Purpose: To review and critique complexity science applications in social and health related disciplines that are relevant to public health research and, specifically, population health interventions (PHIs) aimed at reducing health inequity.

Research objectives: To conduct a modified meta-narrative synthesis of the diverse literature on complexity science (CS) systems thinking with particular attention to literature in public health, public health care, and organizational development.

On the basis of this synthesis, we are constructing a conceptual framework that can be used to guide the development, implementation, and evaluation of PHIs by knowledge users and researchers. This includes practical guidelines, methods, and tools for applying complexity science concepts to the development and analysis of PHIs, including those that address the interface of the public health system with society and the environment.

Here we summarize the more fully developed narrative of complex networks and epidemics, and the emerging but still developing systems thinking and complexity narrative. For this presentation, we trace the evolution of thinking in these areas.

Systems Thinking and Complexity

- Systems Thinking (ST) emerged simultaneously in many disciplines in the early part of the 20th century, but has its roots in pioneering work by biologists as far back as 1850. Early ST came from three theoretical strands including: ecological, gestalt psychology, and social services theory. By the 1950s, systems theory and cybernetics had become important components of organizational theory and the management of organizations.

- In the 1980s, ecological and systems theory in public health research and practice, with some of the earliest applications appearing in the work of Alper. This work, much of it in the US and in the 1980s, social justice as an explicit aim of public health was advocated for, with the work of the new public health/health promotion of the 1980s, and later, ST applied in public health, addressing issues of health equity, e.g. (SDOH = Syndemics).

- Other theories that influenced the development of current systems, ecological, complexity and, complexity approaches in PH included chaos theory, social learning theory, and human ecology. During this period, new methodologies approached the critique of systems theory that it could not be used in practical applications to solve important social problems. These methodologies included systems dynamic modeling and soft systems approaches that emerged from organizational theory and the management discipline.

- In the 1980s, the eco-social and eco-epidemiology perspectives emerged within social epidemiology echoing the earlier ecological thinking in PH. This reflected, in part, a critique of risk factor epidemiology as applied to the early community wide-intervention studies, and raised critical methodological questions about how to study contextual influences on the outcomes of community interventions. At the same time, the fields of health promotion and health education were launching a socio-ecological approach, as reflected in the Ottawa Charter, based on explicit values existing the importance of community participation, empowerment, and intersectoral collaboration. Given the ecological understandings of these developments, a systems perspective was often implicit but not named. This work was followed by a new book that included more sophisticated applications of ecological models in community intervention research, also referred to as to multiple levels and interventions. In communities (e.g., communities) on multiple levels.

- Another important school of thought that influenced the emerging ST and complexity applications in PH is critical systems thinking, and systems intervention, drawing on soft systems methodology, systems dynamic modeling, community based participatory research, and complexity thinking. The research in this area was focused on the development of new models for understanding complex systems and the development of new models for understanding complex systems. This included work in feminist critical systems thinking. Finally, another distinct ST narrative began during the 1980-2000 period that we have named the systems thinking and change. This narrative is focused on health at large, external to public health. We have not completed work on this narrative, but it has had a significant influence on the development of the ST and complexity narrative in PH.

- This brings us to the current status of the ST and complexity narrative in PH. Up to the year 2000, distinct yet overlapping streams of ST were developing in PH as based on early work in systems theory, (but incorporating other theoretical ideas) and their later applications in social theory, and the other based on ecological theory, particularly human ecology, and social ecological theory. Since 2000, the PH literature has begun to incorporate ecological, complex adaptive systems theory, sometimes independent of ST, sometimes conflating with ST, still other times linking ST and complexity.

Future Work and Recommendations

- The work presented here represents preliminary findings, emphasizing the two main narratives that have emerged within the field of public health: public health interventions and concepts and methodologies derived from complexity science and systems thinking.

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- However, the most recent development in the narrative reflects a much more explicit identification of the need to integrate the longer standing traditions of systems thinking in PH with both a complex adaptive systems perspective, and an ecological approach, with the aim of reducing health inequity. A special issue of AJP in 2006 was central in advance this discussion. An emerging body of work in the area of syndemics (Ginger, Mittler). A syndemics is ‘the interaction of two or more diseases in a population in which there is some level of biological interaction that exacerbates the negative health effects, the degree to which the health effects caused by one disease is intensified, strengthened, or exacerbated by the presence of the other disease.”

- The rise of syndemics has been driven by the need to understand the structural complexity of syndemic health science. Understanding health systems and complex interventions, and potential, of these emerging research".

- The work of the "meta-narrative" synthesis remains to be completed. The synthesis is a complex challenge, both because of the judgment of the authors’ expertise (current and potential), of these emerging research, the narratives to advance the field of public health science in general, and more specifically, the population health intervention research agenda.

- In particular, we are interested in how complexity science and systems thinking concepts and methods influence, or should influence, how public health addresses health inequity.

- As Galea et al., argue, social epidemiology, chronic disease prevention and health promotion have yet to integrate much of the complexity science work on health and health systems. Our findings suggest that there is more emphasis in PH systems thinking than on complex systems thinking. By contrast, although the number of studies is relatively small, a few studies have explored some aspects of these systems. Galea et al., note that despite the advocacy of Kosson and others, public health has yet to integrate these novel modeling tools.

- Current developments see some cross-pollination between complex network science, reality mining and agent-based modeling simulation models. This emerging hybrid research field is raising different modeling questions raised by studying complex disease epidemiology (Christiansen), along with infectious diseases.