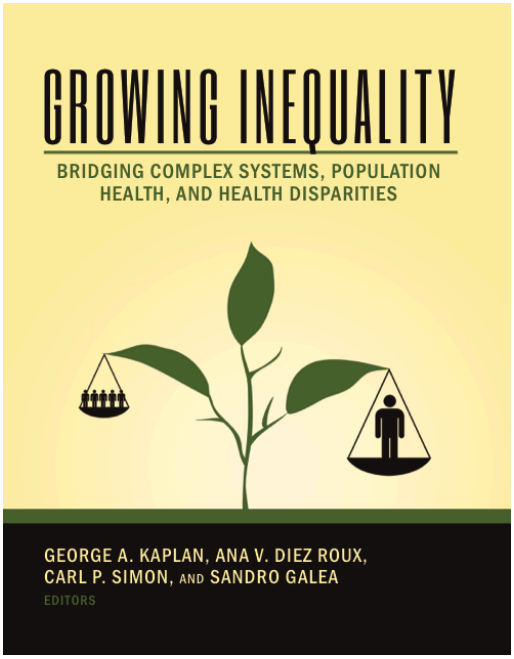

No single factor—but a system of intertwined causes -- explains why America's health is poorer than the health of other wealthy countries and why health inequities persist despite our efforts. Teasing apart the relationships between these many causes to find solutions has proven extraordinarily difficult. But now, in this book, researchers report on groundbreaking insights using computer-based systems science tools to simulate how these determinants come together to produce levels of population health and disparities and test new solutions.

The culmination of over five years of work by experts from a more than a dozen disciplines, this book represents a bold step forward in identifying why some populations are healthy and others are not. Applying the techniques of systems science, it shows how these tools can be used to increase our understanding of the individual, group, and institutional factors that generate a wide range of health and social problems. Most importantly, it demonstrates the utility and power of these techniques to both wisely guide our understanding and help policy makers know what works.

This book begins the process of unraveling some of the most 'wicked' problems in public health.

Tony Iton, MD, JD, MPH, The California Endowment

... an intellectually courageous undertaking. It faces up to the reality of complexity in the social determinants of health. Its achievements and its documentation of difficulties will serve as a valuable foundation for the next generation of scientists and scholars who aim to understand the determinants of health and of health disparities.

Harvey V. Fineberg, MD, PhD, President, Gordon and Betty Moore Foundation and Former President, the Institute of Medicine

---

...goes beyond the search for a simplistic answer to health disparities and instead embraces the complexity. This is exactly what is needed if we are to improve population health and eliminate disparities.

Thomas A. LaVeist, PhD, Chairman, Department of Health Policy & Management, Milken Institute School of Public Health, George Washington University

---

It is increasingly likely that in the non-distant future that population health policy will be fully informed by a coherent computational decision-support system that integrates data, analytics, systems modeling, forecasting, and cost-effectiveness. This book marks a serious movement toward that future.

Donald S. Burke, MD, Associate Vice Chancellor for Global Health, Dean, Graduate School of Public Health UPMC, Graduate School of Public Health, University of Pittsburgh

Westphalia Press

GROWING INEQUALITY

BRIDGING COMPLEX SYSTEMS, POPULATION HEALTH, AND HEALTH DISPARITIES

GEORGE A. KAPLAN, ANA V. DIEZ ROUX,
CARL P. SIMON, AND SANDRO GALEA
EDITORS

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CHAPTER 1

BRIDGING COMPLEX SYSTEMS, HEALTH DISPARITIES, AND POPULATION HEALTH

George A. Kaplan, PhD
Thomas Francis Collegiate Professor Emeritus of Public Health
University of Michigan

Carl P. Simon, PhD
Professor of Mathematics, Complex Systems and Public Policy
University of Michigan

Ana V. Diez Roux, MD, PhD, MPH
Dean and Distinguished University Professor
Dornsife School of Public Health
Drexel University

Sandro Galea, MD, MPH, DrPH
Dean and Robert A Knox Professor
School of Public Health
Boston University

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Myra: A Case Study in Growing Inequality

Consider the case of Myra, who is now 12 years old. Her parents have been unemployed on and off for

most of her life, including the entire year before she was born. They move from apartment to apartment as one health or job crisis follows another and are evicted because they are unable to pay the rent on time. Sometimes they need to move because heat and hot water are not available enough, or their landlord has lapsed on providing pest control so rats and cockroaches are prevalent. Often they reach the end of the month with little money to spend on food or other necessities, and the little they get in food vouchers has been spent. An occasional treat following a payday for one of her parents is a fast food hamburger, fries, and giant soft drink. They live in a neighborhood bereft of parks but with a surplus of abandoned buildings and crime. Grocery stores with aisles of fresh food are miles away, while stores that feature cigarettes, sugar-filled soft drinks, and chips are around the corner. Myra does not play outside much because it does not feel safe. She did not have any early childhood education classes or informal programs and began school in kindergarten. There are few books but lots television in her home. School is now a refuge for Myra—it is safe and she has friends there, but the teachers are overburdened by too many students, too few books, too little pay, and too little training. She is in 7th grade, but reads at the 4th grade level and is not so sure about simple mathematics. There is no recess, physical or health education, school nurse or counselor, or computer training. Some days she feels pretty low and just does not feel like getting out of bed and going to school, so she just stays home and watches television. Sometimes her friends, also not in school and sometimes older than her, come over.

Her mother has a minimum-wage cleaning job in a mall an hour's ride away by bus, with a work schedule that changes unpredictably from day to day. She is employed on an hourly basis by a subcontractor to the mall and receives no health, retirement, or other benefits. Her father is a non-union carpenter, but works only intermittently due to the poor economy and a previous injury from a fall from unsafe scaffolding. He received unemployment and disability benefits for a while, but they have been discontinued due to time limits on eligibility. Because of the fall and lack of proper medical treatment, he has lost some mobility. Needless to say, even with the Affordable Care Act and expansion of Medicaid in some states (but not theirs), her parents may still not have any health insurance and have to rely on public clinics and emergency rooms for care.

Clearly, the circumstances in which Myra and her family live are difficult and taxing. Many Myras will do fine despite this adversity, but far too many will live out lives of blunted aspirations and achievement. Central to this is poor health, for Myra's circumstances endanger her current and future health, and she is headed for a vicious spiral of poor conditions begetting poor health and poor health leading to worsening conditions.[1,2] We know from the epidemiologic literature that Myra is more likely to develop a large number of health problems in her lifetime, including obesity,[3] asthma and other respiratory diseases,[4] type 2 diabetes,[5] depression,[6] cardiovascular disease,[7] impaired physiological response to stress,[8] neurological changes and dementia, hypertension,[9] hampered resistance to infection,[10] the risks associated with early sexual activity,[11] early substance use,[12] motor vehicle accidents and other injuries,[13] musculoskeletal disorders,[14] and poorer prognosis and faster progression of many of these and more.[15]

The social, environmental, behavioral, and health challenges Myra faces are not independent forces but represent an interconnected ecology of experiences that constrain many aspects of Myra's life over her lifetime, constraints that are likely to be passed on to her children. At the individual level these constraints will exact a toll, but the toll is even greater when we consider the many others like her and how these

interconnected challenges result in the collective loss of her and others' contributions to society.

Understanding Myra's Health

But what is to be done about it? The usual approach would be to search for a magic bullet, for example a single factor that would turn Myra's trajectory around such as better food stores, smoking cessation programs, early childhood education, improved access to health care, and a new pharmaceutical agent. Each of these has value, but many of the problems are so intertwined that singling out one remedy might not be effective. For example, if Myra had been fortunate enough to have access to early childhood education, would she have overcome the challenges of attending an under-resourced and overburdened school in a dangerous neighborhood? Or, would the availability of healthier food in her neighborhood help if her parents could not afford it? Or, conversely, would improvement in her parents' economic situation allow her family to move to a better neighborhood, bringing with it higher quality schools, better access to healthy food and recreational facilities, improved air quality, and more positive role models?

Understanding Myra's current and future health and the many other health problems that she faces requires grappling with the multiple, tightly interrelated, and causally tangled determinants of her health, many of which are outside the usual purview of health sciences (figure 1).[16–20] The considerable interconnection and interaction within and across domains that she faces, the multiple levels and scales of the determinants of her health, and the complex dynamics operating over her life course do not easily lend themselves to the conventional tools of the health or social sciences.[21,22]

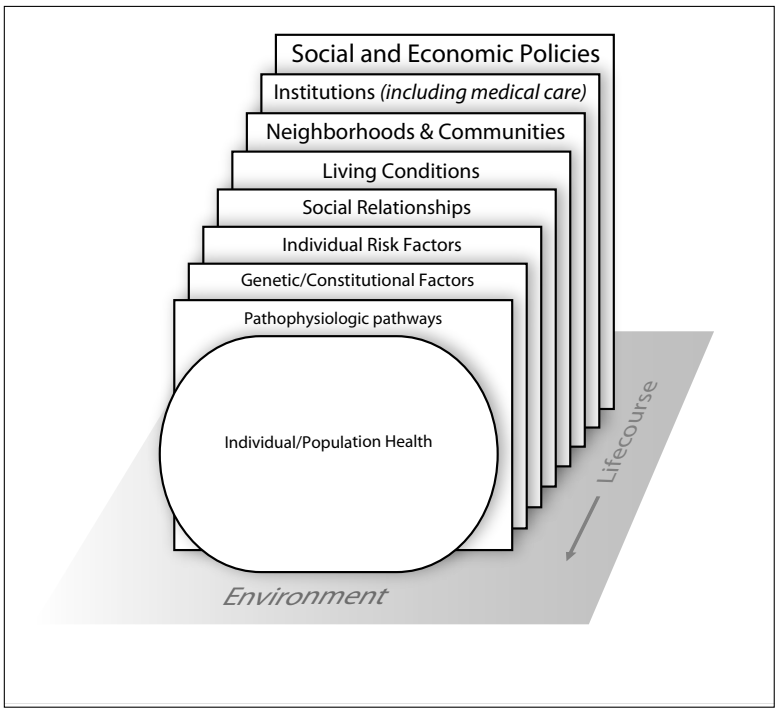

Figure 1. Multilevel and multiscale determinants of population health and health disparities[16]

Many Myras—Populations and Inequality

Myra is one child but she represents many. The interlocking threats to their individual and collective social, economic, and behavioral functioning—biologically embedded over the life course and across generations—create compelling patterns of health inequality that confront our society. These inequalities are all the more dramatic when populations are arrayed by race, ethnicity, or socioeconomic position.[23–27] These threats are not distributed randomly in the population but are burdens reflecting the historical and contemporary social, economic, and political forces that, when bundled together, have a deleterious impact on the health of particular groups.

It is abundantly clear that there are no simple solutions to eliminating these disparities, as they represent the confluence of so many factors that determine levels of health and function.[16] Many of these factors are considerably upstream from the usual focus of the health sciences, and they have a broad footprint on more proximal determinants of health.[27–30] In addition, they do not operate in a vacuum but instead are interacting threads that weave a garment of inequality stretching from conception to death. This dense network of interacting factors—covering multiple domains, extending across multiple levels and scales, and playing out over the life course and across generations—poses major analytic and conceptual challenges to the goal of eliminating, or even reducing, health disparities. The standard approach of looking for single, independent factors and directing interventions at them may not be sufficient to meet the challenges posed by the systematic patterns of disparities in health that we observe between racial, ethnic, and socioeconomic groups. Small steps may be taken, but the level of complexity involved in such an endeavor calls for a new approach.

The Network on Inequality, Complexity and Health (NICH)

On a fall day in 2010, scholars from across the United States and Canada gathered at the University of Michigan to commit themselves to collaborating for the next four and a half years on a new approach to understanding the health of Myra and those like her.

With support from the Office of Behavioral and Social Science Research (OBSSR) at the National Institutes of Health (NIH), they formed the NICH. Representing about 18 academic fields (table 1), their self-described interests cut a broad swath, covering social stratification, neighborhood change, segregation, income inequality, systems thinking, stress, ecology, education and economic development, racial achievement gaps, interventions, stress physiology, neuroscience, health behavior, emotions, socioeconomic position, sex hormones, complexity, dynamic systems, diversity, economic and political systems, genetic and environmental factors in shaping development, bio-behavioral development, social isolation, continuity versus change in development, policy-oriented research on the development of young children focusing on family and community influences, designing and evaluating interventions and policies aimed at enhancing the well-being of children living in poverty, inequalities in communication and health disparities, addressing disparities through communication and dissemination, life events, immunology, social support/networks, life course perspectives, mental health, stress pathways, civil rights, state and local government, state and local finance, land use, regional governance and the legislative process, domestic poverty and federal fiscal policy, social epidemiology, nutrition, minority health and women's health issues

Table 1

NICH Members

Member	Institution	Fields of expertise
George Kaplan, chair	University of Michigan	Social Epidemiology
W. Thomas Boyce	University of California, San Francisco	Developmental Neurosciences
Jeanne Brooks-Gunn	Columbia University	Child Development
Elizabeth Bruch	University of Michigan	Sociology, Complex Systems
Sandro Galea, co-Chair	University of Michigan, Columbia University, Boston University	Epidemiology (Social and Psychiatric)
Ross Hammond	Brookings Institution	Political Science, Complex Systems
Rucker Johnson	University of California, Berkeley	Economics, Public Policy
Shiriki Kumanyika	University of Pennsylvania	Epidemiology, Nutrition
Myron Orfield	University of Minnesota	Law, Inequality
Nathanial Osgood	University of Saskatchewan	Computer Science, Public Health
Sean Reardon	Stanford University	Education, Sociology
Rick Riolo	University of Michigan	Complex Systems
Ana Diez Roux, co-chair	University of Michigan, Drexel University	Social Epidemiology
Carl Simon, co-chair	University of Michigan	Mathematics, Public Policy, Complex Systems
Kurt Stange	Case Western University	Medicine, Epidemiology, Sociology
Steve Suomi	Eunice Kennedy Shriver National Institute of Child Health and Human Development, NIH	Comparative Ethnology, Psychology
Vish Viswanath	Harvard University	Communications
Michael Wolfson	University of Ottawa	Economics, Complex Systems

with a focus on prevention, modeling of population health trends and health policy trade-offs, systems models of disease, development of modeling techniques, clinical research, practice-based research, cancer control, health services research, health policy, minority health, poverty and inequality, neighborhood effects, educational effects, public policy, and the modeling of complex social, economic, and biological systems using agent-based computational models and nonlinear dynamical systems.

Already experts in their fields and likely overcommitted, what would motivate them to commit considerable time and effort to work with colleagues coming from different disciplines, who used different analytic

and conceptual tools than they did, and whose professional vocabulary often seemed to require a translator? Their effort, the results of which are reported in this volume, was driven by three considerations. First, there was a critical need to develop a better understanding of the factors contributing to health disparities and population health; second, that the development of such an understanding would be best served by bringing together a broad spectrum of expertise; and finally, that a new approach was needed that embraced and analyzed the complexity of the systems that produce health disparities and population health.

The need to better understand of the determinants of population health and health disparities has been addressed in many places,[16,17,31,32] as has the need for cross- and transdisciplinary approaches.[33] What was unique about this effort was the explicit incorporation of complex systems approaches into the discussion. Starting with the recognition that it is systems that generate health disparities and population health, complex systems approaches allow us to appreciate that the production of health inequalities does not rest only on complicated systems with lots of pieces, but instead on complex systems involving multiple interacting factors with dense, and sometimes nonlinear, feedback. As such, health inequalities, as complex systems, cannot be easily reduced to independent components with analyses of the isolated impacts of single components.

Complex systems approaches provide tools that can accommodate the complex, dynamic, multilevel structures and processes, sometimes nonlinear, that are required for analyzing of many critical problems in health disparities and population health.[22,34] These tools are computational approaches that make use of computer-based algorithms to model dynamic interactions between components, within, and across levels of influence. With the potential for both spatial and temporal dimensions, complex systems analytic approaches allow us to simulate the growth of inequalities across space, time, and generations. While long adopted by many branches of science, complex systems approaches are largely new to population health, and our efforts to understand the complex systems that generate health inequalities and overall patterns of population health remain in their infancy. NICH was the first effort, to our knowledge, to bring together a broad array of health science, social science, and computer science scholars to see what could be added to our understanding of the systems that grow health inequality. The remainder of this volume presents the results of some of our analyses, and ends with thoughts on the strengths and limitations of using complex systems tools and recommendations for moving forward. Our hope is that this work can catalyze the building of further bridges between complex systems, health disparities, and population health researchers.

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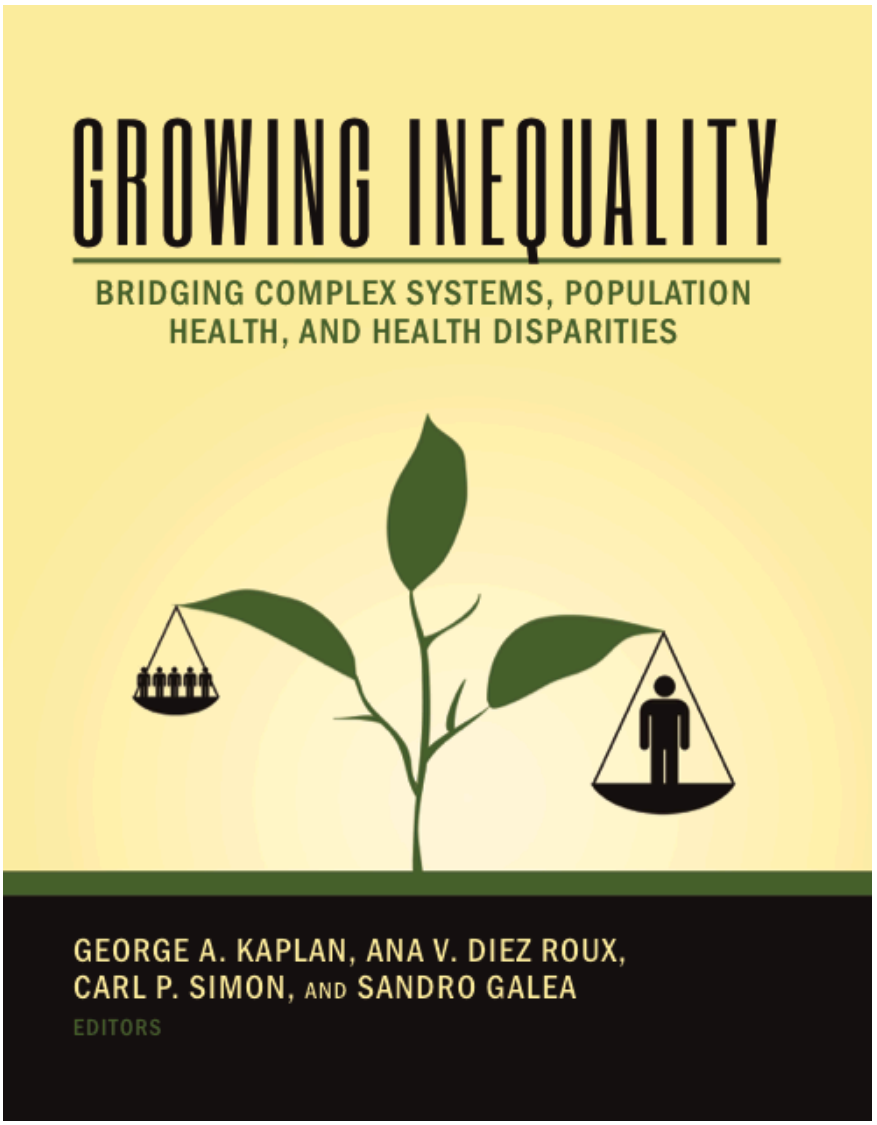

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