Computer Modeling of Complex Systems in Family Practice

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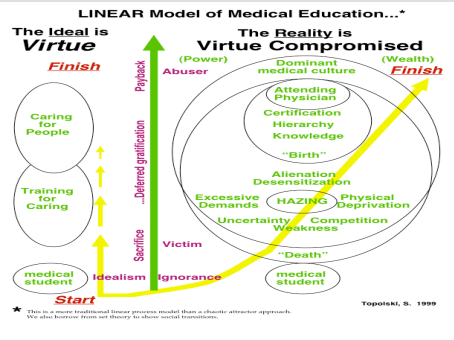
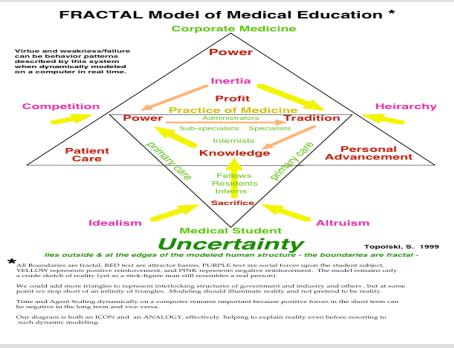
Introduction

Our healing arts evolve constantly. Physicians carry epochs of experience forward while testing new ideas today. We now live in a 300 year revolution of modern science built on the human habits and traditions of the past. Newton & Bacon's scientific revolution, however, has, become limited by its reductionist, determinist, and linear simplifications.[1] It has poorly advanced the scientific art of Family Practice.

The study of complex systems offers new methods from a different approach. Computer science advances have been crucial. Cross-discipline collaboration is common. Physicians now have effective tools to study complex human health. Better theory can inform practice and we can use medical practice to test theory. We demonstrate several novel computer models of complexity principles with application to the healing arts today.

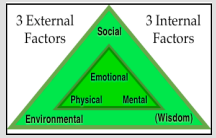
Linear vs. Complex Modeling

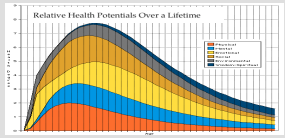




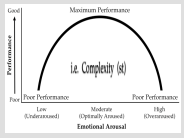
Multiple Applications

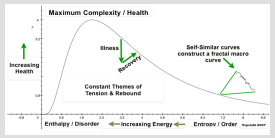
New Model of Health Beyond Bio-Psycho-Social



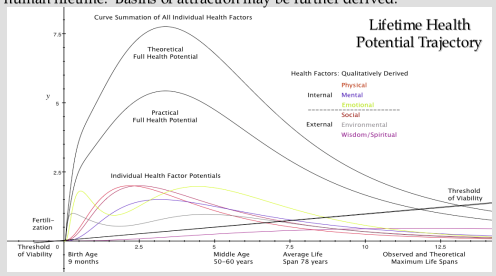


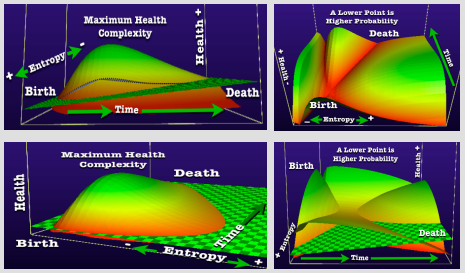
Health Potential Space & Attraction Basins



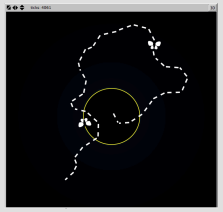


The bio-psycho-social model of health can be improved with J. Sturmberg's semiotic ideal[2] and more carefully measuring the connection between organism and environment that can be viewed as tensors at model vertices. Log normal frequency distributions are also prominent throughout nature and best model life processes as products of sequential independently cumulative processes.[3] Combining these with an improved version of common inverse-U performance curves derived from physiology,[4] information theory and entropy concepts gives a 3 dimensional health potential space over a human lifetime. Basins of attraction may be further derived.

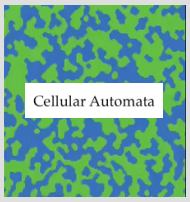




Recidivist Behaviors

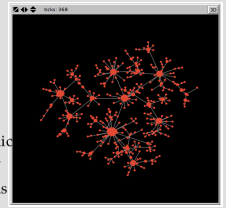


Many illnesses in family medicine are behavioral and recidivist like a bad habit that one returns to erratically but repeatedly. Drug addiction and domestic violence have patterns with behavior bifurcations which are better modeled by cellular automata than traditional differential equations.



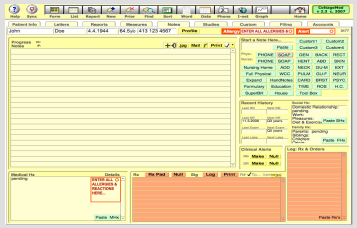
Syndemics and Causal Networks

Networks are the infrastructure of information exchange and crucial to understanding family and social dynamics. Traditional family genograms and recent epidemiologic syndemic theory can benefit from quantitative and qualitative data analysis of computer modeling.

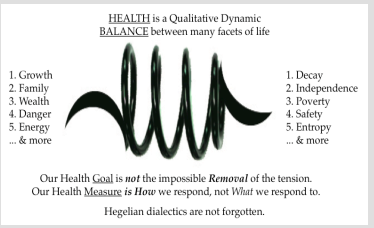


The Patient Encounter

Flexible structure, open work flow, and continuous redesign are principles of complex systems which more effectively model patient care and data structures. Such an Electronic Medical Record (EMR) can be simple, powerful, quick to learn & easy to use. For 8 years our pilot study CottageMed remains the first free, open-source, cross-platform and patient-centered EMR used worldwide. It owes its success to applied principles of complex systems.



Balance in Tension



Conclusions Suggested

This is a partial review of original applications modeling complex systems principles in family medicine. Additional qualitative and quantitative testing and application could test the following predictions.

1. Health can be a tension between internal and external factors that vary with time and culture.
2. Health can be better defined by slope of surface, fractal texture of surface, total complexity of system, or total complexity of system minus viability threshold.
3. Hence the rate of change in health is more important than the quantity of change.[6]
4. Full health at different ages is not equivalent - Infants are *less* healthy than adults and *different* healthy than the elderly.
5. Chronic illness comes in distinct and opposite forms - excess entropy (underuse) or energy (overuse) - which heal through fundamentally *opposite* processes.
6. Acute illness is a third form with a fundamentally *different* healing process.
7. Complexity offers a new concept of viability threshold with slope changed by age, genetics and chronic illness.
8. Complexity more clearly suggests which health interventions have better yield.
9. Complexity can illuminate relationships and patterns in the study of community health and individual illness.
10. Complexity principles can improve patient care tools with robust flexibility, intuitive ease of use, and greater utility.

Literature Cited

1. Henry H. Q. Heng, "The Conflict Between Complex Systems and Reductionism," JAMA 300, no. 13 (October 1, 2008): 1580-1581.
2. Joachim P. Sturmberg, Ian R. McWhinney, and Carmel M. Martin, The Foundations of Primary Care, 2007.
3. E Limpert, WA Stahel, and M Abbt, "Log-normal Distributions across the Sciences: Keys and Clues," BioScience 51, no. 5 (May 1, 2001): 352, 341.
4. Williams, J.M., Landers, D.M., Boutcher, S.H., (1993), Arousal-Performance Relationships, Applied Sport Psychology: Personal Growth to Peak Performance, pgs 170-184.
5. Keith Warren et al., "Substance abuse as a dynamical disease: Evidence and clinical implications of nonlinearity in a time series of daily alcohol consumption," Addictive Behaviors 28, no. 2 (March 2003): 369-374.
6. Oskar Morgenstern and John Von Neumann, Theory of Games and Economic Behavior, 3rd ed. (Princeton University Press, 1980).

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