Big health data come in a wide array of types and formats and at multiple levels of scale, including inconsistencies in how a factor or variable is defined or measured, as in the case of a disease or health condition. Third is *velocity*: In our big data world, the issue is not just the speed at which health data are being generated, but also the speed at which they often need to be acquired. Also, there is a significant amount of health data that need to be understood in real time (e.g., flu season trends), which speeds up the decision-making process, forcing population health officials to make decisions, often times, in a matter of days or weeks. Fourth is *variability*: While the velocity and volume of health data appear constant, in actuality they are rather variable, with inconsistencies in their flow, as in the case of a sudden Twitter trend or online searches in response to a disease outbreak. Fifth is *veracity*: Big health data are often not in a format that makes them easily explored or linked together. Consider, for example, the massively unstructured and inconsistent formats in which health data are currently available. Sixth is *vulnerability*, which exists in two major forms: (a) hardware or software breakdown and (b) hacking, cybersecurity, and privacy issues.

p. 276 C19.P17 As a result of these six major challenges, the critics of big data warn that, for all of its potential, it cannot fully deliver on its promise, as there is a major difference between lots of data and high quality information.[26] Correct or not, the problem is that big data are not going away, particularly in terms of the massive increase in health data (ranging from smart phones and health apps to government gathered public health data). The more important focus, therefore—as argued in the new field of digital sociology[27]—is for public health experts (along with the public) to engage in a critical dialogue about how best to deal with big health data.[24,25,26,27] Getting such a critical interdisciplinary debate to happen, however, is particularly difficult, given that such changes are as much about changing culture and getting population health experts out of their comfort zones, as they are about advancing institutional bureaucracy and undergraduate and postgraduate curriculum to better educate the next generation of population health experts.[28]

19.3.5. Overcoming Simplicity

C19.S8

C19.P18 In addition to embracing an organized complexity view of population health, experts also need to overcome the entrenched view that the best models are the simplest. Consider, for example, the way most health research (or policy) is done. As outlined elsewhere,[25,28] the brilliance of reductionist modeling is as follows: (1) population health is treated as a form of disorganized complexity, (2) which is best studied using statistics, (3) where the goal is to explain majority (aggregate) behavior in terms of probability theory and the macroscopic laws of averages, (4) which is done by developing simple linear models, as in the case of conventional epidemiology or randomized clinical trials, (5) and in which variables are treated as "rigorously real" measures of health outcomes. (6) Then, model-in-hand, the goal is to identify, measure, describe (or remove control or manage, as in randomized clinical trials) how certain independent variables impact one or more dependent variables of concern. (7) And, if done right, these models will lead to reasonably generalizable explanations of why health outcomes happen the way they do, (8) which, in turn, will lead to relatively straightforward population health policy recommendations for what to do about them.

C19.P19 Such a review is not to suggest, however, that this approach is not useful. In fact, as I stated earlier, quite the opposite: The problem is that it has been almost too successful! In fact, as Andersson et al.,[29] explain, there are times when viewing complex systems as simple remains crucial. However, many of the population

health problems we currently face demand a different approach. All of which takes us to the importance of cases.

19.3.6. Cases versus Variables

C19.S9

As we all learn in our first courses on the history of population health, the field was born of the *case*. That is, the "science" of population health emerged from experts using case-comparative observation to understand why, for example, one part of a city got sick while other parts did not. Eventually, however, as population ↳ health moved along into the 1950s, the study of cases was replaced with survey research and, in turn, during the 1970s and 1980s, powerful variable-based statistical software. And, in the process, case-comparison went to the wayside. Or, at least, it did so in the health sciences.

C19.P20

p. 277

In other areas, such as field research and qualitative method, as well as the data mining and the computational and complexity sciences, the case remained the primary focus.[24,28,30] In other words, despite their significant technical differences, all of these "other" methods focus on modeling, exploring, clustering, or cataloguing cases, based on key characteristics or etiological differences. For example, smart machines can be used to identify tumor or disease types; predictive analytics can explore public policies and their multiple outcomes; artificial intelligence can identify reliable community health opportunities; genetic algorithms can detect subtle changes in an epidemic; agent-based modelling can be used to explore simulated interventions into disease-outbreak patterns; and network analyses can find the fastest route through a health informatics network to get from a healthcare question to the best answer.

C19.P21

And—in terms of the issue of health complexity—all of them (albeit to varying degrees) can be counted as an improvement on conventional statistics, mainly because they avoid aggregate-based, one-size-fits-all solutions; instead, they focus on identifying multiple case-based trends, which, in turn, they catalogue and examine based on differences in their respective profile of key factors and variables. In short, all of these techniques treat the topics they study as evolving sets of complex cases, which is a very effective way of "decomplexifying" complex data by breaking it down into multiple and much smaller groupings (i.e., trends, models), while at the same time holding on to the complexity of the topic being studied.[28,30,31,32]

C19.P22

19.3.7. Changing Journal Publishing Culture

C19.S10

The other needed shift is a change in journal culture. For example, while the academic book publishing industry has been steadily advancing the cause of complexity, the population health journals have yet to make the *complexity turn* in any meaningful way. Even more problematic is that, even when editors are sympathetic to the complexity sciences, their reviewers are not. Case in point is the strategy many of my colleagues and I use to get published. We start by sending our study to a health journal or two (my best score so far is five rejections!), it gets rejected, and then, given the need to move on, we publish it (with almost no problems) in a complexity science or computational modeling journal, which often then means it does not get read by population health experts. If population health is truly going to make the *complexity turn*, which it desperately needs to do, this sort of approach to publishing needs to change.

C19.P23

19.3.8. Opening the Social Sciences C19.S11

Related, population health—as an academic discipline tied to department and schools—needs to be "opened up" into some type of complexity-based, postdisciplinary applied science. And, unfortunately, this C19.P24
p. 278 is not a new ↳ point: Weaver made it in 1948; Talcott Parsons did the same with the Department of Social Relations in 1946 at Harvard, and so did the Gulbenkian Report[33] and, more recently, Nicholas Christakis.[34] The key here is that population health scholars and practitioners need to work more directly (via curriculum, funding, research and institutional and departmental arrangements) with computational and complexity scientists. However, this requires two additional advances, which have as much to do with the complexity sciences as they do population health. And so, we turn to these two advances now.

19.3.9. Grounding Computational Modelling in Social Theory C19.S12

While the first eight points on my top 10 list focused on population health experts, the last two address the complexity (and computational) sciences. Here the main issue is that, while complexity and computational scientists are heavily trained in systems thinking and computational methods, they do not have a background in population health or, more widely, the social and health sciences upon which population health is based. For example, as Duncan Watts (the theoretical physicist famous for developing the small-world hypothesis) pointed out regarding the field of complex network analysis: C19.P25

> Physicists [and complexity scientists] may be marvelous technicians, but they are mediocre sociologists. Thus, if the science of networks is to live up to its early promise, then the other disciplines—sociology in particular—must offer guidance in, for example, the interpretation of empirical and theoretical findings, particularly in the context of policy applications, and also in suggesting measures and models that are increasingly relevant to the important problems at hand.[35p264] C19.P26

And so, complexity scientists need to be just as open-minded and thoughtful about their own theoretical and substantive limits as they are of the limits of others—which takes me to my final point. C19.P27

19.3.10. Facilitating the Complexity Turn C19.S13

To effectively foster the global complexity turn, population health scholars need to engage in a much more rigorous and critical engagement with the complexity sciences. For example, while a growing network of population health researchers have made the complexity turn, it has been of a limited nature. Case in point is Chughtai and Blanchet's[36] *Systems Thinking in Population Health: A Bibliographic Contribution to a Meta-Narrative Review*, which found that, while there has been, since 2010, a significant and positive advance in the population health literature's usage of complexity science, the articles (N = 557) they examined nonetheless left room for significant improvement. C19.P28

p. 279 I agree with their assessment. For example, population health scholars employing the tools of complexity science tend to cluster into what Chughtai and Blanchet[36,p588] identify as "distinct citation and co-authorship groups homophilous by common geography, research focus, inspiration or institutional affiliation." As Sturmberg et al.[14,15] point out in their edited two volumes on complexity in health and healthcare research, this insularity is potentially problematic, as it means scholars are regularly ignoring the work of others involved in the intersection of population health and the complexity sciences or, worse, reinventing ideas already developed. C19.P29

Chughtai and Blanchet's[36] review also found that some of the complexity science literature in population health tends to be highly abstract and less clearly empirical; what one could call *metaphorical complexity*. C19.P30

Also, given the tendency of this approach to draw from the managerial sciences literature, there is a tendency to uncritically apply key concepts from the complexity sciences—as in the case of self-organization, emergence, chaos, and nonlinearity—to the study of health systems and population health, the results being that, while the insights of this approach are not entirely wrong, are also potentially not right.

The other major issue is a tendency amongst population health researchers toward what Morin[37] and others[28,30,33] call *restrictive complexity*. For Morin,[37] the problem with the restrictive approach is that, while it has certainly made for some of the most important discoveries that established the field in the 1980s, it is trapped in the epistemological limitations of classical science insomuch as it (a) continues to look for the fundamental laws governing all complex systems (or, alternatively, complex networks); (b) treats complexity as an extension of, rather than a critical response to conventional science; (c) noncritically approaches the observation of complex systems and networks as objective and real; and (d) attempts to "decomplexify" the global-temporal behavior of complex systems by reducing them to their smaller microscopic interactions and by ignoring macroscopic factors. Given the critical role that differences in health outcomes and sociopolitical and economic context play in population health, such an approach is rather problematic. And that is not the end of it. A restrictive approach to complexity is also problematic for population health, as it rarely deals with power relations, structured inequality, and, generally speaking, lacks a sociological imagination.[3,5,10,13,25,28] It also tends to assume that mathematical and computational modeling is superior to qualitative analysis, and that all such computational methods work equally well for any topic.[28] C19.P31

Given these concerns, Chughtai and Blanchet[36p593] concluded as follows: C19.P32

> Based on our review, we argue a need to balance adapted theory with empirical study beyond unidisciplinary mathematical modelling or network analysis and encourage scientists to conduct further interdisciplinary studies in order to acquaint themselves with unfamiliar methods and combinations. We advise a greater emphasis on synthesizing higher order mental constructs with high-quality empirical evidence in order to refine existing definitions and adapted models to population health systems. C19.P33

p. 280 I completely agree with these recommendations. All of which brings me to my conclusion. C19.P34

19.4. Conclusion C19.S14

As my top 10 list has hopefully made clear, while population health faces a rather significant set of challenges relative to its crisis of complexity, it is necessary for the field to make the *global complexity turn* and adopt many of the latest advances in the complexity and computational sciences. Equally important is to ground these advances in a *complex global systems* view of population health—particularly one that is as critical of the new ideas coming out of the complexity sciences as it is of the conventions of population health research and practice. C19.P35

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