The S-curve discontinuity theory predicts the path towards a "well" society and increased longevity

Lisa B.E. Shields[a], Tyler A. Gertz[b], Kenneth C. Wilson[b], Ginger L. Figg[b], Steven T. Hester[b], Joshua T. Honaker[b],*

[a] Norton Neuroscience Institute, Norton Healthcare, Louisville, KY 40202, USA
[b] Norton Medical Group, Norton Healthcare, Louisville, KY, 40241, USA

ABSTRACT

The logistic function or logistic growth curve is an "S" shape (sigmoid curve) that has been applied to numerous fields, including geology, physics, biology, mathematics, chemistry, economics, sociology, oncology, and statistics. The S-curve initiates with exponential growth, followed by slowing of growth as saturation occurs, and completion of growth at maturity. The S-curve follows the law of natural growth with a limiting factor, whether it be a competition for resources, investigation and demand for new products, or an economic bubble. The concept of the S-curve has been utilized in medicine to describe the advancements in the 20th century based on the diagnosis and treatment of disease (the "illness" curve [first S-curve]) and predict the future focused on disease prevention and health promotion (the "wellness" curve [second S-curve]). Herein, we propose a third S-curve that we are labeling the "longevity" curve.

Multiple S-curves in business

The principle of the S-curve has been applied to business where a company initially starts with modest growth and then enters a period of rapid growth until it reaches the period of maximum growth [1]. A saturated market then follows when maturity is reached with shrinking returns, followed by a plateau and a minimal decline. The inflection point for a company occurs when there is a transition to a new S-curve [2]. The "discontinuity" period between the two S-curves is marked by a stagnating or decline in the growth of technology. The new S-curve materializes and exponentially grows as new technology is perfected. Companies are able to view their likely potential by utilizing the S-curve theory [3]. Interestingly, the evolution of technology has been described as multiple and successive S-curves with irregular step functions rather than a single S-curve [4,5]. The term "jumping S-curves" refers to a successful progression to new growth opportunities [3]. For example, UPS jumped S-curves numerous times when it transitioned from a messenger service to a business delivery service to a public parcel delivery service. Additionally, the world's leading technology company Apple has perfected the art of jumping S-curves by altering its focus from profitability to quality of products with its iPod, iPhone, and iPad. The momentum that UPS and Apple has generated has shortened each subsequent S-curve.

Use of the S-curve discontinuity theory to illustrate the "chaotic" period between the "illness" and "wellness" curves of healthcare

We previously described Adler's application of the S-curve to medicine and the theory of S-curve "discontinuity" to explain healthcare's past and predict its future [6–9]. The medical field prior to the 20th century lacked standardized care and quality. The initial steep "illness" S-curve was characterized by antibiotics, vaccinations, anesthesia, imaging capabilities, and surgical and technological advances (Fig. 1). This S-curve plateaued at the end of the 20th century due to a host of factors, including high healthcare costs, growing chronic diseases, bureaucracies, unnecessary medical testing, large malpractice claims, and abuse of the system by patients and physicians [8].

Adler predicted the start of a second "wellness" S-curve with a focus on disease prevention and health promotion [8]. The "discontinuity" period reflects the overlapping of the two S-curves and a shift from one curve to the next. This "chaotic" phase, known as "discontinuity" to Adler, is marked by a deterioration in healthcare progression and is primarily represented by chronic disease and rising healthcare costs. Several other competing factors also play a significant role during this
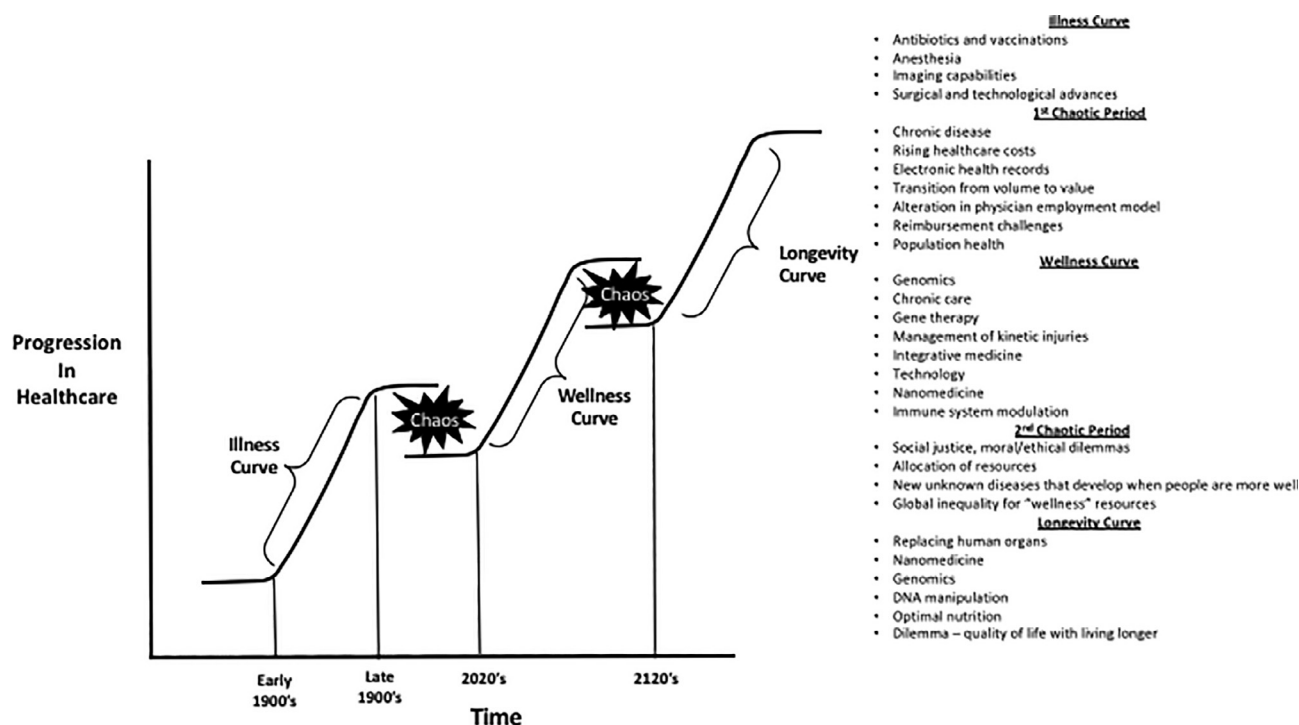
Fig. 1. Utilizing the S-curve discontinuity theory in healthcare, featuring the "illness", "wellness", and "longevity" curves.

period, including the chronic disease, electronic health record, the transition from volume to value, alterations in the physician employment model, reimbursement challenges, and population health (Fig. 1). We predict that the "chaotic" period started in the late 20th century and will extend until the 2020's decade. The efforts to ameliorate the detrimental elements of the "chaotic" phase will spur the momentum to initiate the transition to the next "wellness" S-curve.

Frist describes that American health care is currently at a crossroads, with the innovative forms of technology dramatically enhancing lives while escalating costs and disparities in health care pose hurdles to transforming healthcare [10]. This "crossroads" is similar to our "chaotic" phase where advancements and challenges create a tumultuous period. Frist's solution is a patient-centered, consumer-driven, and provider-friendly healthcare system [10].

Use of the S-curve discontinuity theory to predict the "wellness" phase of healthcare

After the "chaotic" phase, there will be a steady rise and steepness of the next S-curve which will represent the "wellness" curve. The culmination and plateau of the second S-curve is attained when most people in society are well. What will healthcare look like when the majority is well? Will there be hospitals, emergency clinics, and surgeons when no one is suffering from a medical illness or requires surgical intervention? Is it possible for most members of society to be well when individuals choose better lifestyles? Individuals with a healthy lifestyle (exercise, healthy eating, no smoking) are more likely to promote, encourage, and maintain a "well" society, while those with vices will compromise this goal of a completely "well" society. Social incentives may reward the former group for their positive decisions, whereas the latter group may face repercussions for their unhealthy choices, such as increased taxes on carbonated beverages and cigarettes. Advances in genomics and technology will also ease entry into the wellness phase.

Obesity is an obstacle to progressing to the wellness curve. Obesity poses a significant global health challenge due to its escalating prevalence in both adults and children and the associated health risks. The 2013 Global Burden of Disease Study reported that the prevalence of overweight and obese children and adults worldwide rose by 47.1% and 27.5%, respectively, between 1980 and 2013 [11]. Childhood obesity is associated with an increased risk of obesity, cardiac disease, Type 2 diabetes, stroke, and premature morbidity and mortality in adulthood. Furthermore, obese children have a higher risk of bone and joint problems, sleep apnea, and social and psychological problems.

A focus on mental and behavioral health in childhood is another key strategy for promoting the wellness curve. Good decision making skills need to be nurtured and secured in childhood, with a focus on mental and behavioral health. The key factor in minimizing chronic disease in adults is targeting children through a multifaceted approach. In Felitti and colleagues' Adverse Childhood Experiences (ACE) study, a host of adverse childhood experiences (psychological, physical, or sexual abuse; violence against mother; or living with household members who were substance abusers, mentally ill or suicidal or ever imprisoned) were compared to measures of adult risk behavior, health status, and disease [12]. Adults who experienced four or more categories of childhood exposure compared to those who had experienced none had a 4- to 12-fold increased health risks for alcoholism, drug abuse, depression, and suicide attempt [12].

In addition to an emphasis on obesity and mental behavior, a focus on the payment system is warranted. Established in 2015, the Merit-based Incentive Payment System (MIPS) is a Medicare physician payment system that promotes value-based payments [13]. It encompasses four components: (1) quality (Physician Quality Reporting System); (2) cost (value-based payment modifier); (3) Advancing Care Information based on the Medicare HER incentive program; and (4) improvement activities. This physician payment model emphasizes value versus volume which encourages continuity and quality of patient care. One of the primary goals of the MIPS program is to curtail the overwhelming burden of chronic disease on society with its associated morbidity, mortality, and financial ramifications. Through this realignment of finances and resources with accompanying penalties issued by the Centers for Medicare and Medicaid Services (CMS), the primary outcomes are healthier patients with better experiences, increased quality, and improved safety.