

The Emerging Theoretical Framework of Life Course Health Development¹

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Informed by new theoretical perspectives emerging from such fields of study as developmental psychology, systems biology, epigenetics, the developmental origins of chronic disease, and evolutionary developmental biology, a transdisciplinary framework is emerging which we call Life Course Health Development (LCHD). The LCHD framework can be characterized with reference to seven principles: (1) health development, (2) unfolding, (3) complexity, (4) timing, (5) plasticity, (6) thriving, and (7) harmony. LCHD offers a new perspective to guide future scientific inquiry on health development and also helps to facilitate a much needed synthesis of medicine and public health linking treatment, prevention, and health promotion and catalyzing more integrated and networked strategies for designing, organizing, and implementing multilevel health interventions that transcend individual and population dichotomies.

Part 1: Context and Background

Stimulated originally, by a series of studies demonstrating how growth during early life is related to chronic health conditions that emerge many decades later, an eruption of new research is identifying developmental processes that shape long-term health trajectories. This research is demonstrating how complex and evolutionary determined developmental processes integrate a range of behavioral, social, and environmental influences that modify gene expression, modulate physiologic and behavioral function, and dynamically shape different pathways of health development.

The LCHD framework addresses the developmental origins of health, the role that biological and behavioral plasticity play in facilitating different levels of adaptation, and how mismatches between biological propensity and environmental context interact to produce breakdowns in health, known as disease.

Table 1 Principles of the Life Course Health-Development Framework

Principle	Brief Description
1. Health-Development	Health-development integrates the concepts of health and developmental processes into a unified whole.
2. Unfolding	Health-development unfolds continuously over the lifespan, from conception to death, and is shaped by prior experiences and environmental interactions.
3. Complexity	Health-development results from adaptive, multi-level, and reciprocal interactions between individuals and their physical, natural, and social environments.
4. Timing	Health-development is sensitive to the timing and social structuring of environmental exposures and experiences.
5. Plasticity	Health-development phenotypes are malleable and enabled and constrained by evolution to enhance adaptability to diverse environments.
6. Thriving	Optimal health-development promotes survival, enhances well-being, and protects against disease.
7. Harmony	Health-development results from the balanced interactions of molecular, physiological, behavioral, cultural, and evolutionary processes.

¹ Halfon N., Forrest C.B. (2018) The Emerging Theoretical Framework of Life Course Health Development. In: Halfon N., Forrest C., Lerner R., Faustman E. (eds) Handbook of Life Course Health Development. Springer, Cham.

Part 2: Emergence of the Life Course Health Development Framework

The LCHD framework emerges from a network of theories, conceptual models, and empirical findings and provides a more comprehensive description of how health develops over the life course than any single component part.

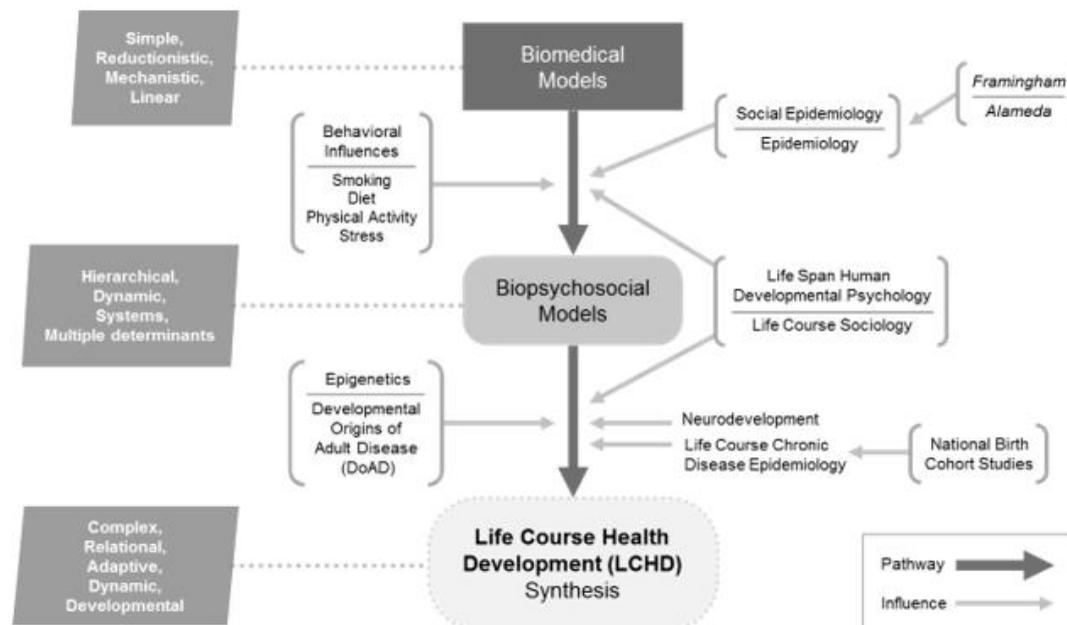


Fig. 1 The Evolution of Conceptual Models of Health Development.

Two converging streams of biological research and conceptual constructs have contributed to the LCHD framework. The first stream represents the basic biology of human development, informed by the neo-Darwinian synthesis that resulted from the convergence of Darwin's theory of evolution and Mendel's notion of genes as the building blocks of heredity. Recent advances in panomics (e.g., genomics, epigenetics, proteomics, metabolomics) and systems biology are redefining our understanding of how gene networks are regulated and dynamically interact with each other and the environment, resulting in a new synthesis of biological systems development and functioning. The second stream of inquiry, which interacted with genetic concepts and models, represents the evolution of models of disease causation, informed by contributions from basic, clinical, epidemiologic, social, and psychological research disciplines. Several decades of research on the "upstream" social and behavioral determinants of health, stimulated by epidemiologic studies like the Framingham Study and Alameda County Study highlight how cardiovascular and other chronic diseases were not caused by bad germs, bad genes, or bad luck, but are associated with behaviors like smoking, diet, exercise, and other social factors as well as modifications in the development of metabolic regulatory systems that these social and behavioral risk factors induced. This led to a more dynamic ecological analysis of the multiple risk factors that lead to disease causation, informing the creation of a multi-causal, biopsychosocial framework of disease.

Life course theories emerged in sociology research in the 1960s, and distinguished how social institutions and history shape the roles, personal events, transitions, and trajectories of individuals who follow different developmental pathways. This work focused on how macro-level social processes and social relationships influence interweaving trajectories at different ages, stages, and transitions of development. Untangling age, period, and cohort effects and understanding the cumulative impact of experience on socially and institutionally constructed life pathways form the basis of life course sociology. Life course theories, which have been part of human developmental psychology for over a century, emerged more definitely in developmental psychology in the 1960s as well. Life course health development integrates several fundamental principles of the biopsychosocial model of health with the theoretical notions that have come from life course studies in sociology, developmental psychology, as well as more recently in life course chronic disease epidemiology, epigenetics, neurobiology, and economics.

Part 3: Principles of the Life Course Health Development Framework

Principle 1: Health Development

Health development integrates the concepts of health and developmental processes into a unified whole. The health development of an individual is comprised of an integrated set of capacities that dynamically mature and are involved in managing energy flows; processing and acting on information; recovering from, adapting to, and growing with environmental challenges; learning and forming capabilities; and producing offspring.¹⁵ Health development is a life course-informed phenomenon that results from transactions between the organism and its internal (i.e., gene, panomic, organ system, and physiologic networks) and external environments (i.e., family, social, cultural, and physical networks and environments).

The optimization of health development is codependent on several contributing developmental processes and resulting propensities that are highlighted in the other LCHD principles and informed by relational developmental systems theory, developmental systems theory, dynamic systems theory, and the unified theory of development.

The health development principle signals the importance of context and our inability to reduce health to its component parts divorced from the contexts within which they develop.

Principle 2: Unfolding

The unfolding principle describes the developmental processes by which expression of a few thousand genes—none of which has a blueprint or roadmap for constituting a viable, living human body—can unfold in an ordered, coherent pattern and shaped by the adaptive success of what has worked before. The adaptive, self-organizing, autocatalytic processes of unfolding can help to explain how genes and culture have coevolved. As humans evolved, cultural information and practices began to accumulate and produce cultural adaptations. These new cultural adaptations feed forward and produce significant selection pressure on genes to improve psychological capacities to further acquire, store, process, and organize an array of fitness-enhancing skills and practices.

The concept of health development as a continuously unfolding adaptive and self-organizing process comprised of distinct yet overlapping functional phases provides a framework for considering how evolutionarily defined stages from life history theory, psychological constructs from lifespan human development theory, and sociological constructs from life course sociology can be aligned, compared, and potentially integrated.

The adaptive, self-organizing, and autocatalytic way that health development unfolds via complex sensing, communication, and regulatory processes implies that our basic, clinical, and translational research needs to elucidate how these processes influence the adaptive capacity of individuals and populations.

Principle 3: Complexity

Health development results from adaptive, multilevel, and reciprocal relations between individuals and their physical, natural, and social environments. This principle indicates that health development occurs within living systems that are not only adaptive, self-organizing, and autocatalytic but also complex and hierarchically arranged. Transactions between different environments can influence gene expression, and gene expression and resultant phenotype can influence various environments, which will, in turn, influence additional gene expression.

Principle 4: Timing

Health development is sensitive to the timing and social structuring of environmental exposures and experiences. Health development is not a linear process where exposures to environmental stimuli or internalized experiences have equal effects, regardless of when in the life course they occur. Instead, health development results from nonlinear interactions that are both time-specific and time-dependent. Time-specific health development pathways refer to biological conditioning that occurs during these sensitive periods, when developing systems are most adaptable and plastic. These represent times when exogenous and endogenous influences can result in different adaptive responses. In other words, the same exposures can have very different effects depending on when during the life course they occur.

Several theories, frameworks, and perspectives including developmental origins of health and disease, life course perspective, biological embedding, chronobiology, developmental time, and adaptive developmental plasticity inform how timing is understood.

Principle 5: Plasticity

Health development phenotypes can either be malleable or constrained by evolution to enhance adaptability to diverse environments. The relative plasticity of these phenotypes is responsive to transactions between evolutionarily selected biological and behavioral conditioning and supportive, challenging, and constraining environments. These phenotypes have evolved to provide adaptive capacity, plasticity (i.e., ability of the organism to systematically alter its phenotype in response to environmental challenges, opportunities, barriers, and constraints), and growth potential, which in aggregate refer to the robustness of an individual's health development.

Although Darwin's theory of evolution laid the foundation for understanding the principle of plasticity, more recent syntheses have expanded our understanding of heredity as including not just genetic change but also epigenetic, behavioral, and cultural phenomena that are transmitted across generations.

Principle 6: Thriving

Optimal health development promotes survival, enhances well-being, and protects against disease. Health development bestows upon the individual resources that have instrumental value, enabling an individual to pursue goals and thrive. It provides assets that individuals employ to pursue the beings and doings that characterize each person's lived experiences. Thus, health development phenotypes are instrumental resources that enable individuals to pursue desired goals and live long, flourishing lives.

LCHD recognizes that phenotypes develop by the continuous coactions of at least five factors: genome, epigenome, environment, developmental time, and life course stage. These coactions do not merely produce single outcomes; instead, they produce developmental landscapes of possibilities with peaks and valleys shaped by an individual's life history, evolutionary determined possibilities and constraints, and the five-way interaction. Which "attractor" state (i.e., health development phenotype) an individual settles in is the result of this complex, nonlinear process.

Principle 7: Harmony

Health development results from the balanced and coherent relations among molecular, physiological, behavioral, cultural, and evolutionary processes. Genetic modulations that occur in molecular time frames measured in nanoseconds are linked to biochemical modulation measured in milliseconds, homeostatic mechanisms measured in seconds to days, social norms that evolve over years and decades, cultural processes that change from years to centuries, and ecological processes that until recently took millennia. Harmonious synchronization of these processes produces the rhythms and variability that characterize health development.

The timing principle introduced the concepts of time dependence, time sensitivity, and social structuring of exposures. The harmony principle extends these concepts by adding the notions of harmonious and balanced relations of the various biological, behavioral, environmental, and cultural systems that an individual is embedded within.

Summary

Health and development, unified into a single construct (health development principle) that adaptively unfolds over the life course (unfolding principle) according to the principles of complex adaptive systems (complexity principle). Change in health development results from time-specific processes (timing principle) that influence bio-behavioral systems during sensitive periods when they are most susceptible (plasticity principle), and the balanced alignment of molecular, biological, behavioral, cultural, and evolutionary process (harmony principle) can result in developmental coherence. Health development provides instrumental assets that enable individuals and populations to pursue desired lived experiences (thriving principle).

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