AN ABSTRACT OF THE THESIS OF

Lucia Darrow for the degree of Master of Science in Industrial Engineering presented on May 15, 2017.

Title: Exploring the Factors that Drive Organizational Resilience: Lessons from Healthcare

Abstract approved: _____

Chinweike I. Eseonu

In the face of a disruptive event or prolonged period of stress, resilient performance is characterized by preventative measures, effective response, and the integration of lessons learned. In healthcare, resilience significantly affects patient safety. However, current guidelines for healthcare performance assessment, such as the Triple Aim, do not consider physician satisfaction and preventative measures against burnout. Consequently, burnout significantly affects healthcare providers' cognitive and emotional capacity. In addition, process improvement projects in healthcare often have a negative impact on resilience by over-standardizing processes.

This research utilizes Resilience Engineering approaches to evaluate organizational resilience in one emergency department and two primary care case study

examples. A qualitative method is applied to gain understanding of characteristics of resilient employees and learning behaviors that impact overall resilience. Frequency of single and double loop learning behaviors are observed and a resilient healthcare system is defined as one in which all organizational actors exhibit double loop learning behaviors.

Results give insights into the relationship between individual and organizational resilience by adapting resilient systems attributes and capabilities to healthcare settings. A typology based on the dimensions of organizational and individual resilience is presented, providing a mode for healthcare managers and academic professionals to characterize resilience in specific organizations.

Exploring the Factors that Drive Organizational Resilience: Lessons from Healthcare

by
Lucia Darrow

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

Presented May 15, 2017
Commencement June 2017

Master of Science thesis of Lucia Darrow presented on May 15, 2017

APPROVED:

Major Professor, representing Industrial Engineering

Head of the School of Mechanical, Industrial, and Manufacturing Engineering

Dean of the Graduate School

I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Lucia Darrow, Author

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my advisor Dr. Chinweike Eseonu for his continuous support of my Master's thesis and related research. His guidance, motivation, and knowledge were invaluable in the completion of this work. I sincerely thank my committee members, Dr. Hector Vergara, Dr. Harriet Nembhard, and Dr. Liney Arnadottir, for their time and constructive criticism. Finally, I would like to thank my parents, Nicholas and Cecilia Darrow, for their unwavering love, support and encouragement throughout my academic journey.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

1.1 Motivation

Globalization and technological advancement have increased competition and collaboration, making organizational adaptability integral to success (Home, 1997). Organizations must acknowledge disruptions and errors as realities of the increasing complexity and speed of operations in today's world (Hollnagel, Wears, & Braithwaite, 2015). Resilience provides a strategic solution to organizations that aim to be one step ahead of the unknown (Sahebjamnia, Torabi, & Mansouri, 2015). Resilient organizations "bounce back" from disruptions to operations, through adjustments made before, during or following a disruptive event (Hollnagel, 2010). The draw of this concept as a cure-all has spurred interest in the application of resilience in a wide array of disciplines, such as Psychology, Business, and Civil Engineering. Researchers and practitioners have frequently used "resilience" to broadly describe a desired system state, without considering the full meaning and implications (Alexander, 2013). Ultimately, understanding the factors that enhance resilient organizations will impact community resilience on a regional, national, and global level (Drabek, 2005; Lee, Vargo, & Seville, 2013).

Economic pressures to make the United States healthcare system leaner have led to innumerable improvement projects aimed at cutting cost and increasing quality. Despite these goals, quality problems in healthcare remain and dissatisfaction with the system is high (Vincent, Burnett, & Carthey, 2014). This sense of dissatisfaction extends to healthcare employees. An estimated 46% of US physicians experience burnout (Bodenheimer & Sinsky, 2014). In addition, preventable errors account for approximately

50,000 deaths per year (Naveh, Katz-Navon & Stern, 2005). Improvement programs commonly address quality and cost issues by standardizing operations (Nemeth and Cook, 2007). This regulation of workflows by external parties often disrupts normal work processes and adversely impacts healthcare workers' flexibility and ability to respond to disruptive events (Perry, McDonald, Anderson, Tran & Wears, 2007). In addition, these initiatives lack a physician-centered aspect and as such contribute to a conceptual gap between expectation and reality of primary care outcomes (Bodenheimer & Sinsky, 2014). The divergence in expectations has a negative effect on healthcare providers' job satisfaction and psychological safety, posing a considerable threat to healthcare organizations (Bodenheimer & Sinsky, 2014). Psychological safety is an individual's feeling of security to think and act without fear of negative consequence (Mazur et al., 2012). Degradation of these aspects of working life has an impact on individual workplace resilience, creating employees that are less likely to engage in positive organizational learning behaviors (Edmondson, 2004).

Current models to measure resilience are incompatible and use inconsistent terminology, with assessment often sourced from one individual (Kantur & İşeri-Say, 2012; Lee et al., 2013). As the concept of resilience is rooted in physical systems, many frameworks overlook the strong influence of human systems on overall resilience. In practice, empirical research on resilience is overwhelmingly predictive and normative, targeting outcomes, rather than processes (Boin & van Eeten, 2013). In the healthcare industry, this means that there is a lack of effective tools to assess the effectiveness of government and organizational funds being spent to improve the quality and efficiency of

care and to reduce disruptions through process improvement and information sharing initiatives (Fairbanks, Wears, Woods, Hollnagel, & Plsek et al., 2012).

The motivation for this research was derived from observed inconsistency in key organizational resilience constructs, as well as a need for translation of traditional resilience terminology and frameworks to healthcare systems. By developing and testing a tool to measure resilience in healthcare, this work provides practitioners with the resources to better understand their organization's state of resilience.

1.2 Research Objectives

The purpose of this research is to identify the attributes of resilient healthcare organizations and assess the relationship between individual and overall resilience of a healthcare system. This research aims to develop a healthcare-specific tool to assess overall system resilience. Using this tool in conjunction with qualitative methods, resilience of case study organizations will be assessed. Additionally, resilient learning behaviors will be studied through case study examples.

1.3 Research Questions

What factors drive resilience in healthcare organizations?

1.3.1 First Sub-Question

What learning behaviors are considered resilient?

1.3.2 Second Sub-Question

What factors create resilient employees?

1.3.3 Third Sub-Question

What is the relationship between organizational and individual resilience?

1.3.4 Fourth Sub-Question

How can organizations be categorized considering this relationship?

1.4 Literature Review Overview

Resilience research is divided into equilibrium and non-equilibrium based schools of thought. In the equilibrium school of thought, ecologists define resilience as the capability of a system to return to a set point of stability following an interruption (Pickett, Cadenasso & Grove, 2004). In the non-equilibrium view, resilience is the capability of a system to adapt in the face of internal and external changes (Holling, 1973). Most organizational theorists adhere to the non-equilibrium view in which resilience is seen as the ability of a system to continuously improve by learning from each interruption or destabilizing event. This view aligns with Toyota's lean manufacturing principle of continuous improvement and the broader concept of a learning organization.

The complexities of a disruptive event or emergency can be distilled to an immediate need for resources (Cook & Nemeth, 2006). In healthcare, destabilizing events range from commonplace disruptions such as employee absences and human errors to large-scale disasters that overwhelm a healthcare system. The response patterns formed in reaction to small disruptions strengthen overall system resilience by providing lessons on adjustments required prior to a major disruptive event (Voss & Wagner, 2010). So, resilience is not just the ability to return to normalcy, but the extent to which a system learns from a disruptive event (Hollnagel, 2010).

For this research, resilience will be discussed in terms of attributes and capabilities. In the attribute view of resilience, Bruneau et al. (2003) developed the four

R's of resilience, which are robustness, redundancy, resourcefulness and rapidity as an approach for assessing community resilience following an earthquake. Bruneau et al. (2003) discussed each attribute based on four dimensions: organizational, technical, social and economic. Capabilities are measures of control that assess a system's ability to respond, monitor, learn, and anticipate (Hollnagel, 2010). The first manuscript presents a literature review of organizational resilience. The third manuscript includes a second literature review, focused specifically on resilience in healthcare.

1.5 Research Methodology

This section provides a concise overview of the methodology applied in this research. A detailed explanation of the methods used can be found in Chapter 3. This thesis is based on results of a Resilience Analysis Grid survey that was adapted for application in healthcare as well as observations within a case study organization. The survey targets the four capabilities of resilient performance for organizations and aspects of employee resilience. Direct observations and interview methods were used to characterize resilient learning behaviors in primary care and emergency department settings.

1.6 Thesis Organization

A manuscript format was selected for the organization of this thesis. Three manuscripts make up the core of this research: Manuscript 1, Manuscript 2 and Manuscript 3. Chapter 1 is an overview of the thesis, including an explanation of the need for this work, a discussion of research approaches selected, and a brief summary of key findings. Chapter 2 is a literature review on resilience in healthcare, including the first manuscript: Resilience for Engineering Management: A State of the Art Matrix Analysis of Select Literature. Chapter 3 includes the methodology utilized in this research, including survey

and interview design, data analysis methods, and methodological issues. Chapter 4 contains the second manuscript: Development of a Resilience Analysis Grid Survey Tool for Healthcare. Chapter 5 contains the third manuscript: Measuring Resilience in Healthcare: A Characterization and Categorization of Organizational and Individual Resilience. The first two manuscripts have been published in conference proceedings, while the third manuscript is to be submitted for publicaiton in a research journal. Chapter 6 is an in-depth summary of research findings, their implications, and avenues for future research.

1.7 Key Findings

Organizational resilience is gaining importance in healthcare systems dealing with increased complexity and need for rapidity in delivery of care. Before developing a framework to characterize individual and organizational resilience, the first manuscript uncovered patterns in the literature on Resilience Engineering. Notably, it was observed that the learn capability of resilient performance is rarely addressed in empirical studies. Additionally, similarities among varying constructs of resilience were observed, indicating a need for uniform nomenclature in descriptions of resilience. Previous research has explored definitions of organizational resilience, measurement tools, and disaster resilience in healthcare (Carthey, Leval, & Reason, 2001; Bruneau & Reinhorn, 2007; Zhong, Clark, Hou, Yuli, Zang & FitzGerald, 2014) as well as the psychology of individual resilience (Cook & Nemeth, 2006; Jensen, Kumar, Waters & Everson, 2008). There is a need to understand the interaction between these two areas of research in functioning care teams.

The outcome of the second manuscript is a survey tool for healthcare organizations. The survey is rooted in theories of organizational, workplace, and individual resilience. Results offer improved insight into the relationship between individual and organizational resilience by adapting resilient systems capabilities to healthcare settings.

The third manuscript applied constructs from the survey created in the second manuscript to an interview in order to refine the driving constructs. As this is a preliminary application of the RAG to the field of healthcare, this work adds context to the survey and seeks concreteness that no information was overlooked. The results of this work indicate that an environment open to double-loop learning is beneficial for organizational and individual resilience. Further, a resilient healthcare system was defined as one in which all organizational actors exhibit double-loop learning behaviors. The final result is an organizational resilience typology in which the factors that contribute to individual and organizational resilience are grouped into four categories: ideal, led, repressed, and failing.

1.8 Limitations

The results of this research can only be generalized to healthcare institutions in the United States. A limitation of this work is that only a small number of healthcare organizations were interviewed. As employees were surveyed from varying levels of organizations, their confidence in knowledge about certain resilience criteria may differ.

2 LITERATURE REVIEW

2.1 Introduction

The following review of the resilience literature investigates modern research from the fields of psychology, organizational theory, and resilience engineering to form a complete picture of healthcare resilience. Section 2.2 contains Manuscript 1, providing a thorough review of organizational resilience and resilience engineering. Section 2.3 and Section 2.4 apply the concepts and theories discussed in the first manuscript to healthcare organizations. Section 2.5 provides an introduction to individual resilience in healthcare, which is further investigated in Manuscript 2 and Manuscript 3. Finally, section 2.6 discusses the gap in the literature that this thesis aims to address.

Resilience for Engineering Management: A State of the Art Matrix Analysis of Select Literature

By

Lucia Darrow, Chinweike Eseonu

Submitted for publication in conference proceedings

Note: Edits have been made based on conference feedback.

2.2 First Manuscript: Resilience for Engineering Management: A State of the Art Matrix Analysis of Select Literature

2.2.1 Introduction

Resilience is the capability of a system to adapt in the face of internal and external changes (Holling, 1973). Disruptions to regular operations within an organization can be triggered by emergency events, such as natural disasters and terrorist events, or long-term periods of stress, such as economic downturn (Vogus & Sutcliffe, 2007). The literature often categorizes resilient systems based on their attributes (e.g. Norris, Stevens, Pfefferbaum, Wyche, & Pfefferbaum, 2008; Cimellaro, Reinhorn, & Bruneau, 2010) and capabilities (e.g. Lundberg & Johansson, 2015; van der Beek & Schraagen, 2015). Attributes are characteristics of resilient systems that describe how the system responds to a disturbance (Bruneau et al., 2003). Capabilities are measures of the extent to which a system can effectively address, recover from, and prevent future disruptions (Hollnagel, 2010). In this section, the attributes and capabilities are defined and shown through two illustrative examples in the fields of nuclear engineering and healthcare.

When a system breaks down, the recovery is largely based on individual and collective decision-making power (Mallak, 1999). For engineering managers, this implies that the foundation of resilient systems is a strong team formed through well-defined role systems and distributed decision-making power (Mallak, 1998). The field of Resilience Engineering (RE) emerged in the early 2000's to address the preventative and structural requirements of resilient performance. Use of the term "Resilience Engineering" can be found as early as 2003 by Woods, while the first organized Resilience Engineering Symposium was held in 2004 (Woods, Hollnagel, & Leveson, 2006). Resilience

Engineering uses engineering principles to design robust and adaptable processes, manage risk, and allocate resources in times of stress (Resilience Engineering Association, 2017).

With the rapid emergence and popularity of resilience studies, several organizations have attempted to apply resilience concepts in industries like manufacturing (Heinicke, 2014) and healthcare (Nemeth & Cook, 2007). Table 1 outlines six notable resilience tools and their industries of origin. The first manuscript includes a discussion of the principles, methods, and objectives associated with each tool.

Table 1. Frameworks for Measuring Resilience.

Name	Author	Year	Origin Industry
CAIR: Checklist for Assessing Institutional Resilience	Carthey, Leval, & Reason	2001	Healthcare
FRAM: Functional Analysis Resonance Method	Hollnagel & Goteman	2004	Aviation
ROR: Relative Overall Resilience	McManus	2008	Manufacturing
MAUT: Multi-Attribute Utility Theory	Stolker, Karydas & Rouvroye	2008	Not Specified
Framework for Analytical Quantification of Disaster Resilience	Cimellaro, Reinhorn & Bruneau	2010	Seismic Engineering
RAG: Resilience Analysis Grid	Hollnagel	2010	Not Specified

Cross-discipline translation of resilience concepts is essential for effective application of resilience principles (MacAskill & Guthrie, 2014). Current frameworks to measure resilience are difficult to compare and use varying terminology. Depending on the

discipline, resilience may be defined as a process (e.g. psychology), a state (e.g. ecology) or a quality (e.g. material science) (Reghezza-Zitt, Rufat, Djament-Tran, Le Blanc & Lhomme, 2012). Moreover, the majority of measurement tools are industry specific and frameworks to quantify system resilience are tailored to physical systems (MacAskill & Guthrie, 2014). Given the many interpretations of resilience, there is a need to reduce inconsistency among definitions of resilience and refine key constructs in the literature (Righi, Saurin, & Wachs, 2015; Reghezza-Zitt et al., 2012). This study focuses on finding gaps in existing research with regards to the development of the underlying principles of resilience and leading measurement tools.

2.2.1.1 Introduction of Cases

Two cases will be utilized to illustrate the attributes and capabilities of resilience. The first is the Three Mile Island nuclear meltdown of 1979. In this case, a combination of malfunctioning equipment, misread gauges, and failed decision-making led to a partial meltdown of the reactor core (U.S. NCR, 2014). This accident heightened public interest in the safety of nuclear fuel.

The attributes of resilience can also be represented in healthcare systems. These can be illustrated by an account of a fatal medication error at a regional hospital in the United States Pacific Northwest. In this case three key mistakes led to the death of the patient:

1. A pharmacy worker inadvertently placed a paralyzing agent into the patient's IV bag, instead of the similarly labeled prescribed drug.
2. The contents of the IV bag were not verified by subsequent caregivers.
3. The patient was not properly monitored after the IV was administered (Moore, 2014).

The following sections define the attributes and capabilities and apply them to the cases described above.

2.2.1.2 Attributes of Resilient Performance

Attributes include r**obustness**, **redundancy**, **resourcefulness** and **rapidity**, also referred to as the four R's (Bruneau, et al*.,* 2003). **Robustness** is the extent to which a system maintains normal function after a disruptive event. **Robustness** measures vulnerability, which is the extent to which the system is susceptible to degradation, or is degraded by a disruptive event (Dalziell & McManus, 2004). **Redundancy** is displayed by the presence of effective substitute resources and reliable mechanisms for substitution when a primary resource is disabled. **Resourcefulness** is displayed when the components in a system understand the capabilities, resources, and other attributes of the system and are able to effectively deploy needed resources in response to a disruption. Finally, **rapidity** is displayed by the speed at which the previous three R's are activated and the speed at which the system returns to normal function (Bruneau et al., 2003).

To illustrate the four R's, consider the Three Mile Island nuclear meltdown. In a high-risk system, plant operators misunderstood the reaction of the technical system after a cooling malfunction caused a reactor to shutdown. This caused part of the core to melt in the number 2 reactor (TMI-2) and resulted in the release of radioactive gases (U.S. NCR, 2014). Although the system was technically **robust** − resources were built into the technical system to handle the initial malfunction of the cooling unit − the operators were not properly trained in the other aspects of the system. Assessing the unfamiliar situation, operators misinterpreted increasing internal pressure and overrode the automatic emergency cooling system. The operators were not trained to interpret the true meaning

of the pilot-operated relief valve indicator and, as a result, did not seek alternate confirmation that the main relief valve was closed.

Despite several human errors, Three Mile Island was still quite **robust** to disturbance and a regional crisis was averted. An alarm went off following the overflow of a pressurizer relief tank and eventually new water was pumped into the system to reduce pressure. Because the system was self regulating, a portion of the core remained covered with water and only a small amount of radiation was released. After the restoration of cooling, the team acted to remove a hydrogen bubble that could have caused a more significant disaster. The **rapidity** and **redundancy** of the system is displayed by the number 1 reactor (TMI-1), which continued energy production following the conclusion of proceedings by the Nuclear Regulatory Commission. This reactor represents a viable substitutable **resource** for the second reactor that was lost. The first reactor reopened six years after the incident, with highly rated levels of safety and reliability. This can be attributed to the revised training and operating procedures put in place following the disaster, a sign that learning and growth had occurred.

The triangle in Figure 1 was introduced by Bruneau et al. (2003) and is commonly used to visualize and quantify resilience. The drop along the "y-axis" represents the system deviation from the top line, which represents normal function. The four attributes are represented in their relationship with the loss in system functionality. In the 1979 accident, this loss of functionality is represented by the reactor core exposure and the effect on regional power supply. The slope of the recovery line is determined by the **resourcefulness** of the system: how resources are prepared and how well the system

components execute emergency response mechanisms. In the Three Mile Island example, this line is determined by pre-existing safety measures in place and operator knowledge.

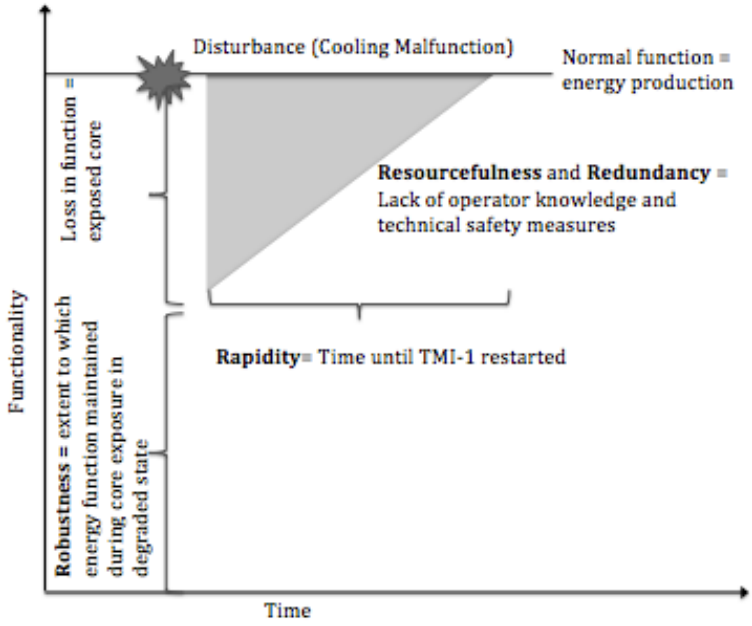


Figure 1. Resilience Triangle for Three Mile Island Incident.
Adapted from Bruneau, Change, Lee, et al. (2003) in Earthquake Spectra

In the medical error case, normal function of the system is providing high-level care to all patients in the hospital. This high-level of care includes monitoring patient progress and responding rapidly to changes in status. **Robustness** is the extent to which this level of care is maintained as disruptions occur. Similar to Three Mile Island, this case represents a failure of situational awareness. It can be assumed that the initial error occurred due to distractions in the workplace that degraded the attentional supply of the pharmacist. The hospital failed to monitor for errors of this kind by not having a verification system in place for IV drugs. Furthermore, due to a fire alarm, the hospital staff failed to watch over the patient as the incorrect drug was administered. It is possible that the patient could have been saved after IV administration if employees had been

present. The system was not sufficiently **robust** to small disturbances, so the error escalated.

Resourcefulness and **redundancy** are concerned with both human and technical systems in place to monitor the patient. When the fire alarm occurred, another person or mechanism was not in place to monitor the patient, indicating a failure to build redundancy into the system. The **rapidity** of the system is represented by the delayed response following the delivery of the incorrect drug. The four R's in this medical error case is displayed in the resilience triangle diagram in Figure 3.

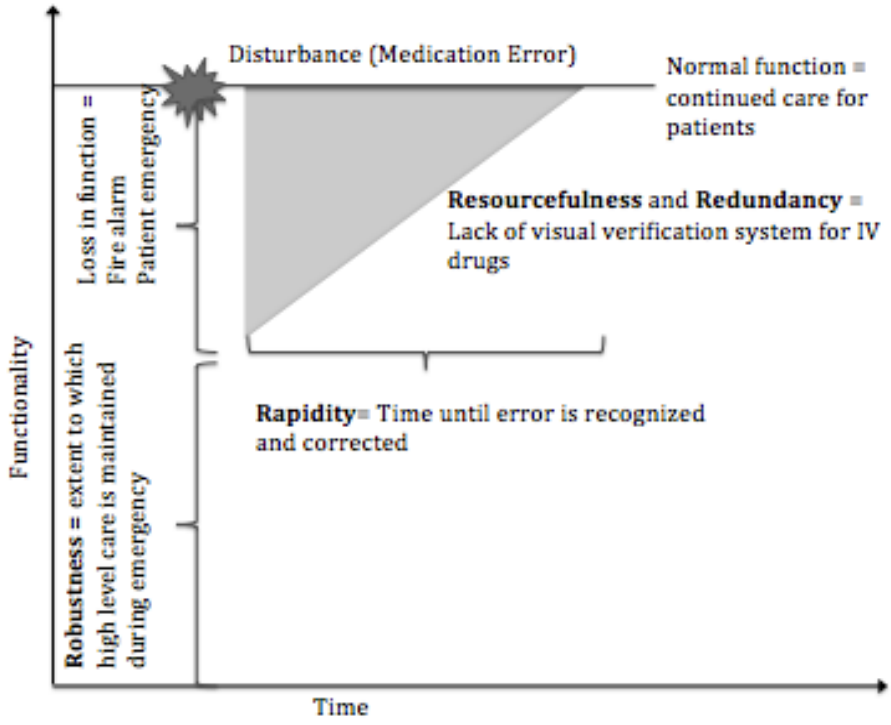


Figure 3. Resilience Triangle for Medication Error Incident
Adapted from Bruneau, Change, Lee, et al. (2003) in Earthquake Spectra

While resilient performance is highly dependent on the attributes discussed above, these alone do not capture all aspects of organizational resilience. Beyond response to disruptions, resilient performance includes preparation for disturbance and the adaptations made following a disturbance, so the new training protocols at Three Mile

Island are a good example of resilient operations. The following section is focused on the capabilities perspective of resilient performance.

2.2.1.3 Capabilities of Resilient Performance

While attributes are used broadly in organizational resilience literature, resilience engineers use a second set of measures – capabilities – to assess the extent to which a system can monitor for, respond to, learn from, and anticipate disruptions (Hollnagel, 2010). The capabilities of resilient performance can be used to understand the preparation for this occurrence and the lessons learned as a result. Heinicke (2014) defines this resilience approach as a blend of reactive and proactive strategies coming from the domains of agility and robustness. Table 2 contains the capabilities of resilient performance, alongside generalized examples of each capability. The following discussion relates each capability to the Three Mile Island and medical error cases.

Table 2: The Capabilities of Resilient Performance

	Monitor	Respond	Learn	Anticipate
Description	Observe organization/ system and track performance relative to set benchmarks to identify leading indicators of a disruptive event.	Identify and deploy resources efficiently and effectively to address a disruptive event.	Review what happened during a disruption and revise operating procedures as needed.	Modify operational benchmarks and procedures to enable early disruption identification and rapid resolution.
Practices	- Performance measurement - Competitive monitoring - Observation of industry standards	- Resourcefulness - Robustness - Redundancy - Rapidity	- Debriefing sessions - Roundtable meetings among team members - Narrative learning	- Long-term disaster planning - Risk assessment - Opportunity assessment

Response is a reactive capability that is based on adjustment and prepared strategies (Hollnagel, 2010). In a resilient response, organizations identify and deploy resources efficiently and effectively to address a disruptive event.

At Three Mile Island, the response capability is considered from the time that the problem was recognized until the time the crisis ended and cleanup began. In this case, the disturbance is represented by mechanical failure, while the response is represented by operator actions and automatic reactions of the technical system. In the hospital incident, activation of the response capability occurred when a member of the care team recognized an abnormality. The delay in this recognition was in part due to infrequent check-ins and unclear responsibilities (Moore, 2014).

In the **learn** capability, organizational actors review what happened during a disruption and revise operating procedures as needed. The ability to learn corresponds to the ideas of single and double-loop behavior described by Argyris (1976). Single-loop learning behaviors involve detection and correction of an error without addressing underlying causes (Mazur et al., 2012). In contrast to single-loop, double-loop behavior includes the act of reflection on root cause in the case of an error or disturbance. The intent of double-loop learning is to identify the sources of defects within the system to prevent their reoccurrence (Mazur et al., 2012). Research shows that learning from small disruptions and errors helps organizations to be better prepared for future events (Voss & Wagner, 2010).

Organizational learning took place as a result of the Three Mile Island incident, making TMI-1 function efficiently and safely in later years. Some changes that provide evidence of lessons learned include enhanced emergency preparedness, upgraded

equipment requirements, and investigation into the role of human performance in plant safety (NRC, 2014). Following the medication error event, the hospital successfully implemented the learn capability of resilient performance by working closely with the victim's family and adopting new safety measures to prevent its recurrence. One such safety measure is a "safety zone" in which pharmacists can work without distraction (Moore, 2014).

The proficiencies to monitor and anticipate are proactive strategies to be utilized by an organization. The **monitor** capability is dependent on the ability to distinguish and handle normal and abnormal events at all levels of an organization. In the monitor capability, organizational actors observe the system and track performance relative to set benchmarks to identify leading indicators of a disruptive event.

In the Three Mile Island example presented above, a lack of situational awareness affected the monitor capability of the operators and was a key contributor to the growth of the problem. Situational awareness describes the perception and understanding of the current and future state of one's surroundings (Endsley, 1995). The literature describes situational awareness as central to resilience (Weick & Sutcliffe, 2001; Lee, Vargo, & Seville, 2013). Monitoring for the first disruption (the medical error) failed due to a lack of a policy to ensure each medicine of a certain type is checked before delivery. For the second disruption (the fire alarm), employees of the hospital failed to receive forewarning of scheduled drills.

Anticipation of disruptions involves the planning stages of resilience and is displayed by preoccupation with failure (Weick & Sutcliffe, 2001). In the anticipate

capability, organizations modify operational benchmarks and procedures to enable early disruption identification and rapid resolution.

Although Three Mile Island has been called a "normal accident" (one that is inevitable in complex systems) (Perrow, 2000), Hopkins (2001) argues that it was a failure of management anticipation. Portions of the failure event sequence, such as the failed relief valve, had occurred previously at similar institutions. Management failed to revise risk policy based on these lessons from industry. Anticipation of the medical error event showed a lack of preoccupation with failure at a management level. Effective anticipation would have been displayed in the form of a reduction in process complexity, a reduction in distractions in the medication area, and the clear labeling of paralyzing drugs. Lean concepts such as visual workplace and poka yoke can be utilized towards this aim. Table 3 summarizes the capabilities in these two cases.

Table 3: The Capabilities of Resilient Performance Exemplified

	Monitor	Respond	Learn	Anticipate
Three Mile Island Case	- Operator monitoring of indicators - Technical system monitoring	- Operator situational awareness - Emergency protocol	- Changes to procedures and technical interface - Publicized lessons shared with nuclear community	- Revision of risk management procedures - Attention to warning events
Medical Error Case	- Procedure in place to ensure correct drug delivery - Physical monitoring of patient status through observation	- Clear role definition to indicate responsibility for patient care - Care team's situational awareness - Frequency of patient check-ins	- Adoption of revised safety measures - "Safety zone" for pharmacists - Increased patient vigilance	- Management level of preoccupation with failure - Culture of continuous improvement

The Three Mile Island and hospital examples illustrate the importance of the reactive and preventative aspects of resilient performance. Considering the expanding nature of the resilience discipline (Righi, Saurin, & Wachs, 2015), this study aims to identify gaps in current research with regards to the types of studies performed on resilience and the approaches utilized. The following section is an outline of the methods used to analyze pertinent resilience literature.

2.2.2 Methodology

The State of the Art Matrix (SAM) was developed by Beruvides and Omachonu (2001) to identify research trends and gaps in the literature by classifying existing research into categories related to type of theory, type of data, and content. The literature for this study was collected through EBSCO host, Academic Search Premier, 1Search, Web of Science, and Google Scholar. The selected papers were chosen from the date range of 2001-2016. Although resilience studies date back to the 1970's, these dates were selected because of the focus on Resilience Engineering, which began in this period (Woods, 2003). A total of 77 papers were reviewed. Papers were selected based on unique contribution to the body of knowledge. As such, papers that repeated theories or produced incremental improvements were not considered. The main keywords used in search queries include, but were not limited to: "resilience," "organizational resilience," "resilience engineering," and "resilience measures." Additional papers were identified through the references and citations of papers found in the initial keyword searches. The literature was divided into theoretical studies, empirical studies, and reviews. The categorical definitions are provided below:

- **Theoretical studies**: articles that develop new or improved theory.

- **Empirical studies**: articles that base results on quantitative or qualitative data.
- **Review articles**: articles that study preceding work to identify trends and future areas of research.

Papers were further categorized based on the approach used to assess resilient performance. Approaches are organized in three categories: preventative measures, response capabilities, and learning behaviors. Due to similarities in the monitor and anticipate capabilities of resilient performance, these two capabilities were grouped under "preventative measures" for the purpose of this categorization. The following criteria were used for content analysis and paper categorization:

- **Preventative measures**: articles that mention preoccupation with failure, monitoring, situational awareness, anticipation, event list, planning, and resilience ethos.
- **Response capabilities**: articles that mention response, robustness, redundancy, resourcefulness, and rapidity.
- **Learning behaviors**: articles that mention double-loop learning, integration of lessons learned, and knowledge management.

After the keyword search, paper abstracts were reviewed for inclusion. If the abstract content was relevant to organizational resilience, the full paper was reviewed to categorize by type of study and resilience approaches discussed. The search proceeded until redundancies in content were noted and as such the sample can be considered representative of the literature. Content redundancy includes repetition of theoretical framework and application methods.

2.2.3 Results

Figure 4 is a chronological representation of the types of resilience research conducted between 2001 and 2016. As the field of Resilience Engineering gained prominence in the early 2000's, the time period 2001-2008 shows a significant focus (56% of articles) on

theory development. Specifically, researchers focused on defining disaster resilience (Smith, Walley & Dowell, 2000; Paton, Millar, & Johnston, 2001) and understanding the relationship to the inverse concept of vulnerability (Dalziell and McManus, 2004; Gallopı́n, 2006). In recent years, resilience research focus shifted to empirical studies (56% of articles from 2009-2016) with focus on application areas of transportation (Tamvakis & Xenidis, 2012, Miller-Hooks, Zhang & Faturechi, 2012), supply chain networks (Rice & Caniato, 2003; Ivanov, Sokolov & Dolgui, 2014) and healthcare (Bruneau & Reinhorn, 2007; Zhong, Clark, Hou, Zang & FitzGerald, 2014). Among these studies, the FRAM: functional resonance analysis method and RAG: resilience analysis grid dominate, cumulatively accounting for 20% of empirical studies reviewed.

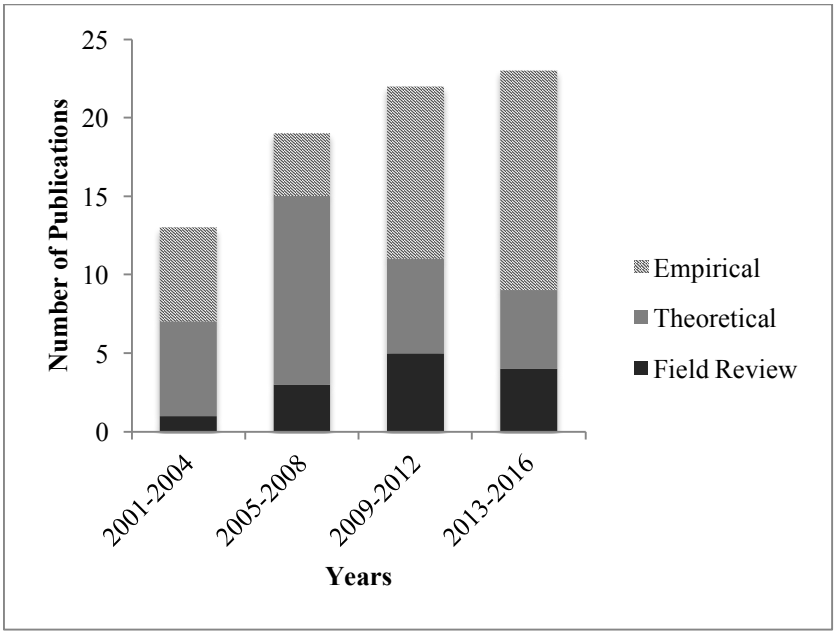


Figure 4. Distribution of Types of Resilience Studies, n=77.

Beyond Resilience Engineering, resilience research volume and focus appears to fluctuate in response to major disasters. Research between 2000 and 2006 largely focused on specific case studies such as the Columbia Space Shuttle accident (Woods, 2003), the

9-11 attacks (Tierney, 2003), and emergency department incidents (Wears, Perry, & McFauls, 2006). Woods (2003) identified patterns in the Colombia Space Shuttle accident that formed the basis for the capabilities of resilient systems (Vogus & Sutcliffe, 2007; Righi, Saurin, & Wachs, 2015). Other researchers assessed natural and humanitarian disasters through emerging theories like the 4 R's (Bruneau et al., 2003) and initial definitions of Resilience Engineering (Woods, 2003).

Following the World Trade Center disaster in 2001, there was an increased focus on emergent relationships and community resilience during emergency events (e.g. Tierney, 2003; Dalziell & McManus, 2004; Hollnagel & Goteman, 2004; Tierney & Trainor, 2004). Emergent relationships are interdependent associations that form in response to a disaster and have no pre-existing structure (Majchrzak, Jarvenpaa, & Hollingshead, 2007). These studies formed a basis for understanding how organizational structures reorganize, adapt, and create new relationships during a disruptive event. The response to the 9-11 disaster was characterized by volunteer and first responder rapidity and resourcefulness, due to the accommodation of emergence (Tierney & Trainor, 2004). One such instance of this resourcefulness is the waterborne evacuation of lower Manhattan, which was lauded as a creative success despite its ad-hoc nature (Kendra & Wachtendorf, 2003). Tierney (2003) applied the 4 R's to a disaster setting, discovering a link between resourcefulness and network mobilization. The formation of loosely coupled networks in the aftermath of the 9-11 disaster provides an example for emergent networks at the organizational and community levels (Tierney, 2003). Loosely coupled networks are made up of components that are nearly independent, acting with flexibility, and making little to no use of other components in the network (Orton & Weick, 1990).

The events following 9-11 showed that resilience extends beyond planning to include stakeholder creativity and teamwork toward common goals (Tierney, 2003). Events like 9-11 are referred to as unexampled events because they cannot be properly anticipated (Westrum, 2007).

Unlike mass terrorist events, natural disasters are generally events that can be predicted and for which the community has a planned response (Westrum, 2007). There was an increase in interest surrounding healthcare systems resilience after hurricane Katrina in 2005 (e.g. Anders, Woods, Wears, Perry, & Patterson, 2006; Bruneau & Reinhorn, 2007; Nemeth & Cook, 2007; Nemeth, Wears, Woods, Hollnagel, & Cook, 2008) and community resilience (e.g. Norris et al., 2008). Government response to the Katrina disaster lacked rapidity, with many people left stranded and in need of medical attention (Sobel & Leeson, 2006). The inadequate response is attributed in part to administrative failure in the coordination of relief efforts with international NGO's (Eikenberry, Arroyave, & Cooper, 2007). Resilience research suggests that organizational resilience impacts community resilience (Dalziell & McManus, 2004; Drabek, 2005). For instance, Paturas, Smith, Smith, and Albanese (2010) distinguish hospitals at the core of community response to a disaster. These findings lend weight to the importance of organizational resilience studies by showing the broader impacts of resilient healthcare networks.

As the field began to mature, research focus shifted to developing several measurement frameworks including ROR: Relative Overall Resilience (McManus, 2008), MAUT: Multi-Attribute Utility Theory (Stolker, Karydas & Rouvroye, 2008), Framework for Analytical Quantification of Disaster Resilience (Cimellaro, Reinhorn &

Bruneau, 2010), and the RAG: Resilience Analysis Grid (Hollnagel, 2010). Following the development of these frameworks, there was an increase in empirical studies to test the frameworks by assessing resilience in a variety of industries, including chemical manufacturing (Shirali, Motamedzade, & Mohammadfam. et al., 2012), transportation (Freckleton, Heaslip, Louisell, & Collura, 2012; Miller-Hooks, Zhang, & Faturechi, 2012), and energy (Lay, Branlat, & Woods, 2015). In one of these industries, healthcare, government policy changes appear to have increased research interest in resilience and Resilience Engineering (Fairbanks et al., 2012).

Between 2010 and 2017, Resilience Engineering studies focused on validating current frameworks and assessing the progress of the discipline through field review. This is reflected in the shift from theory development (63% of papers in the period from 2005-2008) to empirical studies (61% of papers in the period from 2013-2016). Cimellaro, Reinhorn, and Bruneau (2010) introduced and validated a resilience framework to show that the four R's could be quantified, using analytical functions to assess technical and organizational resilience. Cimellaro et al. (2010) tested an analytical model for the four R's through application to a Californian hospital network, displaying not only the impact of an earthquake, but also the importance of response and recovery. In this model for physical systems, the recovery is defined as restoration of functionality of a structure, including electric power, water supply, and repairs to bring buildings back to code (Cimellaro et al., 2010).

In addition to a rise in empirical studies, an increase was seen in field review studies. Frequency of field review papers increased from 12% of papers between 2001 and 2008 to 20% of papers between 2009 and 2016. Righi, Saurin, and Wachs (2015)

performed an extensive review of 237 papers in the field of resilience engineering from a safety perspective and identified six research areas in Resilience Engineering: descriptive knowledge, safety management, analysis of accidents, risk assessment, and training. While this work provides an overview of areas of research, little consideration is given to trends in the Resilience Engineering field since inception. Righi et al. cite a limitation of their work as the inclusion of many papers (33% of papers reviewed) that did not specify procedures for data collection and a majority (67% of papers reviewed) sourced from Resilience Engineering Symposium proceedings. This research builds on those preliminary findings by placing focus on practical implications of theories of capabilities and attributes of resilience. Attention to exploratory works lacking replicable methodology was restricted in this research, with conference papers constituting 11% of papers reviewed. Further, this work applies a categorization of papers by the foci of response, proactive measures, and learning.

Figure 4 is a plot of strategies for assessing resilience in the literature between 2001 and 2016. Many of the papers reviewed fit into multiple categories. Of the 77 papers analyzed, 73 considered organizational response concepts such as adaptive capacity (McManus, Seville, Vargo & Brunsdon, 2008) and uniformity of response practices across organizational levels (Carthey, de Leval, & Reason, 2001). Forty considered preventative concepts, such as the impact of reflection on preparedness (Nathanael & Marmaras, 2006) or the relationship between standardization of procedure and resilience (Nemeth & Cook, 2007). Thirty-three papers, or 43% of those considered, focused on the *learn* capability of resilient performance. Of these 33 papers, 16 were focused on theory development (e.g. Woods, 2003; Nathanael & Marmaras, 2006;

Nemeth & Cook, 2007). The majority of the 16 theoretical papers focusing on the *learn* capability were published prior to 2007, indicating that the field is beginning to mature.

The notion of Safety-II is a notable learning construct in the field of Resilience Engineering. Resilience Engineers stress the importance of expanding definitions of safety from purely Safety-I to Safety-II (Hollnagel et al., 2015). In the scope of Safety-I, organizations learn from what goes wrong. In Safety-II, organizations learn from what goes right-- the small adjustments that humans make to steer the organization away from a disaster (Hollnagel et al., 2015).

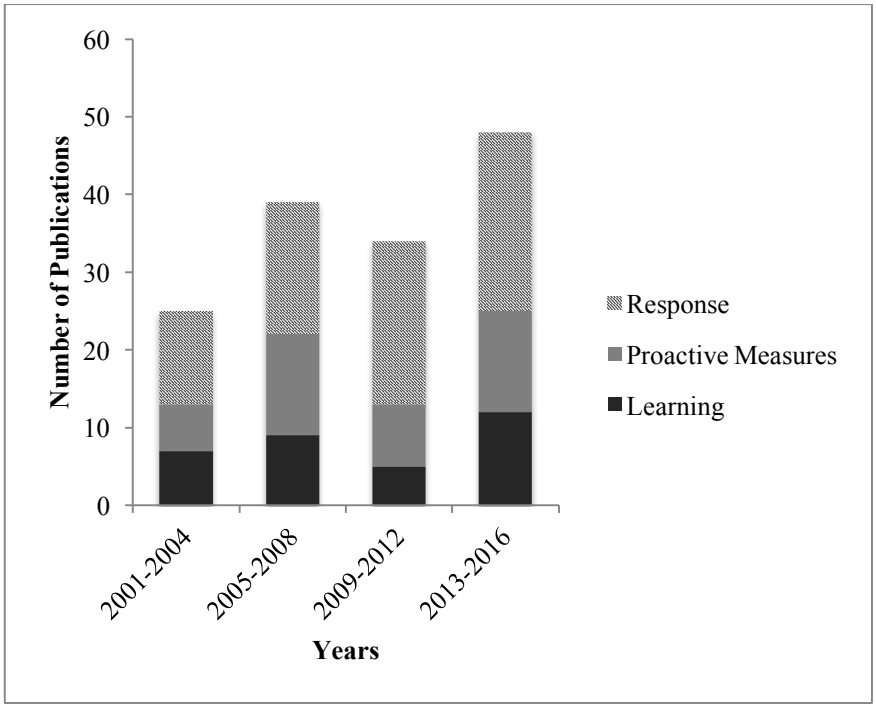


Figure 4. Distribution of Papers by Content, n=77.

The nascence of resilience research is also portrayed in the dominant research focus on the *response* capability (95% of papers considered). This focus is evident in the 4R's proposed by Bruneau et al. (2003), which focus on describing and measuring how the system reacts when disturbed. Although reaction and recovery depends whether

proactive measures exist and are effective, the dominant research focus on *response* does not highlight the significance of long term, proactive improvements. Recognizing this gap, Vogus and Sutcliffe (2007) highlight the centrality of organizational learning culture to resilience.

Recent research introduced measurement tools like the ROR: Relative Overall Resilience (McManus, 2008) and RAG: Resilience Analysis Grid (Hollnagel, 2010) that attempt to bring proactive and learning strategies of resilience to the forefront. The RAG was specialized by van der Beek and Schraagen (2015) to assess team resilience through the ADAPTER (Analyzing and Developing Adaptability and Performance in Teams to Enhance Resilience) tool. In addition to the four capabilities of resilient performance outlined by Hollnagel (2010), ADAPTER includes two sections, cooperation with other departments and shared leadership, which target team resilience.

2.2.4 Measurement Tools

Six resilience tools were identified in the literature. The focus of this section is on outlining the principles, methods, and objectives associated with each tool.

The first tool, the CAIR: Checklist for Assessing Institutional Resilience (Carthey et al., 2001), is a measurement tool focused on patient safety in healthcare. While it is related to resilience, its strong focus on patient safety makes it an ineffective method for measuring organizational resilience on the whole. Furthermore, its structure is analogous to a safety checklist. Its foundational concepts of commitment, cognizance, and competence relate to Bruneau's attributes of resilience. Commitment is associated with an organization's allocation of effort and resources. Competence relates to resourcefulness in that employees must have knowledge of the surrounding system. Finally, cognizance, an

attribute akin to collective awareness, relates to the capability to monitor for disruptive events.

A second tool, the Resilience Analysis Grid (RAG) is used to assess overall system resilience. It should be noted that the RAG has a broader scope than the CAIR, which focuses on patient safety. The RAG has been successfully applied widely in areas such as the oil and gas industry (Apneseth, Wahl, & Hollnagel, 2013), rail traffic management (Rigaud & Martin, 2013), and healthcare (Hegde, Hettinger, Fairbanks, Wreathall, Wears, et al. 2015). The RAG is based on the capabilities of resilient performance, in which the response capability encompasses the attributes of resilience (4 R's).

The FRAM: Functional Resonance Analysis Method measures system performance based on how daily operations deviate from a predetermined benchmark (Hollnagel & Goteman, 2004). Specifically, the FRAM uses process and organization mapping to understand system components and analyzes relationships and interdependencies between essential system functions. Unlike the CAIR and the RAG, the FRAM assesses how interconnectedness compounds the effect of disruptive events. This approach is particularly useful in managing critical infrastructure like energy generation, transmission, and distribution (Bellini, Nesi, Pantaleo, & Venturi, 2016). The FRAM is largely focused on system state and relationships in the stages before and during a disruption. For human systems, like healthcare systems, the lack of attention to organizational learning is a detriment. Furthermore, adaptation of this tool to a healthcare system would require an observable event and the selection of a metric to define regular functioning of the system, such as number of occupied beds.

The ROR: Relative Overall Resilience measurement tool creates a resilience profile of a system (McManus, 2008). The ROR is generally focused on the response capability, given its principles of situation awareness, management of keystone vulnerabilities, and adaptive capacity, all of which are employed in a response. Organizations are rated on each principle on a five-point scale from *very low* to *very high*. These ratings form the resilience profile. Lee et al. (2013) modified the ROR to include a fourth principle: resilience ethos. The resilience ethos principle is comprised of commitment to resilience and network perspective (Lee et al., 2013). This added principle broadens the framework to include a sense of preoccupation with failure and become more preventative in nature.

The Framework for Analytical Quantification of Disaster Resilience (Cimellaro, Reinhorn & Bruneau, 2010) is a framework that quantifies the attributes of resilience to generate a resilience index that can be used to communicate resilience level and compare levels across systems. The performance of the system is based on attributes that are represented by functions of random variables. Both direct and indirect losses (e.g. direct casualties and indirect economic losses) of disasters are considered (Cimellaro et al., 2010). The Framework for Analytical Quantification of Disaster Resilience is directly based on the attributes of resilience.

Finally, MAUT: Multi-Attribute Utility Theory allows the user to consider multiple resilience objectives through construction of a value tree. Stolker, Karydas & Rouvroye (2008) define operational resilience by the abilities to prevent, respond to, and recover from disruptions. In the MAUT tool, value tree is used to map out various performance measures that quantify progress towards resilience objectives. Then a

checklist is used to measure performance of an organization on each objective. As an approach to managing resilience, the MAUT places considerable emphasis on risk analysis and management, associable to the anticipation and response capabilities of resilient performance. Additionally, by considering incident reporting, communication of results, and maintenance of resilience, the MAUT addresses the learn capability of resilient performance.

Table 4 outlines these six measurement tools popular in resilience and Resilience Engineering studies. Similarities between the underlying principles have been drawn to the attributes and capabilities of resilient performance. Organizations can use this reference to identify the most appropriate tool based on method and purpose.

Table 4. Description of Frameworks for Measuring Resilience.

Name	Author	Year	Principles	Method	Purpose
CAIR: Checklist for Assessing Institutional Resilience	Carthey, Leval, & Rea-son	2001	Commitment, competence, cognizance	Checklist	Gauge institutional resilience through patient safety
FRAM: Functional Analysis Resonance Method	Hollnagel & Goteman	2004	Approximate adjustments, equivalence of successes and failures, emergence, functional resonance	Model of organizational functions	Accident investigation and safety assessment
ROR: Relative Overall Resilience	McManus	2008	Situation awareness, management of keystone vulnerabilities, adaptive capacity	Relative ranking based on qualitative observation (adapted to survey form by Lee et al., 2013)	Evaluation of day-to-day as well as crisis resilience; comparison tool
MAUT: Multi-Attribute Utility Theory	Stolker, Karydas & Rouvroye	2008	Risk analysis, implementation success factors, maintenance	Value tree	Evaluation of the resilience management performance of a company
Framework for Analytical Quantification of Disaster Resilience	Cimellaro, Reinhorn & Bruneau	2010	Robustness, redundancy, resourcefulness, rapidity	Mathematical representation of functionality	Evaluation of disaster resilience; physical systems
RAG: Resilience Analysis Grid	Hollnagel	2010	Respond, monitor, learn, and anticipate	Rating based on defined indicators	Formation of a resilience profile

2.2.5 Conclusions

The focus of this paper was on summarizing the literature on Resilience Engineering between 2001 and 2016. The review was conducted using the State of the Art Matrix (SAM) approach introduced by Beruvides and Omachonu (2001). In total, 77 papers were

reviewed and categorized based on type of research: theoretical, empirical, and field review and approaches to resilience: preventative measures, response capabilities, and learning behaviors.

The response phase of resilience is most commonly addressed in the literature, with 95% of papers reviewed discussing response. Research on the preventative and learn capabilities of resilient performance is largely focused on theory development or field review (64% of papers), with little focus on empirical study. Incorporation of both reactive and proactive measures into current tools will yield a broader assessment of resilience (Carthey et al., 2001).

Furthermore, many measurement tools presented in the literature are based on similar principles. A more in-depth analysis of the leading measurement tools could identify the key driving principles of resilience and draw upon similarities between the many constructions of resilience. It is important that future works in resilience assess and validate these measurement tools to further clarify their respective applicability. There is a need for cross-disciplinary translation of methods and frameworks used to define and measure organizational resilience to enable learning (MacAskill & Guthrie, 2014).

2.3 Attributes of Resilience in Healthcare

This section translates the attributes of resilience to a healthcare setting.

2.3.1 Robustness

Robustness can be considered the extent to which an organization maintains function during a disruptive event. In healthcare, this means that care team members must first recognize that a disruptive event has occurred and then deploy the correct strategy to mitigate the effect on system function from the onset. High physician satisfaction is one characteristic of a robust healthcare system, which has been shown to effect physician adherence to care plans (Sinsky, Willard-Grace, Schutzbank, Sinsky, & Margolius, 2013).

Situational awareness is the perception of one's environment and projection of future states, taking one's objectives into account. Situational awareness can be tested through a set of "consequence scenarios," in which the reaction to a predetermined range of hypothetical and directed scenarios provides the researcher with a better idea of the state of awareness of the organization (McManus, Seville, Vargo & Brunsdon, 2008).

After the event has been recognized, organizational actors use their basis of past experience and organizational knowledge to create a personal understanding of the situation, a practice referred to as sensemaking. Weick (1993) describes sensemaking as a process, from recognition of an atypical situation to articulated reflection on the experience. The actor must continuously adapt his or her understanding to an evolving and unfamiliar situation.

In a hierarchical organizational, such as the structure commonly found in healthcare, organizational actors typically look to a supervisor or person in charge early

on in the sensemaking process (Weick, 1993). As the event develops, reflection on narrative information from past interactions with patients and information shared in debriefing sessions becomes crucial in dealing with an unfamiliar situation (Garud, Dunbar, & Bartel, 2011).

2.3.2 Redundancy

Redundancies in healthcare can be observed in workflows and responsibility distribution. Procedural redundancies paired with employee compliance to existing procedures have proven effective in safeguarding against errors (Ong & Coiera, 2010). In addition to procedural redundancy, this trait can be achieved through shared responsibilities. In order to create a network of substitutable actors, Sinsky et al. (2013) recommend a shift of focus to a shared-care model in which team members perform to the top of their competencies. Scribes and nurses hold greater responsibility in the shared-care model. In recent years, interest in expanding the role of nurses and reducing physician supervision has increased as healthcare researchers gain interest in the shared-care model (Lang, 2011). Similarly the utilization of scribes has been identified as a positive shift towards the shared-care model (Carthey et al., 2001).

2.3.3 Resourcefulness

Researchers and policy makers are concerned about healthcare provider resourcefulness because there is a drive to reduce per capita cost, provide effective care in low resource settings, deploy appropriately trained providers, and prevent provider burn out increase. Learning from past events can increase resourcefulness. Nemeth and Cook (2007) identify the practices that clinicians have developed to manage with limited resources in a highly variable environment. These include advance planning, sign-out

sheets and call schedules (Nemeth & Cook, 2007). Strategies of this kind practically affect resourcefulness by increasing the organizational actors' understanding of what resources are available and how others use them.

2.3.4 Rapidity

Rapidity is the speed at which a healthcare organization is able to return to normal after a disruptive event. A recent study by Abramson, Grattan, Mayer, Colten, Arosemena, et al. (2015) suggests that increasing the resilience of individuals or small social structures can have a significant impact on the overall rapidity of a systems response in a disaster situation. The ability of a healthcare provider to respond with rapidity is impacted by the assistance of IT and master scheduling (Nemeth and Cook, 2007). The following section applies the capabilities of resilient performance to healthcare.

2.4 Capabilities of Resilience in Healthcare

In this section the capabilities of resilient performance are translated from Resilience Engineering to healthcare. The role of Resilience Engineering is to help organizational actors make the right decisions and trade-offs in the face of an emergency (Fairbanks et al., 2012). In healthcare, the employees making these crucial decisions can be any members of the care team (Rapely, 2008). As such, mechanisms for learning and effective training in this regard are essential.

2.4.2 Monitor

Monitoring involves observing both internal and external factors for indicators of a disruption (Hollnagel, 2010). In healthcare systems this can extend from internal monitoring of patients and processes to external monitoring of environmental factors

(Hedge et al., 2015). In internal monitoring, both care team members and technical devices at patient bedsides perform patient monitoring. Design ineffectiveness in bed alarms has been cited as a risk to patient monitoring (Hedge et al., 2013). External monitoring considers disaster situations such as natural disasters and terrorist events in addition to community factors such as economic and community health stressors. In the CAIR model proposed by Carthey et al. (2001), the principle of commitment reinforces the importance of risk management motivation throughout a healthcare organization. At the management level, commitment to monitoring risk is displaying by adequate staffing levels, training, and dedicated risk employees (Carthey et al., 2001).

2.4.3 Respond

The internal and external factors considered in the monitor capability extend to the response capability. Resilience researchers have investigated response to internal abnormalities such as challenging patient diagnoses (Hedge et al., 2013) and external events such as a natural disaster (Cimellaro et al., 2010). Fairbanks et al. (2012) note that resilient response depends on a system's configuration and the opportunities it provides, specifically with regards to workplace autonomy. This means that organizations set the structure for resilient teams. Within teams, Carthey et al. (2001) stress the importance of shared responsibilities in healthcare teams for effective response.

2.4.3 Learn

The learn competence of resilient performance extends beyond the experience of individual actors in an unfamiliar situation. In order for a system or organization to learn, the lesson must be recorded and integrated into the system. There are three main ways of processing occurrences of novel experience: *scientific, experiential and narrative*. The

scientific and *experiential* approaches focus on forming specific categories based on known situational characteristics so that later decisions can be made based on past experiences.

In the *scientific* approach, organizational actors use predetermined methods to assess incoming information about a situation. In the *experiential* approach, organizational actors use previous experience to assess incoming information then categorize into classes established by previous experience. To avoid a sense of false familiarity with past experiences, Garud, Dunbar, & Bartel (2011) recommend a *narrative* method for individual and organizational learning.

The *narrative* approach requires organizational actors to be aware of their knowledge, experiences, and situation. In the narrative approach, organizational actors reflect on these experiences, situations and knowledge and share lessons learned with other organizational actors to build an organizational memory of shared knowledge. Nathanael and Marmaras (2006) propose a RDD model of *repetition, distinction*, and *description* as a practical way to operationalize the narrative approach. In this model, *repetition* refers to the reinforcement of organizational strategies, as familiar experiences are re-enacted. As new experiences enter the system, the organizational actor notes *distinctions* from past events, which inform a *description* of the new event. These two processes transform abnormal incidents into repetitive occurrences that the system can manage in future incidences.

Another theory on learning separates behaviors into two models that describe an individual's experience with the detection of an error or abnormal event. The first is single-loop learning, which involves recognition and correction of an error. When a

single-loop learner perceives a gap between actual and desired results, they change their actions in order to fix the problem (Carthey et al., 2001). This is referred to as quick-fixing. Mazur, McCreery and Chen (2012) observed that single-loop behavior is overwhelmingly more common in healthcare environments. This can be attributed to the need to save time and reduce unnecessary effort in a high-pressure environment. In relation to the RDD model, single-loop learners engage in *repetition* and *distinction*, but fail to form a *description* of the event to inform future interactions with similar events.

In the model of double-loop learning, the individual not only changes their actions, but also their assumptions (Carthey et al., 2001). Mazur et al. (2012) refer to these behaviors as initiating, as the organizational actor introduces a change to a workflow or policy in order to eliminate the defect. The change to one's mental model that occurs in double loop learning can extend to the organization through *descriptions* that provide proper protocol for future instances of the event. Mazur et al. (2012) emphasize the importance of this aspect of double-loop learning for continuous improvement of standardized work in a lean organization.

When no defect is present in the system, there are three modes for organizational learning: conforming, expediting, and enhancing (Mazur et al., 2012). Conforming behaviors follow procedure, without contributing to the organizational knowledge base. Commonly seen in healthcare environments, expediting behaviors are work arounds that employees use to speed up their workflow (Mazur et al., 2012). While confirming and expediting are single-loop in nature, enhancing is a double-loop behavior in which employees seek ways to improve their current workflow (Mazur et al., 2012).

2.4.4 Anticipate

In any complex sociotechnical system, anticipation can happen at an organizational or individual level (Comfort, Sungu, Johnson, & Dunn, 2001). In healthcare, this could be an employee completing tasks early in preparation for a day with many appointments or organization-wide protocol in place for a larger event such as an active shooter, disease outbreak, or natural disaster. At the individual level, Carthey et al. (2001) present anticipation as the mental skill of foreseeing potential errors and rehearsing appropriate response.

The outcomes of organizational learning play a role in the anticipate capability. In addition to recording new instances into an organizational knowledge base, research has shown that it is important to change the mental model of organizational actors (Argryis, 1976). Shared knowledge extends an individual awareness to team awareness, improving organizational resilience (Mirdad & Eseonu, 2015).

2.5 Burnout and Individual Resilience in Healthcare

Burnout is the state of emotional exhaustion and disconnectedness that is frequently observed in employees involved in socially intensive work. Freudenberger first identified the phenomenon of burnout in 1974 in observations of the behaviors of staff at a free clinic. These observations included descriptions of physical displays of burnout, including headaches, sleeplessness, and outward signs of depression. It was later applied to family practice (Rafferty, Lemkau, Purdy, & Rudisill, 1986) and emergency physicians (Keller & Koenig, 1989) as similar traits have been observed among healthcare employees. Interest in its causes and effects has continued to grow (Schaufeli, Leiter, & Maslach, 2009), with increasing demands of Electronic Health Records (EHR) being

identified as a risk factor for occupational burnout (Shanafelt, Dyrbye, Sinsky, Hasan, Satele et al., 2016).

In healthcare, occupational burnout is associated with loss of empathy for patients, cynicism and disregard for ones work (Maslach, Jackson, & Leiter, 1997; Shanafelt, West, Zhao, Novotny, Kolars et al, 2005). Suggested causes of burnout include loss of autonomy, long hours, and reduced connectedness to colleagues (Swensen, & Shanafelt, 2016).

Psychologists define resilience as the ability to adapt and move forward in the face of negative experiences or long periods of stress (American Psychology Association, 2017). Many studies have assessed resilience to traumatic situations, such as childhood tragedies, post-traumatic stress, and crisis management (Masten, 2001; Bonanno, 2004). These extreme cases provide valuable insights into how people react to disruptions and setbacks in their daily lives.

Psychologists and organizational theorists have addressed individual employee resilience (McLarnon & Rothstein, 2013; Mallak & Yildiz, 2016). Mallak and Yildiz (2016) developed a four-factor model of active problem solving, team efficacy, confident sensemaking, and bricolage. Active problem solving is identified as the need to have positive involvement in problem resolution; instead of hoping a problem will be resolved (Mallak & Yildiz, 2016). Team efficacy refers to both how well an individual works in a team as well as how well the individual understands roles and responsibilities within the team (Mallak & Yildiz, 2016). In complex systems, confident sensemaking relies on an individual's ability to differentiate between unnecessary and necessary information (Mallak & Yildiz, 2016). Bricolage is the creative invention or recognition of solutions

using known resources during a disruptive event (Weick, 1993). Workplace resilience will be discussed in detail in Chapter 4. Psychological resilience differs from organizational resilience in that a driving factor is positivity or hope held by the individual (Rushton, Batcheller, Schroeder, & Donohue, 2015). This aspect of hope is a determinant of personal robustness, or how much an adverse event affects an individual. When employees become burned out, this sense of hope is degraded.

In occupations that require long hours and human interaction, resilient practices provide a strategy for mitigating and overcoming burnout (Zwack & Schweitzer, 2013). Research also shows that exposure to stressors, such as those related to occupational burnout have a negative impact on performance (Spector & Jex 1998). Burnout is not only dangerous for the individual, but also the organization for which they work and the patients who they serve (Balch, Freischlag & Shanafelt, 2009). A more in depth discussion of individual resilience can be found in Chapter 5.

2.6 Gap in the Literature

As interest in organizational and individual resilience in healthcare grows, there is a need for an accepted and accessible assessment of resilience that addresses the unique system characteristics of healthcare systems. Concurrently, there is a need to understand the relationship between individual and organizational resilience. Van der Vorm, van der Beek, Bos, Steijger, Gallis et al. (2011) noted the need to incorporate multi-level aspects, such as the resilience of the individual, into resilience analysis grid applications. At a more fundamental level, resilience literature continues to grow in many fields and directions (Righi, Saurin, & Wachs, 2015), consistency among definitions and usages of constructs across disciplines is lacking (MacAskill & Guthrie, 2014). This thesis aims to

address these gaps by providing an example of resilience measurement in healthcare, through which a typology to characterize the relationship between organizational and individual resilience can be understood.

3 METHODOLOGY

This chapter outlines the methodology used in this thesis. The logic model in Figure 6 is an overview of the research questions, theoretical constructs, research methods, expected outcomes and significance and impact of this research. Section 3.1 describes the overall research design. Section 3.2 outlines the development and approval of the survey used in Chapter 5. Sections 3.3 and 3.4 detail the methods used for quantitative and qualitative data collection and analysis.

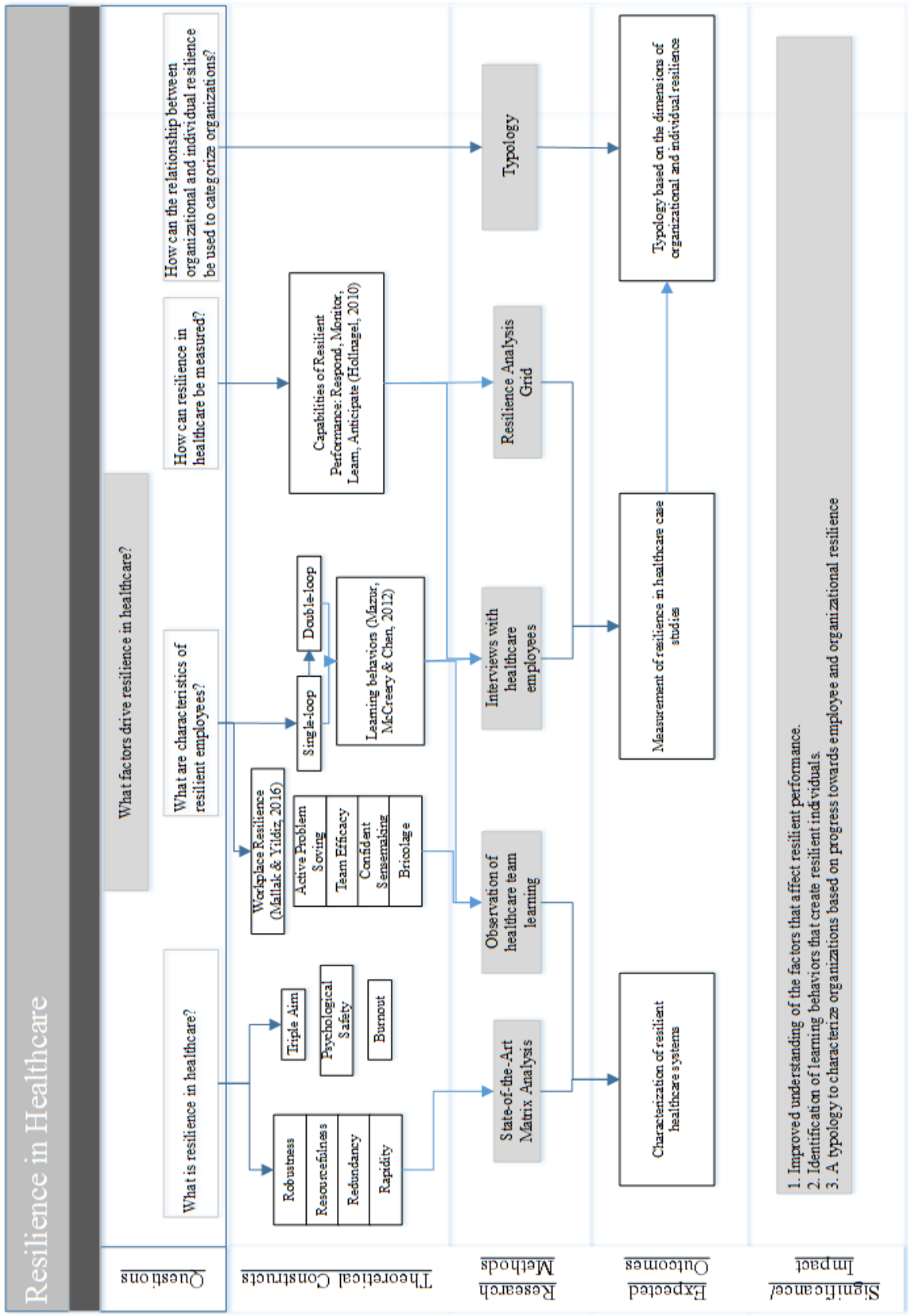


Figure 6: Logic Model

3.1 Research Design

3.1.1 Type of Research

This research uses qualitative methods to measure health systems resilience. This section describes the qualitative procedure used to answer the following questions:

1. What is resilience in healthcare?
2. What are the characteristics of resilient employees?
3. How can resilience in healthcare be measured?
4. How can the relationship between organizational and individual resilience be used to categorize organizations?

3.1.2 Research Focus

The focus of this research is in healthcare resilience. A Resilience Analysis Grid based survey was developed from the literature. In this research, the constructs of the survey tool are targeted in semi-structured interviews to better understand the drivers of resilience and refine the tool for future application. Three groups were solicited for participation. The first two groups are primary care locations with four and seven dedicated attending physicians on staff, respectively. The third group is a six-bed emergency department employing one dedicated attending physician in any given shift. Healthcare employees including physicians, nurses, receptionists, and managers will be involved in this study. Members of the care team and administrative support were included in this study to gain a full picture of organizational understanding of and consensus on resilience.

3.2 Sample Selection

Two primary care and one emergency department (ED) are included in this study. All three groups chosen operate under the same organization. While definitions of a "disruptive event" may vary significantly between primary care and ED employees, the focus at this exploratory research stage is to understand both. Interview participants were identified either through assistance of a manager or through volunteers on the day of the interviews, based on the location's preference. Organizations within the state of Oregon were selected for the qualitative analysis. Significant demographic differences exist among the populations served by the three organizations. The impact of this difference on their workflow will be discussed in the analysis.

3.3 Survey Instrument Design

3.3.1 Survey Formation

The survey instrument was adapted from RAG interview guidelines provided by Hollnagel (2010) and Resilience Analysis Grid (RAG) survey proposed by Lindvall, Kecklund, and Arvidsson (2016). The survey developed in this research focuses on the four capabilities of resilience: respond, monitor, learn, and anticipate. The questions also assess individual resilience. Lindvall et al. (2016) developed their survey to assess resilience in a railway example. Survey questions were modified to make them applicable to healthcare. Additionally, due to the large reliance of healthcare systems resilience on individuals, a fifth section of individual resilience was added to the survey. This section addresses the themes of workplace resilience: bricolage, team efficacy, active problem solving and sensemaking identified by Mallak and Yildiz (2016). Given that healthcare employees experience burnout at a rate more than double that of the general population (Shanafelt, Hasan, Dyrbye, Sinsky, Satele, et al., 2015), a section focused on emotional

capacity was included. Greater detail on survey formation is provided in Manuscript 2. The complete RAG survey used in this study is provided in Appendix A.

3.3.2 Instrument Approval

The survey and observation plans were approved by the Oregon State University's Institutional Review Board (IRB). The methods were determined to meet all federal, institutional, and ethical guidelines. The study *Understanding Resilient Process Improvement in Organizations* (IRB number 7138) was accepted on March 16, 2017. The research protocol and approval notice are in Appendix C.

3.4 Collection and Treatment of Data

3.4.1 Data Collection

The interviews were conducted on site by the author. A second researcher transcribed interviewee responses. Although more resource intensive than assertion from, the interview delivery method was selected as it has been shown to ensure that respondents understand the concepts of resilience and leads to more complete, detailed answers (Ljungberg & Lundh, 2013). Due to the knowledge of organizational policies and culture required, participants who had worked for the organization for less than a month were not considered. Interviews were conducted in locations of the interviewees choosing, which for most was a room outside of their work area. Each of the interviews began with a brief introduction to the purpose of this thesis and the definition of resilience in healthcare. Interviewees were then asked to brainstorm about disruptive events that had occurred in their time at the clinic or hospital to guide the interview. The transcripts of these interviews are provided in Appendix B.

3.4.2 Treatment of Data

Following the interview sessions, the transcripts were reviewed by the author and two additional researchers. Researchers had previous experience with resilience studies and a strong understanding of the capabilities of resilient performance. All were provided with the same form for analyzing the interview data, as shown in Figure 7 below. The raters used the form in Figure 7 to organize notes and preliminary ratings on each of the sub-items of resilient performance. These ratings created a basis for the RAG rating of organizational capabilities to monitor, respond, learn and anticipate. The individual sub-items were used to guide raters understanding of resilient individuals.

		Primary Care Location 1				
		Resident	Receptionist	Receptionist	Physician	Nurse
Monitor	Measurement					
	Communication of metrics					
	Indicator List (existence, accessibility)					
Response	Resourcefulness					
	Rapidity					
	Threshold					
Anticipation	Risk					
	Opportunity					
Learn	From bad					
	From good					
	Psychological safety					
Individual	Problem Solving					
	Team Efficacy					
	Sensemaking					
	Emotional Capacity					

Figure 7: Resilience Assessment Form 1

Previous research suggests interviewer rating of RAG scale items on a seven-point Likert scale to be an effective way of determining resilience (Hollnagel, 2010). Independently, the researchers used the interview transcripts and form in Figure 7 to provide a rating on

a seven-point Likert scale (1 ="Strongly Disagree," 2 = "Disagree," 3 = "Somewhat Disagree," 4 = "Neither Agree nor Disagree," 5 = "Somewhat Agree," 6 = "Agree," 7 = "Strongly Agree") for each of the items in the form in Figure 8. In this study, a rating of "agreement" denotes assertion that the organization possesses a high level of the capability

As resilience is systemic (Lundberg & Johansson, 2015), the consideration of multiple intra-organizational perspectives on the items in Figure 7 allows raters to see commonalities and discrepancies among organizational actors. For this exploratory study, raters gave equal weight to the sub-factors in Figure 7 in their consideration of high-level factors in Figure 8.

	Location 1	Location 2	Location 3
Monitor			
Respond			
Anticipate			
Learn			
Individual			

Figure 8: Resilience Assessment Form 2

For the second portion of analysis, the researchers identified all instances of learning at the individual or organizational level from the transcripts and separated these into a spreadsheet. These were randomized and then categorized by researchers based on type of learning behavior. The list below shows indicators used for classification of behaviors, which were drawn from the Mazur, McCreery and Chen (2012) framework.

- Quick Fixing: Behaviors in which the employee faced a defect and attempted to resolve the problem and continue with work as quickly as possible.

- Initiating: Behaviors in which the employee faced a defect and made an effort to change their own workflow, the team's workflow, or the organization's policy to handle the problem better in the future.
- Conforming: Behaviors in which the employee faced no defect and worked according to standard procedure.
- Expediting: Behaviors in which the employee faced no defect and used "work-arounds" to speed up their process.
- Enhancing: Behaviors in which the employee faced no defect and looked for ways to improve (based on personal observation, industry standard, etc.).

The final form structure is shown in Figure 9.

	Defect Exists		No Defect			Unclassifiable
Instance	Quick Fix	Initiating	Conforming	Expediting	Enhancing	
"Not much changes for me, just try to complete each encounter as quickly as possible"						
"We learn from what goes wrong. We don't change things if it's right"						
I try to find ways to make it work"						
"After a large number [of suicidal patients] called in, there was a workflow sent out to clarify"						
"Try to screen beforehand and try to address what needs to be done in the appointment. Many times you can prepare"						
"Take care of the situation as fast as I can, then get back to the day [...] Try and get people in as fast as possible, or step in and work harder"						

Figure 9: Learning Behavior Assessment Form

3.5 Research Analysis

The mean of the three raters results were taken for each of the resilience ratings on the form, to create an aggregate evaluation. That is, equal weight was given to each researcher's assessment. The informed higher-level ratings allow the researchers to not

only assess individual perceptions of resilience, but how the capabilities of resilient performance are viewed across the organization. In this sense, researchers were also looking for patterns and inconsistencies among organizational responses.

A different approach was used to analyze learning behaviors. In cases where disagreement existed in classification, a majority rule was used to classify. In instances where no majority existed, the three researchers discussed the specific behavior and came to a consensus.

3.6 Reliability

A considerable benefit of the interview delivery format is the assurance that interviewees understand the underlying constructs. Results of the interviews will be used to guide alterations to the survey tool to increase its clarity and internal reliability.

Krippendorff's alpha was selected to assess inter-rater reliability for the Resilience Analysis Grid interview response ratings. Originating in content analysis, Krippendorff's alpha indicates the degree of agreement among raters (Krippendorff, 2004). This method was selected as ordinal data is utilized and the number of raters is greater than two. Generally, alpha (α) is calculated as: $\propto = 1 - \frac{D_o}{D_e}$, where D_o is the disagreement observed among ratings and D_e is the disagreement expected by chance (Krippendorff, 2007). Thus, when raters completely agree, $D_o = 0$ and $\alpha = 1$.

A value of 0.8 is generally accepted as reliable agreement, while a value of 0.667 and above indicates a level of agreement appropriate for exploratory analyses (Krippendorff, 2004; DeSwert, 2012). The reliability analysis was completed using the inter-rater reliability (IRR) package in R software.

3.6.1 Bias

In the qualitative portion of the work, the primary researcher had a preconceived idea of what factors affect resilience and may be more cognizant of those factors than others. To address this, three researchers well-versed in resilience engineering concepts coded the interviews.

3.6.2 Representativeness

The results of the interview analysis can be assumed to be generalizable for the same institutions in Oregon.

3.7 Research Constraints

Two constraints of this research are sample size and time. Provided a longer span of time for this research (several years), the resilience analysis grid results could be collected and compared over time.

Development of a Resilience Analysis Grid Survey Tool for Healthcare

By

Lucia Darrow, Chinweike Eseonu

Submitted for publication in conference proceedings

4 Second Manuscript: Development of a Resilience Analysis Grid Survey Tool for Healthcare

4.1 Introduction

Organizational resilience is the ability of an organization to maintain normal function during disruptive events and long-term periods of stress. Resilient organizations learn from disruptive events and stressors, using these lessons to improve daily operations. Modern resilience research extends resilient thinking beyond traditional major events, to include daily improvements by all organizational actors to reduce negative impacts of, or to avoid disruptions (Braithwaite, Wears, & Hollnagel, 2015). However, resilience research in healthcare largely addresses overall resilience in the face of a major disaster such as an earthquake or terrorist event (Nemeth, Wears, & Woods et. al., 2008, Cimellaro, Reinhorn & Bruneau, 2010, Zhong, Clark, & Hou et. al., 2014). Recent concerns about physician burnout raise questions about resilience to minor, daily disruptions to ideal or expected workflow. Engineering and psychology experts are investigating ways to mitigate burnout and create resilient healthcare employees (Sands, Stanley, & Charon, 2008, Moll, Frolic, & Key, 2015, Mallak & Yildiz, 2016). Resilience of an organization is highly dependent on both the strength of technical infrastructure and human systems (Fairbanks et. al., 2012). When a system breaks down, the recovery is largely based on individual and collective decision-making power. As such, there is a need to assess the connection between individual resilience and organizational resilience in a healthcare setting.

This study aims to improve insight into the relationship between individual and organizational resilience by adapting resilient systems attributes and capabilities to healthcare settings. In this research, the four dimensions of resilience are used to map and overcome the vulnerabilities of healthcare systems. Attributes are characteristics of resilient systems. Attributes include robustness, redundancy, resourcefulness and rapidity, also referred to as the four R's (Bruneau, Chang, Eguchi et. al., 2003). Capabilities are measures of control that assess a system's ability to respond, monitor, learn, and anticipate (Hollnagel, 2010). A Resilience Analysis Grid (RAG) survey (Hollnagel, 2010) is adapted from Lindvall, Kecklund, and Arvidsson (2016), which produced a version of the RAG in survey form. Focus is placed on human system robustness through the inclusion of 16 questions related to individual resilience. The results of the RAG can be used to demonstrate impacts of process improvement initiatives that are not evident by other methods.

4.2 Background

4.2.1 Individual Resilience

Individual resilience has been researched extensively from a psychology perspective through studies on child psychology, stress, and crisis management (Doepel, 1991; Masten, 2011). Individual resilience, similar to organizational resilience, can be considered in the face of either major challenging life events or in the face of daily stressors. Ong, Bergeman, Bisconti and Wallace describe resilience as incorporating both the processes of resistance and recovery (Ong, Bergeman, Bisconti, & Wallace, 2006). Bonanno considers resilience as a regular experience that is separate from the recovery process (Bonanno, 2004). That is, resilience is based on complex personal factors that

extend beyond their stages of recovery. This idea is important to consider in the ability of healthcare employees to deal with continued stress. Emotional complexity- the experience of both positive and negative emotion- is crucial for highly resilient individuals (Ong, Bergeman, Bisconti, & Wallace, 2006). For healthcare workers, this implies that difficult work experiences must be offset by the perception of positive experience. These theories are important to consider in characterizing organizational resilience in high stress environments. Individuals are central to an organization's ability to detect disruptive events, respond, and learn. The resilience of individuals in a workplace has been investigated in the literature (Mallak & Yildiz, 2016), yet the interaction between individual resilience and organizational resilience has not been explored extensively (van der Vorm et. al., 2011).

The intersection of individual resilience and organizational resilience can be better understood when individuals are considered employees. This places focus on employee training and communication. Mallak and Yildiz (2016) characterize workplace resilience through four factors: active problem solving, team efficacy, confident sensemaking, and bricolage. By considering employee and organizational resilience concurrently, insights on the interdependencies and relationships among facets of resilience can be drawn. The following section will characterize organizational resilience in healthcare, while considering the role of the individual.

4.2.2 Attributes of Resilience

At the organizational level, a resilient response is characterized by robustness, redundancy, resourcefulness, and rapidity (Bruneau, Chang, Eguchi et. al., 2003). The principles of the four R's extend to the study of many complex, interdependent systems

and have been successfully applied to healthcare systems (Cimallaro, Reinhorn, & Bruneau, 2010, Jacques, McIntosh, & Giovinazzi et. al., 2014). When applied to healthcare, the dependency of the four R's on individuals− their knowledge, training, and ability to act quickly in changing environments− becomes evident.

The first attribute of robustness is demonstrated by the extent to which normal function is disrupted when a system endures a disturbance. Characteristics of a robust healthcare system include low burnout rate, a high level of physician fulfillment, and clearly delegated responsibilities (Sinsky, Willard-Grace, Schutzbank, et. al., 2013). Redundancy is displayed by the presence of effective substitute resources and reliable mechanisms for substitution when a primary resource is disabled. In order to create a network of substitutable actors and increase redundancy, organizations can adopt a shared-care model in which team members perform to the top of their competencies and utilize a system of shared knowledge (Sinsky, Willard-Grace, Schutzbank, et. al., 2013). One way of achieving shared organizational knowledge of this kind is narrative learning, which forms a story-based knowledge foundation for the organization (Garud, Dunbar, & Bartel, 2011).

Resourcefulness is displayed when the components in a system understand the capabilities, resources, and other attributes of the system and are able to effectively deploy needed resources in response to a disruption. Resourcefulness of healthcare providers is of increasing concern as the drive to reduce per capita cost, provide effective care in low resource settings, deploy appropriately trained providers, and prevent provider burnout increases. Finally, rapidity is displayed by the speed at which the previous three R's are activated and the speed at which the system returns to normal

function (Bruneau, Chang, Eguchi et. al., 2003). Rapidity of a healthcare system is also affected by the awareness the system has of potential disturbances. Engineering approaches such as lean can be utilized in the standardization of handoff procedures and the mapping of communication flow to increase rapidity during a disruptive event. While resilient performance is highly dependent on the attributes discussed above, these alone do not capture all aspects of organizational resilience. Resilient performance extends beyond the response of a system to include preparation for disturbance and the adaptations made following a disturbance.

4.2.3 Capabilities of Resilient Performance and RAG Measurement

Resilience engineering literature evaluates resilient performance by the abilities of a system to respond, monitor, learn, and anticipate (Hollnagel, 2010). The RAG (Hollnagel, 2010) is a highly adaptable measurement tool based off these capabilities that is well suited for healthcare systems. The RAG has been successfully applied widely in areas such as the oil and gas industry (Apneseth, Wahl, & Hollnagel, 2013), rail traffic management (Riguad & Martin, 2013), and healthcare (Hedge, Hettinger, Fairbanks, Wreathall, Wears et. al., 2015). The RAG tool is targeted towards assessing the overall resilience of the system against disturbances by gauging each of the four capabilities of resilience through a set of contextualized questions for the system of interest. The benefit of the RAG is that it is highly modifiable to fit the system it assesses. By displaying the results of the analysis in radar charts, resilience can be visualized and compared as it changes over time. Thus, this is a suitable tool to show the effects of process improvement projects and initiatives that target resilience. The RAG is applicable for healthcare systems because the underlying principles are simple, yet address complex

issues in healthcare. This work adapts the RAG to a concrete survey form that is applicable to healthcare organizations.

4.3 Methodology

The survey instrument presented is adapted from RAG interview guidelines provided by Hollnagel (2010) and a resilience survey by Lindvall, Kecklund, and Arvidsson (2016). An assessment of individual resilience is provided based on the four factors of workplace resilience as developed by Mallak and Yildiz (2016). The 50-point survey tool targets the four capabilities of resilience: respond, monitor, learn, and anticipate, as well as the resilience of the individual. Each question is rated on a 7-point Likert scale. Respondents were provided with the following statement to ensure uniform understanding:

"A disruptive event includes anything that alters or reduces normal flow of operations, ranging from a small event (e.g. unexpected employee absence), to a medium event (e.g. IT system malfunctioning), to a large event (e.g. natural disaster)."

The alterations made to the Lindvall et al. (2016) survey make this version more applicable to healthcare systems by lending clarity and placing greater focus on psychological safety, communication systems, and factors that impact an individual's ability to make sense of changing conditions. Research shows that greater psychological safety in the workplace increases the likelihood of individuals engaging in error reporting (Tucker & Edmondson, 2003) and improves team performance (Edmondson, 1999). In healthcare, sensemaking is seen as a social and systemic process (Weick, Sutcliffe, & Obstfeld, 2005). Sensemaking has been identified as a strategy to overcome communication barriers and improve patient safety (Manojlovich, 2010). The RAG is to

be applied to several levels of an organization, gaining insights from physicians, nurses, medical assistants, and residents as well as administrative employees and management. The aim is to better understand how healthcare employees at different levels of the organization perceive resilience and the value of resilience improvement. In the survey formulation section that follows, each of the capabilities of resilient performance is described from a healthcare perspective and sample corresponding survey questions are provided.

4.4 Survey Development

4.4.1 Monitor Capability

The first section of the survey focused on the monitor capability of resilient performance, which involves continuously monitoring system performance to distinguish between normal and disrupted operations. This requires organizational actors to have a strong understanding of the characteristics of normal operations and a disruptive event, as well as leading indicators that signify the shift (Hollnagel, 2010). The monitoring of established performance measures is one way to improve organizational knowledge about these characteristics. In the RDD model of repetition, distinction, and description presented by Nathanael and Marmaras (2006), monitoring is the act of categorizing events as normal, indicating a repetitive response, or abnormal, indicating the need for distinction. In healthcare, experiential knowledge plays a large role in the ability to recognize and understand unfamiliar situations as they develop (Hedge et al., 2013). Information sharing regarding past disruptive events and commonplace adjustments to avoid these events is essential across teams (Van der Beek & Schraagen, 2015). These shared experiences in conjunction with industry standards can be utilized in the

construction of an indicator list. Table 5 provides sample questions relating to the ability to monitor both normal operations and abnormal situations.

Table 5: Monitor Capability

Focus	Sample Questions
Measurement	My organization has clearly defined metrics for system performance. My organization continuously monitors the metrics for system performance.
Communication	My organization communicates the results from continuous monitoring to employees (Lindvall et al., 2016).
Indicator List	My organization has defined indicators for disruptive events (from industry standard, expertise, etc.) (Hollnagel, 2010).

4.4.2 Respond Capability

The response capability is highly dependent on the 4 R's of robustness, resourcefulness, redundancy, and rapidity, as discussed in the attributes of resilience. In an unfamiliar situation, defined role systems foster resourcefulness and are crucial for a resilient response (Mallak, 1998). A role structure can be achieved in the shared care model through the standardization of workflows, implementation of team documentation, and team collocation (Bruneau, Chang, Eguchi et. al., 2003).

In addition to clearly defined roles, resilient organizations maintain a list of events for which they have a detailed response plan. Results from continuous monitoring can be used in the determination of limits defining the beginning and end of a disruptive event. This threshold between normal operations and disturbance should be defined and recognizable by all organizational actors (Hollnagel, 2010). Table 6 outlines the key determinants of a resilient response.

Table 6: Response Capability

Focus	Sample Questions
Resourcefulness	My organization has adequate resources (people, materials, competence, expertise, and time) available to handle disruptive events (Lindvall et al., 2016).
Rapidity	My organization responds rapidly to disruptive events (Hollnagel, 2010).
Threshold	Most people in my organization recognize when the organization has fully recovered from a disruptive event.

4.4.3 Anticipation Capability

Beyond monitoring current operations for signs of a disruption or stressor, resilient organizations look into the future, considering possible changes in conditions (Hollnagel, 2010). These changes in conditions can create risks or opportunities, which necessitate a prepared response. The ability to anticipate unexpected events depends on the quality and frequency of risk assessment performed by the organization. Resilience Engineers stress the importance of incorporating lessons from successes, as well as failures, into risk management strategy (Hedge et al., 2013). Effective anticipation requires a preoccupation with failure across organizational levels (Weick & Sutcliffe, 2001). In this sense, the communication of risk strategy to personal is essential. The questions in Table 7 investigate an organization's ability to anticipate future risks and opportunities effectively.

Table 7: Anticipation Capability

Focus	Sample Questions
Strategy	My organization works actively to anticipate future risks (Lindvall et al., 2016).
	My organization works actively to anticipate future opportunities for improvement (Lindvall et al., 2016).
Communication	My organization is good at communicating future risks to the personnel (Lindvall et al., 2016).

4.4.4 Learn Capability

The fourth section of the survey consists of questions related to the learn capability of resilient performance. Resilient organizational learning is depends on lessons being recorded and integrated into shared knowledge and strategy. Without a defect present, a resilient organization learns from what is functioning properly and finds ways to enhance. An organization must learn from both what goes wrong and what goes right to be truly preoccupied with failure (Braithwaite, Wears, & Hollnagel, 2015). To this aim, healthcare workers can employ double-loop learning, an idea pioneered by Argyris, which involves addressing root causes of disruptive events (Argyris, 1976).

Double-loop learning impacts organizations by changing the mental model employed when a disruptive event is encountered. Mazur et al. (2012) identify five categories of improvement behaviors: quick fixing, initiating, conforming, expediting, and enhancing. In the presence of a defect, the organization should aim to transform from quick fixing to initiating behaviors. Initiating behaviors investigate the root cause of errors and prevent them from reoccurring, thereby making the organization more resilient to changing conditions.

A psychologically safe organizational culture that emphasizes conforming to procedure and provides feedback supports this transition (Mazur et al., 2012). In order to make enhancements, employees must feel as though their suggestions will be heard and supported. Organizational learning can be measured based on the communication of new knowledge and action taken based upon this new knowledge. The questions in Table 8 are targeted at the learn capabilities discussed in this section.

Table 8: Learn Capability

Focus	Sample Questions
Safety II	My organization learns from disruptive events (Lindvall et al., 2016). My organization shares best practices from well functioning areas (Lindvall et al., 2016).
Psychological Safety	Employees at my organization feel comfortable discussing root causes when disruptive events occur. Employees at my organization feel comfortable suggesting solutions to peers when disruptive events occur.

4.4.5 Individual Resilience

The fifth section of the survey is based on individual resilience. This research considers the resilience of the care team members as integral to organizational resilience. The first three constructs below of active problem solving, team efficacy, and sensemaking and bricolage were derived from the workplace resilience instrument developed by Mallak and Yildiz (2016). Individuals that use active problem solving take initiative in managing disruptive events and enhancing operations. Individuals that employ enhancing behaviors are innately concerned about the organization, their co-workers and patients (Mazur et al., 2012). The capacity for this concern comes, in part, from a resistance to burnout. Team efficacy addresses the strength and structure of care teams, in an industry where the

roles of clinicians, technicians, scribes, and medical assistants are often mixed. With clear roles and task delegation, physicians are able to perform to the top of their competencies and thereby maintain a greater sense of job satisfaction.

In the absence of a framework for handling the unexpected, healthcare workers try to make sense of the altered state caused by disruptive events. Sensemaking and bricolage are intrinsically tied to any definition of resilience and are actively a part of the respond and monitor stages. Sensemaking is a process, from recognition of an atypical situation to articulated reflection on the experience (Weick, 1993). Bricolage refers to the ability to creatively generate solutions using known resources during a disruptive event (Weick, 1993). The emotional capacity of healthcare workers is defined as personal robustness in an industry plagued by burnout. This capacity includes emotional complexity: the experience of positive and negative emotion, empathy, coping strategies and fulfillment.

Table 6: Individual Resilience

Focus	Sample Questions
Active Problem-Solving	Most people like me take delight in solving difficult problems (Mallak & Yildiz, 2016). Most people like me create alternative ways to get work done in spite of disruptive events.
Team Efficacy	Most people like me would explicitly state expectations for work performance. Most people like me understand organizational goals. Most people like me have a clear idea of team member roles and responsibilities.
Sensemaking and Bricolage	Most people like me know what resources are needed when a disruptive event occurs. Most people like me can usually differentiate between necessary and unnecessary information during a disruptive event.

Emotional	Most people like me regularly experience a combination of positive and negative emotion (Ong, Bergeman, Bisconti, & Wallace, 2006).
Capacity	Most people like me can easily understand what their patients feel (Maslach et al., 1997).
	Most people like me have strategies for coping in times of high stress.

4.5 Conclusion

The RAG was adapted to survey form for use in a healthcare organization. Resilience of a healthcare organization was defined and the relationship between individual well-being and system performance was outlined. The satisfaction and job fulfillment of healthcare workers has an impact on financial, patient, community and long-term organizational outcomes. The measurement of resilience through the RAG provides incentive for organizations to work towards resilience goals and to conceptualize resilience, without experiencing a major disturbance. This paper is the first step in a wider study. In future research, the survey will be validated and analyzed. Possible next steps include surveying respondents using the RAG at an early stage of continuous improvement projects aimed at improving employee satisfaction. As the projects progress, respondents will be surveyed with the RAG to pinpoint potential shifts in areas of organizational resilience. A final result will be the improved understanding of cultural and technical factors that affect resilience in healthcare systems.

Measuring Resilience in Healthcare: A Characterization and Categorization of Organizational and Individual Resilience

By

Lucia Darrow, Chinweike Eseonu

To be submitted for publication in a peer-reviewed journal

5 Third Manuscript: Measuring Resilience in Healthcare: A Characterization and Categorization of Organizational and Individual Resilience

5.1 Introduction

Despite efforts to rework safety procedures and prevent patient harm, quality issues in healthcare persist (Vincent, Burnett, & Carthey, 2014). Quality improvement projects can paradoxically undermine organizational resilience in healthcare by reducing adaptive capacity and over-standardizing operations. The systematic standardization of workflows by outside parties often necessitates translation of information by healthcare workers, thereby reducing their flexibility and ability to monitor for disruptive events (Perry et al., 2007). Additionally, the sustainability of traditional root cause analysis efforts is often limited by failure to incorporate lessons learned into patient-care workflows (Hedge et. al., 2013). While the assessment of root causes following events gives insights into what went wrong, the events in which organizational actors steer the organization away from a disaster are often overlooked.

The concept of learning from what goes right in daily interactions with disruptive events of varying magnitude is referred to as Safety II (Hollnagel, 2011). Resilience engineering incorporates both traditional definitions of safety and Safety II to offer a more holistic approach to event analysis. Resilience engineering offers potential to improve quality in healthcare and increase the effectiveness of process improvement projects (Perry et al., 2007). Given the nascence of resilience engineering applications in healthcare (Fairbanks et al., 2012), there is a need to investigate the factors and individual behaviors that contribute to resilient care teams. The objective of this article is to understand the relationship between individual and organizational resilience.

The following section provides an overview of the literature on resilience and resilience engineering in healthcare. In this study, organizational resilience is considered with respect to disruptive events. These events vary in magnitude, from commonplace errors, to continued stress on the system, to large-scale disaster events. System failure can be caused by external disturbances, such as a natural disaster, or internal errors, such as the delivery of the wrong drug, that disrupt normal function. Observational and interview data from three healthcare locations are used to form a more complete understanding of interactions between resilience at different levels. Finally, a typology based on the dimensions of resilience in organizations is presented, offering implications for healthcare quality directors and healthcare engineering researchers.

5.2 Literature Review

5.2.1 Individual Resilience

The American Psychological Association (2017) defines resilience as the process of adaptation in significant stress or trauma, involving both flexibility and learning. In healthcare, this means that resilient providers not only endure difficult scenarios, but use personal lessons to respond more effectively in the future. The 2016 Physician Foundation survey indicates that 89% of physicians have experienced burnout in their careers. Healthcare providers often find themselves occupied with work below their competencies. The corresponding gap between expectation and reality has been identified as a key source of burnout (Alsaiji, 2017). Physicians experiencing high stress and symptoms of burnout are associated with lower levels of empathy and situational awareness (Rall & Gaba, 2004; Shanafelt et al., 2005). In turn, employees experiencing burnout have a reduced ability to monitor and respond to disruptions to operations. In this

research, individuals will be considered as components of organizations and as such, workforce resilience is the focus of this study.

5.2.2 Workforce Resilience

Workforce resilience is the ability of a team to maintain well being and performance throughout periods of stress or following adverse events. Modern studies in workplace resilience investigate the influence of personal characteristics, support networks, and self-regulatory processes (McLarnon & Rothstein, 2013). King and Rothstein (2010) suggested that workplace resilience is a regular process defined by affective, behavioral, and cognitive adaptive responses to an adverse event. Rees, Breen, Cusack, and Hegney (2015) presented a model of workforce resilience that relates the intrapersonal factors of neuroticism, mindfulness, self-efficacy, and coping to psychological adjustment. In addition to these items, employee resilience is related to team structure and individuals problem solving methods. Mallak and Yildiz (2016) presented the workplace resilience instrument based on four constructs: active problem solving, team efficacy, confident sensemaking, and bricolage.

5.2.3 Resilient Learning Behaviors

Resilient employees contribute to organizational knowledge by engaging in double loop learning behaviors. In double loop learning, the root causes of problems are assessed and managed (Argryis, 1976). When a double loop learner recognizes a gap between expectations and reality, they not only change their actions, but also alter the set of assumptions that define their mental model (Carthey et al., 2001). Organizationally, lessons learned are shared and impact the way teams approach similar problems in the future Mazur, McCreery, & Chen (2012) identify five categories of improvement

behaviors: quick fixing, initiating, conforming, expediting, and enhancing. Quick fixing behaviors are commonly observed in healthcare environments, as there is a need to work rapidly (Mazur et al., 2012). In the presence of a defect, the organization should aim to transform from quick fixing to initiating behaviors. Initiating behaviors investigate the root cause of errors and prevent them from reoccurring, thereby making the organization more resilient to changing conditions. The organization's ability to make this shift is dependent upon the culture. A psychologically safe culture that emphasizes conforming to procedure and provides feedback supports this transition (Mazur et al., 2012).

In the case of no pressing defect, healthcare providers often engage in expediting behaviors, more commonly referred to as "workarounds," which deviate from standard procedure. Alternately, conforming behavior describes actions that follow standard organizational procedures. Without a defect present, a resilient organization learns from what is functioning properly and finds ways to enhance. Healthcare providers that employ enhancing behaviors are innately concerned about the organization, their co-workers and patients. The capacity for this concern comes, in part, from a resistance to burnout (Shanafelt, West, Zhao, Novotny, Kolars et al, 2005). In order to make enhancements, employees must feel as though their suggestions will be heard and supported. The combination of initiating and enhancing strategies make up double-loop learning behaviors. In this research, case study examples are used to investigate the manifestation of these learning behaviors in healthcare. These behaviors are illustrated in Figure 9.

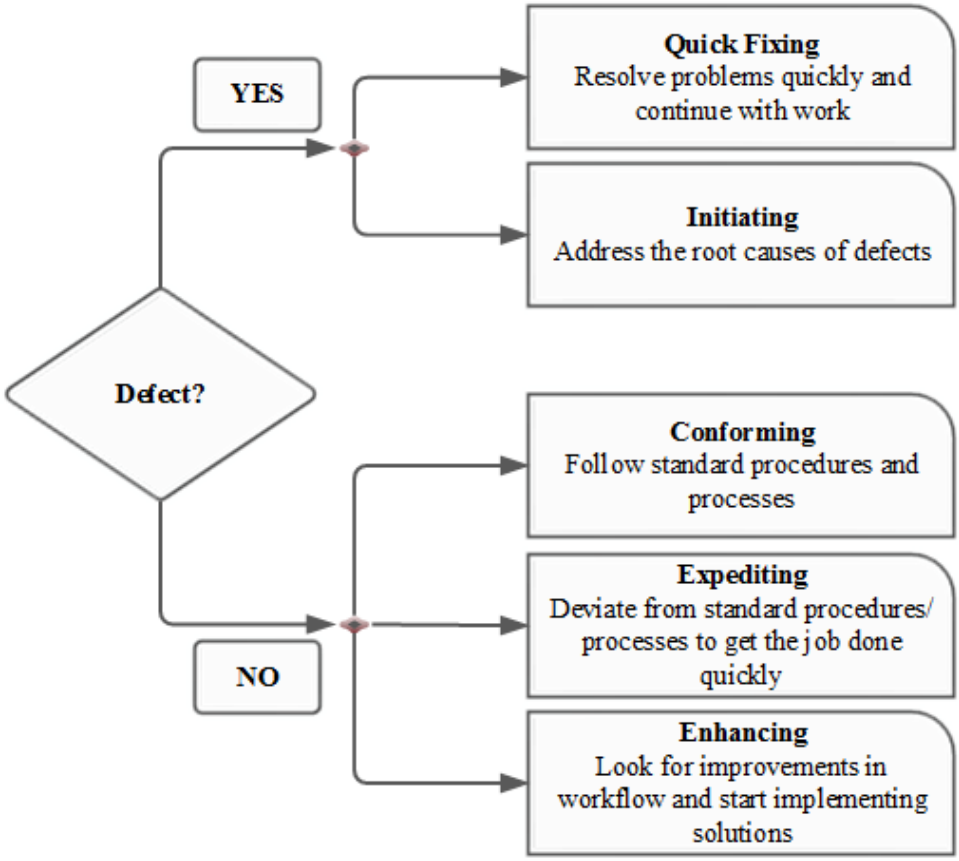


Figure 9: Single and Double Loop Learning Behaviors (Adapted from Mazur et al., 2012)

5.2.4 Organizational Resilience

Resilience is the ability of an organization to maintain normal function in the face of a disruptive event and use lessons learned from an event to improve operations (Hollnagel, 2010). Resilience is dependent on the capability of an organization to monitor for, respond to, learn from, and anticipate disruptive events. Monitoring involves being able to distinguish between normal and abnormal operations based on performance measures or leading indicators (Hollnagel, 2010). Response is based in the ability to recognize and deploy the necessary resources and procedures to address a disruptive event.

Learning systems use lessons from disruptive events to improve performance. Resilient learning systems are composed of double loop learners, who address the root

causes of issues to change organization wide strategies to handling disturbances. The root cause analysis that occurs when double loop learners encounter small disruptions strengthen the overall resilience of the system by adjusting functioning prior to a major disruptive event (Voss & Wagner, 2010). By learning from both what goes wrong and what goes right in an interaction with a disruptive event, organizations anticipate future risk and opportunity (Hollnagel, Wears, & Braithwaite, 2015).

5.2.5 State of the Art Matrix Review

The state of the art matrix (SAM) method was introduced by Beruvides and Omachonu (2001) as a literature review method that uses categorical matrices to identify research trends and gaps in the literature. The literature for this study was collected through EBSCO host, Academic Search Premier, 1Search, Web of Science, and Google Scholar. Selected papers were chosen from the date range of 2000-2016. Although resilience studies date back to the 1970's, these dates were selected because of the focus on Resilience Engineering, which began in this period. A total of 55 papers were reviewed.

This SAM differs from the review presented in the first manuscript in that it is concerned with resilience in **healthcare**-- individual, organizational, and systemic. The main keywords used in search queries include, but were not limited to: "healthcare resilience," "organizational resilience in healthcare," "resilience engineering healthcare," and "physician resilience." Additional papers were identified through the references and citations of papers found in the initial keyword searches. The literature was divided into theoretical studies, empirical studies, and reviews. The papers were further divided by their scope: system or individual. Figures 10 and 11 display the results of the SAM analysis.

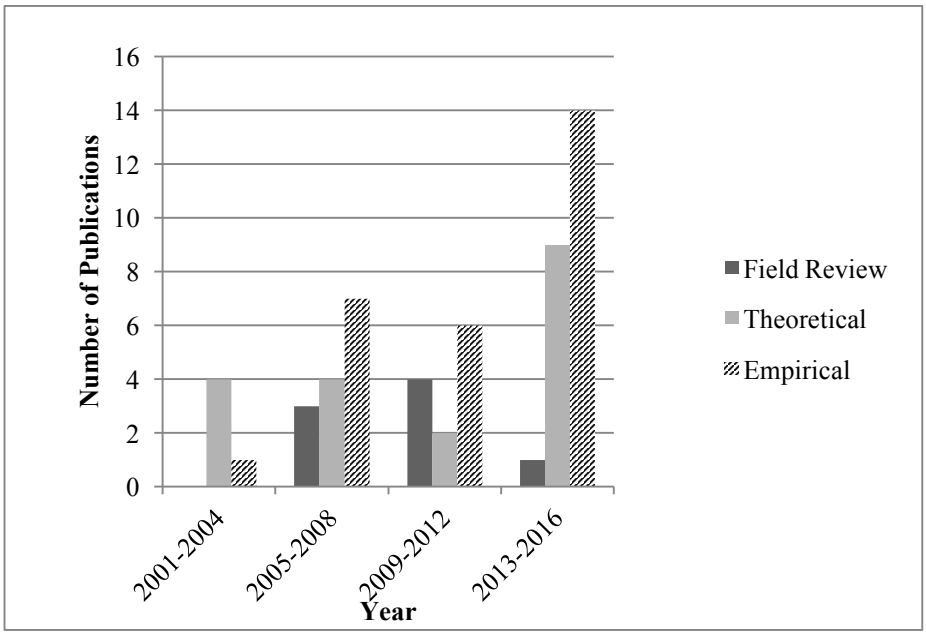


Figure 10. Review of Healthcare Resilience Literature by Type, n = 55

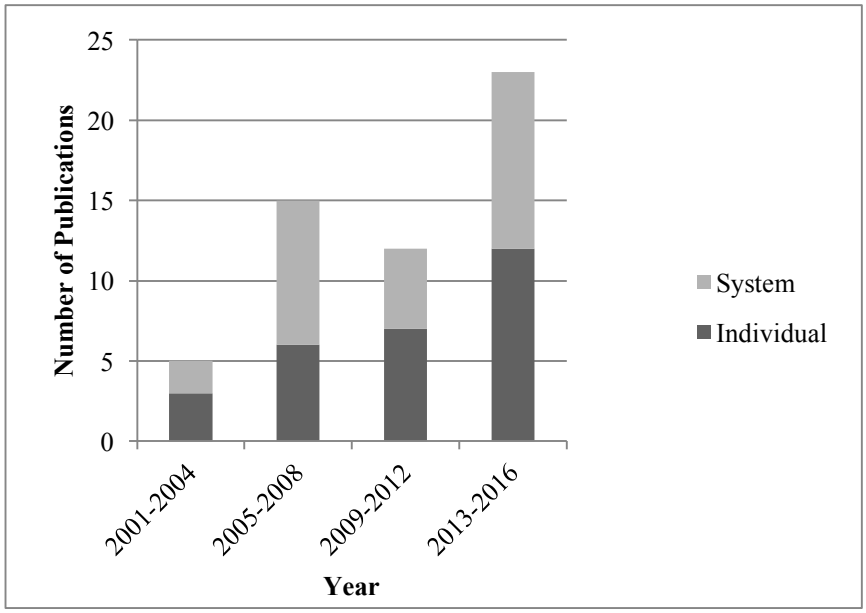


Figure 11. Review of Healthcare Resilience Literature by Scope, n = 55

In recent years, interest in both organizational resilience and individual resilience in healthcare has seen considerable growth. The split between scopes of studies has remained fairly constant, with 51% of papers reviewed focused on individual resilience and 49% of papers reviewed focused on organizational resilience. Many researchers have

used empirical methods to learn more about resilience in healthcare (58% of the papers between 2013 and 2016). Notably common methods include event analysis (Hedge et al, 2013), the application of burnout scales (Cooke, Doust, & Steele, 2013; Taku, 2014), and semi-structured interviews (Zwack & Schweitzer, 2013). At the organizational level, researchers have examined resilience in the face of crisis (Jacques, Mcintosh, Giovinazzi, Kirsch, et. al., 2014; Shirali, Azadian, & Saki, 2016), loss of infrastructure (Vugrin, Verzi, Finley, Turnquist, et. al., 2015), and redevelopment (Steele, Wilkinson, Alvaro, & Harvey, 2015).

At the individual level, recent works have investigated factors such as job satisfaction (Hudgins, 2016), leadership (Halter & Sturgeon, 2013), and the effect of mindfulness on personal resilience (Moll, Frolic, & Key, 2015; Montero-Marin, Tops, Manzanera, Demarzo, et. al., 2015). Despite this, the number of papers explicitly discussing the relationship between the two constructs is limited. Perry et al. (2007) noted: "Attention to conflicts between goals and tasks across the organization and the role of workers in creating resilience are overlooked as contributors to system safety." There is a need to investigate the relationship between individual and organizational resilience (Burnard and Bhamra, 2012).

5.3 Methodology

This research utilizes a qualitative approach to characterize the resilience of three case study organizations. The locations were selected based on experience with burnout, proximity to the researchers, and willingness to participate in the study. The following sections describe the methodology for the collection of qualitative interview data related capabilities of resilience in three healthcare organizations.

5.3.1 Measurement Tool Selection

Tools from resilience engineering assess progress towards resilience goals through rigorous measurement of key competencies. The Resilience Analysis Grid (RAG) assesses each of the four capabilities of resilience through a set of contextualized questions for the system of interest. Based on the responses to the issues presented, each of the four areas is assigned a rating on a Likert scale. The benefit of the RAG is that it can be highly modified to fit the system it assesses. By displaying the results of the analysis in radar charts, resilience can be visualized and compared as it changes over time. Thus, this is a suitable tool to show the effects of process improvement projects and initiatives that target resilience.

The RAG is a highly adaptable interview tool to measure the four capabilities of resilient performance-- monitor, respond, learn, and anticipate. It has been used in the oil and gas industry (Apneseth, Wahl, & Hollnagel, 2013), rail traffic management (Rigaud & Martin, 2013), and healthcare (Hegde, Hettinger, Fairbanks, Wreathall, Wears, et al. 2015). This research utilizes a healthcare-specific adaptation of the RAG developed by Darrow and Eseonu (2017). The survey contains 34 questions focused on the capabilities of resilient performance as well as 16 questions specific to individual resilience. The tool was applied through semi-structured interviews, targeting constructs of the survey created by Darrow and Eseonu (2017). These capabilities to monitor, respond, learn, anticipate and maintain individual resilience were then rated on a seven-point Likert scale (1 ="Strongly Disagree," 2 = "Disagree," 3 = "Somewhat Disagree," 4 = "Neither Agree nor Disagree," 5 = "Somewhat Agree," 6 = "Agree," 7 = "Strongly Agree"), where

"Agreement" indicates affirmation that the organization possesses a high level of the capability.

5.3.2 Measurement Tool Application

The researchers performed interviews with members of three organizations, two primary care and one emergency department. Sample sizes were five, three, and four, respectively. A combination of physicians, residents, MAs, nurses, receptionists and management employees were interviewed, with a mix of care team members and administrative employees at each location. Interviewees were asked a set of general questions related to the four capabilities of resilient performance and individual resilience. The questions were adapted from the survey to better understand experiences that might drive survey responses. Examples include:

- "Does your organization learn from successes (what goes right) as well as failures (what goes wrong) in the case of a disruptive event?"
- "For what events does your organization have a prepared response?"
- "How do you solve difficult problems in your workday?"

Based on the interviewees' initial responses, the interview was framed relative to personal experiences with disruptive events within the organization. Responses from each organization were then reviewed for common elements in the themes of organizational resilience. Coding information and key resilience concepts by organization preserved the uniqueness of organizations.

5.3.3 Learning Behaviors Identification

In addition to scoring resilience, the researchers extracted 21 learning behaviors from interview transcripts with the 12 employees. These behaviors were then randomized in a

spreadsheet and characterized by the three researchers using the Mazur, McCreery and Chen (2012) typology. In instances with no consensus, a majority rule was followed. In cases where three separate classifications were made, the researchers discussed the learning behavior and collectively agreed based on evidence.

5.3.4 Data Preparation

Three researchers analyzed the interview data and rated the items below on a 7-point Likert scale. To begin the analysis, the researchers reviewed the transcripts for overall themes or notable information based on the categories in Table 10, which was recorded in an Excel spreadsheet. This data was used to inform the ratings on the Resilience Analysis Grid. The three raters' ratings on the five categories of resilience were then averaged.

Table 10: Resilience Analysis Grid Interview Targets

Monitor	Performance measurement
	Communication of metrics
	Indicator list (existence and accessibility)
Response	Resourcefulness
	Rapidity
	Clarity of threshold
Anticipation	Risk
	Opportunity
Learn	From failures
	From successes
	Psychological safety
Individual	Problem Solving
	Team Efficacy
	Sensemaking
	Emotional Capacity

5.4 Results

5.4.1 Resilient Learning Behaviors Results

Interview transcripts were reviewed for instances of resilient learning behaviors. The results of these behaviors are shown below. In the emergency department, it was observed that despite a greater sense of urgency and pressure, organizational actors found significant opportunities to improve. This can be explained in part by the formal structures in place to facilitate organizational learning. One such example is the debriefing that occurs following large-scale mass casualty events. After the event, team members get together and discuss what went wrong and what went right. A similar debriefing occurs among teams following drills for these types of events. Similarly, the emergency department location had a program called "let's fix what bugs you" in place to provide a safe and convenient space for employees to report areas in their workflow that could be improved. A summary of the recorded behaviors is provided in Figure 12.

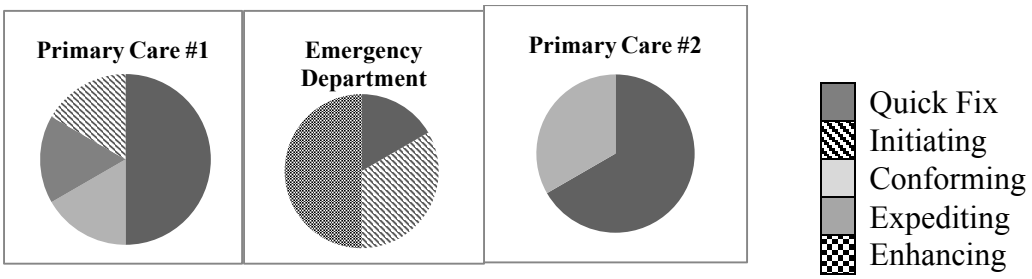


Figure 12: Learning Behavior Distribution

In line with the literature, the most commonly observed behavior was quick fixing, making up nearly half of the observed behaviors. In the face of a disruptive event, indicators of quick fixing included statements such as:

- *"Not much changes for me, just try to complete each encounter as quickly as possible."*

- *"Just work through it."*
- *"Take care of the situation as fast as I can, then get back to the day."*

A common theme in observed initiating behaviors is the sharing of new and revised organizational knowledge through debriefing sessions, workflows, and standard operating procedures. Enhancing behaviors were observed on an individual level, as healthcare providers adjusted their own workflows to prepare for disruptions.

5.4.2 Resilience Results

While instances of organizational learning were found in all organizations studied, the presence of strategy to support Safety-II (learning from successes), was observed to be lacking. Remarks such as: "*We learn when it goes wrong. We don't change things if it's right."* support this observation. Among organizations, the researchers were able to draw similarities in understanding of certain resilience metrics. For example, when employees at the same organization were asked whether their organization had an accessible indicator list sample responses were:

- *"No, but for larger scale I know that there is one, but don't know where."*
- *"Probably, not that I could tell you where to find one. I know we have been doing disaster planning. I rely on administrators to tell me."*

These responses indicate a uniform lack of accessibility of the indicator list. In the measurement of individual resilience, burnout was observed to be a recurring experience, which many respondents had encountered in their careers. Examples of items used to rate individual resilience include:

- *"There will always be burnout because this department is very stressful. They [the patients] all want your undivided attention, in all rooms at the same time. [...] We do pretty well such a variable, stressful job."*
- *"It's my goal to give 75% all the time. If you do give 100%, you will be burned out in the first 3 days."*

The radar chart in Figure 13 displays the aggregate resilience of the three case study organizations for the five aspects of resilience. On the radar chart, a zero represents a very low degree of the capability while a seven represents very high degree of the capability. Overall resilience varies among the three locations. Key differences between the first and second primary care locations lie in the dissemination of information related to disruptive events. At the second primary care location, employees had little knowledge of whether or not plans existed, as well as little knowledge of the organizational learning occurring following disruptive event. The emergency department in Figure 13 is a location caring for a fluctuating population with limited resources, affecting the abilities to monitor and respond. Despite this, the ability to learn was observed to be relatively high.

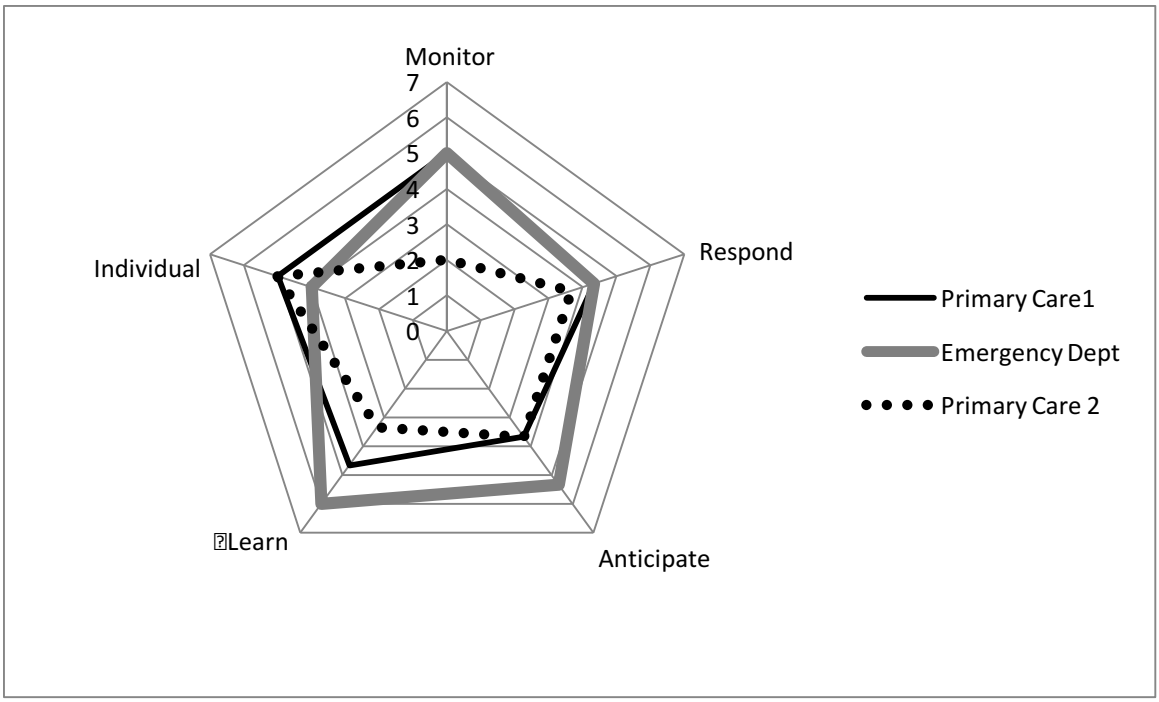


Figure 13: RAG Radar Chart (0 = low degree of capability, 7 = high degree of capability)

Inter-rater reliability was assessed using Krippendorff's alpha. This measure was selected due to its appropriateness for ordinal data with multiple raters (Krippendorff, 2007). With three raters judging each of 15 resilience items, 45 judgments were collected in total. A Krippendorff's alpha value of 0.688 was obtained. Given the exploratory nature of this work, values of alpha above 0.667 indicate agreement (Krippendorff, 2004; DeSwert, 2012).

5.4.2 Resilience Typology

The typology is a useful method to summarize multifaceted ideas into clear-cut categories. Organizational culture and safety researchers have used typologies to synthesize organizational patterns and phenomena (Shrivastava, 1983; Westrum, 2004). To the best of the authors' knowledge, the dimensions of organizational and individual resilience have not been fused into a typology. Figure 14 presents the research typology

for resilience. In the repressed quadrant, highly resilient individuals are required to keep a fragile organization functioning. In a led organization, strong formalized structures retain overall resilience despite employees that may be experiencing burnout. Neither of these states can be viewed as sustainable in the long term. In the ideal state, the high resilience of an organization and teams feed off one another to continuously improve. Industrial professionals can use this descriptive tool in investigating impacts of program or staffing changes.

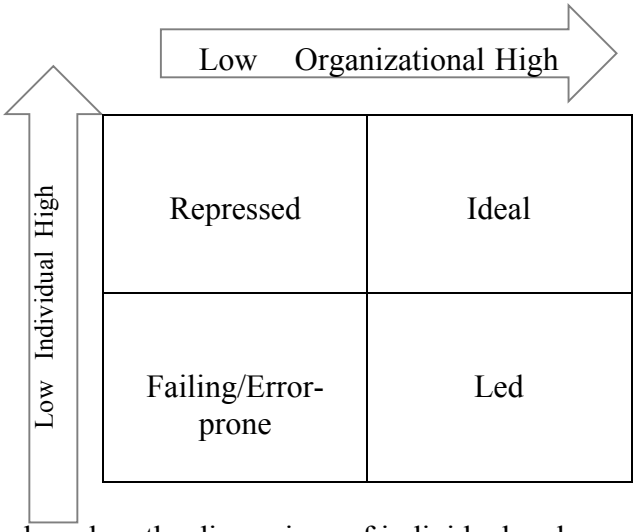
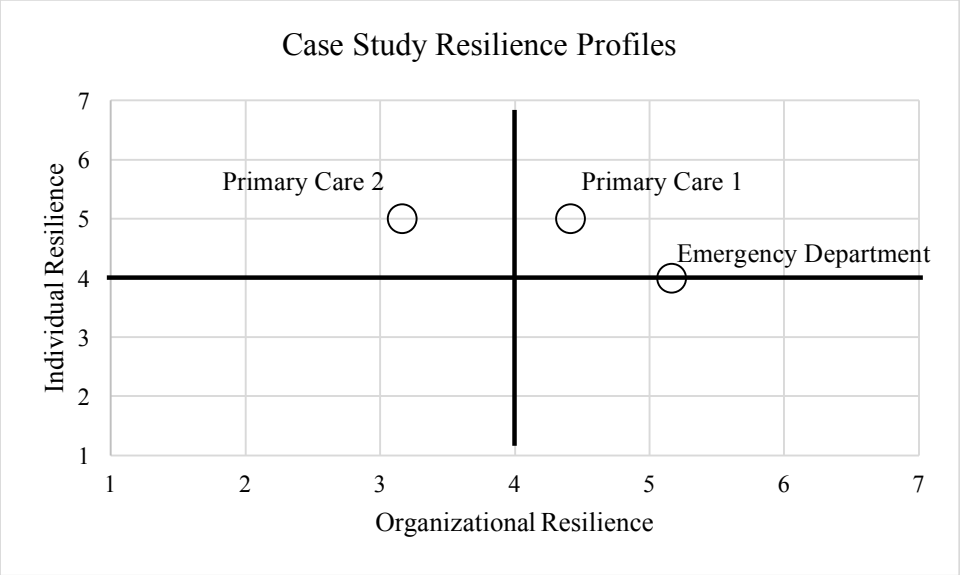


Figure 14: Typology based on the dimensions of individual and organizational resilience



The second primary care location represents a clear example of a repressed organization--individual resilience stands out as much stronger than organizational resilience. The first primary care and the emergency department fall in the middle of the typology, with the emergency department leaning towards a led status. In these two cases, levels of individual and organizational resilience are similar.

5.5 Conclusion

Resilience research in healthcare is traditionally concerned with capabilities at either the organizational or individual level. Increased interest in recent years has led to an upsurge in empirical studies in resilience. This study provided an example of assessment of two levels of resilience in three case study organizations. The result from the second primary care location showed that it is possible to have relatively high individual resilience in an environment of low organizational resilience. This is reflected in the typology of dimensions of individual and organizational resilience. Further research will lend additional insights into patterns in states of organizational and individual resilience. Organizations and researchers can use the RAG radar chart tool to pinpoint areas for improvement and compare progress towards resilience goals.

6 CONCLUSIONS AND FUTURE WORK

6.1 Summary

The application of resilience engineering principles to the relationship between individual and organizational resilience is limited. While many works address systemic resilience in healthcare or the resilience of the individual healthcare employee, the relationship between these components is not well documented (Van der Vorm et al., 2011). Additionally, healthcare practitioners do not utilize the available tools to measure organizational resilience, indicating a need for an accessible tool.

This study has applied the attributes and capabilities of resilience to healthcare. It identified factors that contribute to and detract from healthcare resilience and lent clarity to the manifestation and frequency of double-loop learning behaviors in primary care and emergency department settings. In addition, this work presented a survey tool to target the interaction between individual and organizational resilience. Lastly, this research proposed a resilience typology based on the dimensions of individual and organizational resilience.

This thesis includes: (a) a review of the literature on organizational resilience; (b) an investigation of resilient learning behaviors; (c) the identification of factors affecting resilience in healthcare; (d) the development of a resilience typology to characterize organizations. The outcomes will assist healthcare managers and quality directors in characterizing resilience and visualizing organizational resilience as it changes over time. This research will also be beneficial for researchers in forming an understanding of the relationship between key resilience constructs.

6.2 Conclusions

In the first manuscript, a review of resilience frameworks showed the spread of resilience research and the similarities among the foundational principles of various measurement tools. It was observed that trends in resilience research tend to follow major disaster events, which hold valuable lessons for organizations. The second manuscript created a Resilience Analysis Grid survey tool for healthcare, incorporating the individual resilience principles of active problem solving, team efficacy, sensemaking and emotional capacity into the traditional framework of the capabilities to monitor, respond, learn and anticipate. Results of the third manuscript provided three case study examples of Resilience Analysis Grid measurement. A notable benefit of interview distribution of the RAG is the ability to understand and characterize commonalities and discrepancies in interview responses. The author used the RAG results to characterize the three case study healthcare organizations based on the resilience typology of ideal, led, repressed, and failing organizations. Cumulatively, the findings from the three manuscripts contribute to the healthcare resilience literature by filling the gaps identified in Table 11.

Table 11. Fulfillment of Gaps in the Literature

Gap in the Literature	Relevant Findings
Lack of translation of resilience and resilience engineering terms and constructs to healthcare environment	Themes from literature and case study observations identified
Lack of measurement tool for healthcare systems	Development of a Resilience Analysis Grid survey tool specific to healthcare
Limited treatment to the relationship between organization and individual resilience	Typology to characterize organizations

6.3 Implications for Healthcare Organizations

Practicing engineering managers or quality directors in healthcare can use the tool presented in the second manuscript to assess resilience in healthcare organizations. The format of the RAG makes it highly adaptable to organization's needs. It can be applied in survey (assertion) form or in an interview assessment format. The researcher suggests caution in internal interview assessment, as members of an organization may have a preconceived idea of resilience. As such, interviews by a third party or neutral team of individuals with expertise in resilience are recommended. Once a RAG assessment is performed, the radar chart format allows managers to easily visualize how resilience changes over time. Based on the organization, goals for each of the constructs of resilience may vary. These results can be framed through the resilience typology presented in the third manuscript.

6.4 Weaknesses and Improvement Opportunities

This research is based on twelve interviews at three locations, with five, four and three interviewees. Of those interviewed, three were physicians, one was a resident, four were nurses or medical assistants, and four held administrative or management roles. Future studies should aim to expand sample sizes, both at the locations studied and within subgroups to achieve statistical validity.

6.5 Future Research Opportunities

The second manuscript presents a tool for measuring resilience in healthcare. Future work will be required for construct validation of the RAG in survey form. The third manuscript is based on interviews with twelve employees. In future case studies, the

author suggests interviewing or surveying more individuals from varying departments to draw conclusions about perceptions of resilience at different levels of the organization.

Another avenue for future research is in the impact of the degree of each capability of resilient performance on long-term organizational performance. This research would vary by industry, providing insights on the importance of proactive measures and learning behaviors on effective response. Hollnagel (2010) advises that there is no set balance among the four capabilities of resilient performance that can be applied to all domains. For instance, in an emergency department, the capability to respond may be more important than the capability to anticipate. For a community health center, the capability to anticipate may be of highest importance. Future studies can explore the optimal balance among the four capabilities based on type of healthcare facility and objectives they maintain.

Ultimately, further studies seeking to identify the patterns among US healthcare facilities in the dimensions of individual and organizational resilience are needed. These studies should consider discrepancies and similarities among different kinds of healthcare facilities: primary care, hospitals, specialists and emergency departments. Studies of this kind will yield a better understanding of the generalizability of patterns observed in specific organizations and locations.

7 References

Abramson, D. M., Grattan, L. M., Mayer, B., Colten, C. E., Arosemena, F. A., Bedimo-Rung, A., & Lichtveld, M. (2015). The Resilience Activation Framework: A conceptual model of how access to social resources promotes adaptation and rapid recovery in post-disaster settings. *The journal of behavioral health services & research*, *42*(1), 42-57.

Alexander, D. E. (2013). Resilience and disaster risk reduction: an etymological journey. *Natural Hazards and Earth System Sciences*, *13*(11), 2707-2716.

Alsaiji, R. (2017). Physician Burnout: A Preliminary Model. In Proceedings of the 2017 IISE Conference.

Anders, S., Woods, D. D., Wears, R. L., Perry, S. J., & Patterson, E. (2006). Limits on Adaptation: Modeling Resilience and Brittleness in Hospital Emergency. *Learning from Diversity: Model-Based Evaluation of Opportunities for Process (Re)-Design and Increasing Company Resilience*, 1.

Apneseth, K., Wahl, A. M., and Hollnagel, E., 2013, "Measuring resilience in integrated planning," Oil and Gas, Technology and Humans. Ashgate.

Argyris, Chris (1976). Single-Loop and Double-Loop Models in Research on Decision Making. *Administrative Science Quarterly, 21(3).* 363-375.

Balch, C. M., Freischlag, J. A., & Shanafelt, T. D. (2009). Stress and burnout among surgeons: understanding and managing the syndrome and avoiding the adverse consequences. *Archives of surgery*, *144*(4), 371-376.

Bellini, E., Nesi, P., Pantaleo, G., & Venturi, A. (2016). Functional resonance analysis method based-decision support tool for urban transport system resilience

management. In *Smart Cities Conference (ISC2), 2016 IEEE International* (pp. 1-7). IEEE.

Beruvides, M., & Omachonu, V. (2001). A Systematic-Statistical Approach for Managing Research Information: The State-of-the-Art-Matrix Analysis. In Industrial Engineering Research Conference Proceedings. Dallas, Texas.

Bodenheimer T, Sinsky C. (2014). From triple to quadruple aim: care of the patient requires care of the provider. *Ann Fam Med. 12(6):* 573–576.

Boin, A., & Van Eeten, M. J. (2013). The resilient organization. *Public Management Review*, *15*(3), 429-445.

Bonanno, G. A., 2004, "Loss, trauma, and human resilience: have we underestimated the human capacity to thrive after extremely aversive events?," American psychologist, 59(1), 20.

Braithwaite, J., Wears, R., and Hollnagel, E., 2015, "Resilient health care: turning patient safety on its head," Int J Qual Health Care, 27(5), 418-420.

Bruneau, M., & Reinhorn, A. (2007). Exploring the concept of seismic resilience for acute care facilities. *Earthquake Spectra*, *23*(1), 41-62.

Bruneau, S. E. Chang, R. T. Eguchi, G. C. Lee, T. D. O'Rourke, Andrei M. Reinhorn, Masanobu Shinozuka, Kathleen Tierney, William A. Wallace, and Detlof von Winterfeldt (2003). A Framework to Quantitatively Assess and Enhance the Seismic Resilience of Communities. *Earthquake Spectra 19(4).* 733-752.

Burnard, K., Bhamra, R., & Young, R. I. (2012). Critical factors of organisational resilience. In *Proceedings of the 19th International EurOMA Conference*.

Carthey, J, MR de Leval, & JT Reason, (2001). Institutional Resilience in Healthcare Systems. *Quality in Health Care, 10*. 29-32.

Cimellaro, G. P., Reinhorn, A. M., & Bruneau, M. (2010). Seismic resilience of a hospital system. *Structure and Infrastructure Engineering*, *6*(1-2), 127-144.

Comfort, L. K., Sungu, Y., Johnson, D., & Dunn, M. (2001). Complex systems in crisis: Anticipation and resilience in dynamic environments. *Journal of contingencies and crisis management*, *9*(3), 144-158.

Cook, R. I. & C. Nemeth (2006). Taking Things in One's Stride: Cognitive features of two resilient performances In *Resilience Engineering: Concepts And Precepts*, edited by Erik Hollnagel, David D. Woods, Nancy Leveson. 205-221.

Cooke, G. P., Doust, J. A., & Steele, M. C. (2013). A survey of resilience, burnout, and tolerance of uncertainty in Australian general practice registrars. *BMC medical education*, *13*(1), 2.

Dalziell, E., & McManus, S. (2004). "Resilience, vulnerability and adaptive capacity: Implications for system performance." *Int. Forum for Engineering Decision Making*, Stoos, Switzerland.

Darrow, L. & C. Eseonu. (2017). Development of a Resilience Analysis Grid Survey Tool for Healthcare. *In Proceedings of the 2017 IISE Conference*. Pittsburgh, PA.

De Swert, K. (2012). Calculating inter-coder reliability in media content analysis using Krippendorff's Alpha. *Center for Politics and Communication*, 1-15.

DeVellis, R. F. (1991), *Scale Development: Theory and Application*, Newbury Park, CA: Sage Publishing.

Doepel, D. G. (1991). Crisis management: the psychological dimension. *Industrial crisis quarterly*, *5*(3), 177-188.

Drabek, T. (2005). Predicting Disaster Response Effectiveness. *International Journal of Mass Emergencies and Disasters.* 23(1), pp. 49–72.

Edmondson, A. (1999). Psychological safety and learning behavior in work teams. *Administrative science quarterly*, *44*(2), 350-383.

Edmondson, A. C. (2004). Learning from failure in health care: frequent opportunities, pervasive barriers. *Quality and safety in Health Care*, *13*(2), ii3-ii9.

Eikenberry, A. M., Arroyave, V., & Cooper, T. (2007). Administrative failure and the international NGO response to Hurricane Katrina. *Public Administration Review*, *67*(s1), 160-170.

Endsley, M. R. (1995). Toward a theory of situation awareness in dynamic systems. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *37*(1), 32-64.

"Fact Sheet on the Three Mile Island Accident". U.S. Nuclear Regulatory Commission. Updated December 2014.

Fairbanks, R. J., Wears, R. L., Woods, D. D., Hollnagel, E., Plsek, P, and Cook, R., 2012, "Resilience and resilience engineering in health care," Health Care (Don Mills), 14(3), 253-260.

Freckleton, D., Heaslip, K., Louisell, W., & Collura, J. (2012, January). Evaluation of transportation network resiliency with consideration for disaster magnitude. In *91st annual meeting of the transportation research board, Washington, DC*.

Freudenberger, H. J. (1974). Staff burn-out. *Journal of social issues*, *30*(1), 159-165.

Gallopín, G. C. (2006). Linkages between vulnerability, resilience, and adaptive capacity. *Global environmental change*, *16*(3), 293-303.

Garud, Raghu, Dunbar, Roger L.M., & Bartel, Caroline A. (2011). Dealing with Unusual Experiences: A Narrative Perspective on Organizational Learning. *Organization Science, 22(3)*. 587-601.

Hatler, C., & Sturgeon, P. (2013). Resilience building: A necessary leadership competence. *Nurse Leader*, *11*(4), 32-39.

Hegde, S., Hettinger, A. Z., Fairbanks, R. J., Wreathall, J., Wears, R. L., and Bisantz, A. M., 2015, "Knowledge Elicitation for Resilience Engineering in Health Care," Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 59(1), 175-179.

Heinicke, Matthias. (2014). Implementation of Resilient Production Systems by Production Control. *Robust Manufacturing Conference Proceedings,* 105-110.

Holling, C.S. (1973). Resilience and Stability of Ecological Systems. *Annual Review of Ecological Systems, 4.* 1-23.

Hollnagel, E. and Goteman, O. (2004). The Functional Resonance Accident Model. *Proceedings of Cognitive System Engineering in Process Plant* (2004), pp. 155–161.

Hollnagel, E., Wears, R. L., & Braithwaite, J. (2015). From Safety-I to Safety-II: A white paper. *The Resilient Health Care Net: Published simultaneously by the University of Southern Denmark, University of Florida, USA, and Macquarie University, Australia*.

Hollnagel, E. (2010). How Resilient Is Your Organisation? An Introduction to the Resilience Analysis Grid (RAG). *Sustainable Transformation: Building a Resilient Organization*. Toronto, Canada.

Hopkins, A. (2001). Was Three Mile Island a 'Normal Accident'?. *Journal of contingencies and crisis management*, *9*(2), 65-72.

Horne III, J. F. (1997, April). The coming age of organizational resilience. In *Business forum* (Vol. 22, No. 2/3, p. 24). California State University, Los Angeles, School of Business and Economics.

Hudgins, T. A. (2016). Resilience, job satisfaction and anticipated turnover in nurse leaders. *Journal of nursing management*, *24*(1), E62-E69.

Ivanov, D., Sokolov, B., & Dolgui, A. (2014). The Ripple effect in supply chains: trade-off 'efficiency-flexibility-resilience' in disruption management. *International Journal of Production Research*, *52*(7), 2154-2172.

Jacques, C. C., McIntosh, J., Giovinazzi, S., Kirsch, T. D., Wilson, T., and Mitrani-Reiser, J., 2014, "Resilience of the Canterbury hospital system to the 2011 Christchurch earthquake," Earthquake Spectra, 30(1), 533-554.

Jensen, P. M., Trollope-Kumar, K., Waters, H., & Everson, J. (2008). Building physician resilience. *Canadian Family Physician*, *54*(5), 722-729.

Kantur, D., & İşeri-Say, A. (2012). Organizational resilience: A conceptual integrative framework. *Journal of Management & Organization*, *18*(06), 762-773.

Katz-Navon, T. A. L., Naveh, E., & Stern, Z. (2005). Safety climate in health care organizations: A multidimensional approach. *Academy of Management Journal*, *48*(6), 1075-1089.

Keller, K. L., & Koenig, W. J. (1989). Management of stress and prevention of burnout in emergency physicians. *Annals of emergency medicine*, *18*(1), 42-47.

Kendra, J., & Wachtendorf, T. (2003). Creativity in emergency response to the World Trade Center disaster. *Beyond September 11th: An account of post-disaster research*, 121-146.

King, G. A., & Rothstein, M. G. (2010). 13. Resilience and leadership: the self-management of failure. *Self-management and leadership development*, 361.

Krippendorff, K. (2004). Reliability in Content Analysis: Some Common Misconceptions and Recommendations. Human Communication Research, 30 (3), 411-433.

Krippendorff, K. (2007). Computing Krippendorff's alpha reliability. *Departmental papers (ASC)*, 43.

Lang, L. (2011). IOM Report Urges Expanding Role of Nurses. *Gastroenterology*, *140*(1), 5.

Lay, E., Branlat, M., & Woods, Z. (2015). A practitioner's experiences operationalizing Resilience Engineering. *Reliability Engineering & System Safety*, *141*, 63-73.

Lee, A. V., Vargo, J., & Seville, E. (2013). Developing a tool to measure and compare organizations' resilience. *Natural hazards review*, *14*(1), 29-41.

Lindvall, J., Kecklund, L., and Arvidsson, M., 2016, "Measuring and visualizing resilience: a railway example," Nordic Ergonomics Society Annual Conference, 331-336.

Ljungberg, D., & Lundh, V. (2013). Resilience Engineering within ATM-Development, adaption, and application of the Resilience Analysis Grid (RAG).

Lundberg, J., & Johansson, B. J. (2015). Systemic resilience model. *Reliability Engineering & System Safety*, *141*, 22-32.

MacAskill, K., & Guthrie, P. (2014). Multiple interpretations of resilience in disaster risk management. *Procedia Economics and Finance*, *18*, 667-674.

Majchrzak, A., Jarvenpaa, S. L., & Hollingshead, A. B. (2007). Coordinating expertise among emergent groups responding to disasters. *Organization science*, *18*(1), 147-161.

Mallak, L. A. (1999). Toward a theory of organizational resilience. In *Management of Engineering and Technology, 1999. Technology and Innovation Management. PICMET'99. Portland International Conference on* (Vol. 1, pp. 223-vol). IEEE.

Mallak, L. A., and Yildiz, M., 2016, "Developing a workplace resilience instrument." *Work* Preprint, 1-13.

Mallak, L., 1998, "Putting organizational resilience to work," Industrial Management, 40(6), 8-13.

Manojlovich, M. (2010). Nurse/physician communication through a sensemaking lens: shifting the paradigm to improve patient safety. *Medical care*, *48*(11), 941-946.

Maslach, C., Jackson, S. E., and Leiter, M. P., 1997. "Maslach burnout inventory." Evaluating stress: A book of resources, 3, 191-218.

Masten, A. S. (2001). Ordinary magic: Resilience processes in development. *American psychologist*, *56*(3), 227.

Masten, A. S. (2011). Resilience in children threatened by extreme adversity: Frameworks for research, practice, and translational synergy. *Development and Psychopathology*, *23*(02), 493-506.

Mazur, L., McCreery, J., and Chen, S. J., 2012. "Quality improvement in hospitals: Identifying and understanding behaviors," Journal of Healthcare Engineering, 3(4), 621-648.

McLarnon, M. J., & Rothstein, M. G. (2013). Development and initial validation of the Workplace Resilience Inventory. *Journal of Personnel Psychology*.

McManus, S. (2008). "Organisational resilience in New Zealand." Ph.D. thesis, Univ. of Canterbury, Christchurch, New Zealand.

McManus, Sonia, Erica Seville, John Vargo and David Brunsdon (2008). Facilitated Process for Improving Organizational Resilience. *Natural Hazards Review,* 9(2). 81-90.

Miller-Hooks, E., Zhang, X., & Faturechi, R. (2012). Measuring and maximizing resilience of freight transportation networks. *Computers & Operations Research*, *39*(7), 1633-1643.

Mirdad, W. K., & Eseonu, C. I. (2015). A Conceptual Map of the Lean Nomenclature: Comparing Expert Classification to the Lean Literature. *Engineering Management Journal*, *27*(4), 188-202.

Moll, S., A. Frolic, & B. Key. (2015). Investing in compassion: exploring mindfulness as a strategy to enhance interpersonal relationships in healthcare practice. *Journal of Hospital Administration.* Vol. 4. No. 6. 36-45.

Montero-Marin, J., Tops, M., Manzanera, R., Demarzo, M. M. P., de Mon, M. Á., & García-Campayo, J. (2015). Mindfulness, resilience, and burnout subtypes in primary care physicians: the possible mediating role of positive and negative affect. *Frontiers in psychology*, *6*.

Moore, W. (2014, December 8). Wrong drug put in IV bag led to fatal Bend hospital error. *KTVZ.*

Nathanael, D., and N. Marmaras (2006). The Interplay between work practices and prescription: A Key Issue for Organizational Resilience.

Nemeth, C., Wears, R., Woods, D., Hollnagel, E., & Cook, R. (2008). Minding the gaps: creating resilience in health care. *Advances in patient safety: new directions and alternative approaches*, *3*, 1-13.

Nemeth, Christopher and Richard Cook (2007) Reliability Versus Resilience: What does Healthcare Need? *Proceedings of the Human Factors and Ergonomics Society 51st Annual Meeting.* 621-625.

Norris, F. H., Stevens, S. P., Pfefferbaum, B., Wyche, K. F., & Pfefferbaum, R. L. (2008). Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness. *American journal of community psychology*, *41*(1-2), 127-150.

Ong, A. D., Bergeman, C. S., Bisconti, T. L., and Wallace, K. A., (2006). "Psychological resilience, positive emotions, and successful adaptation to stress in later life," Journal of personality and social psychology, *91*(4), 730.

Ong, M. S., & Coiera, E. (2010). Safety through redundancy: a case study of in-hospital patient transfers. *Quality and Safety in Health Care*, *19*(5), 1-7.

Orton, J. D., & Weick, K. E. (1990). Loosely coupled systems: A reconceptualization. *Academy of management review*, *15*(2), 203-223.

Paton, D., Millar, M., & Johnston, D. (2001). Community resilience to volcanic hazard consequences. *Natural hazards*, *24*(2), 157-169.

Paturas, J., Smith, D., Smith, S., & Albanese, J. (2010). Collective response to public health emergencies and large-scale disasters: putting hospitals at the core of community resilience. *Journal of business continuity & emergency planning*, *4*(3), 286-295.

Perrow, Charles (2000). "Organizationally Induced Catastrophes" Institute for the Study of Society and Environment. University Corporation for Atmospheric Research.

Perry, S., McDonald, S., Anderson, B., Tran, T., & Wears, R. (2007, October). Ironies of improvement: Organizational factors undermining resilient performance in healthcare. In *Systems, Man and Cybernetics. IEEE International Conference on* (pp. 3413-3417). IEEE.

Pickett, S.T.A., Cadenasso, M.L., & Grove,J.M. (2004). Resilient Cities: Meaning, models, and metaphor for integrating the ecological, socio-economic, and planning realms. *Landscape and Urban Planning, 69*. 369-384.

Rafferty, J. P., Lemkau, J. P., Purdy, R. R., & Rudisill, J. R. (1986). Validity of the Maslach Burnout Inventory for family practice physicians. *Journal of clinical psychology*, *42*(3), 488-492.

Rall M, Gaba DM. (2004). Human performance and patient safety. In: *Miller RD, ed. Anesthesia, 6th edn*. New York: Elsevier, 3021–72.

Rapley, T. (2008). Distributed decision making: the anatomy of decisions‐in‐action. *Sociology of health & illness*, *30*(3), 429-444.

Rees, C. S., Breen, L. J., Cusack, L., & Hegney, D. (2015). Understanding individual resilience in the workplace: the international collaboration of workforce resilience model. *Frontiers in psychology*, *6*, 73.

Reghezza-Zitt, M., Rufat, S., Djament-Tran, G., Le Blanc, A., & Lhomme, S. (2012). What resilience is not: uses and abuses. *Cybergeo: European Journal of Geography*.

Resilience Engineering Association. (n.d.). About Resilience Engineering. Retrieved March 4, 2016 from http://www.resilience-engineering-association.org.

Rice, J. B., & Caniato, F. (2003). Building a secure and resilient supply network. *Supply Chain Management Review,* 7(5). 22-30.

Rigaud, E., and Martin, C., 2013, "Considering trade-offs when assessing resilience," In 5th Symposium on Resilience Engineering, 115.

Righi, A. W., Saurin, T. A., & Wachs, P. (2015). A systematic literature review of resilience engineering: Research areas and a research agenda proposal. *Reliability Engineering & System Safety*, *141*, 142-152.

Rushton, C. H., Batcheller, J., Schroeder, K., & Donohue, P. (2015). Burnout and resilience among nurses practicing in high-intensity settings. *American Journal of Critical Care*, *24*(5), 412-420.

Sahebjamnia, N., Torabi, S. A., & Mansouri, S. A. (2015). Integrated business continuity and disaster recovery planning: Towards organizational resilience. *European Journal of Operational Research*, *242*(1), 261-273.

Sands, S. A., Stanley, P., & Charon, R. (2008). Pediatric narrative oncology: interprofessional training to promote empathy, build teams, and prevent burnout. *J Support Oncol*, *6*(7), 307-312.

Schaufeli, W. B., Leiter, M. P., & Maslach, C. (2009). Burnout: 35 years of research and practice. *Career development international*, *14*(3), 204-220.

Shanafelt, T. D., Dyrbye, L. N., Sinsky, C., Hasan, O., Satele, D., Sloan, J., & West, C. P. (2016). Relationship between clerical burden and characteristics of the electronic environment with physician burnout and professional satisfaction. In *Mayo Clinic Proceedings* (Vol. 91, No. 7, pp. 836-848). Elsevier.

Shanafelt, T. D., Hasan, O., Dyrbye, L. N., Sinsky, C., Satele, D., Sloan, J., & West, C. P. (2015). Changes in burnout and satisfaction with work-life balance in physicians and

the general US working population between 2011 and 2014. In *Mayo Clinic Proceedings* (Vol. 90, No. 12, pp. 1600-1613). Elsevier.

Shanafelt, T. D., West, C., Zhao, X., Novotny, P., Kolars, J., Habermann, T., & Sloan, J. (2005). Relationship between increased personal well-being and enhanced empathy among internal medicine residents. *Journal of General Internal Medicine*, *20*(7), 559-564.

Shirali, G. A., Azadian, S., & Saki, A. (2016). A new framework for assessing hospital crisis management based on resilience engineering approach. *Work*, *54*(2), 435-444.

Shirali, G. H. A., Motamedzade, M., Mohammadfam, I., Ebrahimipour, V., & Moghimbeigi, A. (2012). Challenges in building resilience engineering (RE) and adaptive capacity: A field study in a chemical plant. *Process safety and environmental protection*, *90*(2), 83-90.

Shrivastava, P. (1983). A typology of organizational learning systems. *Journal of management studies*, *20*(1), 7-28.

Sinsky CA, Willard-Grace R, Schutzbank AM, Sinsky TA, Margolius D, Bodenheimer T. In search of joy in practice: a report of 23 high-functioning primary care practices. *Ann Fam Med*. 2013;11(3): 272-278.

Smith, W., & Dowell, J. (2000). A case study of co-ordinative decision-making in disaster management. *Ergonomics*, *43*(8), 1153-1166.

Sobel, R. S., & Leeson, P. T. (2006). Government's response to Hurricane Katrina: A public choice analysis. Public Choice, 127(1-2), 55-73.

Spector, P. E., & Jex, S. M. (1998). Development of four self-report measures of job stressors and strain: Interpersonal Conflict at Work Scale, Organizational Constraints Scale, Quantitative Workload Inventory, and Physical Symptoms Inventory.

Steele Gray, C., Wilkinson, A., Alvaro, C., Wilkinson, K., & Harvey, M. (2015). Building Resilience and Organizational Readiness During Healthcare Facility Redevelopment Transitions: Is It Possible to Thrive?. *HERD: Health Environments Research & Design Journal*, *9*(1), 10-33.

Stolker, R. J. M., D. M. Karydas, and J. L. Rouvroye. 2008. "A Comprehensive Approach to Assess Operational Resilience." Paper presented at the proceedings of the Third Resilience Engineering Symposium, Antibes-Juan-les-Pins, France, October 28–30.

Swensen, S., & Shanafelt, T. (2016). Physician‐Organization Collaboration Reduces Physician Burnout and Promotes Engagement: The Mayo Clinic Experience. *Journal of Healthcare Management*, *61*(2), 105-127.

Tamvakis, P., & Xenidis, Y. (2012). Resilience in transportation systems. *Procedia-Social and Behavioral Sciences*, *48*, 3441-3450.

Taylor, R. M. (1990). Situation awareness rating technique (SART): the development of a tool for aircrew systems design. In Situational Awareness in Aerospace Operations (Chapter 3). France: Neuilly sur-Seine, NATO-AGARD-CP-478.

Tierney, K. J. (2003). Conceptualizing and measuring organizational and community resilience: Lessons from the emergency response following the September 11, 2001 attack on the World Trade Center.

Tierney, K., & Trainor, J. (2004). Networks and resilience in the World Trade Center disaster. *MCEER: Research Progress and Accomplishments 2003-2004*, 157-172.

Tucker, A. L., & Edmondson, A. C. (2003). Why hospitals don't learn from failures: Organizational and psychological dynamics that inhibit system change. *California management review*, *45*(2), 55-72.

van der Beek, D., & Schraagen, J. M. (2015). ADAPTER: Analysing and developing adaptability and performance in teams to enhance resilience. *Reliability engineering & system safety*, *141*, 33-44.

van der Vorm, J., van der Beek, D., Bos, E., Steijger, N., Gallis, R., and Zwetsloot, G., (2011) "Images Of Resilience: The Resilience Analysis Grid Applicable At Several Organizational Levels?," Paris: TRANSVALOR-Presses des MINES.

Vincent, C., Burnett, S., & Carthey, J. (2014). Safety measurement and monitoring in healthcare: a framework to guide clinical teams and healthcare organisations in maintaining safety. *BMJ quality & safety*, *23*(8), 670-677.

Vogus, T. J., & Sutcliffe, K. M. (2007, October). Organizational resilience: towards a theory and research agenda. In *Systems, Man and Cybernetics, 2007. ISIC. IEEE International Conference on* (pp. 3418-3422). IEEE.

Voss, M., & Wagner, K. (2010). Learning from (small) disasters. *Natural hazards*, *55*(3), 657-669.

Vugrin, E. D., Verzi, S. J., Finley, P. D., Turnquist, M. A., Griffin, A. R., Ricci, K. A., & Wyte-Lake, T. (2015). Modeling Hospitals' Adaptive Capacity during a Loss of Infrastructure Services. *Journal of healthcare engineering*, *6*(1), 85-120.

Wears, R. L., Perry, S. J., & McFauls, A. (2006). Free fall-a case study of resilience, its degradation, and recovery, in an emergency department. In *2nd International*

Symposium on Resilience Engineering, Juan-les-Pins, France, Mines Paris Les Presses.

Weick, K. E., and Sutcliffe, K. M., 2001, "Managing the unexpected: Assuring high performance in an age of complexity," John Wiley and Sons.

Weick, K.E. Sutcliffe, K. M., & Obstfeld, D. (2005). Organizing and the Process of Sensemaking. *Organization Science, 16(4),* 409-421.

Weick, Karl E. (1993). The Collapse of Sensemaking in Organizations: The Mann Gulch Disaster *Administrative Science Quarterly, 38(4).* 628-652.

Westrum, R. (2004). A typology of organisational cultures. *Quality and safety in health care*, *13*(suppl 2), ii22-ii27.

Westrum, R. (2007). A Typology of Resilience Situations. In Hollnagel, E., Woods, D. D., & Leveson, N. (Eds.), *Resilience engineering: Concepts and precepts* (pp 55-65). Hampshire: Ashgate Publishing, Ltd.

Woods, D. (2003). Creating foresight: How resilience engineering can transform NASA's approach to risky decision making. *US Senate Testimony for the Committee on Commerce, Science and Transportation*.

Woods, D., Hollnagel, E., & Leveson, N. (2006). *Resilience engineering*. E. Hollnagel, D. D Woods. and N.

Zhong, S., Clark, M., Hou, X. Y., Zang, Y. L., and Fitzgerald, G., 2014, "Development of hospital disaster resilience: conceptual framework and potential measurement," Emergency Medicine Journal, 31(11), 930-938.

Zhong, S., Clark, M., Hou, X. Y., Zang, Y., & FitzGerald, G. (2014). Validation of a framework for measuring hospital disaster resilience using factor analysis. *International journal of environmental research and public health*, *11*(6), 6335-6353.

Zwack, J., & Schweitzer, J. (2013). If every fifth physician is affected by burnout, what about the other four? Resilience strategies of experienced physicians. *Academic Medicine*, *88*(3), 382-389.

8 APPENDICIES

8.1 Appendix A: RAG Survey

The following questions deal with your organization's response to disruptive events. A disruptive event is anything that alters or reduces normal flow of operations, ranging from a small event (e.g. unexpected employee absence), to a medium event (e.g. IT system malfunctioning), to a large event (e.g. a natural disaster).

Please rate the following (1 ="Strongly Disagree," 2 = "Disagree," 3 = "Somewhat Disagree," 4 = "Neither Agree nor Disagree," 5 = "Somewhat Agree," 6 = "Agree," 7 = "Strongly Agree").

Question	**Rating**
My organization continuously monitors normal functioning of the system	
My organization has clearly defined metrics for system performance.	
My organization continuously monitors the metrics for system performance.	
My organization continuously monitors potential risks.	
My organization communicates performance metrics during normal operations.	
My organization communicates when a disruptive event occurs.	
My organization communicates the results from continuous monitoring to employees.	
My organization has clearly defined warning systems to help employees spot disruptive events (from industry standard, expertise, etc).	
My organization is good at handling disruptive events.	
My organization has a clear method for handling disruptive events.	
My organization usually resolves disruptive events in a satisfactory manner.	
My organization responds rapidly to disruptive events.	
My organization has regular drills for disruptive events.	
My organization has a list of events for which the organization has prepared responses.	
My organization maintains an easily accessible set of steps to handle disruptive events for which the organization has a prepared response.	
My organization has adequate resources (people, materials, competence, expertise, and time) available to handle disruptive events.	
My organization has clear descriptions of when to return to normal operations after a disruptive event.	
Most people in my organization recognize when a disruptive event occurs.	
Most people in my organization recognize when the organization has fully recovered from a disruptive event.	

My organization works actively to anticipate future risks.	
My organization works actively to anticipate future opportunities for improvement.	
My organization is trying to make long-term plans in anticipation of future risks.	
My organization is good at communicating future risks to the personnel.	
My organization is good at communicating future possibilities to the personnel.	
My organization learns from disruptive events.	
My organization shares best practices from well functioning areas.	
My organization is good at taking actions to make sure that everything works as planned.	
My organization is good at communicating the effects of actions taken.	
My organization is good at modifying plans based on the effects of actions taken.	
Employees at my organization feel comfortable discussing root causes when disruptive events occur.	
Employees at my organization feel comfortable suggesting solutions to peers when disruptive events occur.	
Employees at my organization feel comfortable suggesting solutions to supervisors when disruptive events occur.	
Most people like me focus on solutions rather than complaining about disruptive events.	
Most people like me take delight in solving difficult problems.	
Most people like me would follow a step-by-step plan in the case of a disruptive event.	
Most people like me create alternative ways to get work done in spite of disruptive events.	
Most people like me would assume that team members understand my expectations for work performance.	
Most people like me would explicitly state expectations for work performance.	
Most people like me understand organizational goals.	
Most people like me have a clear idea of team member roles and responsibilities.	
When under pressure, most people like me take time to assess risks of possible actions.	
Most people like me take intelligent risks.	
Most people like me make sense of the situation when a disruptive event occurs.	
Most people like me know what resources are needed when a disruptive event occurs.	
Most people like me can usually differentiate between necessary and unnecessary information during a disruptive event.	

Most people like me experience a combination of positive and negative emotion.	
Most people like me can easily understand what their patients feel.	
Most people like me feel accomplished.	
Most people like me have strategies for coping in times of high stress.	
Most people like me look forward to going to work everyday.	

8.2 Appendix B: Interview Transcripts

Primary Care 1: Resident
How long have you been working at this clinic?
Three years.

How does clinic monitor for disruptive events?
Several things. Our manager keeps running statistics on care, length of encounters etc. Attendings know how we are running because they pull up our schedules. Patient staggering really helps out. Statistics are reported out by email
Efficiency is always a strain in a resident facility. You see the patient, and then you step out, and then present it. You are supposed to do it in an allotted time. This is always a factor in how our days go. I encounter many of these problems if on a weekly basis. Depending on what is coming, you can easily get an hour behind"

When a disruptive event happens, how does clinic respond?
Usually, first thing I try to do is regardless what happens, this is where I am. How can I move forward without cutting corners? For example, you go and see someone, I have three or four complaints, and you are an hour behind. I am sorry I am running behind, if I've got time allotted, please let me take care of only one thing instead of three."

Do you have a list of larger scale events for which you have a prepared response?
No, but for larger scale I know that there is one, but don't know where.

What about drills for these events?
Hospital does either yearly or bi-yearly, I haven't done them

Does the clinic have adequate resources to handle a larger scale disruption?
I think so, if this were a care - for disaster site, maybe. I would say yes.

Do other members of your team help out when you get behind with patients?
I would say that usually attendings are really good at being efficient.

Would you say the clinic anticipates future risks?
Not really, we did recently review how we approach patients who are suicidal.

What about anticipating future growth?

Always doing it well, and quality improvement in the last year has been great.

Does the clinic learn from success, and on the other hand, from failures?
I think so, failures we always try to fix things that fall through the cracks. There is not a typical method because everything is very different dependent on where the gap was.

Do employees feel comfortable suggesting solutions to problems in the system?
Yes

What do you do to overcome disruptions in your day?
Try to screen before hand and try to address what needs to be done in the appt. Many times you can prepare. At least half work better.

Can you describe an outlier case in which the solution was not clear?
Saw a guy who came in for vague complaint for corroded artery complaint. Med student gives beginning workup. I go back into room and 13 things that could be wrong. I ordered labs that were most appropriate. Clarity of his case must unfold over time.

How do you differentiate between necessary and unnecessary information in a case like this?
I would say that when I am pressed for time, I write in more fragments. What information do I need to exchange in order to help them, what do I need to write that accurately reflects that encounter.

Do you enjoy solving difficult, unfamiliar problems at work?
I look forward to that if I am on schedule.

How would you describe your team dynamic?
Absolutely work well. This is seen as a learning environment in that it's not just residents that get trained; it's also MAs and attendings. There is a lot of progression and depending on where everyone is at, they need a certain level of support."

To what extent have you experienced burnout while working at this clinic?
I have experienced burnout. It fluctuates. It's gotten better with time. I have seen it at 7 or 8.

Primary Care 1: Nurse
How long have you been working at this clinic?
11 months.

How does the clinic monitor for disruptive events?
Never know where you're going to go, you just go with the flow. If someone gets behind, we pick up the slack. We will ask for help if there is an issue"

How does the clinic respond to disruptive events?

"Disruptions happen all the time. Medical field is never ever stable. Always lays on outlying factors."

If a large-scale event were to occur, how would the clinic respond?
Procedures in place for evacuation

Are there any drills for these kinds of events?
We have done an evac drill. We have not done earthquake drills in the time I've been here.

Do you think the clinic has adequate resources to respond to a large-scale event?
During orientation they do emergency unit training. If we need to go out to the field, we are all set. We have very adequate resources to respond to disaster.

What about a small event-- are the resources available?
We are pulling people from one area to another. It's a workplace, so people don't show up at times. We always have 2 or 3 people per day calling out. I don't think we have adequate resources. Yesterday, they pulled my partner to another place, and it got too busy. I managed by running around with a chicken head cut off. If I have to give a kid two shots or more, I want someone with me. Yesterday it was hard to have enough people.

In terms of the clinic, is there anticipation of future risk and opportunities for growth?
Yes, risk if you want to just fill voids with bodies, you run the risk of bringing in conflicting personalities. Growth, I don't want to be in management, I don't want to listen to complaints.

How does the clinic learn from what goes right and wrong?
I don't know the interworkings, but I know that so a vaccination was given by someone who is no longer here that [messed up], so we now have the doctor give the injection. We learned not to take it out of our hands, but more to others.

Do employees feel confortable suggesting solutions to peers and supervisors?
Yes there is an open area.

How do you overcome disruptions in your day?
Go with the flow. The second this dot turns black [patient arrival notification], I need to be out there. Other times they are going to have to wait because there is not any space. When they go 'man that was fast' that makes me feel good

When something unfamiliar happens, do you enjoy figuring it out?
If I am not swamped, yes.

How do you differentiate between necessary and unnecessary info during a disruptive event?

When we have an SBIRT, if I cant get to yes or no answer, I talk directly to the patient and talk to them. I know I said I only had a hang nail but I have THIS, we need to reschedule.

To what extent have you experienced burnout in your role?
Job satisfaction through the roof. Love Love Love my job. We work four-ten hour days, I am more tired on Tuesday than after 4 ten hour shifts on Friday.

Primary Care 1: Resident director
How long have you been working at this clinic?
14 years.

Can you recall a recent disruptive event that has occurred at this clinic?
It would have to be something catastrophic for me to consider catastrophic. A scribe was not scheduled, did not occur to me to complain so I just wrote my own notes. We have had near walkouts of MAs, and it's normal to me, I can't think of any disruptive events.

How does clinic monitor for changes in flow of operations?
Lots of things are measured. Quality metrics from insurance, every visit our patients are surveyed about experience. If they show up on time. This is shared with all employees. We have all staff meetings weekly where this info is disseminated.

Is there a list of disruptive events for which the clinic has a prepared response?
Probably, not that I could tell you where to find one. I know we have been doing disaster planning. I rely on administrators to tell me.

Do you think the clinic has adequate resources to handle a small-scale event? Large-scale event?
Small yes, big one I have no idea.

How does the clinic anticipate future risks and opportunities for growth?
They have their ears to the tracks and are looking to improve all the time. Organization releases documents on how we may need to modify our processes to comply.

Would you say the clinic learns from successes?
We learn when it goes wrong. We don't change things if it's right. For example, settings for epic had changed. Results were faxed instead of sent electronically. Discovered that there was a box checked unexpectedly. This is now being changed.

What do you do to overcome disruptions?
Try to find ways to make it work.

Do you enjoy solving difficult, unfamiliar problems?
Yes, I don't dread it. Every day there are variables I cant control. I don't need to control my day for me to enjoy my day.

How would you describe your team dynamic?
I would say that is improving. Very clear what my role is.

To what extent have you personally experienced burnout?
Job satisfaction very high, burnout, there have been times in the past year when felt I was approaching burnout. I have always been able to distract myself.

Primary Care 1: Reception
How long have you been working at this clinic?
A little over two months.

Can you recall a recent disruptive event that has occurred at this clinic?
Patient [enters clinic] more than one time and threatens to kill everyone every time she comes in.

How does clinic monitor for disruptive events?
In a different situation we have binders full of operating procedures

How does clinic respond to disruptive events like the one you just described?
Usually involves a supervisor and working with mental heath, and the provider she wants to speak to.

Does that disrupt your workflow at reception?
Sometimes it holds up the line, or constantly calling the red phone

When things get backed up, is there a way you can know when you return to normal?
When the line is gone

When huge line of patients, do you have adequate resources? How do you manage?
We have the check-in kiosk; we can have someone from the back come up to help with the issue.

Is there a list of events for which clinic has prepared?
Natural disaster, alarm drills in middle of the night.

Does the clinic anticipate future risk and opportunity for growth?
I feel like we are doing that all the time. With that patient, when she is calling in all the time, we developed a plan on what everyone would say to her, and communicated that plan to the call center.

How does the clinic learn from what goes wrong and right in these situations?
Been patients with pain management agreements. If they continue to abide, they get meds. If they don't, they get angry.

Do employees feel comfortable suggesting solutions to supervisors and peers?

Yes, we feel comfortable.

What do you do to overcome disruptions in your workday?
J*ust work through it.*

When obscure cases come up, do you enjoy finding solutions?
Yes, as simple as scheduling things, I always ask others questions.

Do you think there is a good expectation of roles?
I think that people do more than what they are supposed to but you are responsible to get your stuff done.

Primary Care 1: Receptionist 2
How long have you been working at this clinic?
11 months

How does the clinic monitor for disruptive events?
Line grows or you can see there are more appointments scheduled than normal, or you see a problem patient on the schedule.

After dealing with a difficult patient, how do you know how to know return to normal?
Get through the line and then you're back on track

How does the clinic respond to disruptive events?
One of back office receptionist is brought up to the front, seamless.

Is there a list of events for which organization has a prepared response?
If epic went down, we have boxes for downtime procedures. When I worked at the hospital there were more procedures set up.

What about drills for these events?
I think we have drills, but not much.

Do you think the clinic has adequate resources to respond to a large-scale event?
Yes for small, if there was a larger event does not really apply.

How does the clinic anticipate future risks and opportunities for growth?
Always driving to move us forward. Always striving to be better. Metrics for hospital are tracked"

Would you say the clinic learns from successes?
Yes, failures as well, suicidal patients: after a large number called in, there was a workflow sent out to clarify.

Are these communicated to the employees?

It was in once a month staff meetings.

Do employees feel confortable suggesting solutions to peers and supervisors?
Employees generally feel comfortable. I think some don't, but most do.
How do you overcome disruptions in your workday?
I don't know, they don't really bother me. Work through it.

Do you enjoy solving difficult, obscure problems that you encounter?
Most things you can think through it and figure out what to do.

To what extent have you experienced burnout?
I'm not burned out. Least stress I've ever had in a job, to me it's pretty easy.

Emergency Department: Physician
How long have you been working at this clinic?
Been working here 5 years

How do you monitor for disruptive events?
Epic charting system can data mine through that. A good number. Patients per Day. This determines how many providers/ nurses we need. Thousands per year. Some see 100,000; some see 11,000 patients per year (us). Industry standards. 1.8 - 2.2 per hour, per physician. Things that doctor does, labs, ekg, xray, moving patient around. Categorizing some of the metrics. if the doctor calls in sick, that's a problem. What if a nurse calls in sick: great disruption if we cannot get them replaced.

How does the ED respond to a large influx of patients?
There is a term called "surge capacity" if a school bus of kids wrecks and how do we handle that. We have six beds, one hall bed, and one triage bed? If we have beds on the flow that are not being used. For a mass casualty event, there are problems. Disaster drills once a year. Everbridge, if an earthquake hits, sends a message. Emergency person deals with that.

How does Lincoln city ED handle disruptive events?
Starts with ID and charting, rapid triage. Not sure what that process entails. Blank folders with paper charts in case computers go down. we have to do that occasionally when epic does an upgrade over night. Everything else is the same as normal. Can order CT scans and X-rays. We had a very bad flu season, every ED was hammered. Places had 20-30 patients. ER boarding. Patients are emitted, and no beds on the floor, sick enough to admit, but too sick to not discharge. Imaging and everything

Are there any most common events for drills?
Most recent one was the school shooting practice; primary goal is transportation to larger hospitals.

Does the hospital anticipate future risks and opportunities for growth?

He is planning the layout from a book that is made by an architect. Table tells you how many beds, what type of bed, "Emergency Department Design" by John Huddy. Portland business journal article that does analysis as costal cities as fastest growing city on the Oregon coast.
Always looking at times, data, trying to come up with different ways to expedite patient care. Try to avoid work-arounds. There is a performance improvement and then the re-build. Once every two or three months the PI group meets to discuss problems and solutions controlled at the beginning. [Name] controls data. Door to doctor. Literature shows that if you can get doctor to person as soon as possible, everything else will follow

How does the ED learn from disruptive events?
"Hot wash" meeting immediately after the event and doing a tabletop discussion on what went well. Two weeks later we do a "Cold wash" that is the same thing. Hot wash is anticipated police, fire rescue, EMTS, healthcare, incident commander are all involved. All of the people underneath incident command are invited. Cold wash have the same people involved. We have not had a "true mass casualty since I have been here. Overall, we learn from events.

Do employees at LC feel comfortable suggesting solutions to peers and supervisors?
We put our employees thru a team steps program that encourages voice (pause for the cause) If someone is about to cut off the leg, pause for the cause, scrub nurse says stop cutting off the wrong leg.

How do you overcome disruptions in your day?
As far as ED we have algorithms to go thru. Based on patient presentation, story, you can get what issue is, then order labs. If something doesn't make sense, backpedal. When you do have a zebra, must be admitted.

To what extent have you experienced burnout in your time at this clinic?
*Satisfaction, high. **B**urnout, look at things that are easy to change but thigh yield. Try to have a good schedule. If there are any time off requests, grant it. One thing that is happening is that we are asking doctors to do more and more non-doctor things. Paperwork. Scribes do the "Scutt work" Work that is necessary. Burnout rating is 1 of 10. Have fun projects, work with small work groups. Overall pretty good. Answer might be different with schedule. Scheduling is really important. "Lets fix what bugs you" [Name] developed this. Nurse manager in the ED*

Do you enjoy solving difficult problems in your workday?
I do enjoy. Has not advanced enough to be replaced by a robot. ATLS Student course manual approaching through algorithm patients

Emergency Department: Nurse 1
How long have you been working at this hospital?
14 years

How does the Lincoln City ED monitor for disruptive events?
Can't monitor for things like tsunamis. If we need to call people in, we have a list to call people in.

How does the Lincoln City ED respond to disruptive events?
We fill out a form each time an event happens. We fill out who is here and deliver it to the command center. Mass casualty, earthquake, tsunami. Depends on how full we are, five patients is considered a mass casualty, when we don't have enough beds, four or five ends up.

How does the Lincoln City ED respond to disruptive events?
We are usually needed in here. There are stations set up elsewhere. We are so limited on staff that we don't leave. Say there was an incident where there was 20 people, we set up places at community center. We get 5 people and then they send others to incident commander makes decisions. Whoever is in charge of the event designated (usually fire department or medics on scene doing quick triage)

How does the ED try to learn from success as well as failures?
We gather everyone that was involved in the event and we go thru what did and did not go well.

Does the Lincoln City ED communicate the effects of actions taken?
We don't really share it with people who were not in the specific event.

Do employees at LC feel comfortable suggesting solutions to peers and supervisors?
Employees are very open-minded and we have a program on the computer where you can make suggestions. Let's fix what bugs you. You can put in anything goes to managers. Suggestions are usually taken. Very good tight hospital. I like how admin will listen to everyone. Same is true for peers and supervisors. We all have a voice. We can go to supervisors and communicate.

How do you overcome disruptions in your day?
Lack of staffing: everyone understands that we are not getting a lunch break. It depends on what is going on in here. If some kind of error was made, it is here within a few minutes when something is wrong. Normally when we call them with something.

To what extent have you experienced burnout in your role?
Don't have a high turnover; I love it here. It's a small hospital, tight knit group knowing everyone you work with, can anticipate what others need. Makes it much more enjoyable coming to work.

How do you cope when there is a more difficult day?
Step out the back door and take a breath.

Do you enjoy solving difficult problems you encounter at work?

Always something else going on.

Emergency Department: Nurse 2
How long have you been working at this clinic?
22 years

Are there any visual systems to show disruptive events?
It depends on what we receive from person handling stuff. If there was a disaster we would have a person.

How does clinic handle disruptive events?
We have volunteer patients. We have people come in in other areas.

Are there any standards on how to respond to common disruptive events?
Emergency planning has improved dramatically in the past few years

Does Lincoln City ED try to learn from success as well as failures?
Many different ways. Always have a debrief.

Do employees at LC feel comfortable suggesting solutions to peers and supervisors?
Very supportive management and DCEO team. If its a situation where it should be anonymous, they have a good ear.

To what extent have you experienced burnout in your role?
There will always be burnout because this department is very stressful. They all want your undivided attention, in all rooms at the same time. It's also good teamwork. Burnout today is dependent on what is going for life. We do pretty well such a variable stressful job. "Let's fix what bugs you" they listen and I like it.

Emergency Department: Reception Manager/ Patient Access Manager

How does the Lincoln City ED monitor for disruptive events? Are there any metrics for performance?

1. *Audit accounts (calling in sick)*
2. *Patient satisfaction scores*
3. *Unique to this hospital is that the main entrance is in the ED. This creates a backlog. 4 people in could be having a heart attack but we wouldn't know.*

How does the Lincoln City ED respond to disruptive events?
If anyone is sick, call manager, IT 365 days a year.

Do you have adequate resources to respond?
Minimally adequate resources. A girl was killed by a tree and her husband is volunteer firefighter. It is possible to respond rapidly 3 min.

In terms of the department, is there anticipation of future risk and opportunities for growth?
With new hospital expanding to more rooms, will help us get patients in and out faster. Also direct bedding, made our patient satisfaction scores increase.

How does the Lincoln City ED monitor for disruptive events?
"Everbridge system" staff notified if disaster code silver is with gunman. Communicated by text, phone, email etc."

How does Lincoln City ED communicate these metrics to the employees?
Not communicated to front-line employees.

Can you give an example of when the ED learned from a disruptive event?
Yes, in bomb threat, when all intercoms were down. Only POTS phone was working; not tied to any other systems. Phone call that there was a bomb and we couldn't' page. We had to evacuate the hospital. Set up tent in 40 minutes. Patients went to nursing home across the street. Surgical patients across the street. We learned that people forgot about people in basement and we didn't know.
We had a fire downstairs. A dryer shot up flames. Op called fire department but did not pull fire alarm to notify others.

Were these lessons communicated to employees?
After event we have a debrief meeting. Not sure what policy was going forward. Department managers, environmental managers [were involved].

Does the hospital anticipate opportunities for growth?
Epic implementation team supervisor to manager. I like how I can grow in the hospital. They pay for education. I try to be an advocate for the hospital, come back and start using us as a resource. I like the management; CEO leads by example.

How do you work as a team?
We all work together very well and are willing to cover for each other. In my position there is usually a supervisor, but I don't have a supervisor. They all pulled together to do well when I was gone. I would not ask my team to do anything I wouldn't do [middle of the night calls-- employee is also night shift manager].

Do you enjoy solving difficult problems in your workday?
I do enjoy fixing

How do you overcome disruptions in your day?
Take care of situation as fast as can, and then get back to the day-- finding the root cause if possible.

How would you find the root cause?
Try and get people in as fast as possible, or step in and work harder. Trainee patch.

In the bomb threat, how did you make sense of what was happening and what was your first action?
Pull out disaster box, notified house supervisor, very well trained to evacuate hospital. Well prepared and drill for twice a year on emergency response. We practice plane crash into lake and get the patients into hospital. Shooting at the high school and we all try different roles in the event. Open to learning.

To what extent have you experienced burnout in your role?
Amount of work that must be done by only two employees. Each employee does 30 people. When my staff feels overwhelmed, I feel overwhelmed.

Primary Care 2: MA

How long have you worked at this clinic?
17 years

Based on the definition provided, can you give an example of a disruptive event you've encountered in your time here?
There was a drop from 8-4 doctors. People take the job and they leave. Obamacare. Urgent care. That's where they went. That's where all the providers went. It's worrisome at least 2 patients are no show. They want doctors really bad but when they get one they don't show. I always say if patients were charged for appointments, we won't have no shows. I think sometimes we give people things for free. They don't appreciate it.

How do you monitor for no shows? Is there any way to predict these?
We call patients the day before and remind them of the appointment. Care coordinator calls them and warns them. Second time they get a letter. Third time meeting with care coordinator to sign contract.

How does the clinic respond when no shows occur?
We have a plan sometimes it works sometimes it don't. It depends who you're working for. Some schedules work around this [no-show] it kind of depends. Doctors are stressed having to care of everything [due to others out on leave]. I sweet-talk everybody; it gets hard after a while.

Does the clinic have drills for larger scale events?
I think so. I have to stop and really think about that.

How does your workflow change when there is a disruptive event?
I'll do more investigation; do more research for doctors. We have protocols to follow for refill. You have to really research. I do that for our doctors anyway but more so when they're out.

How would the clinic respond to a larger scale event, such as a disaster?

We have a disaster plan we can still serve the public and for doctors I have no idea, nobody is talking.

Does the clinic anticipate future risks and opportunities for growth?
I think so. They're trying to train new doctors. We have one doctor today. I asked downstairs. One doctor from downstairs gave me [slots] to meet patients.

Would you say the clinic learns from failures?
I don't know because you know a lot of people try to fix things that aren't broken. A few years ago we had 8 doctors and we weren't broken and they fixed it

Would you say the clinic learns from successes?
I hope so. I can't think of.

Do employees feel comfortable suggesting solutions to peers and supervisors?
Oh yeah, I think so a lot of us been here long we're comfortable.

How do you solve difficult problems in your workday?
Positive thinking. Talk to back office lead for opinion.

Do you enjoy solving difficult problems at work?
Sometimes enjoy finding solution sometimes not. For example, a patient called for catheter supplies. So I did some investigation, got the answer, wrote down, gave to doctor.

Would you say there is a clear understanding of team member roles and responsibilities?
Oh yeah we actually have a book we can read that tells us responsibility. It's a job description. But also says as work determined by supervisor.

How do you solve difficult problems in your workday?
Communication is a big plus. You read the chart. Gather information from the chart. I can either take it back office or ask doctor I don't know what it is you never know he might know it

To what extent have you experienced burnout in your role?
I love my job. I think it's important to take time off. It can be emotional.

Do you ever find yourself working below your license?
Oh yeah it happens stuffing envelope with letters. Fax prescription to pharmacies.

Care coordinator/ LPN
How long have you been working at this clinic?
5 months

What does being a care coordinator entail?

Follow ups, make sure they have prescription. The goal is to keep them out of ED, keep eye on diabetic risk patients.
Community resources (home child care/ drug-rehab)
Point: monitor high-risk patients

Can you think of a disruptive event that the clinic has experienced recently?
There's been quite a few. A manager went on vacation and never came back. Another provider out indefinitely, but supervisors telling us she is coming back. Also to reschedule her appointments.

no-show appointment frequently
impact more on nurse than doctors
conversation: no show vs late cancelation
reach out
assist with barriers
decision making left to providers
at least 4 conversations happen for no shows

productivity quota
patient education

How does the clinic monitor for disruptive events?
I can't answer if they're different in clinic or if were paying attention to it more.

How does the clinic to respond to disruptive events like the instance of provider absence?
[The organization] has an emergency protocol. There's no protocol in place for providers not showing up. There are rules as staff we don't know. The back office supervisor holds one-on-one conversations. Sometimes the supervisor comes in "so and so not here." Sometimes things passed by supervisor.

What about in the case of a larger event? How do you think the clinic would respond?
We have down time forms most people here know how to do paper charting. Receptionists would reschedule non-emergent appointments. Catch up. The protocol is to see new patients unless the organization says not to.

Is there a list of events for which the clinic has a prepared response?
Rely on admin. Training drills. Spill drills. New employee orientation. Online education.

How does the clinic anticipate future risks or opportunities for growth.
Employees would have to discuss with management. No open forms. No brainstorming activities.

Do employees feel comfortable discussing problems and solutions with peers? Supervisors?

I would think to supervisors. I feel like they always listen but have not seen it. No feedback

Would you say the clinic learns from successes?
I don't know.

Would you say the clinic learns from disruptive events?
I would think so. I don't feel anything different. When manager vs provider left. Encounter not handled as well as manager absence. Every provider has their own preference. There's no continuity, so it's difficult to step in and assess.

How do you solve difficult problems in your workday?
If I am unsure, refer to someone who done it before or look at protocol if I have to. I'm more worried about losing license. If any thing seems off and I'm still not figuring it out, get second opinion.

What are team dynamics like? Would you say roles and responsibilities are clear?
Yes. Very clear. At beginning there was a little issue, but a meeting made it clear. Usually someone is very willing to jump in and help works really well.

To what extent have you experienced burnout in your role?
Huge burnout in Corvallis. That clinic is very toxic. Huge exit, extremely short staff. A lot of conflict with management. Extremely overwhelming got to the point where "I cant do this." It's easy to get sucked in to toxicity.

What about at this clinic? Has the experience been similar?
No burnout in Lebanon. Old manager was very open.

Do you ever find yourself doing work you were not trained to do?
MAs job all the time but were intertwined. Doesn't happen very often, but it's part of being a team.

Primary Care 2: Provider
How long have you been working at this clinic?
Since February '06

Power outage
I'm pretty resilient
Key thing: stay focused on task in front of you

How would the clinic respond to an event like the power outage you mentioned?
Normally kick in fear pre discussed plan. I developed paper version of a chart. I write my notes and they scan it later. Need for another plan. Anticipate what those may be and have plan.

Would your team members respond as quickly?
They may not. Initial confusion; we then huddle together to figure out what to do. Transition. Be flexible.

Does the clinic have a list of events for which it has a prepared response?
Fire and that kind of thing. I think that's it. A bit fussy. It would help to have clearer policies

No not really admin people do step up and come up with a bit of a plan

Does the clinic anticipate future risks and opportunities?
There needs to be a more collaborative plan. It's an opportunity to develop policy

Does the clinic learn from successes and failures?
Unfortunately [organization] as healthcare organization is poor at making policies. Leadership. They can do better.

Can you think of any examples of learning from disruptive events in the clinic?
Front office may have more input slit of speed bumps/glitches. I wouldn't be aware of not really

What about an example of learning from successes?
Yes. I suggested one Monday's policy. They were receptive to pointing that out.

How do you solve difficult problems in your workday?
It's my goal to give 75% all the time. If you do give 100%, you will be burned out in the first 3 days. Nothing rattles me. The important thing is patients. The rest doesn't matter.

How do you make sense of difficult problems in your workday?
If I don't know what I'm dealing that's the time to ask someone else and if we both don't know we develop a plan

To what extent have you experienced burnout in your role?
I see burnout for what it is. When there is a frustration aura, regroup. I find something to look forward to change.

Do you have any strategies for coping when you feel yourself nearing burnout?
When a change is introduced I buy a new gun every time.

8.3 Appendix C: RAG Ratings

		Rater 1	Rater 2	Rater 3
Primary Care 1	Monitor	5	5	5
	Respond	5	3	5
	Learn	4	3	4
	Anticipate	5	4	5
	Individual	5	6	4
Emergency Department	Monitor	5	5	5
	Respond	4	5	4
	Learn	5	6	5
	Anticipate	6	6	6
	Individual	4	4	4
Primary Care 2	Monitor	2	2	2
	Respond	4	4	3
	Learn	4	3	4
	Anticipate	3	4	3
	Individual	5	5	5

8.4 Appendix D: Manuscript 3 IRB Documents

Institutional Review Board
Office of Research Integrity | Oregon State University
B308 Kerr Administration Building, Corvallis, OR 97331-2140
Telephone (541) 737-8008
irb@oregonstate.edu | http://research.oregonstate.edu/irb

RESEARCH PROTOCOL

RESEARCH PROTOCOL
February 20, 2017

1. Title: Understanding Resilient Process Improvement in Organizations

PERSONNEL

2. Principal Investigator: Chinweike Eseonu
3. Student Researcher(s): Joshua Hille, Paola Grijalva, Waleed Mirdad, Lucia Darrow, Bhuvana Karaikudi
4. Co-investigator(s): N/A
5. Study Staff: N/A
6. Investigator Qualifications

   Dr. Eseonu is an Assistant Professor in the School of Mechanical, Industrial, and Manufacturing Engineering. Dr. Eseonu conducts research on socio-technical process optimization, with a focus on factors that lead to sustained acceptance of an idea or innovation (which includes methods, technologies, etc).

   Mr. Hille, Ms. Grijalva, Ms. Darrow, and Ms. Karaikudi are Masters students in the School of Mechanical, Industrial, and Manufacturing Engineering. All students work with Dr. Eseonu in the Process Improvement Group.

   Mr. Mirdad is a doctoral student, also in the Process Improvement Group (PIGroup)

7. Training and Oversight

   The PI has verified that all study researchers have completed the required IRB training in the ethical use of human participants in research. The PI has reviewed all IRB related documents before submission and will continue to review any future documents that require IRB approval.

   All initial survey data collection will be carried out using an online survey software.

   The PI will hold weekly meetings with the team to ensure compliance with protocol.

8. Conflict of Interest

   None.

FUNDING

9. Sources of Support for this project (unfunded, pending, or awarded)

   Funded: Unfunded. Research conducted alongside funded projects, which grant access but do not directly fund study.

DESCRIPTION OF RESEARCH

10. Description of Research

OSU Oregon State University

The OSU researchers are interested in identifying factors that affect resilience in process improvement projects. The OSU researchers will be conducting survey and observation-based research to identify significant factors. For the survey, a pilot study will be completed initially to ensure consistency. Journal articles, conference proceedings, and theses summarizing significant findings are anticipated. The journal articles, conference proceedings, or theses will not identify any participants, including any companies involved. The focus of the research is on changes in broad work related processes. No directly identifiable employee or position specific information will be collected.

11. Background Justification

The change management literature is comprised of many theories describing techniques to achieve a successful change project (Burnes, 2009; Hayes, 2014; Mitchell, 2013; Todnem, 2005). Furthermore, much of this research is focused on implementation (Adel M. Aladwani, 2001; McMurray, Chaboyer, Wallis, & Fetherston, 2010; Yi Zou & Sang-Hoon Lee, 2009), which supports the needs of industry managers. However, there is still a lack of research that studies all phases of these change projects to identify effective measures, process based signs of success, etc. The focus of this study is on addressing these issues.

12. Multi-center Study
N/A – this study involves OSU researchers only.

13. External Research or Recruitment Site(s)

a) Name or description of each research site: Samaritan has indicated that this research is approved under the MOU. The team will obtain necessary approvals from other locations as needed.

b) Name and role of appropriate authority from each site providing a letter of support or permission (when applicable): Barbara Corney for Good Samaritan

c) Name of each recruitment site: Regional Hospitals (including Good Samaritan Hospital)

d) If recruitment method involves more than an advertisement (newspaper classified, flier, listserv email), name and role of appropriate authority from each site providing a letter of support: N/A

e) Attach or include the final content of the ad or correspondence to be used for recruitment
See attachment

14. Subject Population

- Participants include anyone involved in the process being studied. These are largely employees of the companies at which existing PIGroup projects are conducted, or customers who access the organization. Employees will be invited to participate in an email from a non managerial administrative person, such as the hospital director's assistant. This individual is in charge of normal mailing list communications, such as newsletters, so this will pose no undue duress. Where the hospital is willing, the PIGroup will obtain email addresses from the hospital and send the invitations.
- Total target enrollment number: 1000

OSU
Oregon State
UNIVERSITY

- We do not envision participants under the age of 18. It is possible an employee or customer may be:
  - Pregnant
  - An OSU student
  - Of American Indian ethnicity
  - Of Alaska Native ethnicity

Employees and customers at these companies are assumed to be English speakers, as English is the formal language of business at these companies. For employees, we will recruit either via email or in person. We will use the text of the email as a guide for our in person statement.

- The following email will be sent to potential participants:

Dear (NAME),

Dr. Chinweike Eseonu and the Process Improvement Group at Oregon State University need your help in a research study that aims to improve our understanding process improvement strategies in organizations like yours. You are being contacted because, as an integral part of this organization, your input will help us get a true picture of your daily operations and experiences.

Our aim is to learn and subsequently discuss findings with you. This will not be used in personnel evaluations.

Participation in this study involves a time commitment of 20 minutes for a brief survey. (SURVEY LINK)

For more information about this study, please contact the principal investigator, Dr. Eseonu, by phone at 541-737-0024 or email at Chinweike.eseonu@oregonstate.edu.

Thank you,

Chinweike I. Eseonu, PhD

Oregon State University

Study Title: Understanding Resilient Process Improvement in Organizations

For Customers, there will either be flyers at reception, or surveys with the attached consent information

15. Consent Process

Potential survey participants will be given a consent and invitation email or a just consent cover letter that contains relevant contact information for both the PI and the IRB, and the possible risks of participating.

The research team requests a waiver of signed documentation of informed consent. Participation in the survey after reading the consent statement will demonstrate consent.

It is anticipated that all participants will have capacity to consent.

16. Assent Process

N/A

17. Eligibility Screening

An eligibility screening process is not anticipated as being necessary.

18. Methods and Procedures

An invitation email will be sent to potential employee participants, which will include a link to an online survey software. They will be given the opportunity to complete one or both surveys. Customer participants will receive a flyer or printer survey and consent information at reception. Employee participants will also be given the option to complete one or both surveys in person. The Servqual survey will be modified to reflect the type of organization of interest. The flyer will contain a link to a web based survey. The following survey subsections apply to all participants. For the Resilience Analysis Grid survey, if the participant gives examples or narratives while answering the question, researchers will take notes. Researchers will ask the questions verbally and will fill out the survey accordingly.

SURVEY:

The team will close the survey once the number of participants is reached

The team will use statistical analysis to identify cause effect relationships in the survey data

The team will publish results in graduate student thesis and in research journals

PRELIMINARY OBSERVATIONS AND ANALYSIS

The team will observe processes at each location and create value stream maps. This will not include information about the individual.

The Value Stream Maps will be used to identify process bottlenecks and drive discussions about problem solving in Kaizen events.

The team will observe post event processes to (a) identify improvements, (b) assess methods for implementation, and (c) assess effectiveness after implementation.

19. Compensation

No compensation will be given to participants.

20. Costs

No foreseen participation costs (beyond time spent completing the survey) are associated with this research.

21. Drugs or Biologics

N/A – no drugs or biologics are utilized in this study.

22. Dietary Supplements or Food

    N/A – this study does not involve dietary supplements or food.

23. Medical Devices

    N/A – this study does not involve any medical devices.

24. Radiation

    N/A – this study does not involve radiation.

25. Biological Samples

    N/A – this study does not involve biological samples.

26. Anonymity or Confidentiality

    Survey responses will be anonymous, or confidential if participant provides identifying information. All study information will be stored for 3 years post-study terminiation by the PI. Data will be stored on an encrupted computer in the PI's office, or in the OSU Library database. Only authorized individuals will have access to the data. IRB permission will be obtained before raw data is shared with others. Results from the study including statistics and final reports that include general observations will be provided to the companeis. No individual level information will be shared. The research team will use the "anonymyze" feature on Qualtrics to prevent identification of participants through their IP addresses. Data uploaded to the library database will not include raw data.The library database is fully protected with updated anti-virus protections. For the in person surveys, researchers will collect all documents immediately following collection and take them back to OSU for secure storage in the PI's or lab office. Information regarding the employee's department and level within the organization will be recorded.

27. Risks

    There is a risk of breach of confidentiality. However, any impact is minimal as (a) the PIGroup has been invited to "burning platform" locations (managers are eager to find and solve true, underlying problems), (b) the PIGroup will not collect identifying information. Additionally, data will not be stored at the research sites to protect confidentially. In addition, no names or identifying information will be recorded on the survey. Although the PI group will collect information about individual's organizational level and department, the probability of identifying a specific individual in a breach of confidentiality will be low as multiple organizations will be surveyed. Data collected online can be hacked, or otherwise accessed. The team used OSU passwords, which are frequently updated, to access the survey software.

28. Benefits

    The research will potentially provide information on strategies for improving employee work experience during change, or process improvement projects. The research may be published in accessible journals, conferences proceedings and/or theses.

29. Assessment of the risks and benefits.

    Benefits in #28 outweigh risks in #27.

Dear Participant,

Thank you for your willingness to participate in this research on Understanding Resilient Process Improvement in Organizations. The goal of this research is to **help understand your experience at this organization** and learn about what strategies you use in daily operations. At this stage, Dr. Chinweike Eseonu and the Process Improvement Group (PIGroup) at Oregon State University needs your help in completing the attached survey. **We appreciate your help**.

Voluntary Participation

Your participation is voluntary. You are not required to respond to any of the questions, but we greatly appreciate your response to all questions. This will provide a more complete picture to guide discussions on patient flow. **The survey should take approximately 20 minutes** or less.

Confidential

You are not required to provide your name or other identifying information. However, we invite you to provide general information about your experiences at this organization and the nature of your visits. This will help us match your responses with the right work area and improve our understanding. We appreciate that your time is very valuable and thank you for your help in shaping our knowledge of resilient process improvement initiatives. The principal investigator (Dr. Eseonu) and student researchers will have access to individual survey results. **Results will be confidential.** Aggregate, non identifiable results will be shared with the organization. There is a chance that we could accidentally disclose information that identifies you. If we collect information online, the security and confidentiality of information collected from you online cannot be guaranteed. Confidentiality will be kept to the extent permitted by the technology being used. Information collected online can be intercepted, corrupted, lost, destroyed, arrive late or incomplete, or contain viruses. Your responses will also be used to help improve processes at this organization; so de-identified results will be shared with the organization.

Eligibility

You must be at least 18 years old to participate in this study. There are no foreseen risks nor direct immediate benefits to you for participation in this study.

Please contact Dr. Eseonu (chinweike.eseonu@oregonstate.edu or 541.737.0024) if you have any questions or comments about the survey. If you have questions about your rights as a research participant, please contact the Institutional Review Board (IRB) at Oregon State University (email: irb@oregonstate.edu or 541.737.8008).

Thank you,

Chinweike Eseonu, PhD
Assistant Professor,
Oregon State University
chinweike.eseonu@oregonstate.edu

Human Research Protection Program
Institutional Review Board
Office of Research Integrity
B308 Kerr Administration Building, Corvallis, Oregon 97331-2140
(541) 737-8008
IRB@oregonstate.edu | http://research.oregonstate.edu/irb

APPROVAL NOTICE

Date of Notification	02/21/2017	Date Approved	02/20/2017
Principal Investigator	Chinweike Eseonu	Study ID	7138
Study Title	Understanding Resilient Process Improvement in Organizations		
Study Team Members	Lucia Darrow, Paola Grijalva, Joshua Hille, Bhuvana Karaikudi Ramesh, Waleed Mirdad		
Review Level	Expedited	Category(ies)	7
Submission Type	Project Revision		
Waiver(s)	Documentation of Informed Consent		
Risk Level for Children	N/A		
Number of Participants	1000 Do not exceed this number without prior approval		
Funding Source	Internal (Ended)	PI on Funding	N/A
Proposal #	N/A	Cayuse #	N/A

The above referenced study was reviewed and approved by the OSU Institutional Review Board (IRB).

EXPIRATION DATE: 02/19/2018
Continuing review applications are due at least 30 days prior to expiration date

Comments: Waiver of documentation of consent for all participants. Reclassified from exempt to expedited. Revisions to add new test instrument; revised to include in-person data collection.

Please note when applicable, if the PI has not already done so, the HRPP staff will update the version date on the protocol and consent document(s).

Principal Investigator responsibilities for fulfilling the requirements of approval:

- All study team members should be kept informed of the status of the research.
- Any changes to the research must be submitted to the IRB for review and approval prior to the activation of the changes. **This includes, but is not limited to, increasing the number of subjects to be enrolled.** Failure to adhere to the approved protocol can result in study suspension or termination and data stemming from protocol deviations cannot be represented as having IRB Approval.
- Reports of unanticipated problems involving risks to participants or others must be submitted to the HRPP office within three calendar days.
- Only consent forms with a valid approval stamp may be presented to participants.
- Submit a continuing review application or final report to the HRPP office for review at least four weeks prior to the expiration date. Failure to submit a continuing review application prior to the expiration date will result in termination of the research, discontinuation of enrolled participants, and the submission of a new application to the IRB.