6th International Conference on Applied Human Factors and Ergonomics (AHFE 2015) and the Affiliated Conferences, AHFE 2015

Introducing routine measurement of healthcare worker's well-being as a leading indicator for proactive safety management systems based on Resilience Engineering

Bobbie N. Ray-Sannerud*, Stephen Leyshon, Vibeke B. Vallevik

DNV GL, Healthcare Program, Strategic Research and Innovation, Veritasveien 1, 1363 Høvik, Norway

Abstract

Although the need to improve patient safety is widely recognized, there is general agreement that ambitious targets for improvement have not been met. Resilience Engineering focuses on complex adaptive systems and provides a holistic view of interacting elements that adjust, adapt and reinforce one another in response to emerging forces. This provides a framework to understand both why organizations succeed or fail and, therefore, how to improve their reliability. One component that is often identified as a key factor in safety and reliability by complex adaptive systems and RE are the individuals within the system and their relationship to organizational performance. The goal of this paper is to identify and transfer knowledge regarding healthcare worker's well-being from health sciences to the development of proactive safety management systems, with a specific emphasis on the RE framework as offering the most potential for this. To achieve this, the paper will: First provide a review of relevant determinants associated with a healthcare worker's well-being that suggest both risk and contribution to the success of system performance. Next, the benefits of utilizing indicators for proactively monitoring system performance in healthcare will be reviewed. This will have a particular focus on the benefits and challenges to the routine monitoring of the healthcare worker's well-being as a specific indicator for system performance and patient safety. Finally, further research necessary to address a number of critical key factors to investigate the utility, validity, and usability of the design and implementation of healthcare worker well-being indicators into healthcare safety management systems are identified.

Keywords: Resilience engineering; Well-being; System performance; Healthcare; Patient safety; Healthcare workers

* Corresponding author. Tel.:47-414-02298.
E-mail address: bobbie.nicole.ray-sannerud@dnvgl.com

1. Introduction

Patient safety has long been a concern for policy makers, the public, and clinicians. Although progress has been made in increasing patient safety, challenges remain linked to the sustained scale and spread of improvement [1-3]. Due to the inherent complexities of the healthcare system, over the past decade, professionals and researchers from human factors, systems engineering, and health science disciplines have attempted to combine skills and knowledge to redesign safer healthcare systems [4]. One area that has received a substantial amount of attention is the well-being of those who deliver care. The literature that covers healthcare staff well-being often describes the working environment of the healthcare employee to have inherent risk factors related to their psychological, physical, and social health [5-7]. Unfortunately, despite this recognition, there has been relatively little attention to its potential in yielding predictive measures in order to identify weaknesses or strengths for taking corrective actions before a system fails. Within Resilience Engineering (RE)[8], leading indicators are developed as a means for proactively monitoring and managing risk as according to not only their potential for harm, but also their strengths. The purpose of this paper is to advocate for monitoring of the worker's well-being within the healthcare organization as a leading indicator of system performance with emphasis of the RE framework as offering potential for this. This paper also calls for further research to investigate the utility of leading indicators of healthcare worker well-being.

2. Review of healthcare worker well-being determinants that suggest risk and contribution system performance

The well-being of the healthcare worker is an increasingly popular topic in research and the media. Currently, there is no universally accepted definition of well-being and as a result, most researchers will describe well-being as covering the interactional outcome of a number of differing dimensions regarding an individual's subjective state. Dodge and colleagues conducted a multi-disciplinary review of past attempts to define well-being and proposed a definition of well-being that includes constructs that are arguably measureable, operational, and universally applicable[9]. Their definition highlights that a stable well-being is when individuals have the psychological, social, and physical resources they need to meet a particular psychological, social, and/or physical challenge[9]. Although a direct relationship between the well-being of healthcare workers as defined by Dodge and colleagues and outcomes to the healthcare system has not been established, the determinants related to the psychological, social, and physical dimensions of healthcare workers well-being have been thoroughly investigated. This growing evidence presents both negative and positive determinants related to the psychological, physical, and social determinants of a healthcare worker's well-being that suggest a risk or contribution to the healthcare system based on its socio-technical response. That is, the interaction between the healthcare organization's complex infrastructures and human behavior. A selection of these determinants is reviewed below.

2.1. Overview of selected negative determinants related to the healthcare worker's well-being that suggest a risk to the healthcare system

The negative determinants related to one's compromised well-being, such as burnout, stress, fatigue, poor physical health and poor social capital have been thoroughly documented and reflect inherent consequences to the healthcare profession. In short, a review of the literature suggests that despite the fact that fundamentally different healthcare systems exist globally, these issues are not unique to one country, regardless of their development or socio-economic status, and does not discriminate against one's clinical area of work, population served, or phase of professional development or specialty. The E.R.[10], internal medicine[11], primary care[12], and mental health[13] are just a few of the clinical areas that have been documented to have negative outcomes to the well-being of the healthcare workers who work there. Phases of a healthcare worker's professional development, such as being in training [11, 14], and junior and senior staff[15] within a range of healthcare professions such as nursing [16] and physicians[17, 18] have all been identified as risk factors for healthcare professionals. Additionally, several populations that healthcare workers serve have been identified to also place the worker at risk. Populations such HIV[19], pediatrics[20], disorders of the consciousness[21], and older adults[22], are among just a few. Although there is evidence to suggest that certain personality traits and personal coping skills can increase one's risk to stress

and burnout[23], there is considerable research that suggests there are organizational, occupational and environmental factors within the healthcare workforce that also have a major contribution to these stressors[24]. This relationship is made more serious due to its influence on performance and impact to the healthcare system that affects patient care. In order to illustrate this, Table 1 provides a brief overview to a selection of the negative determinants related to the psychological, physical, and social dimensions of well-being that could have an impact to the healthcare system.

Table 1. Negative determinants related to the well-being that suggest an impact to the healthcare system.

Well-being Dimensions	Related Determinants	Influence on performance	Suggested impact to the system
Psychological	Burnout	Suboptimal patient care practices[25]	Increase risk for adverse event, increased risk to low quality of care
		Unprofessional conduct & less altruistic professional values[14]	Increase risk for patient dissatisfaction, increased risk to low quality of care
	Psychological distress	Error making[26], Malpractice claims[27]	Increased risk for adverse event
	Low job satisfaction	Turnover intention[28, 29]	Increased costs, poor patient provider ratio, increased risk to adverse event
Physical	Fatigue	Poor performance[30-32]	Increase risk to adverse event
	Poor health (e.g. musculoskeletal problems)	Medical leave and turnover intentions[33]	Poor work attendance, Poor patient provider ratio
Social	Poor social capital	Turnover intentions[34]	Poor work attendance, Poor patient provider ratio
	Poor workplace relationships	Turnover intentions[16]	Poor work attendance, Poor patient provider ratio
	Work-Home Interference	Emotional exhaustion[35]	Work interference, increased risk to low quality of care

2.2. Overview of selected negative determinants related to the healthcare worker's well-being that suggest a risk to the healthcare system

Although less extensive, there is emerging research that suggests a relationship between the positive determinants of well-being to the healthcare system. In order to illustrate this, Table 2 provides a brief overview to the selection of positive determinants related to the psychological, physical, and social dimensions of well-being dimensions that suggest an impact to the healthcare system.

2.3. Limitations and challenges to identifying a relationship between well-being and healthcare system outcomes

Although there is a growing awareness in the healthcare community regarding the well-being of healthcare workers and its impact to the healthcare system, efforts to intervene are often met by challenges in convincing healthcare leaders and policy makers that this is a critical component of patient safety that warrants further attention. In addition, due to the lack of a standardized definition of well-being there are limitations to properly linking this concept with healthcare system outcomes. Nevertheless, the selection of negative and positive determinants related to well-being presented in Tables 1 and 2 suggest an association between healthcare workers' well-being and the way that care is delivered. Most of the well-being literature for healthcare workers often highlights just one dimension or one determinant of well-being, for example assessing healthcare workers for their level of stress and labeling this as "well-being." These types of inferences may be misleading as the focus of just one dimension may

neglect the interaction effect that the psychological, physical, and social dimensions have on one another that impact the way in which one performs. More research is needed to further explore and establish this relationship.

Table 2. Positive determinants of well-being that suggest an impact to the healthcare system.

Well-being Dimensions	Determinants	Influence on performance	Suggested impact to the system
Psychological	Job satisfaction	Patients' adherence to treatment[36], Low turnover intention[29, 37]	Reduced risk to adverse event, Improved costs
	Empowerment	Low turnover intentions[6, 38]	Improved patient provider ratio, improved costs, reduced risk to adverse events
	Low burnout	Patient satisfaction[39], positive safety culture[40], high empathy[41]	Improved patient satisfaction, reduced risk to adverse events, improved quality of care
Physical	Quality sleep	High performance[32, 42]	Reduced risk to adverse event, improved quality of care
	Physically active lifestyle	Lower malpractice claims[43], patient adoption of healthier lifestyle[44]	Reduced risk to adverse events, improved patient outcomes
Social	High social capital	Low turnover intentions[34]	Improved costs, improved patient provider ratios, reduced risk to adverse event.
	Positive workplace relationships	Improved safety attitudes[45]	Improved quality of care

3. The measurement of healthcare worker's well-being to proactively monitor system performance

3.1. Systems thinking and resilience engineering in healthcare

To succeed, patient safety initiatives must consider not only the clinical, but the organizational factors in the healthcare system. Traditional safety logic techniques in healthcare; however, are often based on linear models that essentially follow a step by step progression with structural rules that assume adverse events are caused by directly interconnected chains of failure events. The complexity of the healthcare system that characterize modern healthcare can produce unintended incidents. These can be difficult to detect through traditional linear analysis logic and solutions. The conceptualization of patient safety within a systems approach takes into consideration the inherent complexities of the healthcare organization. Despite this, patient safety initiatives that attempt to integrate the healthcare worker's well-being tend to be employed within isolated smaller parts of the system, such as within separate clinics, disciplines and professions (each within their own system of processes), and result in disparate strategies, tools, interventions for this (i.e. stress management training). For a successful adaptation strategy, healthcare demands a more dynamic approach that focuses on the system as a whole by including all levels of the organization. Recently, a paper by Edwards and colleagues advocates that elements of well-being and productivity of the worker play an important role in system design or redesign and considerations to how this is monitored and managed are important functions of this process [46]. In pursuit of this, the authors recommend basic conditions for system redesign that include performance management, leadership and key performance indicators (KPIs) with the aim to improve both productivity and well-being of the workers[46]. The authors argue that the purpose is not to develop a mathematically optimal solution to productivity and well-being through the redesign of the system, but rather to arrive at a collective understanding regarding the purpose, function and challenges to be addressed in the design process. Similar to Edwards and colleagues is the Interim Report by NHS on Health and Well-Being in Review that in addition to providing links between healthcare worker well-being and patient outcomes, the report makes strong recommendations to NHS organization leaders and managers to recognize the link between healthcare worker health and system performance and embed this knowledge into the NHS system and infrastructure[47].

Resilience engineering[8] is described by four cornerstones that take into account all levels of the organization a) to respond to what happens, b) to monitor critical developments, c) to anticipate future threats and opportunities, and d) to learn from past experience – to include both successes as well as failures. According to the authors, RE strives

to identify and correctly value behaviors and resources that contribute to a systems ability to respond to the unexpected. Resilience engineering has gained popularity in various safety-critical sectors. Specifically in healthcare, the framework for RE has been advocated for by Hollnagel and colleagues (2013), who outline a new purpose in safety management through the understanding of what goes right, rather than what goes wrong[48]. According to the authors, the human factor is referred to as an "asset rather than a liability and their ability to adjust what they do to the conditions is a strength rather than a threat (p.4)[49]". Although risk management principles and practices exists that recognize the importance of the individual within the system, such as Human-Technology-Organization (HTO), RE may provide a theoretical framework for developing solutions that not only incorporate the monitoring of the healthcare worker's risks, but their strengths into safety management thinking. Specifically, this offers potential for the development of leading indicators that provide an opportunity for monitoring the organization's resilience with regards to the health and functioning of their workers.

3.2. Leading indicators based on Resilient Engineering

Traditional methods for developing leading indicators recommend starting by identifying "what can go wrong?" RE, however, takes a deviation from this method by asking "what can go right?[8]." Within this context, RE takes an approach that in order to be more proactive, more information is required not just from the outputs of the process but the intermediate activities along the way. This first entails establishing what it means to have a resilient system within the organization and identifying indicators for this. The Resilience Analysis Grid (RAG) developed by Hollnagel and colleagues[50] is a question based tool designed to support management in its effort to improve the resiliency of an organization and may guide a path for developing indicators of resilience. In addition, the Functional Resonance Accident Model (FRAM) developed by Hollnagel describes failures and successes as a result of coping and adaption to complexity[8]. Utilization of the FRAModel provides utility in understanding system performance as it relates to resilient characteristics for the monitoring of performance variability.

3.3. Current use of indicators in healthcare

Monitoring and measuring performance has always been a part of safety management systems; however, the development and implementation of indicators within healthcare organizations for patient safety is considered to be in its early stages. Healthcare organizations implement indicators at either the organizational or clinical level; however, most activities regarding the investigation and implementation of indicators in healthcare appear to be at the clinical level of delivering healthcare. For example, at the clinical level, the Agency for Healthcare Research and Quality[51] has developed Patient Safety Indicators (PSIs) for the use of identifying potentially in-hospital safety events[52]. PSIs were specifically developed for "potentially preventable adverse events (p.3)[52]" for patient safety in the inpatient setting, such as surgical complications, death in cases with low-mortality diagnoses, and decubitus ulcers. Prevention quality indicators for example, are utilized by clinicians as screening tools to help flag potential health care quality problem areas that need further investigation[51]. Within the organizational level, indicators are often implemented in healthcare safety management processes and are often lagging, rather than leading. Lagging indicators provide information after the event has occurred and is used to implement changes. Leading indicators; however, provide information that precedes or indicates a future event that can be used to prevent or mitigate an adverse event in one or more of the hospital organization safety core outputs (e.g., patient falls, loss of life). There are two types of leading indicators that are often described in the literature: those that monitor risk and those that drive it[53]. Monitor indicators identify when something has gone wrong in an organization. Drive indicators on the other hand serve to identify development activities aimed at improving safety[53].

4. Considerations to the use of monitoring the well-being of healthcare workers as a leading indicator

Based on the literature, it is suggested that the monitoring of healthcare worker's well-being function as a *leading monitoring indicator* of system performance. A leading indicator that monitors the well-being of healthcare workers cannot predict safety; however, it offers potential in the monitoring of the internal dynamics of the socio-technical

system that support the management of safety. Healthy workers are associated with a healthy system thus increasing adaptability and resilience to unexpected events. Within this context, healthcare systems would benefit from the use of indicators that provide monitoring of the healthcare organization's workforce well-being and can alert management of changes in the environment that may impact the system. This argument aligns with similar work by Wallace and colleagues [54] and the NHS Health and Well-Being in Review: Interim Report[47] that suggest healthcare worker well-being should be routinely measured for high quality care.

Arguably, the selection of leading indicators for monitoring the well-being of healthcare workers has many possibilities and is dependent on access and ability to measure it. Preferably, the selection of well-being indicators should provide hospital managers with data that enables them to manage the key processes that will lead to better outcomes. Typically, the measurement of well-being is assessed through subjective report instruments. There has been a considerable amount of research on the testing and validating of instruments that measure the determinants of well-being that may offer potential for the measurement of leading indicators within this context. As an example, the Maslach Burnout Inventory (MBI)[55] is a 22-item questionnaire that has been validated on several samples of healthcare professionals and although designed to assess professional burnout, is often cited as an assessment tool in the well-being literature[56]. The MBI assesses three aspects of burnout syndrome that share many similarities to well-being dimensions: emotional exhaustion, depersonalization, and lack of personal achievement [55]. In addition to utilizing subjective report measures such as the MBI, research identifies a number of occupational and environmental factors within the system design that serve as predictors to worker's well-being [24, 42, 47, 57], such as worker social support, decreased level of work demands, reasonable work hours, and a stable workforce. Including such as leading indicators for system design could have the twin benefit of proactively monitoring healthcare workers' well-being as well as enabling the early detection of system deterioration before patient safety incidents occur. The development and design of the environmental and occupational factors that promote healthcare worker's well-being must include resources that are within reach of the organization and therefore it is difficult to suggest a framework that can be readily applied to the healthcare organization without taking into consideration their unique characteristics. A conceptual model to illustrate a general approach to monitoring of well-being as a leading indicator of system performance with measurement of self report and system design is shown in Figure 1.

4.1. Further research and conclusions

This paper presented both the benefits and limitations of measuring healthcare worker's well-being as a leading indicator for proactively monitoring system performance. Within complex socio-technical systems, performance depends on the interaction of social and technical functions. Specifically within RE, in order to proactively manage risk, more information is required not just from the outputs of these interactions but also from the intermediate activities along the way [8]. In addition to having leading indicators that identify risk, RE posits that the selection of indicators should first entail having the organization define what it means to have a resilient system and identifying indicators for this. Currently, there is limited consensus to the definition of well-being which presents challenges to operationalizing and thus, measuring it. However, the determinants related to the psychological, social, and physical dimensions of well-being specific to healthcare workers have been thoroughly investigated and suggest both risks
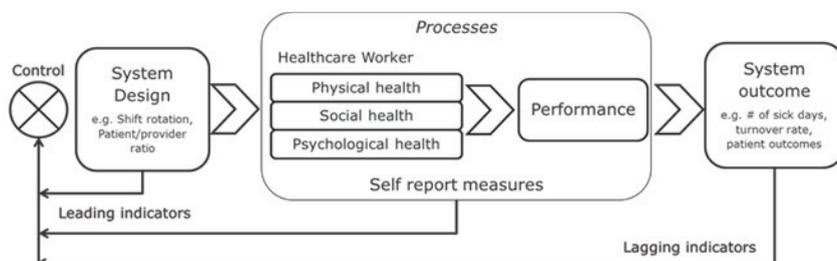

Fig. 1. Conceptual model for monitoring healthcare worker's well-being as a leading indicator for system performance.

and contributions to the healthcare system. In an effort to illustrate this relationship, selected positive and negative determinants related to the physical, psychological, and social dimensions of well-being and their risk or contribution to system performance were presented in Tables I and II. The information presented demonstrates that the well-being of the healthcare worker is an important part of the healthcare system and suggests implications to the quality and safety of patient care. As a result, the monitoring of their overall well-being may offer utility in the proactive management of system performance and warrants further attention. In addition, there may be value in not only selecting negative determinants of the healthcare worker's well-being, but also the positive determinants as a means of ensuring that the workforce is on a path for resilience. Naturally, it is important to be aware that the demands and characteristics of healthcare organizations may differ and therefore, it should not be assumed that a set of well-being indicators would be appropriate to generalize to all healthcare settings. As a result, indicators should be selected and adapted specific to its organization[53]. As outlined in Figure 1, a conceptual model to the general approach of monitoring the healthcare worker's well-being as a leading indicator of system performance is suggested. The model proposes two opportunities of measurement; the monitoring of system design that predicts well-being and through validated measures of self-report by the workforce. These measurements require research to further test their utility within systems management. Future research should explore the potential value of other existing data within the system that may also provide a means of measuring the well-being of healthcare workers as a leading indicator of system performance. Finally, consideration should also be given to the understanding of how this approach can be embedded within the everyday practice of healthcare organizations.

References

[1] Wang, Y., et al., National Trends in Patient Safety for Four Common Conditions, 2005–2011. The New England journal of medicine, 2014. 370(4): p. 341-351.
[2] Shekelle, P.G., et al., Advancing the science of patient safety. Ann Intern Med, 2011. 154(10): p. 693-6.
[3] Dixon-Woods, M., et al., Explaining Matching Michigan: an ethnographic study of a patient safety program. Implementation Science, 2013. 8(1): p. 70.
[4] Carayon, P. and K.E. Wood, Patient Safety: The Role of Human Factors and Systems Engineering. Studies in health technology and informatics, 2010. 153: p. 23-46.
[5] Adriaenssens, J., V. De Gucht, and S. Maes, Determinants and prevalence of burnout in emergency nurses: A systematic review of 25 years of research. Int J Nurs Stud, 2015. 52(2): p. 649-661.
[6] Boudrias, J.S., A.J. Morin, and M.M. Brodeur, Role of psychological empowerment in the reduction of burnout in Canadian healthcare workers. Nurs Health Sci, 2012. 14(1): p. 8-17.
[7] Chiang, Y.-M. and Y. Chang, Stress, depression, and intention to leave among nurses in different medical units: Implications for healthcare management/nursing practice. Health Policy, 2012. 108(2-3): p. 149-157.
[8] Hollnagel, E., Paries, J., Woods, D., Wreathall, J. , Resilience Engineering in Practice: A Guidebook, ed. Ashgate. 2011, United Kingdom Ashgate. 321.
[9] Dodge, R., et al., The challenge of defining wellbeing. International Journal of Wellbeing, 2012. 2(3): p. 222-235.
[10] Gökçen, C., et al., Burnout, job satisfaction and depression in the healthcare personnel who work in the emergency department. Anadolu Psikiyatri Derg, 2013. 14(2): p. 122-128.
[11] Bellini, L.M., M. Baime, and J.A. Shea, Variation of mood and empathy during internship. Jama, 2002. 287(23): p. 3143-6.
[12] Navarro-Gonzalez, D., A. Ayechu-Diaz, and I. Huarte-Labiano, Prevalence of burnout syndrome and its associated factors in Primary Care staff. Semergen, 2014.
[13] Ward, M. and S. Cowman, Job satisfaction in psychiatric nursing. J Psychiatr Ment Health Nurs, 2007. 14(5): p. 454-61.
[14] Dyrbye, L.N., et al., Relationship between burnout and professional conduct and attitudes among US medical students. Jama, 2010. 304(11): p. 1173-80.
[15] Dyrbye, L.N., et al., Burnout among U.S. medical students, residents, and early career physicians relative to the general U.S. population. Acad Med, 2014. 89(3): p. 443-51.
[16] Brunetto, Y., et al., The impact of workplace relationships on engagement, well‐being, commitment and turnover for nurses in Australia and the USA. Journal of Advanced Nursing, 2013. 69(12): p. 2786-2799.
[17] Goldberg, R., et al., Burnout and Its Correlates in Emergency Physicians: Four Years' Experience with a Wellness Booth. Academic Emergency Medicine, 1996. 3(12): p. 1156-1164.
[18] Goldberg, R., et al., Burnout and its correlates in emergency physicians: four years' experience with a wellness booth. Acad Emerg Med, 1996. 3(12): p. 1156-64.
[19] Benevides-Pereira, A.M. and R. Das Neves Alves, A study on burnout syndrome in healthcare providers to people living with HIV. AIDS Care, 2007. 19(4): p. 565-71.
[20] Pantaleoni, J.L., et al., Burnout in pediatric residents over a 2-year period: a longitudinal study. Acad Pediatr, 2014. 14(2): p. 167-72.

[21] Leonardi, M., et al., Burnout in healthcare professionals working with patients with disorders of consciousness. Work, 2013. 45(3): p. 349-56.

[22] Kennedy, B.R., Stress and burnout of nursing staff working with geriatric clients in long-term care. J Nurs Scholarsh, 2005. 37(4): p. 381-2.

[23] Cañadas-De la Fuente, G.A., et al., Risk factors and prevalence of burnout syndrome in the nursing profession. International Journal of Nursing Studies, 2015. 52(1): p. 240-249.

[24] Van Bogaert, P., et al., Nursing unit teams matter: Impact of unit-level nurse practice environment, nurse work characteristics, and burnout on nurse reported job outcomes, and quality of care, and patient adverse events—A cross-sectional survey. International Journal of Nursing Studies, 2014. 51(8): p. 1123-1134.

[25] Shanafelt, T.D., et al., Burnout and self-reported patient care in an internal medicine residency program. Ann Intern Med, 2002. 136(5): p. 358-67.

[26] Houston, D.M. and S.K. Allt, Psychological distress and error making among junior house officers. British Journal of Health Psychology, 1997. 2(2): p. 141-151.

[27] Jones, J.W., et al., Stress and medical malpractice: organizational risk assessment and intervention. J Appl Psychol, 1988. 73(4): p. 727-35.

[28] Gauci Borda, R. and I.J. Norman, Factors influencing turnover and absence of nurses: a research review. Int J Nurs Stud, 1997. 34(6): p. 385-94.

[29] Hayes, L.J., et al., Nurse turnover: A literature review – An update. International Journal of Nursing Studies, 2012. 49(7): p. 887-905.

[30] Barker, L.M. and M.A. Nussbaum, The effects of fatigue on performance in simulated nursing work. Ergonomics, 2011. 54(9): p. 815-29.

[31] Rogers, A.E., The Effects of Fatigue and Sleepiness on Nurse Performance and Patient Safety., in Patient Safety and Quality: An Evidence-Based Handbook for Nurses, e. Hughes RG, Editor. 2008: Rockville (MD): Agency for Healthcare Research and Quality (US).

[32] Lockley, S.W., et al., Effects of health care provider work hours and sleep deprivation on safety and performance. Jt Comm J Qual Patient Saf, 2007. 33(11 Suppl): p. 7-18.

[33] Fochsen, G., et al., Predictors of leaving nursing care: a longitudinal study among Swedish nursing personnel. Occupational and Environmental Medicine, 2006. 63(3): p. 198-201.

[34] Han, J., et al., [Effects of nurses' social capital on turnover intention: focused on the mediating effects organizational commitment and organizational cynicism]. J Korean Acad Nurs, 2013. 43(4): p. 517-25.

[35] Geurts, S., C. Rutte, and M. Peeters, Antecedents and consequences of work–home interference among medical residents. Social Science & Medicine, 1999. 48(9): p. 1135-1148.

[36] DiMatteo, M.R., et al., Physicians' characteristics influence patients' adherence to medical treatment: results from the Medical Outcomes Study. Health Psychol, 1993. 12(2): p. 93-102.

[37] Buchbinder, S.B., et al., Estimates of costs of primary care physician turnover. Am J Manag Care, 1999. 5(11): p. 1431-8.

[38] Cicolini, G., D. Comparcini, and V. Simonetti, Workplace empowerment and nurses' job satisfaction: a systematic literature review. Journal of Nursing Management, 2014. 22(7): p. 855-871.

[39] Vahey, D.C., et al., Nurse burnout and patient satisfaction. Med Care, 2004. 42(2 Suppl): p. II57-66.

[40] Profit, J., et al., Burnout in the NICU setting and its relation to safety culture. BMJ Quality & Safety, 2014.

[41] Thomas, M.R., et al., How Do Distress and Well-being Relate to Medical Student Empathy? A Multicenter Study. J Gen Intern Med, 2007. 22(2): p. 177-83.

[42] Landrigan, C.P., et al., Effective implementation of work-hour limits and systemic improvements. Jt Comm J Qual Patient Saf, 2007. 33(11 Suppl): p. 19-29.

[43] Brooks, E., et al., Physician health programmes and malpractice claims: reducing risk through monitoring. Occup Med (Lond), 2013. 63(4): p. 274-80.

[44] Oberg, E., Lobelop, F., Sallis, R., & Frank, E. , Healthy Docs = Healthy Patients, in First Do No Self Harm: Understanding and Promoting Physician Stress Resilience C. Figley, Huggard, Peter, & Rees, Charlotte, Editor. 2014, Oxford Scholarship

[45] Bognar, A., et al., Errors and the burden of errors: attitudes, perceptions, and the culture of safety in pediatric cardiac surgical teams. Ann Thorac Surg, 2008. 85(4): p. 1374-81.

[46] Edwards, K. and P.L. Jensen, Design of systems for productivity and well being. Applied Ergonomics, 2014. 45(1): p. 26-32.

[47] Review, N.H.a.W.-B., NHS Health and Well-Being Review: Interim Report. 2009, Department of Health: London, U.K. .

[48] Hollnagel, E., Braithwaite, J., Wears, R. , Resilient Healthcare ed. Ashgate. 2013, United Kingdom: Ashgate. 265.

[49] Hollnagel, E., Is safety a subject for science? Safety Science, 2014. 67: p. 21-24.

[50] Hollnagel, E., RAG the Resilience Analysis Grid in Resilience Engineering in Practice: A guide book J.P. E. Hollnagel, D. D. and W.J. Wreathall, Editors. 2011, Ashgate: Farnham, UK.

[51] Quality, A.f.H.R.a. AHR Quality Indicators Quality Indicators; Available from: http://www.qualityindicators.ahrq.gov/.

[52] Rivard, P.E., R.; Loveland, S.; Zhao, S.; Tsilimingras, D.; Elixhauser, A.; Romano, P.; & Rosen, A. , Applying Patient Safety Indicators (PSIs) Across Health Care Systems: Achieving Data Comparability, in Advances in Patient Safety: From Research to Implementation B.J. Henriksen K, Marks ES, et al., , Editor. 2005, Agency for Healthcare Research and Quality (US).

[53] Patient Safety Indicators as Tools for Proactive Safety Management and Safety Culture Improvement. Patient Safety Culture: Theory, Methods, and Application, ed. T.R.a.E. Pietikäinen. 2014, U.K. : Ashgate.

[54] Wallace, J.L., J.; & Ghali, W. , Physician wellness a missing quality indicator. The Lancet, 2009. 374: p. 1714-21.

[55] Maslach, C. and M.P. Leiter, Early predictors of job burnout and engagement. J Appl Psychol, 2008. 93(3): p. 498-512.

[56] Eckleberry-Hunt, J., et al., Changing the Conversation From Burnout to Wellness: Physician Well-being in Residency Training Programs. Journal of Graduate Medical Education, 2009. 1(2): p. 225-230.

[57] Jones, M.C., et al., Work stress and well-being in oncology settings: a multidisciplinary study of health care professionals. Psychooncology, 2013. 22(1): p. 46-53.