

Complex Adaptive Systems Theory and The Tau Conceptual Framework for Understanding Healthcare and Human Services in the United States

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ABSTRACT

Educators applied complexity sciences to analyze healthcare and human services in a complex adaptive system (C.A.S.), which supported the need to restructure services to sustain the goals of the healthcare continuum. C.A.S. theory introduces new perspectives for leaders challenged with meeting inconsistent and seemingly contradictory healthcare mandates. C.A.S. theory enabled identification of variables directly or inversely related based on the direction of their feedback loops and system behaviors from evidence-based research findings. The authors explored the benefits of using this approach as a learning tool for students and faculty engaged in healthcare research and as an evaluation method for healthcare leaders to improve outcomes.

This exploratory review resulted in the development of the Tau Conceptual Framework model, which revealed relationships and elements of a C.A.S. negative feedback system. The name Tau was selected because of the symbolic meaning of the harmonic union between the objective and subjective and the Franciscan ideal to promote the greater good. The research methodology enabled identification of variables related to access, safety and quality, cost considerations, and stakeholder satisfaction. Independent variables were added to the model showing the effects of a direct or inverse relationship with the dependent variables. In using this model, a student-designed submodel was developed using the High Reliability Organization (H.R.O.) theory to improve quality. The models depict healthcare delivery as a multifaceted feedback system that may be used to improve safety and quality within a complex adaptive healthcare system. The model may also enable educators and students develop new submodels and help leaders develop universal practices to improve safety and quality, increase patient and stakeholder satisfaction, and reduce unnecessary and wasteful spending by \$1 trillion annually, thus improving access to services.

INTRODUCTION

Since the startling report by the Institute of Medicine in 1999 that between 44,000 and 98,000 preventable deaths occur annually, a flurry of research has been conducted to explore the problem further.¹ Twenty years later, estimates still range from a low of 25,000 to as high as 200,000.² Government regulators quickly acted to address this problem, with varying results.³ Preventable

¹ Tejal K. Gandhi, Donald M. Berwick, and Kaveh G. Shojania, "Patient Safety at the Crossroads," *JAMA* 315, no. 17 (2016): 1829-1830, doi:10.1001/jama.2016.1759.

² Kevin T. Kavanagh et al. , "Estimating Hospital-Related Deaths Due to Medical Error," *Journal of Patient Safety* 13, no. 1 (2017): 1–5, doi:10.1097/pts.0000000000000364.

³ Gandhi, Berwick, and Shojania, "Patient Safety", 1829-1830.

medical errors remain a problem despite attempts to effect change.⁴ However, the alert provided a starting point for the development and implementation of safer care.⁵ This is just one of the problems healthcare systems must address. Waste, insurance fraud and abuse, misguided regulations, and supply chain management are among the other integrated facets that add increased complexity to a healthcare system.

In 2014, Dr. Joanne Disch from the University of Minnesota described the United States (U.S.) healthcare system before Congress.⁶ She identified ten characteristics of the healthcare system and indicated that the nature of the healthcare system and the current level of dysfunction might be understood based on the following characteristics:

1. Complexity of healthcare problems
2. Patchwork nature of our healthcare systems
3. Perverse nature of our financial reimbursements
4. Time pressures to do things quickly
5. Growth and problems in the use of technology
6. Strong tradition in healthcare that discourages people from speaking up
7. Failure to look at problems from a systems perspective
8. Human Factors
9. Communication errors
10. Leadership problems

Dr. Disch's comments served as another wakeup call across the nation. Her comments prompted additional questions: Have the problems in healthcare been comprehensively examined from a systems perspective? When regulators sought to address the number of safety incidents outlined in the I.O.M. report, had they considered the system comprehensively, or solely focused on individual parts? Systems thinking in healthcare has been explored in recent years, but other

⁴Thomas Diller et al., "The Human Factors Analysis Classification System (HFACS) Applied to Health Care," *American Journal of Medical Quality* 29, no. 3 (2014): 181-190, doi:10.1177/1062860613491623 .

⁵ Kavanagh et al., "Estimating Hospital-Related Deaths," 1-5.

⁶ Joanne Disch, "Patient Safety and Medical Errors," Filmed 2017, C-Span Video, 1:38:31, <https://www.c-span.org/video/?320495-1/hearing-patient-safety>

factors need further review. A review of the literature indicated that though individual systems have been studied within a healthcare organization's context, there is limited information on viewing the interrelationships between these individual systems. For example, organizations do not have full control over the outcomes of the service delivery provided to all patients. Healthcare organizations that admit higher risk patients may experience higher Patient Safety Indicator (P.S.I.) rates, regardless of the quality of care provided.⁷ They also do not have full control over the effects of outside, external events that can also affect the outcomes of the service delivery. These outside events are referred to as third variable problems, wicked problems, or wildcard problems, and they can affect all independent and dependent variables within a system.

Third Variable Problems

An omitted variable or third variable problem occurs when a third variable leads to a mistaken causal relationship between two other variables.⁸ For example, preventable medical errors (X) will cause safety and quality (Y) to decrease, and they seem to be inversely related. However, the confounding third variable (Z) affects both (X) and (Y), which then affects preventable medical errors.⁹ Safety and quality are related to increased implementation of risk mitigation factors. These mitigation factors address (a.) failure to enact needed policies and procedures, (b.) failure to utilize strategic information that can be used to reduce these errors through with evidence-based practices, (c.) organizational mindfulness, (d.) resiliency, (e.) competent, committed and caring staff, (e.) positive patient interactions, (e.) a safety culture, and (f.) positive physician and patient relationships.¹⁰ As these variables increase, preventable medical errors will decrease, and safety and quality will increase. Many of the independent and dependent variables are affected by

⁷ Bernal-Delgado, Enrique, et al., "Should Policy-Makers and Managers Trust PSI? An Empirical Validation Study of Five Patient Safety Indicators in a National Health Service," *BMC Medical Research Methodology*, 12, no. 1 (2012): 19, doi:10.1186/1471-2288-12-19.

⁸ Robert Mauro, "Understanding L.O.V.E. (Left Out Variables Error): A Method for Estimating the Effects of Omitted Variables," *Psychological Bulletin*, 108, no. 2 (1990): 314-329, doi:10.1037/0033-2909.108.2.314.

⁹ Michael Corayer, "The Third Variable Problem (Intro Psych Tutorial #13)," Filmed 2016, YouTube Video, 7:36, <https://youtu.be/ZvHyuJBeCyk>

¹⁰ Padgett, Jared D. "Patient Safety Culture and High Reliability Organizations," DBA diss., Walden University, 2014. ProQuest Dissertations & Theses Global. (Accession No. 1557705479); Taylor-Hyde, Mary Ellen. "Human Resources Strategies for Improving Organizational Performance to Reduce Medical Errors," DBA diss., Walden University, 2017. ProQuest Dissertations & Theses Global. (Accession No. 1896578517).

confounding variables that need to be identified to understand what causes a certain problem and how to correct the problem. Other complications identified as wicked problems must also be addressed.

Wicked Problems

Churchman defined a wicked problem as one that is difficult or impossible to solve because of incomplete, contradictory, and changing requirements that are often difficult to recognize.¹¹ Tonkinwise described a wicked problem as a socially complex problem with no easily-determinable end.¹² Periyakoil indicated wicked problems have incomplete, contradictory, and changing requirements and complex interdependencies that are often unique to the local setting of the problem.¹³ Modern healthcare systems are unpredictable, unstable, and complex adaptive systems often fraught with perverse incentives and internal conflicts that serve as fertile grounds for wicked problems. The term “wicked” has come to denote resistance to resolution, rather than attribution to evil. Moreover, because of complex interdependencies, the effort to solve one aspect of a wicked problem may reveal or create other problems. The stakeholders of a wicked problem often have radically different world views for both understanding the problem and approaching its solution. Given these challenges, it is critical for today’s leaders to understand and manage complex adaptive systems in order to achieve high quality results.

Wildcard Problems

Wildcard problems can surprise and cause considerable havoc to a healthcare system. Peterson defined wildcard problems as low probability, high impact events that could impact the human condition if they were to occur unexpectedly.¹⁴ These wildcard events could affect healthcare services and additional external events including shootings, major accidents, natural disasters like floods, tornadoes, hurricanes, and other disasters like the 1859 Carrington Event, a solar storm that damaged telegraph systems. A similar event able to knock out satellite systems and electrical power

¹¹ C. West Churchman, “Wicked Problems.” *Management Science* 14, no. 4 (1967): B141-B142, doi:10.1287/mnsc.14.4.B141.

¹² Cameron Tonkinwise, “Design for Transitions – From and to What?” *Design Philosophy Papers* 13, no. 1 (2015): 85–92, doi:10.1080/14487136.2015.1085686.

¹³ Vyjeyanthi S. Periyakoil, “Taming Wicked Problems in Modern Health Care Systems.” *Journal of Palliative Medicine* 10, no. 3 (2007): 658–59, doi:10.1089/jpm.2007.9955.

¹⁴ John L. Petersen, *Out of the Blue: How to Anticipate Big Future Surprises*. (Lanham, MD: Madison Books, 1999).

grids could take a decade to recover from and cost at least \$2 trillion to repair.¹⁵

COMPLEX ADAPTIVE SYSTEMS

Holland studied Complex Adaptive Systems (C.A.S.) theory to build computer simulations to help understand and solve challenging problems. To do this, Holland began by identifying the human immune system as one type of complex adaptive system. The immune system faces numerous external threats; too many to account for properly due to the immense volume. Instead, the system learns to adapt to new threats as they arise. In addition to identifying threats, the system must also be able to distinguish self from threat, which adds new levels of complexity. Applied to the immune and other systems, Holland found three related characteristics: evolution, aggregate behavior, and anticipation.¹⁶

Individual parts of the system evolve to enable survival in an ever-changing environment. In describing aggregate behavior, the larger system does not solely respond to movement and function of interrelated parts but is also acted upon by outside sources. Holland identified the aggregate behavior characteristic as something that scientists address in order to change system behavior. This is further complicated by the third characteristic, anticipation. In anticipation of change, a system will adapt and behave in a manner not previously observed. This change occurs even in the absence of the anticipated event. Holland described the threat of an oil shortage as an example, and the resulting activities by individuals and organizations regardless of the realization of the threat. The behavior of stock market investors is similarly affected based on simply the threat of negative news whether or not that threat is realized.¹⁷

A CAS is ever-changing, due to both realized and unrealized potentialities. Though individual parts of the system may perform well, outside influence may affect the outcomes. The system must then adapt to these outside influences and find a new normal. This is part of what makes C.A.S. theory so beneficial in the study of healthcare and human services systems.

¹⁵ Cooper, Christopher and Benjamin Sovacool. "Not Your Father's Y2K: Preparing the North American Power Grid for the Perfect Solar Storm." *IEEE Engineering Management Review* 39, no. 4 (2011): 47–61, doi:10.1016/j.tej.2011.04.005.

¹⁶ John H. Holland, "Complex Adaptive Systems," *Daedalus* 121, no. 1 (1992): 17-30.
<http://www.jstor.org/stable/20025416>.

¹⁷ Holland, "Complex Adaptive Systems," 17-30.

APPLYING C.A.S. TO HEALTHCARE AND HUMAN SERVICES

Systems thinking has been increasingly applied in recent years to healthcare.¹⁸ Simple system factors have been addressed for lifestyle issues, including tobacco addiction and obesity, and health conditions such as tuberculosis programs. However, these successes were not readily applicable to more complex healthcare delivery services. Mutale et al. suggested that the use of systems thinking could be the key to supporting the discovery of innovative and effective tools within healthcare delivery systems. Several areas shown to benefit from systems thinking include (a.) service delivery, (b.) workforce management, (c.) health information services, (d.) medical products and technologies, (e.) financing, and (f.) governance.¹⁹

Healthcare services are designed around derived demands, based on the perceived need to improve some condition or function. Healthcare demand differs from normal demand because an individual does not control the onset of illness nor its severity or duration. When this occurs, the demand for services increases regardless of the available supply or the cost associated with the care (Feldstein, 2012).²⁰ The dynamic nature of this relationship partially explains why the costs of healthcare services continue to escalate in the U.S. and why higher prices will not deter individuals from seeking the care and treatment that they or a family member may need.

Dodder and Dare (2000) identified the most commonly repeated characteristics in the literature regarding complex adaptive systems (C.A.S.s). They found that C.A.S.s: (a.) are balanced between order and anarchy, at the edge of chaos, (b.) are composed of a network of many agents gathering information, learning, and acting in parallel in an environment produced by the interactions of these agents, (c.) co-evolve with their environment, (d.) order is emergent, instead of predetermined, always unfolding and always in transition, (e.) tend to exist in many levels of organization in the sense that agents at one level are the building blocks for agents at the next level

¹⁸ Lauren S. Penney et al., "Interventions to Reduce Readmissions: Can Complex Adaptive System Theory Explain the Heterogeneity in Effectiveness? A Systematic Review," *BMC Health Services Research* 18, no. 1 (2018): 894, doi:10.1186/s12913-018-3712-7.

¹⁹ Wilbroad Mutale et al., "Application of System Thinking Concepts in Health System Strengthening in Low-Income Settings: A Proposed Conceptual Framework for the Evaluation of a Complex Health System Intervention: The Case of the BHOMA Intervention in Zambia," *Journal of Evaluation in Clinical Practice* 22, no. 1 (2016): 112-121. doi:10.1111/jep.12160.

²⁰ Paul J. Feldstein, *Health Care Economics*. (Clifton Park, NY: Delmar/Cengage Learning, 2012).

and (f.) have a future that is hard to predict²¹

To become a systems thinker, one needs to think in terms of inputs, throughputs, outputs, and outcomes. One also needs to identify the independent and dependent variables in the system and determine how are these variables are related to one another. Covariance is a measure of the directional relationship between the variables in the system. A positive covariance or direct relationship (+) means that different variables will move together, while a negative covariance means the variables move inversely (-). Covariance can also be calculated by analyzing data (standard deviations from expected return) or by multiplying the correlation between the two variables by the standard deviation of each variable:
$$\text{Cov}(X, Y) = \frac{\sum (X_i - \bar{X})(Y_i - \bar{Y})}{n}$$

Healthcare services goals include providing maximum coverage for all patients at an affordable cost, providing services that are safe and of a high-quality nature, and providing services that receive high marks in patient and stakeholder satisfaction. However, as costs increase, quality can just as easily decrease. The problem for most healthcare administrators is that the U.S. spends twice as much money as other countries on healthcare services, yet the World Healthcare Organization (WHO) ranks the country 37th in the world.²² Healthcare administrators in the U.S. should consider how the healthcare industry spends over \$1 trillion more annually than other developed countries without notable improvement. How can leaders bend this cost curve? Understanding the larger system is a starting point.

In the business world, a systems thinker can easily interpret what is going on and whether systems within their organization are working. The systems thinker should master certain skills to examine the people and processes that make up their organization. For instance, the relationship between actors and actions in a system are identified. They should know that for every effect, outcome, or result, there is a specific cause. They recognize that the root cause of problems is usually found in faulty systems, not people, which leads to faster resolution and supports a non-punitive and engaging work environment. Another advantage for systems thinkers is to know that

²¹ Rebecca Dodder and Robert Dare. "Complex Adaptive Systems and Complexity Theory: Interrelated Knowledge Domains, In: ESD.83 *Research Seminar in Engineering Systems*, Massachusetts Institute of Technology, 2000. <http://web.mit.edu/esd.83/www/notebook/ComplexityKD.PDF>

²² Ajay Tandon et al., "Measuring Overall Health System Performance for 191 Countries." *Geneva: World Health Organization* (2000).

making improvements requires the use of a mature information system that provides past, present, and future results, as well as process improvement techniques and tools to find the weak-points of a system and fix them. Simultaneously, successful systems thinking leaders pay attention to process planning and measurement to provide timely feedback throughout the organization. Finally, designing and integrating effective, resilient systems enables leaders to increase access, safety and quality, and satisfaction while reducing costs.

As one becomes a systems thinker, problems become more apparent and their solutions more obvious. Ideas are readily available for elevating operational programs to create a reliable and resilient organization. These ideas must be integrated into an organization's culture and adapted as new circumstances warrant. An organization must become a learning organization, striving to be proactive rather than reactive, practicing mindful awareness, and learning from and evaluating events as they occur, whether positive or negative. There is no other way this system-wide change can be achieved.

LEARNING

Educational psychologists explain that any activity which leads to a change in our behavior is learning.²³ While no single definition of learning is universally accepted around the world, three characteristics emerge. Learning: (a.) involves a change in behavior or in the capacity to behave in a given fashion, (b.) endures over time, and (c.) requires practice or other forms of experience. These changes may occur in a person's knowledge, skills, strategies, beliefs, attitudes, and behaviors. Learning involves a change in perceptions or an increased understanding of a complex issue or difficult problem that helps increase knowledge of how things work and why they work the way they do.²⁴

Learning occurs when the "light bulbs go off," and one suddenly can see things in a new way. Bransford identified seven principles tied to the research on increasing understanding:

²³ Detlef R. Prozesky, "Teaching and Learning." *Community Eye Health* 13, no. 34 (2000): 30.

<https://www.cehjournal.org/article/teaching-and-learning-2/>

²⁴ U. Rahayu et al., "The Development of CERDAS Learning Strategy Guide for Science Education Students of Distance Education," *Journal of Physics: Conference Series* 812 (2017), doi:10.1088/1742-6596/812/1/012044.

- Learning with understanding is facilitated when new and existing knowledge is structured around the major concepts and principles of the discipline
- Learners use what they already know to construct new understandings
- Learning is facilitated using metacognitive strategies that identify, monitor and regulate cognitive processes
- Learners have different strategies, approaches, patterns of abilities, and learning styles that are a function of the interaction between their heredity and their prior experiences
- Learners' motivation to learn and sense of self affects what is learned, how much is learned, and how much effort will be put into the learning process
- The practices and activities in which people engage while learning shape what is learned
- Learning is enhanced through socially supported interactions.²⁵

Organizational Learning Theory

Nembhard and Tucker identified Abernathy and Wayne's study in 1974 as the starting point for organizational learning theory. They disagreed with the narrow focus Abernathy, and Wayne applied to organizational cost efficiency, equipment and technology costs, organizational tasks, system characteristics and structure, volume, material costs, and labor costs. Nembhard and Tucker determined that focusing on cost containment alone reduced the organization's innovation and ultimately diminished the organization's long-term success.²⁶ A wider view of the whole system is required through evidence-based learning practices.

Learning Processes

Single-loop learning requires minimal reflection and assumes the status quo regarding strategies and goals is fine. Double-loop learning is more transformative than single-loop learning and is used to reframe the objective. Rather than relying on the status quo, the goal is to make sure the organization's goal is appropriate and adjust as needed. In the healthcare context, double-loop

²⁵ John D. Bransford, *How People Learn: Brain, Mind, Experience, and School* (Washington, DC: National Acad. Press, 2004).

²⁶ Ingrid M. Nembhard and Anita L. Tucker, "Applying Organizational Learning Research to Accountable Care Organizations," *Medical Care Research and Review* 73, no. 6 (2016): 673-84, doi:10.1177/1077558716640415.

learning is more effective than single-loop learning, but to improve safety, something else is needed. Triple-loop learning helps initiate an organizational unlearning of the status quo and actively initiates change. Triple-loop learning incorporates generative learning and strategic thinking.²⁷ With triple-loop learning, individuals within the system learn to adapt and adjust based on real-time input. Capturing these complexities in a model is an effective learning tool to assist leaders in understanding and communicating the cause and effect of relationships between variables within an organization.

DEVELOPING THE MODEL

A healthcare system is an unpredictable, unstable, complex adaptive negative feedback system that requires the interactions of stakeholders that contains both positive (+) and negative (-) feedback loops. A negative feedback system includes a self-correcting mechanism based on variables that are inversely related to one another that works to maintain stability in the system by providing services to meet the derived demands, wants, needs, and patient satisfaction expectations to maintain stability in the system. In an inverse relationship, if X increases, Y will decrease. If X decreases, Y will increase. Regardless of the direction of the outside force, the actions operate in the opposite way to maintain steady outputs in the face of changing external pressures. The key element of any simple negative feedback system is that the system reacts to counter-balance, rather than reinforce, any changes coming in from the environment.

Rouse and Serban introduced basic concepts, principles, models, and methods for understanding and improving healthcare delivery from the perspectives of engineering and statistics. They argued that understanding healthcare delivery as a complex adaptive system would help to design a system that is more efficient, effective, and equitable.²⁸ We developed the Tau Conceptual Model of the U.S. healthcare and human services system. The model identifies healthcare as a negative feedback system, the nature of the system's feedback loops and how methodology helps assess how incremental changes from direct (+) and inverse (-) loops precipitate behavioral changes in a complex system through evidence-based practices.

²⁷ Patrik Nordin, Anna-Aurora Kork, and Inka Koskela, "Value-based Healthcare Measurement as a Context for Organizational Learning," *Leadership in Health Services* 30, no. 2 (2017): 159-70, doi:10.1108/lhs-10-2016-0053.

²⁸ William B. Rouse and Nicoleta Serban, *Understanding and Managing the Complexity of Healthcare* (Cambridge, MA: MIT Press, 2014).

Wildcard problems address events and external pressures attributed to stakeholders of the healthcare system. Stakeholders include the patients, communities, providers, policymakers, payers, government, legislative leaders, lobbyists, consumer groups, insurance companies, pharmaceutical companies, professional bodies like the American Medical Association, the American Nursing Association, and Association of Hospital Administrators, and groups with strong interests in the welfare of the elderly, specific diseases, and disabled populations.²⁹ In the Tau Conceptual Framework model (See [Figure 1](#)), external variables including wicked problems, wildcard events, and third variable problems add real-world complexity and have a direct (+) relationship with the consumer derived demands, needs, and wants. As the pressure from these variables increases, derived demands, needs, and wants will also increase on all stakeholders in the system. The average person has no idea when they will need healthcare services and what those services will cost. Additionally, the exponentially increasing number of senior citizens in need of care must be addressed.

See [Figure 1](#). The Tau Conceptual Framework for Healthcare and Human Service Programs in the Appendix

Adding 80 million baby boomers to Medicare (a federal health insurance payer) at a rate of 10,000 people per day is something the U.S. is now facing with increased urgency.³⁰ By 2050, the U.S. population aged 65 or older is projected to reach 89 million; an increase of 45%. The number of the same demographic with one or more chronic diseases rose from 86.9% in 1998 to 92.2% in 2008. With the chronic care disease set established by the Merit-based Incentive Payment System (MIPS), the incidence of diabetes mellitus is expected to increase by 164% by 2030, Parkinson's disease by 68%, incidents of stroke or heart attack by 27%, and Alzheimer's disease by 40%. Further, outpatient and emergency department visits are projected to increase by

²⁹ R. C. Swanson et al., "Rethinking Health Systems Strengthening: Key Systems Thinking Tools and Strategies for Transformational Change," *Health Policy and Planning* 27, no. Suppl 4 (2012): , doi:10.1093/heapol/czs090.

³⁰ Kathryn Paez and Beth Almeida, "Medicare Enrollment Maze Puts Older Americans at Risk for Financial Penalties and Coverage Gaps," *American Institutes for Research*, (2016): 1-10, <https://www.air.org/system/files/downloads/report/Medicare-Enrollment-Maze-Puts-Older-Americans-at-Risk-October-2016-rev.pdf>.

8-12% with total hospital inpatient days increasing by 19% by 2025.³¹

Wagenaar and Sagaria demonstrated that people significantly underestimate exponential growth, tending to extrapolate in a linear fashion rather than exponentially.³² Wagenaar and Timmers showed using more data points or graphing the data does not help, and mathematical training does not improve performance.³³ With visit utilization and complexity, both increasing exponentially, the future of healthcare must be based on efficiency, high reliability, lean continuous improvement strategies, and high-quality outcomes.

Continuous Quality Improvement

A quality assurance (Q.A.) model is used by regulators to measure quality indicators. Meeting strict Q.A. standards is required for payment. The QA model does not reflect the role of the system design, however. These standards are based on individual performance rather than addressing issues within the larger system.³⁴ This means that a payment structure based on Q.A. data fails to address the larger issues that might otherwise improve safety. A qualitative improvement (Q.I.) model may be more effective than a Q.A. model. The Q.I. model may address organizational or system problems rather than focusing on the individual participants within the system. One way to implement the Q.I. model is through implementation of High Reliability Organization principles.

High Reliability Organizations

A High Reliability Organization (H.R.O.) is one that conducts operations with minimal error, over an extended time, and consistently makes good decisions that result in both high quality and high reliability.³⁵ H.R.O. theory is applied to industries that provide highly complex and risky services; wherein even a small error may have severe consequences. Clements found that hard wiring an

³¹ Christian H. Dall et al., "Effect of Moderate-Versus High-Intensity Exercise on Vascular Function, Biomarkers and Quality of Life in Heart Transplant Recipients: A Randomized, Crossover Trial." *The Journal of Heart and Lung Transplantation* 34, no. 8 (2015): 1033-1041. doi:10.1016/j.healun.2015.02.001.

³² William A. Wagenaar and Sabato D. Sagaria, "Misperception of Exponential Growth," *Perception & Psychophysics* 18, no. 6 (1975): 416-22, doi:10.3758/bf03204114.

³³ W. A. Wagenaar and H. Timmers, "Extrapolation of Exponential Time Series Is Not Enhanced by Having More Data Points," *Perception & Psychophysics* 24, no. 2 (1978): 182-84, doi:10.3758/bf03199548.

³⁴ Marc T. Edwards, "A Longitudinal Study of Clinical Peer Review's Impact on Quality and Safety in US Hospitals." *Journal of Healthcare Management* 58, no. 5 (2013): 369-384.

³⁵ Karlene H. Roberts, "Some Characteristics of One Type of High Reliability Organization," *Organization Science* 1, no. 2 (1990): 160-76, doi:10.1287/orsc.1.2.160.

organizational high reliable culture is critical for health care managers to raise the standard of patient safety.³⁶ Several authors have distilled H.R.O. theory into digestible components. While there are variances in the language, the general concepts either remain the same or are included as subcomponents and complement each other. For example, H.R.O. theory can include developing and maintaining standard processes; implementing checks and redundancy to mitigate potential failure; deferring to individuals with the most information, and developing teams that openly communicate about failure to prevent recurrence of unsafe incidents.³⁷ Based on their prior work, and that of fellow early theorists, Weick and Sutcliffe identified five principles required for organizations engaged in mindful organizing:

1. Preoccupation with failure
2. Reluctance to simplify
3. Sensitivity to operations
4. Commitment to resilience
5. Deference to expertise³⁸

Although regulation has improved patient safety in part, new problems were introduced; a wicked problem. These problems include an increase in inattentiveness. In contrast, H.R.O.s enhance mindfulness and organizational awareness. Enhanced mindfulness increases the rate at which medication and other errors were reported to regulating bodies.³⁹ Implementing H.R.O. principles enhances the application of regulations without diminishing attentiveness. In this way, patient safety improves even as new systems emerge.

Padgett found that when organizational leaders move to an H.R.O. cultural model, they contribute to reduced patient incidents, improve staff perceptions of their contribution to the organization, and reduce costs linked to unsafe care. Padgett also emphasized the continued need for education and training, communication, and teamwork for organizations to enhance reliability

³⁶ Kimberly Clements, "High-Reliability and the I-PASS Communication Tool," *Nursing Management (Springhouse)* 48, no. 3 (2017): 12-13, doi:10.1097/01.numa.0000512897.68425.e5.

³⁷ Christine W. Hartmann et al., "Validation of a Novel Safety Climate Instrument in VHA Nursing Homes," *Medical Care Research and Review* 70, no. 4 (2013): 400-17, doi:10.1177/1077558712474349.

³⁸ Karl E. Weick and Kathleen M. Sutcliffe, *Managing the Unexpected Sustained Performance in a Complex World* (Hoboken, NJ: Wiley, 2015).

³⁹ Cathleen S. Colón-Emeric et al., "Regulation and Mindful Resident Care in Nursing Homes." *Qualitative Health Research* 20, no. 9 (2010): 1283-1294, doi:10.1177/1049732310369337.

and improve patient safety.⁴⁰ These attributes significantly contribute to an organization's goals and improved quality outcomes.

High Reliability Organizations implement the triple-loop learning principle to enhance organizational mindfulness and sustain a culture of safety and quality. The Observe, Orient, Decide, and Act (OODA) Loop, also known as the Boyd Cycle, was developed by Colonel John Boyd.⁴¹ H.R.O. leaders encourage incorporation of the OODA Loop to address system changes in real-time. This process speeds up the decision time and allows for effective decision making as the system changes. Similarly, Periyakoil found the Plan-Do-Study-Act (P.D.S.A.) cycle empowers staff to become change agents and take effective control of the problems in their work setting.⁴² These nonlinear approaches to problem-solving help front-line clinicians and direct care staff to enhance the quality improvement process and may be effective ways to tame wicked problems.

Additional Management Strategies

Implementation of H.R.O. principles is not a zero-sum prospect. Other management systems and styles are compatible with H.R.O. theory and may be simultaneously implemented. These systems include Lean and Six Sigma. Accountable Care Organizations (A.C.O.s) have also been developed using principles compatible with H.R.O. theory.

Lean Principles

Lean principles have demonstrated the ability to improve patient safety, quality of care, efficiency, patient satisfaction, and operational performance. Van Rossum et al. defined the strategy-to-performance gap as the implementation gap or the discrepancy between a strategy for change and its actual implementation.⁴³ Integrated and continuous quality improvement is a requirement for the advancement of quality healthcare delivery in healthcare.⁴⁴ As payment systems are modified to pay-for-performance models, the sustainability of healthcare institutions becomes increasingly tied to clinical performance.

⁴⁰ Jared D. Padgett, "Patient Safety Culture".

⁴¹ Kent Byus, "Observe, Orient, Decide, Act: A Subjectivist Model of Entrepreneurial Decision Making." *Journal of Managerial Issues* 30 no. 3, (2018): 349–362. <https://search-ebscohost-com>.

⁴² Vyjeyanthi S. Periyakoil, "Taming Wicked Problems", 658–59.

⁴³ Lisa Van Rossum et al., "Lean Healthcare from a Change Management Perspective," *Journal of Health Organization and Management* 30, no. 3 (2016): 475-93, doi:10.1108/jhom-06-2014-0090.

⁴⁴ Salva N. Balbale, Sara M. Locatelli, and Sherri L. Lavela, "Through Their Eyes," *Qualitative Health Research* 26, no. 10 (2015): , doi:10.1177/1049732315618386.

Six Sigma

Six Sigma was developed in response to the payment-for-performance structure imposed by regulators. The Six Sigma system is designed to reduce waste and increase efficiency. A five-step process includes problem identification and root cause analysis, and implementation of proposed changes.⁴⁵ As with H.R.O., Six Sigma gains beneficial insight from frontline employees. Lean Six Sigma has been adopted by healthcare organizations to address specific patient safety issues, but the results can fade over time. To improve the sustainability of the Lean Six Sigma system, the closing process in Six Sigma may be used as a control process.⁴⁶ This control process complements the OODA Loop process in H.R.O. theory and the concept of situational awareness. The cycle should repeat continually to address new issues.

Accountable Care Organizations

The Centers for Medicare and Medicaid (C.M.S.) leaders designed the A.C.O. incentive-based program to improve quality through financial rewards and penalties depending on their performance regarding cost and quality measures.⁴⁷ The A.C.O. system includes interactions with physician and nonphysician providers in group practices, A.C.O. provider networks or solo practices, partnerships or joint ventures with hospitals, A.C.O. professionals employed within hospitals, and other designated Medicare providers and suppliers.⁴⁸ There are many moving parts in these systems, and organizational leaders face challenges in achieving efficiency in improving quality while lowering costs. Patient interaction also adds to this complexity. Patient engagement, experience, and satisfaction affect how well managers can meet the A.C.O. quality standards.⁴⁹

Vogus and Singer argued that studying H.R.O.s could provide valuable learning for A.C.O.

⁴⁵ Elaine J. Amato-Vealey, Patricia Fountain, and Deborah Coppola, "Perfecting Patient Flow in the Surgical Setting," *AORN Journal* 96, no. 1 (2012): , doi:10.1016/j.aorn.2012.03.013.

⁴⁶ Paul Murphree, Richard Robert Vath, and Larry Daigle, "Sustaining Lean Six Sigma Projects in Health Care. *Physician Executive*, 37 no. 1, (2001): 44-8, <https://search-proquest-com>.

⁴⁷ Mark McClellan, "Accountable Care Organizations and Evidence-Based Payment Reform," *JAMA* 313, no. 21 (2015): 2128-30, doi:10.1001/jama.2015.5087.

⁴⁸ "Summary of the June 2015 Final Rule Provisions for ...," accessed January 4, 2019,

https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/sharedsavingsprogram/Downloads/ACO_Summary_Factsheet_ICN907404.pdf

⁴⁹ Margae Knox, Hector P. Rodriguez, and Stephen M. Shortell, "Multi-Sectoral Partnerships and Patient-Engagement Strategies in Accountable Care Organizations." *Frontiers in Public Health Services and Systems Research* 5, no. 4 (2016): 27-33, doi:10.13023/FPHSSR.0504.05.

health care managers.⁵⁰ Early A.C.O. leaders indicated the success in meeting and sustaining goals incorporated their capability for managing high-risk patients, access to robust Electronic Health Records (E.H.R.s), a sophisticated care management program, medical staff leadership, and a quality improvement model. This is consistent with the goals and strategies of H.R.O.s. Shortell et al. identified four characteristics useful for creating and implementing a capability package that future A.C.O. leaders should consider: (a.) Behavioral and workflow systems that allow delegation to non-physician providers including nurses, pharmacists, case managers, and other staff, (b.) the ability to create effective teams, (c.) the system redesign of the office visit, and (d.) the capacity to determine if patient populations are large enough to qualify for an A.C.O. and to perform data analytics.⁵¹ These characteristics align with the H.R.O. concepts of deference to expertise, sensitivity to operations, and reluctance to simplify identified by Weick and Sutcliffe, and actively seeking to improve communication and create interdepartmental teams while breaking down silos outlined by Padgett et al., and adapting to an ever-changing environment.⁵²

Financial Considerations

Rutherford described medical practice management as including the basic tasks of financial oversight, revenue and expense reporting, human resource management, stewardship of the physical site, and diplomacy when working with healthcare providers. Changes in the healthcare industry have diminished leaders' and managers' ability to appropriately manage under such traditional models, requiring practice managers to expand knowledge and modify management styles in preparation for five major trends that are and continue to affect the business of healthcare. These trends include "quality as a criterion for reimbursement, regulatory control of fees and services, consumer influence on healthcare payments, the full disclosure of claims data (i.e., transparency), and increases in active patient load per physician."⁵³

One of the weaknesses of the current system under the A.C.A. is that the current fee-for-

⁵⁰ Timothy J. Vogus and Sara J. Singer, "Creating Highly Reliable Accountable Care Organizations," *Medical Care Research and Review* 73, no. 6 (2016):, doi:10.1177/1077558716640413.

⁵¹ Margae Knox, Hector P. Rodriguez, and Stephen M. Shortell, "Multi-Sectoral Partnerships", 27-33.

⁵² Weick and Sutcliffe, "*Managing the Unexpected*"; Jared Padgett et al., "Improving Patient Safety Through High Reliability Organizations," *The Qualitative Report* 22, no. 2 (2017): 410-425, <https://nsuworks.nova.edu/tqr/vol22/iss2/4>.

⁵³ Rick Rutherford, "Five Trends in Healthcare that Will Change the Way Managers Manage." *The Journal of Medical Practice Management: MPM* 32, no. 4 (2017): 239, <https://greenbranch.com/store/index.cfm/category/4/practice-management.cfm>

service model provides no incentive to avoid complications or additional testing. The potential advantages of Bundled Payments (B.P.) reduce costs for improving care coordination while discouraging unnecessary care.⁵⁴ A BP by-product is the improvement of communications between hospitals and doctors who must work together for transparency for the costs of care creates better fiscal responsibility. Alternative payment models include A.C.O.s, medical homes, B.P. arrangements, payment per episode of care, and health plan capitation of payments. Each of these payment methods cites a general yet mutually exclusive characteristic that ties to a risk factor within healthcare yet does not lend to a systems thinking approach, such as the development of a submodel, to truly understand the holistic view of how systems within the larger system must interact and relate to achieve success.

DEVELOPING A SUBMODEL

As the Tau Conceptual Framework model was in its early stages of development, Padgett and Gossett worked to develop a submodel that would be integrated into the larger model to identify additional areas of healthcare safety and quality. Based on Padgett's study, they created a negative feedback submodel (See [Figure 2](#)) to identify the relationship between outside and internal influences on patient safety and quality of care.⁵⁵ The submodel reflects the literature concerning the costs and causes of adverse patient safety events and implementation of H.R.O. principles. In the model, regulations are implemented resulting from adverse patient safety events. These new regulations may have a negative impact on patient or consumer satisfaction measures. However, this negative impact is mitigated if the regulations are supplemented with H.R.O. principles. The submodel was then included in a published paper.⁵⁶

See [Figure 2](#). Patient Safety Culture and High Reliability Organizations: A Negative Feedback System in the Appendix.

As described by Padgett et al., derived patient demands, needs, and wants are identified as the outside driver in this system (See Figure 2). Derived demands, needs, and wants, are directly

⁵⁴ Terry Shih, Lena M. Chen, and Brahmajee K. Nallamothu, "Will Bundled Payments Change Health Care?: Examining the Evidence Thus Far in Cardiovascular Care." *Circulation* 131, no. 24 (2015): 2151-2158, doi:10.1161/circulationaha.114.010393.

⁵⁵ Jared D. Padgett, "Patient Safety Culture"; Jared D. Padgett and Kenneth D. Gossett, "Patient Safety Culture and High Reliability Organizations: A Negative Feedback Model," (2017), doi:10.13140/RG.2.2.29552.87044

⁵⁶ Padgett et al., "Improving Patient Safety" 410-425.

related to the implementation of regulations. As patients are harmed or feel unsafe, regulators implement new rules and regulations for healthcare organizations. These regulations are often one-size-fits-all, which develops an inverse relationship with human factor errors, where an increase in regulations contributes to an increase in human factor errors rather than improving safety. This is attributable to poor communication, blame culture, compassion fatigue, and staff turnover relating to increased demands and pressure resulting from these increased regulations and scrutiny. Patient satisfaction measures also have an inverse relationship with patient drives, needs, and wants. An increase in patient satisfaction decreases the need for new external regulations. Costs associated with unnecessary care, litigation, and defensive medicine are directly related to regulations and increase with new regulations. However, the effects of new regulations on improved care are not always negative.

As indicated in the submodel (See Figure 2), when regulations supplemented with H.R.O. principles, costs associated with adverse events decrease, and human factor errors decrease. A decrease in human factor problems results in an increase in staff competency, organizational knowledge, and a positive relationship between patients and care staff. This leads to an improvement in the quality of patient care, client functioning measures, and patient safety or satisfaction measures.

Adverse events are inversely related to patient safety and quality of care and are directly related to increased costs from litigation, unnecessary care required by new regulations, and defensive medicine as a response to new regulations. Quality of care and quality of life are directly related to client functioning measures which are directly related to patient and consumer satisfaction measures. An increase in client functioning measures then reduces the derived patient demands, needs, and wants and restarts the cycle based on these new factors.⁵⁷

DISCUSSION

A fundamental principle of system dynamics states that the structure of the system gives rise to its behavior. However, people have a strong tendency to attribute others' behavior to dispositional

⁵⁷ Padgett et al., "Improving Patient Safety" 410-425.

rather than situational factors; the fundamental attribution error.⁵⁸ In complex systems, the same policy can lead to very different behavior as the state of the system changes. When differences in behavior are attributed to differences in personality, the role of the system structure in shaping choices is overlooked. Additionally, when behavior is attributed to people rather than to system structure, managers' focus becomes the search for extraordinary people to do the job rather than designing the job for ordinary people. The attribution of behavior to individuals and special circumstances rather than to system structure systematically diverts attention from the high-leverage points, where redesign of the system or governing policy can have significant, sustained, beneficial effects on performance.⁵⁹

Arisha and Rashwan examined 456 articles published by the Winter Simulation Conference from 1967-2015 to measure the relative frequency of approaches used to model healthcare systems to support the decision-making process. A significant evolution of healthcare modeling occurred over the decades, moving from Discrete-Event Simulation as an autonomous method to an integrated and hybrid set of multi-paradigm approaches.⁶⁰ Such a transition aligns with the increasing visit numbers and increasing complexity associated with a growing population. Many healthcare managers believe that traditional models used for decision support are no longer relevant or sufficient to help with their current needs. As the healthcare industry evolves through technological and clinical breakthroughs, so too must executives' mindsets evolve. Failure to do so diminishes the speed and ability to make appropriate decisions that would support sustainability, profit, and high-quality clinical care.

The use of a conceptual model based on C.A.S. theory may also provide validation between proposed theories and help practitioners "bend the cost curve," improve quality and increase stakeholder satisfaction by making changes that will "replace" elements of the A.C.A. in a way that will enhance healthcare for all citizens. If or when this happens, positive social change will occur in the U.S. as healthcare becomes a right of all citizens.

⁵⁸ Lee Ross, "The Intuitive Psychologist and His Shortcomings: Distortions in the Attribution Process," *Advances in Experimental Social Psychology* *Advances in Experimental Social Psychology Volume 10*, (1977): 173-220 , doi:10.1016/s0065-2601(08)60357-3.

⁵⁹ Jay W. Forrester, "Policies, Decisions and Information Sources for Modeling," *European Journal of Operational Research* 59, no. 1 (1992): , doi:10.1016/0377-2217(92)90006-u; .

⁶⁰ Amr Arisha and Wael Rashwan, "Modeling of Healthcare Systems: Past, Current and Future Trends," *2016 Winter Simulation Conference (WSC)*, (2016): 1523-1534, doi:10.1109/wsc.2016.7822203.

The growth of the elderly population in the U.S. prompts questions whether a satisfactory balance of supply and demand creates either viability or liability in the healthcare sector. A favorable balance of supply and demand focuses on consumers requiring good services and healthcare organizations having the ability to meet the demand to keep them coming back. The provisions of the A.C.A. resulted in insurance coverage for 20.0 million adults through early 2016, a 2.4 million increase since September 2015.⁶¹ Although the A.C.A. reduced the uninsured rate, many of the new patients had pre-existing conditions that overwhelmed the healthcare system. Dall et al. concluded that the disease burden of the elderly population required a vast and diverse workforce to diagnose and treat patients with complex medical conditions.⁶²

The supply of doctors to handle the overwhelming demand of new patients with complex medical conditions creates a challenge in healthcare. Meeting the supply and demands of health services will require strategies to promote patient engagement.⁶³ As a result, it should be clear to someone observing this system that the consumer (patients) drive the healthcare market. In the current environment, healthcare managers need to develop strategies that meet patients' needs, ensure compliance with the requirements of various federal agencies, and provide for the psychological needs of physicians, nurses, nurse aides, and other direct care staff. Without adequate, motivated, and engaged staff, the health of the patient, may suffer and supply and demand in healthcare will become a liability without sufficient resources to meet the needs or demands of consumers.

The reception of Padgett et al.'s article was positive.⁶⁴ At the time of this writing, the paper had been downloaded 1,786 times by individual users including some from 325 organizations, 80 countries, and 49 states and the District of Columbia in the U.S. Additional research may be conducted to further develop the Tau Conceptual Framework for Healthcare and Human Services by creating additional evidence-based submodels and identify new relationships that may be

⁶¹ National Center for Health Statistics, "Health, United States, 2016: With Chartbook on Long-term Trends in Health," *U.S. Department of Health and Human Services*. (Hyattsville, MD. 2017) <https://www.cdc.gov/nchs/data/abus/abus16.pdf>

⁶² Christian H. Dall et al., "Effect of Moderate-Versus High-Intensity Exercise," 1033-1041.

⁶³ Guendalina Graffigna et al., "Patient Engagement: The Key to Redesign the Exchange Between the Demand and Supply for Healthcare in the Era of Active Ageing." *Studies in Health Technology and Informatics* 203, (2014): 85-95, doi:10.3233/978-1-61499-425-1-85

⁶⁴ Padgett et al., "Improving Patient Safety," 410-425.

applicable to the larger model. Doing so may assist educators in helping students improve their research skills as they develop new submodels and may help leaders develop and use universal practices that may improve safety and quality, increase patient and stakeholder satisfaction, and reduce unnecessary and wasteful spending by nearly \$1 trillion per year, thus improving access to services.⁶⁵

CONCLUSION

As a learning tool, C.A.S. theory is useful for understanding the complexities of the U.S. healthcare and human services systems. Additional research that identifies covariance between the many variables in this system may be useful to provide a complete understanding of the current system and identify additional means for improvement. Incorporating this research into the Tau Conceptual Framework, faculty, practitioners, current students, and alumni may develop submodels that contribute to a specific knowledge area and the larger framework.

The Tau Conceptual Framework model shows the variables that are the independent and dependent variables in the U.S. healthcare and human services system. The key to understanding the value of a negative feedback model is to identify the variables that are directly related (+) to access, safety and quality, cost considerations, and patient and stakeholder satisfaction. If safety and quality increase, healthcare costs will decrease, and satisfaction will increase. The variables that are inversely related (-) to access, safety and quality, cost considerations, and patient and stakeholder satisfaction must be identified to improve the current healthcare and human services system. If these variables increase, access, safety and quality, and satisfaction will decrease, and costs will continue to increase. If these variables, like preventable medical errors, decrease, then access, safety and quality, and satisfaction will increase, and costs should decrease. The key to “bending the cost curve” is to recognize that there are a trillion dollars of waste in the U.S. healthcare system. Managers need to analyze what they are doing and not doing to improve access, increase safety and quality, and increase patient and stakeholder satisfaction. Evidence based practices should be used as managers address these issues from a C.A.S. approach.

⁶⁵ Juan Liu et al., “Graph Analysis for Detecting Fraud, Waste, and Abuse in Healthcare Data,” *AI Magazine* 37, no. 2 (2016): 33-46 , doi:10.1609/aimag.v37i2.2630.

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APPENDIX

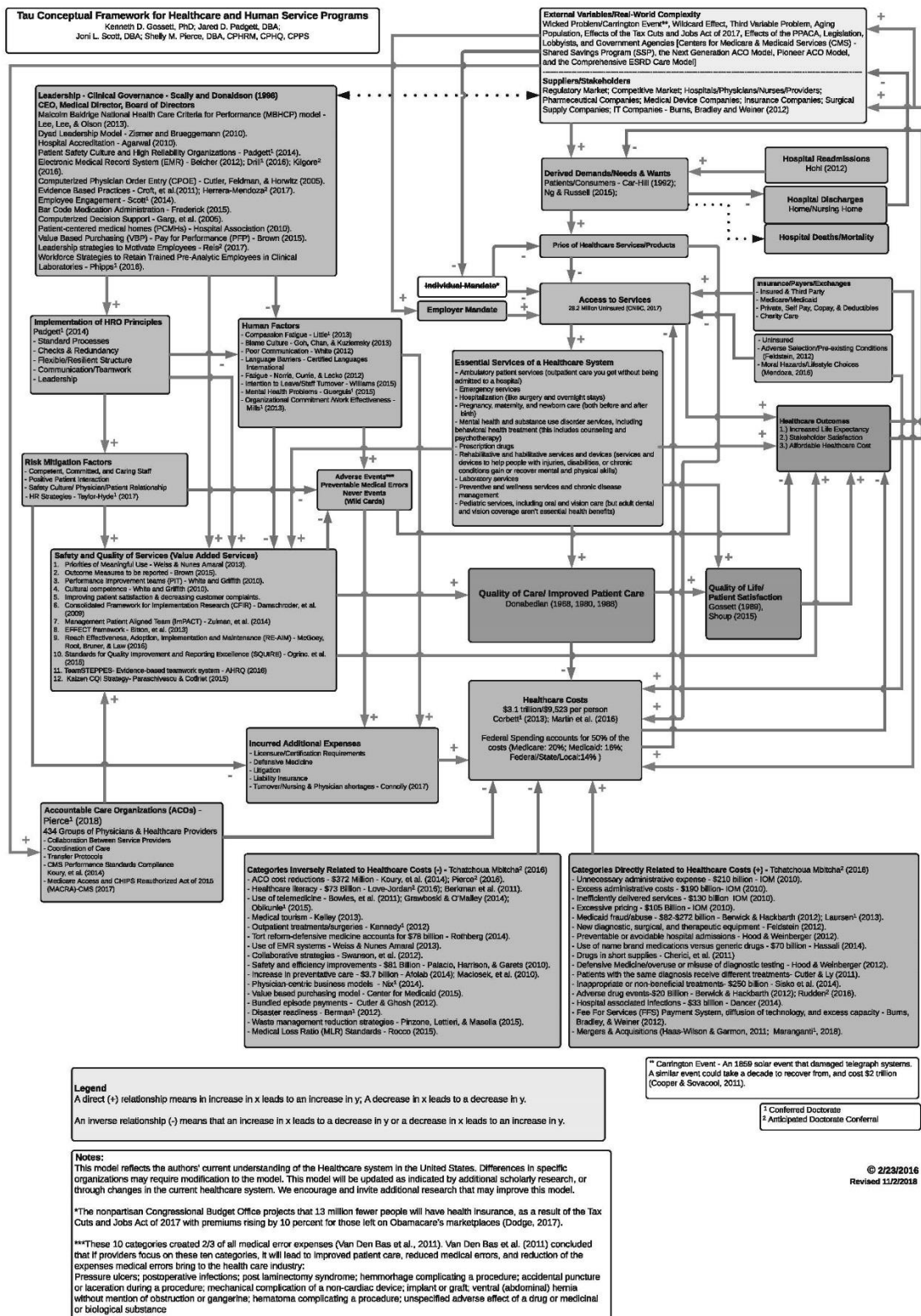


Figure 1. The Tau Conceptual Framework for Healthcare and Human Service Programs

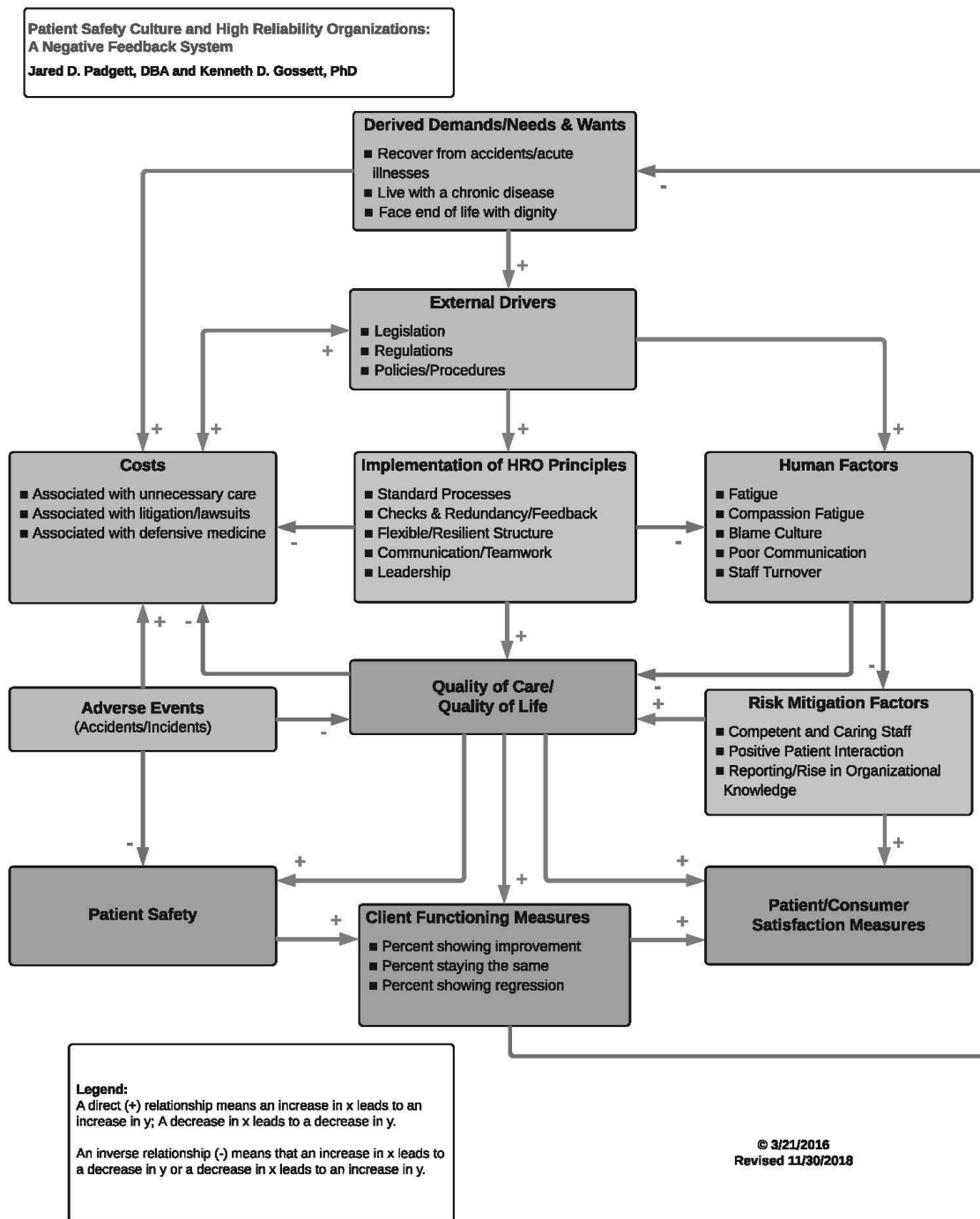


Figure 2. Patient Safety Culture and High Reliability Organizations: A Negative Feedback System