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Promoting Clinician Well-Being and Patient Safety Using Human Factors Science: Reducing Unnecessary Occupational Stress

Michael R. Privitera

Professor Emeritus University of Rochester Medical Center, Rochester, USA
Email: Michael_Privitera@urmc.rochester.edu

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Abstract

Our healthcare delivery system has accumulated complexity of payment, regulation systems, expectations and requirements. Often these are not designed to align with clinical thinking process flow of patient care. As a result, clinicians are utilizing enormous mental (cognitive) resource to comply with these complexities, over and above the baseline mental effort required to give good care to the patient. Recent studies suggest a significant number of physicians, advanced practice providers and nurses no longer want to stay in healthcare due to difficult work expectations and conditions that have become unreasonable. Technology has benefitted healthcare delivery, but also is a conduit of many expectations that have been grafted upon clinician workloads, exceeding the resources provided to accomplish them. Cognitive load is a measure of mental effort and is divided into Intrinsic, Germane and Extraneous Cognitive Load. Extraneous Cognitive Load (ECL) is what is not necessary and can be removed by better design. High cognitive load is associated with increased risk of both medical error and clinician burnout. Chronic high level occupational stress occurs from dealing with this job/resource imbalance and is showing serious personal health impact upon clinicians and the quality of the work they can provide for patients. Since organizational systems have become more complex, leadership methods, clinician wellbeing and patient safety efforts need to adjust to adapt and succeed. Safety efforts have tended to predominantly follow methods of a few decades ago with predominant focus upon how things go wrong (Safety I) but are now being encouraged to include more of the study of how things go right (Safety II). Human Factors/Ergonomics (HFE) science has been used in many industries to preserve worker wellbeing and improve system performance. Patient safety is a product of good system performance. HFE science helps inform mechanisms behind Safety I and II approach. HFE concepts augment existing burnout and

safety interventions by providing a conceptual roadmap to follow that can inform how to improve the multiple human/technology, human/system, and human/work environment interfaces that comprise healthcare delivery. Healthcare leaders, by their influence over culture, resource allocation, and implementation of requirements and workflows are uniquely poised to be effective mitigators of the conditions leading to clinician burnout and latent medical error. Basic knowledge of HFE science is a strategic advantage to leaders and individuals tasked with achieving quality of care, controlling costs, and improving the experiences of receiving and providing care.

Keywords

Human Factors, Ergonomics, Leadership, Work Environment, Burnout, Latent Medical Error, Patient Safety, Clinician Wellbeing, Cognitive Load, Experience of Providing Care

1. Background

Individually based interventions to address clinician burnout are not effective enough by themselves [1] [2]. Systemic/organizational interventions are needed as well as individual to be effective. Eighty percent of occupational stressors associated with burnout are organizational/systemic [3]. Strategies for coping with stress have been classified into Primary Control Coping (attempts to reduce or remove the stressful situations) or Secondary Control Coping (adjusting an aspect of themselves and working with situations as they are) [4]. This paper will focus upon the use of Human Factors/Ergonomics (HFE) science applied in healthcare leadership to mitigate existing high occupational stress situations, and prevent them from occurring.

1.1. Introduction

Human Factors/Ergonomics (HFE) is a science comprised of multiple other sciences, including cognitive science, medicine, industrial engineering, clinical, educational, experimental, and organizational psychology, safety engineering, anthropomorphic, computer and other science [5]. The goals of HFE are both employee wellbeing and efficient system performance [6]. Patient safety is a product of good system performance.

Clinicians are expending an enormous amount of their highly trained but limited cognitive resource over and above the basic mental energy required to give care to the patient. Our healthcare system has layered in complexity, complicated payment systems, non-clinically aligned requirements and processes to achieve compliance with outside authorities [7]. Cognitive load is a measure of mental effort. High cognitive load is associated with increased risk of both medical error [8] and clinician burnout [9].

Cognitive load can be mitigated by better design, organizational coordination,

satisficing (include what is satisfactory and sufficient to meet the requirement, but no extras) and harmonization with existing processes. The portion of cognitive load that is unnecessary and reducible by better design is called Extraneous Cognitive Load (ECL) [10] [11].

ECL comes from many sources, some clinically well-meaning (patient focused), others not as clinically well meaning but other purposes (business/shareholder focused). Patient focused sources come from many healthcare authorities who may not communicate with one another. Accumulated expectations exceed human capabilities contributing to system dysfunction, burnout and error [12] [13].

Because many high level stressors are out of control of the clinician, recent studies have shown they create a neurotoxic impact on the clinician—causing brain anatomical and other biological changes [13]-[19] [See **Figure 1**].

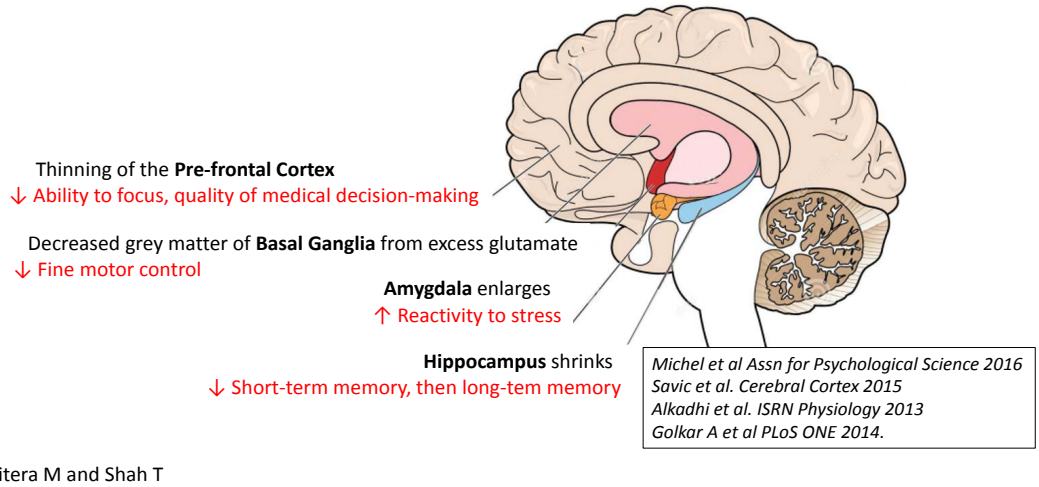

Figure 1. Brain biologic effects of burnout—from chronic high occupational stress with their associated functional impact expressions.

These anatomic areas have similar location to changes associated with PTSD and child maltreatment [15]. High level chronic occupational stress creates a truly toxic work environment and is a force working against sustainable good care. Some of these anatomic changes may be reversible if uncontrolled stress is removed [15], but the time frame available in which reversibility is possible is not currently clear. Further evidence of the effect of this high occupational stress includes telomere shortening (accelerated cellular aging) [19], cortisol levels becoming high, then low, creating coronary artery plaques [16] [17] [18]. The medical culture of endurance and silence, has impeded recognition of the human limitations of clinicians. Normal internal feedback that their work conditions are dangerous and non-sustainable gets suppressed. Medical culture itself has become a contributory and perpetuating factor of the toxic work environment.

Hospital leaders and administrators have also reported high cognitive load. American Hospital Association published a report on regulatory burden upon hospital systems. A quote from hospital leadership: "Every time something changes

there's a cognitive slowdown to figure out what is being required now… It's an added salary to do this without any clinical benefit." [20]. Extra resource is required to handle this increased expectation on the hospital operation. However, once multiple authoritative mandates trickle down and get inserted into the daily workflows of clinicians, there is incremental cognitive load increase which in total can overwhelm and produce high stress. Yet, since the sources are coming from authorities and are incremental, they can seem "invisible" (see Table 1).

Table 1. Problems with recognition/visibility of human factors issues.

1. Observer without knowledge or experience with HFE concepts
2. Authority Effect—we tend to do what authorities tell us to do, trusting that unintended consequences have been considered.
3. Financial measures frequently change, consuming leadership attention
4. Cost silos obscure how costs relate to each other
5. Halo bias-assigning the term "quality" or "patient safety" to a process may reduce challenging the science behind it. Assumption: Must be good since termed "quality" or "safety" metric. Logic becomes circular and self-perpetuating.
6. Failing to recognize how one intervention in isolation may be though to improve quality (e.g. creating a Best Practice Alert on electronic medical record or BPA). However when inserted into the system workflow, may lessen quality at individule and at organizational multi-user level due to increase cognitive load and thought derailment.

Technology insertion capabilities raise new ethical issues.

a. Does an authority have sufficient certainty that the benefit of demanding attention (e.g. BPA) outweighs the risk of disrupting the current existing clinical cognitive thought flow process?

b. Might technology disruption of cognitive thought flow affect quality of thinking that follows, such as differential diagnosis or treatment plan?

More than ever, hospital leadership having some basic understanding of HFE is now critical, especially with existing and anticipated worsening staffing shortages as 1/5 physicians, 1/3 Advanced Practice Providers and 2/5 nurses are reporting they no longer want to be in the profession in two years the way it currently exists [21]. National efforts through the National Academy of Medicine and Office of the Surgeon General have been launched to deal with this healthcare worker crisis [22] [23]. HFE can empower leaders with ability to strategically budget the highly trained cognitive resources of their institution and reduce the occupational stress on our clinicians.

HFE knowledge can help the administrator with informed decision-making as to whether it might be safer to call attention to an issue which uses less cognitive resource (by color, font size, etc.) than demand attention to the issue and risk consequent disruption of thought flow. Once some knowledge of HFE in leadership exists, more visibility of HFE problems should occur. The term "ergo eyes" has been suggested to describe a person's awareness to see, prevent and mitigate the ergonomic problems occurring.

1.2. Integrating Patient Safety and Clinician Wellbeing

HFE informed leadership should promote the collaboration of clinician wellness

efforts with patient safety and quality efforts [13] [24] [25] [26] [27]. In Patient Safety literature, a great deal of focus has been in Safety I framework: defining safety as few things as possible go wrong [28] [29]. This approach also tends to be reactive responding when things go wrong or unacceptable risk. There is now encouragement by the Agency for Healthcare Research and Quality (AHRQ) for moving toward Safety II framework whose goal is as many things as possible go right [30]. This framework is more proactive, compatible with optimizing clinician wellbeing, and continuously trying to anticipate developments and events. Hence a combination of Safety I and II has been suggested.

Complex System Science explains the changes in organizational systems of the last 40 years and why it is essential to start approaching leadership, management as well as patient safety differently as the world has changed how our systems operate [31]. Proponents for more Safety II report that we often follow patient safety methods from 30 - 40 years ago, or adopting methods from low variability fields, whereas healthcare is highly variable and requires adaptation by clinicians at the point of care [29].

Safety I sees humans as hazards or liabilities, with action focus as problems to fix. Safety II sees humans as the resource necessary as the source of flexibility and resilience that come through with solutions to problems that come their way. Safety II framework is conducive to the rationale of encouraging the wellbeing of clinicians and also supports integrating wellbeing and safety efforts. Hence, clinician wellness takes on a central role to the success of all missions of the institution, not as just an optional pursuit. Human Factors/Ergonomics application is the science to help understand and produce interventions for the overlapping factors involved in both clinician wellbeing and patient safety.

1.3. Technostress and Shadow Work

Although technology advancements have been of benefit to society, emerging science is reporting the negative human impact that needs to be better understood, managed and mitigated [32] [33] [34]. Stress is described as physical tension or a feeling of emotional (often frustration, anger, or nervousness) coming from events, thoughts demands or challenges. Mechanisms of how technology causes stress when inserted into operational systems, is beginning to be described. Tarafdar *et al.* described "technostress" coming from Information and Communication Technologies (ICTs) with five techno-related phenomena occurring: 1) *Overload*: forcing users to work faster and longer from channeling inputted expectations for multiple authoritative sources. 2) *Invasion*—creating situations where users can be reached anytime, constantly feeling "connected" and blurring between work-related and personal contexts. 3) *Complexity from lack of intuitive interfaces*—making users feel inadequate in their skills, forcing them to spend extra time and effort understanding ICTs. 4) *Insecurity*—users feeling threatened from ICT replacing them or by other people with better understanding of ICT than them. 5) *Uncertainty*—contexts where continuing

changes and upgrades in ICT unsettle users creating uncertainty [32].

ICTs that connect to internet, (EMR, electronic schedules and e-mail etc.), increase the ability for electronic responses to be remotely monitored and tracked, vastly increasing end-user accountability to federal, state, industry, regulatory, educational, quality and safety over-seers, risk management, legal agencies, payers, and other sources. Each can have profound impact on their career, yet non-coordinated, creating ever-increasing cacophony of expectations.

Work that is not monitored, and not "seen" by administrators and decision-makers who prescribe the work but has to be done to be organizationally functional has been termed "*shadow work*", originally coined as an observation of shifting work costs from corporate overhead to consumers in society [35]. Prescribed work set by administrators + *shadow work*, is the total real workload.

Hundreds of examples of *shadow work* in healthcare can be given, but just a few would be: Sudden EMR software updates, increased security restrictions, passwords expiring with little/no warning with high complexity to establish a new one, outside records scanned into EMR tabs with non-clinically intuitive names that are hard for clinician to find. When, software glitches occur, brainpower (neural resource) expended to try to figure out solutions or spend time on phone with Information Technology (IT). Autocorrect function can keep typing a different word than intended, working against the grain of intended documentation. Significant mental effort is required to overcome *shadow work*, while the clinician tries not to make a mistake that may harm a patient [36] [37]. Shadow work and the emotional effects of technostress are ECL.

1.4. Cognitive Flow and Techno-Viscosity

New concepts applying HFE begin to focus upon how technology may actually interrupt or complicate the needed flow of clinician thinking ("cognitive flow") involved in achieving a task in healthcare. For example, in the process of interacting with a patient for normal baseline cognitive processes involved in diagnosis and treatment, one would want the process to be smooth and without impedance. Technology overlay into healthcare creates new operational situations that justify new terms to label and recognize them. Borrowed from terms in physics (fluid mechanics) "flow" is defined as a process to occur easily and smoothly, "Viscosity" would describe impediments or resistance to that flow.

"*Techno-viscosity*" is the resistance or impediment to ease of cognitive flow caused by lack of user-centered design in an individual tech platform or when combining multiple tech platforms in operational systems. Techno-viscosity is ECL. Each platform may have a purpose to solve a single problem but when combined and infused into the whole system operations, new complexities can multiply. Examples include risk of each individual platform crash, slow application, time for user troubleshooting serial platform navigations, security requirement and timeouts, password complexity, new password updates, software design updates, layout differences, cognitive schema of operations that are each

built with different goals, technical jargon that can intimidate the less tech-savvy user. In total, *techno-viscosity* reduces the ergonomics organizationally [37] Earlier descriptions include "information fatigue" [38] and data smog [39]. A recently suggested synonym is "technological friction" [40].

2. Human Factors/Ergonomics (HFE) Science Application in Leadership

HFE is used in other professions such as for pilots, astronauts, and air traffic controllers, but very little use in healthcare [12]. Three divisions of HFE are—*Physical Ergonomics* (human body's responses to physical and physiological workloads), *Cognitive Ergonomics* (brain and mental processes and capacities of humans when at work), and *Organizational Ergonomics* (organizational structures, policies, and processes in work environment) [6].

Other subdivisions in ergonomics are in relationship to the whole organizational system.

Micro ergonomics would focus upon human and the technological device (e.g. Electronic Medical Record and other medical device interface design) [41].

Macro ergonomics, often used interchangeably with organizational ergonomics, is with respect to the whole healthcare organization. It promotes optimizing a balance of the people subsystem of the organization (socio) and the technological subsystem of the organization, by what is called Socio-Technical System perspective (See separate section below on STS for more detail [42] [43] [44].

Meso-ergonomics has been a term that is between micro and macro, and uses an approach that crosses divisions, units, departments, etc. in uniting micro with macro efforts [45].

Meta ergonomics: Integrating people, technology and ecosystems in a super-ordinate fashion to influence best utilization of resources to achieve results. May be helped by public policy to assist in coordination and collaboration of needed units (e.g., hospitals, states, countries, etc.). Goal is to optimize the production of what is intended and optimize efficiency while maintaining the well-being of the workers [46]. Reduces "tyranny of small decisions" [47] that can over-consume resources, amplifying extraneous cognitive load on all stakeholders. In this regard, National Academy of Medicine's National Plan for Healthcare Workforce Wellbeing (2022) [22] and Addressing Healthcare Worker Burnout. The U.S. Surgeon General's Advisory on Building a Thriving Health Workforce [23] are examples of this super-ordinate plan. If stakeholders would buy-in and participate, these would be meta-ergonomics in practice.

Dr. Hal Hendrick, the Father of Macro Ergonomics has been quoted for two famous dicta: 1) "Think bigger… Think Systems": and 2) "Good ergonomics is good economics" [42]. Taking a systems approach to clinician wellbeing is the focus of National Academy of Medicine 2019 report that came out just before the Covid pandemic [48].

HFE can be applied within each person's circle of influence. It can be applied in individual practice, but the wider the leadership circle of influ-

ence-Unit, Division, Department, Chief Executive Officer (CEO) of a healthcare system and beyond—the greater the number of clinicians and patients that can benefit. See Figure 2. Leadership has already shown a strong influence upon burnout, and work satisfaction [49]. Areas influenced by leadership are in lower box in Figure 2 and makes their knowledge of basic HFE potentially very impactful.

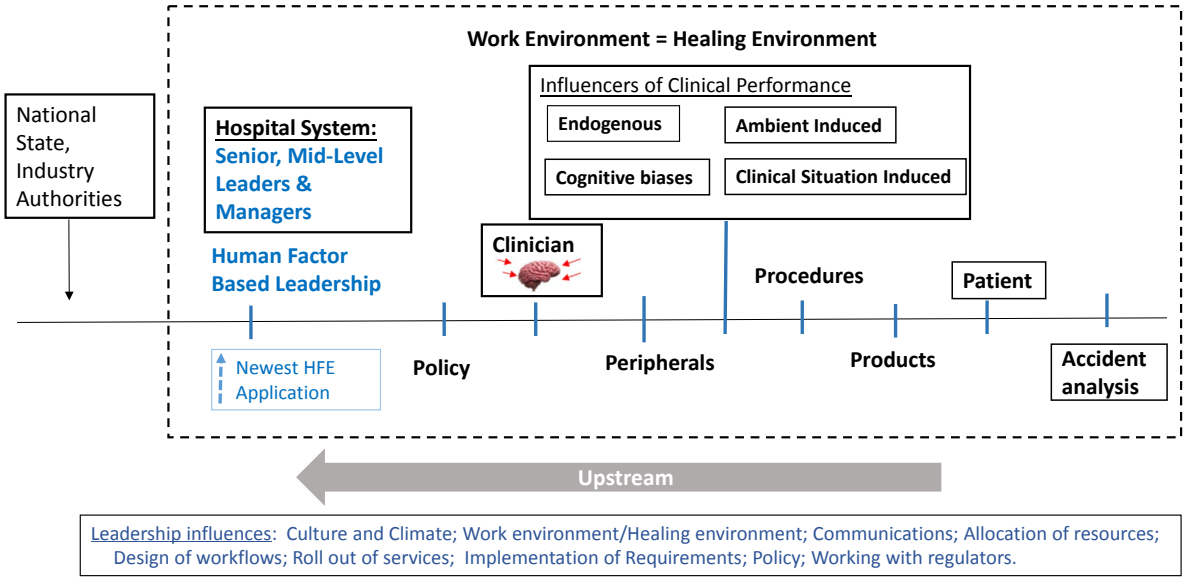

Figure 2. Human factors/ergonomics (HFE) spectrum of applications. Human Factors/Ergonomics (HFE) Science has been used in many phases of healthcare, marked by the vertical blue hash marks. Red arrows toward clinician brain are system based unnecessary occupational stressors. Leadership application of HFE has profound potential to reduce burnout and conditions of latent medical error given areas of leadership influence.

2.1. Sociotechnical System Perspective: Designing Effective Organizations

Technology innovation rapidly increases, one new innovation on the shoulders of the last. Silicon Valley experts have warned us that the rate of technology innovation has now and will continue to outpace human adaptation [50]. Intentional efforts are needed, such as better ways of leading, educating and working in organizations, in order to bridge this gap. As technological innovation continues to expand without optimizing the human subsystem to work in tandem with these changes, the organizational efficiency suffers.

Visionary organizational designers in the 1960s anticipated our current dilemma. Coalmine owners hired engineers in the 1940s without input from the miners, then forced new technical methods of coal mining on to miners. This led to disasters in the coal mining industry [43]. Trist began to study the comparison results *when coal miners were involved with the engineers to design better methods and Socio-Technical* (*STS*) *science for building more effective organizations was born* [51]. STS methods showed marked improvement in turnover, absenteeism, grievances, productivity, safety, quality, costs, morale and attitudes in over 134 organizations studied [43]. STS recognizes the need for joint opti-

mization of both socio (people) and technical (technology and processes) subsystems as technology rapidly expanded Organizational ergonomics with STS perspective would optimize communication, staff resources and management, work schedule design, teamwork, structures, policies, and processes, worker participation into decision on workflow design. Feedback systems that regularly get front-line information back to leadership would be implemented [43] [44].

STS interest grew in 1980s but became overshadowed by Lean and Six Sigma. Getting input from those doing the work requires leadership sharing power to influence processes [44]. Many leaders liked Lean and Six Sigma because they focused upon increasing efficiency of work prescribed by leaders, reducing waste, variation while it allowed preserving autocratic leadership styles. In healthcare, value also was only defined from the perspective of the customer (patient), not the worker. Gratefully, STS is now having a rightful and timely comeback.

To achieve the joint optimization of Socio and Technical subsystems "*environmental sensors*" are utilized that give feedback to organizational leadership about how the organization is performing to meet the needs of the environment [43]. In healthcare, environmental sensors would be both patients and clinicians. See **Figure 3**. The Triple Aim framework of healthcare delivery (costs, quality and experiences of patients receiving healthcare) included patients input but not clinicians [52].

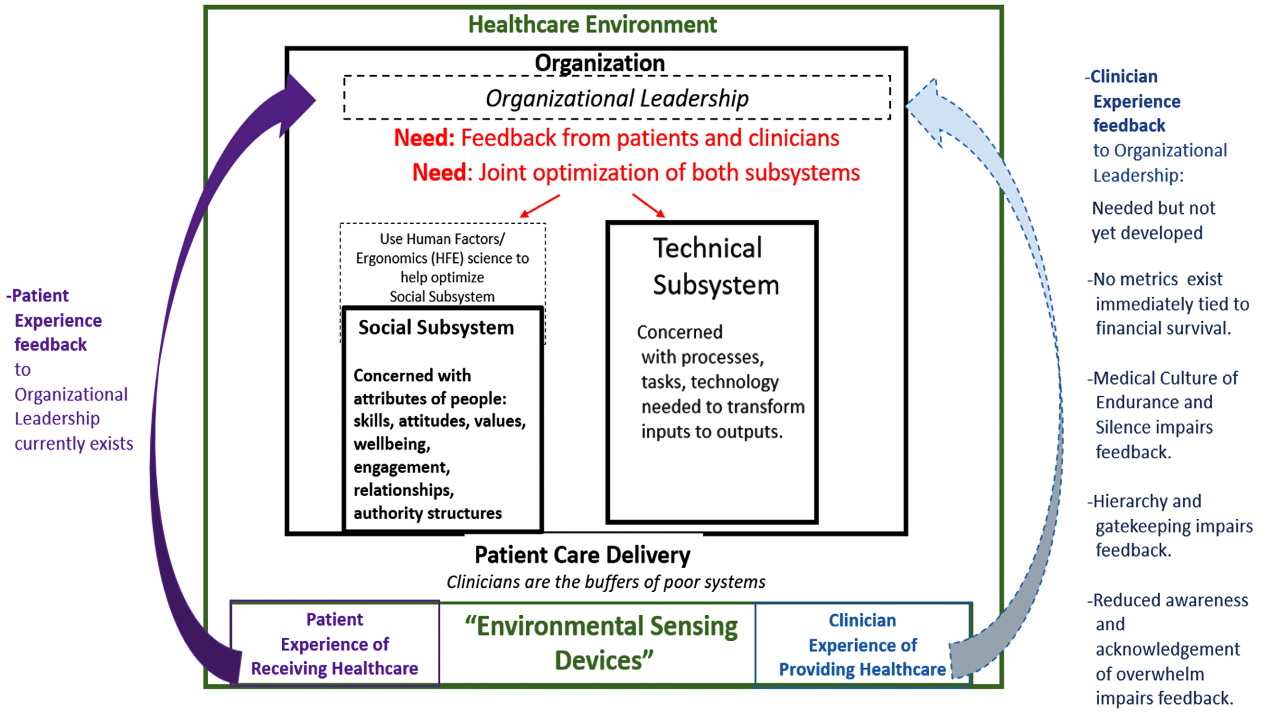

Figure 3. Designing effective organizations: sociotechnical system (STS) Perspective. STS perspective benefits by having input from "environmental sensing devices" that give feedback to Organizational Leadership from those directly experiencing the organization's production effect into the environment. In healthcare, environmental sensors are both patients and clinicians. Currently, patient experience feedback exists but clinician experience feedback does not, hampering effectiveness of the organization and impairing the joint optimization of socio (people) and technology which delivers the organizational effectiveness. Adapted from [43] [44].

The Quadruple Aim (costs, quality, patient experience and clinician experience of providing care) came forward as a framework of approach in healthcare, and this changed the potential to get BOTH patient input and clinician input [53]. For a variety of reasons, metrics essential to financial survival of an institution are still Triple Aim based. HFE application in the hands of leaders can reduce and prevent negative impact by strategically incorporating the experience of providing care into organizational decisions.

Participatory management structures to process input from those closest to the problems are needed. Where decisions are made for EMR or other Information Technology, formation of a Provider Advisory Committee can raise and review the issues that affect the front line use of technology. Institutional wellness efforts touch multiple missions of the institution. Formation of a Wellness Strategic Planning Work Group (WSPWG) should be formed, comprised of administrators and clinician representatives from different disciplines Examples of constituents of such a group would be attending physicians, residents, Advanced Practice Providers, Nursing, Pharmacy, Department representatives, administrators such as Chief Medical Officer, Chief Operations Officer, representatives from Human Resources, Employee Assistance Program, Chaplaincy, etc. Surveys, especially with write in answers give rich data about key stressors. Especially in beginning, surveys should be anonymous to allow freedom to convey information without fear of either retribution, or being considered "weak" in the medical culture. Key questions could include: 1) What gives most meaning at work? 2) What are key stressors? 3) What are reasonable suggestions?

Consider other feedback metrics such as rating systems on how well new initiatives are working, such as a simple scale of 1 - 10 (1 = difficult, 10 = going well). If possible, allow room for some write-in answer to elaborate on the problem.

2.2. Basics of Cognitive Ergonomics

Cognitive Ergonomics is the discipline of making human-system interaction compatible with human abilities and limitations, particularly at work. It uses cognitive sciences knowledge of mental processes such as perception, attention, and memory, decision-making and learning. It takes into account issues of expertise versus being a novice in regard to presented information, software design, etc. The goal is minimizing the amount of cognitive effort to achieve the intended process and making it efficient and effective.

The mental process, cognition, can be Automatic or Controlled (see **Table 2**). Automatic thought requires less brain (neural) resource to operate and comes from deeper structures in the brain. We also shift to Automatic thought by default, when we run out of sufficient brain (neural) resource used up in Controlled thought. It should be noted that Controlled thought is a limited resource that requires significant energy from glucose. This cognitive resource should be budgeted as a highly trained but limited resource for the institution. Decisions about its stewardship become relevant to wellbeing, safety and quality efforts. Basic knowledge of HFE becomes a leadership advantage as it will empower

leaders to more accurately weigh pros and cons when deciding upon support resources and costs. As HFE knowledge in the institution increases, relationships between various institutional costs will become more clear.

Table 2. Cognitive types: cognition can be Automatic or Controlled.

Automatic Thought	
	Habit Memory
	also called **System 1 Thinking**
	Quick stimulus → response
	Utilizes far less neural resource (glucose)
	Shifted to when cognitive resources are low.
Controlled Thought	
	Executive Function, Cognitive Flexible Memory
	also called **System 2 Thinking**
	Used when carefully thinking through differential diagnosis, weighing pros or cons of a plan of treatment, etc.
	Limited resource, high utilization of neural resource (glucose).

Understanding the three types of cognitive load-intrinsic, germane and extraneous-helps leaders to sort out what is (cognitive) waste in a system. Applying HFE knowledge can identify new targets for eliminating waste in the healthcare system (see Figure 4).

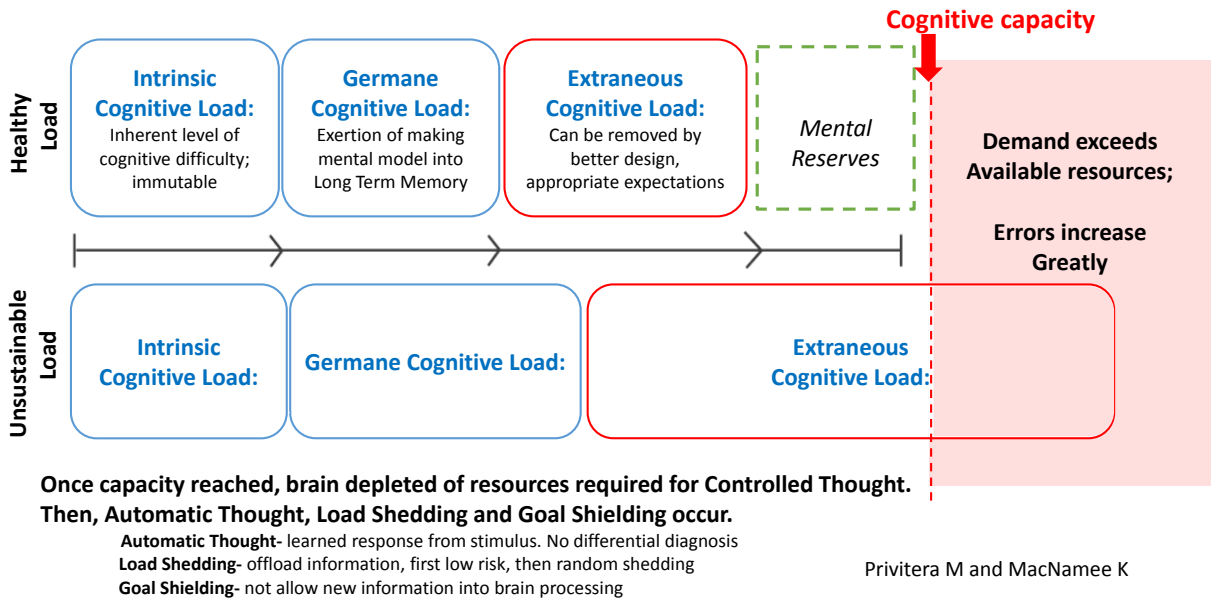

Figure 4. Controlled thought is a limited resource. Utilization is affected by amount of cognitive load. Intrinsic load, Germaine Load, and Extraneous Cognitive Load, make up the total cognitive load. Removing sources of extraneous cognitive load is a main goal of application of Human Factors/Ergonomics (HFE) by leaders to make cognitive load for clinicians more reasonable. Excessive cognitive load leads to burnout and medical error. With high cognitive load exceeding cognitive capacity, clinician brain switches to Automatic Thought from Controlled Thought. Load shedding occurs offloading at first by choice of what might be lower risk material, then as proceeds random shedding occurs. Goal shielding occurs in this over-capacity condition, as no extra resource available. Brain is shielded from handling new information and is highly focused upon finishing the goal at hand.

Becoming somewhat familiar with cognitive actions listed in Table 3 that are prevalent in the work environment will develop the ability to see and mitigate common areas of extraneous cognitive load, developing so called "ergo eyes". This knowledge can be applied in design of policies, roll out of work flows, completion of regulatory requirements, staffing decisions, optimizing the use of high level cognitive processes in clinical care. The most conservative leadership decision may not necessarily be the safest for clinician or the patient. Many sources of ECL are in the name of patient safety and quality, or business of medicine. How these initiatives are rolled out is where the control exists, and hence the advantage for the HFE-informed leader.

Table 3. Controlled thought is used in these processes that create cognitive load.

Highly trained clinician cognitive resources are limited. Must be restored after used. Budget these processes for their best use.
Focusing attention
Decision-making (no matter the size of the decision). *# of EMR clicks matter as each is a decision. Lack of intuitiveness of design matters.*
Sorting
Classifying
Prioritizing
Multi-tasking (shifting back and forth between topics)
Getting back on track after interruption—*Best Practice Alerts* (*BPAs*) *or other hard stops on EMR matter as they demand attention. Calling attention to something* (*color*, *fontsize*, *etc.*) *uses less neural resource than demanding attention*
Maintenance of goals
Maintenance of information active in working memory. *Time/space between finding information and executing action on the information matters.*
Updating working memory with new information
Self-regulation, professionalism, self-effacement, despite how treated
Emotion work-dealing with bad outcomes, distressed patients and families
Maintaining "Aequinimitas" in setting of bleeding, injury, pain, etc.
Suppressing previously learned information to lean and operate new device—*having differently designed devices which are all used for the same purpose matters.*
Lack of cognitive restoration between dognitively draining events. *Work outside of work matters. Only tracking units of work without tracking time needed to do the work hampers feedback to organization as two whether adequate resources were provided to do the job needed.*
Cognitive workload debt. When mandatory requirements like required extra training for regulatory purposes exist without time provided to accomplish them, this creates more cognitive workload to find the time to reduce the workload debt of the job and reduces the cognitive resource for patient care. IF too much cognitive workload debt accumulates, there is a fracture point past which workload debt cascade occurs, and mental processes degrade in quality [54].

Figure 5 gives examples of job demands that can be decreased and job resources that can be increased to reduce burnout coming from job demands exceeding job resources.

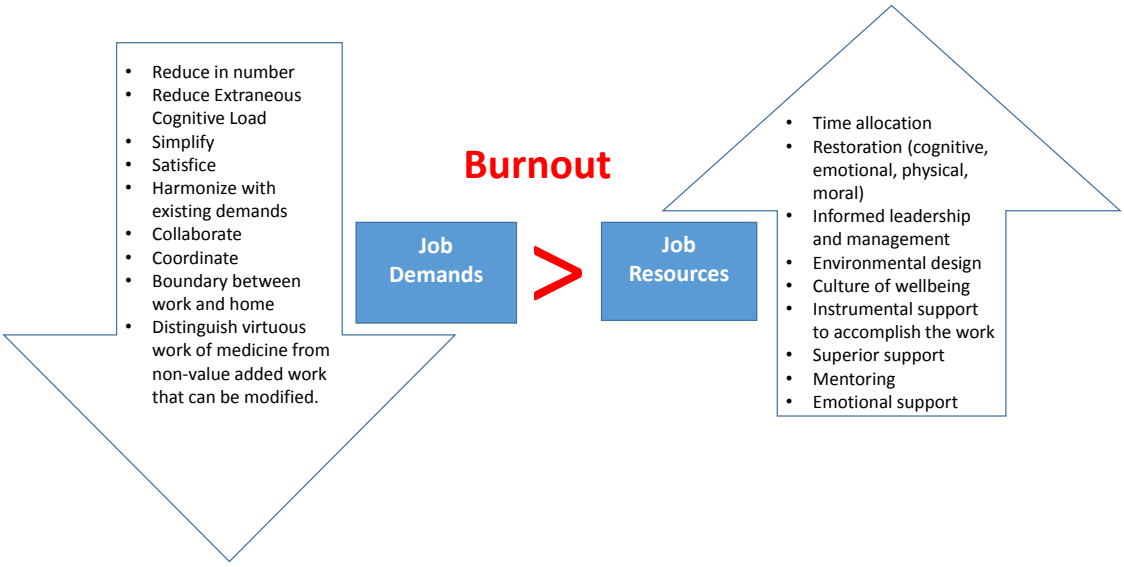

Figure 5. Demand-resource model of burnout with applications. Burnout occurs when Job Demands exceed job resources [55]. Interventions would be to decrease overall job demands (including cognitive job demands), increasing the resources to achieve them, or both.

2.3. Institution Roll out Strategy of HFE for Leaders (Roadmap)

Basic framework and theory of HFE should be presented to provide foundation for immediately applicable action. Efforts are Senior Leadership driven while key administrative leaders and clinicians own the processes. Informational presentations: Brief, high level information for senior level, more detail on application for mid-level and clinician leadership. Have multiple administrative office leaders involved. Key collaboration is between Clinician Wellness and Patient Safety and Quality leadership to galvanize this conceptual connection throughout the enterprise. Utilizing Table 3 to understand factors draining neural resource involved in Controlled thinking and Table 4 to give broad stroke interventions and approaches to reducing Extraneous Cognitive Load (ECL) can help administrators and clinicians understand the overview of how to apply HFE interventions in your organization. Suggested roll out specifics by organizational group suggested below.

Table 4. Broad stroke interventions to reduce Extraneous Cognitive Load (ECL).

Engage Administrative offices of Risk Management, Patient Safety and Quality, Medical Staff Office, Compliance, Wellness, Human Resources, Medical Executive Committee and Communication Office to keep all aware of processes.
1. Evaluate processes, polices and metrics currently in place
Are they strategic (why)?
Are they necessary (why)?
What might be the unintended consequences? (Note: administrative leadership would make more informed decisions if they have foundational knowledge of multiple are of impact of burnout)
In the context of meeting requirements, is there a better way to not drain highly trained clinician time and brain (neural) resource?

Continued

Understand clearly what a regulatory requirement specifies. Look up the written requirement.

Satisfice-satisfactory and sufficient to meet the requirement but no locally added extras.

Can make additional information available for voluntary education or for use to be called up for use in future relevant clinical situations as a clinical resource.

Create a clearing house for all mandatory requirements that senior leadership be made aware of and a mechanism to manage the total mandatory load on clinicians espoused by multiple administrative offices.

Job-Resource model of burnout [55]. When cognitive jobs go up, resources need to also go up to avoid burnout and error. Job-related requirements must be a cost of doing business for the organization. This creates a business-related force to be most efficient and time conscious of clinician time as to what must be mandatory and what can be voluntary.

2. Standardization

What are the core operational processes to standardize and promote routines? When should you allow and encourage aligned autonomy or customization?

Are there opportunities to standardize and simplify layout locations of core functions of care of patients throughout the institution?

Can clinical unit design be standardized (with collaboration of clinicians with architects) to make easier to find what is needed easily regardless of unit worked?

Consider when standardization might jeopardize safety or not meet a patient's unique needs.

Are there options for "wiggle room" built in?

Decision to engage most' wiggle room" options should be under the control of the clinician, but consider when variation might require the authorization of a superior.

3. Consolidate information

Reduce split attention effect. Separated information requires more brain (neural) resource to cognitively process than physically integrated information.

Be user-centric-design groupings of information by what works best for the user.

Keep wording to key information so it can be processed by working memory. Finer detail can be pursued by interest or wish to understand more fully after essentials are understood.

Process Coupling. Workflow processes related to each other should be made physically closer together for ease and simplicity of operations.

4. Decrease redundancy. Redundancies are extra elements not absolutely necessary for understanding or functioning.

In communication of data and design. Irrelevant information clogs up the working memory which transfers information to long term memory. Hence clogging may contribute to forgetting.

Be concise

Be precise

Use emphasis strategically

5. Prioritize design

Equipment and layouts should have deliberate designs that consider human limitations.

Anticipate situations of clinician low cognitive resources, such as occur in burnout, high stress, high volume demand, evening or night shift, extended work hours, sleep and food deprivation.

Over-complexity in design will require high cognitive resources. Keep in mind the competing factors for clinician's attention and potential cognitive processing state affected by situations of low cognitive resource.

Continued

6. Leadership Collaboration

Among all leaders who roll out requirements and work expectations

Collaboration with clinicians, encouraging participatory management, input from those most familiar with the work to be done.

Understand how work-as-imagined compares to total real work done.

Be aware of shadow work (work off metrics, unseen, unpaid but fill the day) and Work Outside of Work (WOW).

Find opportunities to lower total institutional Extraneous Cognitive Load (ECL) by means of the multi-administrative office collaboration.

Work with Human Factors/Ergonomics professionals. Hire them at your institution.

Consider collaboration of HFE professionals with Lean professionals, as HFE science will help both prevent future and mitigate existing risk areas. HFE "waste" to be reduced or eliminated is predominantly ECL. Lean processes are well known in hospitals and can be harnessed to achieve reduction of ECL burden.

Job-resource model of burnout [55]. Table adapted and expanded from [10].

C-Suite and Senior Leadership Level

- Understand what Human Factors/Ergonomics (HFE) is, why important, key terms and key basics of application.
- Be more aware of total work burden on clinician, how it translates to clinical care.
- HFE rationale for why need to reduce total work burden, increase resources or both.
- Progress reports from mid-level administration, and clinician actions to remove unnecessary cognitive load and other workload reductions.
- Consider Enterprise Project Manager and needed resources for success.
- Strategic presence of senior leadership to lead and shepherd progress, help cut through barriers. Optimize power of leadership.

Mid-Level Administration Level

- What HFE is, why important, basics of application.
- More detail on organizational application with worked examples.
- Convergence at C-Suite, senior leadership on methods of intervention and progress.
- Understand importance and act upon reducing work outside of work (WOW). Contain ever-expanding work load.
- New initiatives launched with HFE principles in mind.
- Clinicians as collaborators to optimize existing and new implementations.

Individual Clinicians Level

- What HFE is, why important, collaborate with administration in participatory management structures.
- Clinicians that work with administration in participatory management can learn more about HFE organizational interventions.
- All clinicians—individually based HFE. Optimizing sleep/wake cycles, cogni-

tive and other restoration, boundaries between work and home, cognitive ergonomic individual application for efficiency at work, at documentation, get done and get out. Long-view options to optimize wellbeing reducing WOW.

- Achieve sustainable and meaningful practice.

3. Worked Solution Examples of Common HFE Problems in Hospital Settings

Many examples of HFE application for leaders are reported elsewhere [13] [24] [25] [26] but a few will be emphasized here in greater detail.

3.1. Mandatory Education Requirements

Be aware of the invisibility of risks from numerous uncoordinated expectations, especially when comes with a Halo bias—suggesting that something must be good since name quality or safety associated with it. Multiple mandates from different administrative offices have been prescribed but without adequate resources to achieve. High volume of mandatories, ever-increasing and lack of harmonization with other duties.

1) Recognize dangers of job demand > resources which causes work environmental toxicity to clinician wellbeing and increase risk of error on patient.

2) Engage collaboration of subject matter experts (SMEs) and administrators with clinicians.

3) Need collaboration of all administrative offices involved in assigning mandatories, standardize roll out.

4) IF Computer Based Training (CBT), pay attention to software ease and speed of use and intuitiveness of operations as intuitiveness of design will reduce time to learn its operation.

5) Recognize and track total mandatory load as it has not been thought through regarding effect on safety or human ability to do.

6) Mandatories are a cost of doing business for institution. Need to provide time to do them. Institutional support for their completion helps align incentives to keep mandatories concise, to the point, and logistics of their completion more workable.

7) Flexibility on methods of completion: Group, individual, double purpose for continuing education credits, and/or malpractice reduction credits.

8) Clarify exact wording of requirement. Know minimal requirement to comply, have additional information as voluntary.

9) Satisfice: Satisfactory and sufficient to meet requirement but. No extras for mandatory portion.

10) Having the voluntary component still available still gives respect and justice to the material for its importance, but can be sought by interest or as clinical resource.

11) Allow regular and routine feedback on how to make experience better.

3.2. Interruptions and Best Practice Alerts (BPAs)

Understanding risk of BPA which demands attention, vs calling attention such

as by font size, color, bold, underline, italics, etc. BPA is certain to interrupt and derail current clinical thinking. In light of this, must weigh pro/con decisions administratively. Consider whether importance of BPA content is of greater importance than the clinical thinking occurring at the time, such as differential diagnosis or treatment plan. Inter-administrative office collaboration should occur with clinicians, wellness leadership patient safety, billing, information technology, compliance, risk management offices. Resolve tension of competition for clinician attention, balance risk/benefit, using cognitively less taxing ways to achieve results.

1) Interruption causes increase cognitive load over baseline, less so if interruption is about same context of work than if different context of work interruption, but all increase stress frustration time pressure and effort.

2) Greater # of interruptions extends task completion time of task.

3) Strategically time and batch administrative decisions (e.g. ICD-10 Dx. Are there ways to achieve precision procedure codes, justification for continued admission in hospital, etc. without interfering with clinical thinking flow)?

4) Create system to ensure non urgent pended question for clinician to be addressed between tasks or cases.

5) Consider productivity hours—with minimal interruptions and providing documentation time.

6) Medication distribution: Cone of silence, wear sash "do not interrupt".

7) Administrator—engage clinicians with architects when designing clinical areas to protect concentration: Work space vs community space distinctions. Heat/cold/noise issues, lighting issues, improve eye-contact with patient for planned location of Electronic Medical Record (EMR).

3.3. Work Outside of Work (WOW)

Within hospital leadership, become familiar with "Pajama time" work (chart documentation in evening before bed) effect on personal, family and medical-legal risks. Writing at end of long days when tired, can begin to write gibberish instead of what would have written if contained during a work day with limited hours of work .The longer a person awake, the more impairment of cognition. The longer the time till document a visit, the longer it takes to remember and document it. Technically, Virtual Private Network (VPN) at home slows computer responsivity. Medical culture and normalization of deviance impairs internal signals that this continued and regular work outside of work is abnormal, not sustainable and a risk to wellbeing and error.

1) Senior Leadership support publically and strategically involved to address needed culture change.

2) Leadership messaging: "We care about your wellbeing. We know it is not sustainable, nor safe for you or patients".

a) Risk management, Compliance, Billing, Administration. Senior leadership unified support to take this on.

3) Launch Pajama Time education: Self-care is not selfish but imperative for quality of work, safety, family life and sustainability of career.

4) Work-Home conflict of continued late documentation, effect on family, risk of seriously consideration separation or divorce, burnout, depression, risk of serious error.

5) Teach effect of increased cognitive load and task slowness to recall further from event.

6) Suggest at minimum document critical information/assessment and plan at the time of the visit, before next patient seen.

7) Administrator—Build in documentation time to a planned work day.

8) Team documentation support from Compliance Office.

9) Attending/Chief Resident: Inpatient service—finish rounding earlier and plan documentation time. Use suggested finish times as end pressure to get notes done and get out.

10) Local leadership culture: Clinical work is done at work.

11) Regarding documentation length:

a) Challenge your own thinking on what is really necessary to write down.

b) Print out old note.

c) Review and cross out what is not really necessary.

d) Think through why anything remaining is there.

e) Incorporate new approach in to future notes.

4. Conclusions

Healthcare delivery has become an overwhelming environment in which to work, and is showing serious personal impact upon clinicians and the quality of the work they can provide for patients. Such toxic work environment conditions have now shown harmful biopsychosocial effects on our healthcare workforce. Healthcare leaders, by their influence over culture, resource allocation, and implementation of requirements are in a uniquely poised position to be effective mitigators of the conditions leading to clinician burnout and latent medical error. If they were provided knowledge of basic human factors/ergonomics principles, their potential to improve the healthcare work environment is great, with expected improvement of quality of care provided. *How* various regulations mandatories, laws and policies are implemented is where leaders have control. HFE science in the hands of such leaders can unleash capabilities to positively influence the work environment in ways they may not currently realize they can influence. The author advocates for education systems that have access to current healthcare leaders and for leaders in training to include Human Factors/Ergonomics education in their curriculum. Leadership ability to apply this knowledge in their circle of influence has great potential to tame the expectation overwhelm that currently exists in healthcare delivery. The more that hospital system leadership understands of HFE mechanisms of overwhelm, the more informed feedback they can give to upstream sources of expectations when given

the opportunity.

More upstream sources of these high expectations on healthcare systems could help by re-examining what their regulations and mandatories are, as well as more interagency communication to keep track of total expectations being passed along to hospital systems which pass down to clinicians. The science and methods described are meant to augment existing organizational interventions as concrete "ground level" tools in converting "high level" suggestions into immediate action. Routinely available hospital methods, such as Lean Process can be employed using Extraneous Cognitive Load as the "waste" to be eliminated. HFE provides the science behind why Lean process can help existing problems. Leadership knowledge of HFE can additionally prevent the problems from occurring. Human factors/ergonomics science can be helpful at all levels of the healthcare delivery ecosystem.

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Conflicts of Interest

The author reports no conflicts of interest regarding the publication of this paper.

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