The emergence of high rates of heart disease across the South Asian diaspora 1959-2026: a fractal and complexity approach to understanding and reducing this.

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Abstract: High rates of heart disease have emerged across South Asia and its global diaspora in self similar patterns, since the first report in 1959 from Singapore. This pattern emerges from the nonlinear complex dynamic interaction of biologic, genetic, social, economic, lifestyle, environmental, commercial and other factors in different locations over the past 5 decades, similar and different, and can be described as fractal (lateral fractal). A fractal and complex systems approach can be used to understand this emergence and to guide prevention, recognizing this historical process as complexity, as well as for the individual at a different scale.

India, South Asia, and their diaspora, despite heterogeneity, share the highest rates of NCDs and heart disease, including premature and unexpected heart disease (1-3). This has been consistent for decades, emerging from similar risk factors for heart disease within and in different countries, described as fractal or self similar and different. This pattern of heart disease, described first in 1959 (1-3), reflects sensitivity to or higher levels of usual risk factors, a different pattern of risk across India, SA and their diaspora, or nonlinear emergence from usual and novel risk factors in complex systems. A systems science (complex systems or chaos and complexity) approach to understanding this, and for prevention, has been used for 30 years (4), and is recommended by the WHO and other agencies as a scientific way of addressing such complex and dynamic issues (5).

The usual risk factors for heart disease include smoking, family history of heart disease, high Low Density Lipoprotein (LDL) cholesterol and Lipoprotein (a) (Lp(a)), low High Density Lipoprotein (HDL) cholesterol, high blood pressure, overweight from abdominal or visceral fat, diabetes or prediabetes, unhealthy diet, sedentary lifestyle, stress, etc. Additional factors include socio-economic, social and commercial determinants of health, access and availability of healthcare, other illnesses, air pollution, network effects, climate change, etc. These all add up like a nonlinear web of interactions influencing each other, taking an individual or population towards or away from health and disease, which changes in time and place. Vasan and coauthors describe this as a Life Course that includes in-utero, childhood and adult biological, sociological, and ecological hierarchies that impact an individual's health, which they consider complex adaptive systems (6).

The features of complex adaptive systems and systems thinking include self-organization, feedback and change, bifurcations, emergence of outcomes, and a combination of predictability and uncertainty, seen across complex systems like climate change, pandemics, global crises etc. For instance, a heart attack is caused by many factors, with often a "Tipping Point" of plaque rupture and/or thrombus formation, leading to differing outcomes: immediate sudden death, or stabilization and emergent care. Prediction of the bifurcation point or emergence of severe blockage of an artery is imperfect, with many plaques with mild blockages, normal non-invasive tests and no symptoms remaining stable, while others can rupture, illustrating emergence and unpredictability in complex systems. This can thus lead to a false sense of assurance in patients who later develop sudden unexpected outcomes, which is a challenge to prediction and prevention.

A systems science (complex systems or chaos and complexity) perspective on the development and prevention of heart disease in individuals and populations has been proposed and used to improve prevention, and working around or working with uncertainties in prediction by recognizing their complex dynamics: Jayasinghe proposed "conceptualizing population health from mechanistic to complexity science"(7), Pronk and coauthors suggest "systems science approaches to cardiovascular disease prevention and management in the era of COVID-19: A Humpty-Dumpty dilemma? (8)," Astbury and coauthors review "Systems thinking for noncommunicable disease prevention policy: guidance to bring systems approaches into practice" (9), and Shahid and Masterson describe "Shaping the future: Systems Thinking for chronic disease prevention in Australia (5)."

The WHO recognizes and advocates systems thinking for chronic diseases in various conferences, publications and policies, mentioned by Srivastava and coauthor in "Pivoting from systems "thinking" to systems "doing" in health systems - documenting stakeholder perspectives from Southeast Asia" (10). The WHO addresses heart disease prevention within the framework of complex systems by developing global strategies and technical packages that cover a wide range of interconnected behavioral, environmental, social, and health system determinants.

High rates of heart disease globally, and especially in India, South Asia and their diaspora remain a major challenge today, especially for premature heart disease a decade earlier than in most other countries. The reasons for this can be described as a sensitivity to the usual risk factors and higher levels of usual risk factors, especially in the young, related to diet, lifestyle, the environment and epidemiological shifts. Expected and unexpected heart disease including premature heart disease and unexpected heart attacks and sudden death develop from complex dynamic nonlinear weblike interactions that influence the health of everyone. The common pattern reported of higher rates and earlier heart disease, heart attacks and sudden death, often "unexpected," across India, SA and their diaspora, despite heterogeneity and variable expression, likely reflect a similar pattern of emergence of outcomes from the complex dynamics of a similar pattern of risk factors emerging from a similar web of interactions, with some differences. In complex systems, such differences, even if small, can cascade through the system and lead to large differences in outcomes.

The historical process of the emergence of this pattern of disease and its prevention can be seen as a complex system with fractal patterns. Prevention using this as a guide would recognize the existence of inherent unpredictability, yet enough patterns and certainties to use system science (complex system, chaos and complexity) approaches which are more realistic and holistic (4,11,12). This would be in addition to systematic (logical, and methodical) approaches to target areas for improvement, dynamically responding to changing needs shared across SA and its diaspora. While big data, AI and other newer approaches can also be used, chaos and complexity can be used as a translation factor from these to the complexity of the real world (13-16).

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