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EXAMINING THE IMPACT OF A FATIGUE INTERVENTION ON JOB PERFORMANCE:
A LONGITUDINAL STUDY ACROSS UNITED STATES HOSPITALS

by

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ABSTRACT

Fatigue in healthcare providers has been linked to dangerous outcomes for patients, including medical errors, surgical complications, and accidents. Resident physicians, who traditionally work long hours on minimal sleep, are among the most fatigued. In attempt to mitigate the impact of fatigue on resident physician performance and improve patient safety, the Accreditation Council for Graduate Medical Education (ACGME) implemented a fatigue intervention program in 2011 for medical residency programs in the United States. This caused a significant decrease in the number of hours that first-year residents were permitted to work, compared with hours worked by first-year residents in prior years.

While studies investigating the impact of the 2011 ACGME fatigue intervention on outcomes are limited thus far, some initial evidence seems to be promising. For instance, Pepper, Schweinfurth, and Herrin (2014) found that the rate of transfers to the intensive care unit after a code blue significantly decreased from pre- to post-intervention. However, it is not currently understood what variables may drive positive changes in patient outcomes, nor how long it may take for these changes to occur. Thus, the purpose of this study was to examine the effect that the 2011 ACGME fatigue intervention has had on job performance in healthcare providers in U.S. hospitals. The current study attempted to address this question by taking both a micro perspective, by drawing upon cognitive theories (Kahneman, 1973, 2011) and skill acquisition theory (Fitts, 1964; Fitts & Posner, 1967), as well as a macro perspective, by drawing upon organizational change theories (DiMaggio & Powell, 1983).

This study combined public-use databases provided by the Center for Medicare and Medicaid Services (CMS). Specifically, 1,277 hospitals in the United States were examined over a five year period on job performance behaviors to determine if there was significant change

from pre-intervention to post-intervention. Hospitals were categorized as control hospitals ($n =$ 594) and intervention hospitals ($n =$ 683). More specifically, intervention hospitals were analyzed according to their resident-to-patient bed ratio, using guidelines provided by Patel et al. (2014), including very low resident-to-bed ratio hospitals ($n =$ 174), low resident-to-bed ratio hospitals ($n =$ 287), high resident-to-bed ratio hospitals ($n =$ 143), and very high resident-to-bed ratio hospitals ($n =$ 79). Further, organizational size was examined as a moderator. The current study used discontinuous growth modeling (Bliese, 2008; Ployhart, 2014; J. D. Singer & Willett, 2003) to analyze the data, which allowed for investigation into the magnitude and rate of change from pre- to post-intervention.

Results show that there was a significant improvement in employee job performance over time across both intervention and control hospitals. In particular, job performance significantly improved abruptly at the transition period (i.e., when the intervention was introduced) and continued to improve gradually throughout the post-intervention period; yet, these results held for both intervention and control hospitals. However, exploratory analyses comparing control hospitals to very high resident-to-bed ratio hospitals found that the latter group improved significantly more at the transition period in comparison to control hospitals. I therefore conclude that there may be some effect of the fatigue intervention on job performance, but this effect may be visible only in very high resident-to-bed ratio hospitals. Further, organizational size was not a significant moderator of the relationship. Future research is needed to confirm these findings.

In memory of my grandfather, Dr. D. Keith Millett.

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CHAPTER ONE: INTRODUCTION

Statement of the Problem

In the United States, medical residency is typically a three to seven year journey that begins upon graduation from medical school, contingent upon acceptance into a residency program (ACGME, 2015b). The goal of residency is to increase new physician experience such that these physicians can take on graduated, increasing responsibility for patient care (ACGME, 2015a). The residency experience typically provides residents the knowledge, skills, and abilities (KSAs) needed to sit for a qualifying exam at the end of their residency and become board-certified, allowing them to subsequently practice as fully-independent physicians (ACGME, 2015b). Therefore, the medical community places great value on the training and experiences afforded to residents. This, combined with the 24/7 patient care requirements found in a hospital setting, has traditionally manifested in a culture wherein resident physicians are expected to work long hours, spend additional time on call, and work non-traditional shifts. These conditions, however, result in sleep deprivation and associated fatigue, which have been associated with poor performance (Philibert, 2005; Wickens, Hutchins, Laux, & Sebok, 2015) and increased prevalence of medical errors (Reed, Fletcher, & Arora, 2010).

In a survey study of 132 residents, 34% claimed to be acutely sleep deprived and 64% were chronically sleep deprived (Rosen, Bellini, & Shea, 2004). Even more concerning, half or more of these residents stated it was possible that they would doze off while writing notes in patient charts, reviewing medication lists, interpreting patient labs, and writing patient orders (Rosen et al., 2004). Further, 57% of residents in another study indicated that fatigue had previously impaired their cognitive abilities (Niederee, Knudtson, Byrnes, Helmer, & Smith, 2003), and, in yet another study, 81% reported that sleep deprivation had previously had negative

effects on their work (Whang et al., 2003). Additionally, 84% of residents who took the Epworth Sleepiness Scale (Johns, 1991) in yet another study scored within the range in which clinical intervention is recommended (Papp et al., 2004).

As a result, recent discussion has centered around the extent to which organizational conditions can be modified to reduce resident sleep deprivation and fatigue. One of the more prevalent voices arguing for modifications has been the Accreditation Council for Graduate Medical Education (ACGME), which is a private professional organization overseeing the accreditation of approximately 9,500 residency programs in the U.S. (ACGME, 2015a). In 2003 and again in 2011, as the result of expert panel recommendations, the ACGME mandated that all accredited residency programs implement numerous reforms (i.e., interventions; see Table 1). The main focus of the 2003 intervention was limiting residents to a maximum 80-hour workweek. However, a study requested by Congress and conducted by the Institute of Medicine reached the conclusion that the 2003 intervention did not go far enough in reducing resident fatigue (Ulmer, Miller Wolman, & Johns, 2009). As a result, the 2011 intervention was implemented based upon the belief that it would further improve patient safety and care (Ulmer et al., 2009). As can be seen in Table 1, the major emphasis of the 2011 intervention is upon further mitigating resident physician fatigue by requiring programs to institute fatigue education and policies and by limiting the maximum shift-length that residents can undertake. This is particularly true for first-year residents (also known as "interns" or postgraduate year 1 [PGY-1] residents; see Appendix A for a list of definitions of medical jargon terms), who are limited to a maximum 16-hour shift, down from 30 hours in prior years.

Table 1. Description of 2003 and 2011 ACGME fatigue interventions (see ACGME, 2011b).

Category	2003 Intervention	2011 Intervention
Introduction	- Ensure patient safety - Ensure resident well-being - There should not be excessive reliance on residents to complete service obligations at the expense of fulfilling their learning objectives - Prioritize didactic and clinical education when allotting resident time - Recognize the joint responsibility between faculty and residents for patients	- Residency is essential to transform medical students into competent practitioners, but is "physically, emotionally, and .intellectually demanding." - Residents learn by interacting with patients under the supervision of faculty members. Supervision serves to ensure safe and effective patient care, as well as development of resident skills, knowledge and attitudes - Residents gain more independence as they gain experience
Professionalism, Personal Responsibility, and Patient Safety	N/A	- Programs must educate residents and faculty on appropriate rest - Programs must support patient safety and resident well-being - Ensure that residents are actively involved with interdisciplinary clinical quality improvement and patient safety programs - Program learning objectives must be accomplished through a combination of patient care, clinical teaching, and didactic educational events, and not excessively rely on residents to complete non-physician service obligations - Ensure a culture of professionalism, support for patient safety and personal responsibility, including acceptance of one's role in patient safety and welfare, patient- and family-centered care, assurance that one is fit for duty, time management, recognition of impairment (including illness and fatigue) in oneself and one's colleagues, focus on lifelong learning, patient monitoring, honest and accurate reporting of work hours, patient

Category	2003 Intervention	2011 Intervention
		outcomes, and clinical experience. • Consideration of patient needs above self-interest, including recognizing the need to transition patient care to another qualified, rested provider
Transitions of Care	N/A	• Minimize transitions of care • Use and teach structured hand-over processes
Alertness Management/Fatigue Mitigation	• Educate faculty and residents on the signs of fatigue and sleep deprivation • Adopt and apply policies to prevent and mitigate effects of fatigue on patient care and learning	• Educate all faculty members and residents on the signs of fatigue and sleep deprivation, on alertness management and fatigue mitigation processes • Adopt fatigue mitigation processes, such as naps or back-up call schedules • Have a process to ensure continuity of patient care if a resident cannot perform patient care duties • Provide adequate sleep facilities and/or safe transportation options for fatigued residents
Supervision of Residents	• Ensure that qualified faculty appropriately supervise residents' patient care	• Each patient must have an attending physician. • There should be an appropriate level of supervision for all residents; this can include a more advanced resident or fellow. • Residents must know the limits of their authority as well as the extent to which they have independence. • PGY-1 residents should be supervised directly (i.e., with supervising physician physically present) or indirectly with direct supervision immediately available
Clinical Responsibilities	N/A	• Consider PGY-level, patient safety, resident

Category	2003 Intervention	2011 Intervention
		education, patient complexity and severity, and support services when determining the clinical responsibilities for each resident
Teamwork	N/A	• Environment should facilitate effective communication, by allowing residents to work within an interprofessional team
Maximum Hours of Work per Week	• Duty hours limited to 80 hours per week, averaged over a four-week period, including all in-house call	• Duty hours limited to 80 hours per week, averaged over a four-week period, including all in-house call and all moonlighting
Duty Hour Exceptions	• A review committee may give exceptions for up to 10% (or a maximum of 88 hours) for individual programs based on educational rationale. • Programs must follow specific procedures when requesting this exception.	• A review committee may give exceptions for up to 10% (or a maximum of 88 hours) for individual programs based on educational rationale. • Programs must follow specific procedures when requesting this exception.
Moonlighting	• Moonlighting cannot interfere with achievement of the resident's educational goals and objectives • Internal moonlighting must be counted towards the 80-hour duty limit.	• Moonlighting cannot interfere with achievement of the resident's educational goals and objectives • Internal and external moonlighting must be counted towards the 80-hour duty limit. • PGY-1 residents cannot moonlight.
Mandatory Time Free of Duty	• Residents must have one day in seven free from all educational and clinical responsibilities, averaged over a four-week period, including call.	• Residents must have at least one day in seven free of duty every week (when averaged over a four-week period). At-home call cannot be assigned on these free days.
Maximum Duty Period Length	• On-site duty cannot exceed 24 hours. • Residents can remain on duty for up to 6 additional hours for the following reasons: didactic activities, transfer of care of patients, conducting outpatient clinics, maintaining continuity of medical and	• Duty of PGY-1 residents cannot exceed 16 hours. • Duty of PGY-2 residents and above cannot exceed 24 hours. • Programs should encourage strategic napping between 10pm and 8am, or after 16 hours of

Category	2003 Intervention	2011 Intervention
	surgical care. • Residents cannot accept any new patients after 24 hours of continuous duty.	continuous duty. • Residents can remain for up to 4 hours on-site after 24 hours to transition patient care. • Residents cannot be given additional clinical responsibilities after 24 hours of duty. • Infrequently, residents can choose on their own accord to remain beyond 24 hours of duty to provide care for a single patient; this is limited to cases in which a patient is extremely ill or unstable, the events are of academic importance, or for humanistic attention for the patient or family. In these cases, the resident must hand over care of all other patients, document the reasons for continuing duty, and these documentations should be tracked by the program.
Minimum Time Off between Scheduled Duty Periods	• Residents must be provided with sufficient time for rest and personal activities, i.e., a 10-hour time period between all duty periods and after in-house call.	• PGY-1 residents and intermediate-level residents should have 10 hours off- and must have at least 8 hours off- between duty periods. • Intermediate-level residents must have at least 14 hours off after 24 hours of duty. • Final-year residents may care for patients over irregular or extended periods, but must fall within the 80-hour work week, maximum duty-hour period, and one-day-off-in-seven standards.
Maximum Frequency of In-House Night Float	N/A	• Residents cannot be scheduled for more than six nights in a row of night float.

Category	2003 Intervention	2011 Intervention
Maximum In-House On-Call Frequency	• In-house call cannot occur more frequently than every third night, when averaged over a four-week period.	• PGY-2 residents and above cannot be scheduled for in-house call more often than every third night (when averaged over a four-week period).
At-Home Call	• The frequency of at-home call is not subject to the every-third-night or 24+/1 6 limit, but should allow for rest and reasonable personal time for each resident. • Residents taking at-home call must have one in seven days completely free from clinical responsibilities, when averaged over a four-week period. • When residents are called in from home, the hours in hospital count towards the 80-hour limit.	• When residents are called in from home, the hours in hospital count towards the 80-hour limit. • The frequency of at-home call is not subject to the every-third-night limit, but must satisfy the one in seven days free of duty, when averaged over a four-week period. • At-home call must not preclude rest or reasonable personal time for each resident. • Residents can return to the hospital while on at-home call to care for patients. While this care counts toward the 80-hour limit, it will not constitute a new "off-duty period."

Medical residents number approximately 109,000 across 8,700 residency programs in the U.S. (ACGME, 2015b). Thus, the 2011 fatigue intervention affected a substantial number of professionals and hospitals. Additionally, prior to the 2011 fatigue intervention, 94% of residency programs reported that their first-year residents did not currently adhere to the standard of a maximum of 16-hour work shifts (Antiel et al., 2010). Because of this large impact and the cultural norms of this profession, the 2003 and 2011 interventions have been met with extensive resistance by physicians who have claimed that the mandates harm resident learning and professionalism, and pose danger to patients by increasing the number of care handovers between physicians (e.g., Abraham, Freitas, Frangos, Frankel, & Rabinovici, 2006; Anglen et al., 2009; Auger, Sieplinga, Simmons, & Gonzalez Del Rey, 2009; Babyatsky, Bazari, & Del Valle, 2009; K. R. Borman & Fuhrman, 2009; Brion et al., 2009; Britt, Sachdeva, Healy, Whalen, & Blair, 2009; Carek et al., 2009; Cedfeldt, English, El Youssef, Gilhooly, & Girard, 2009; Cohen-Gadol, Piepgras, Krishnamurthy, & Fessler, 2005; Gallagher et al., 2005; Jagannathan et al., 2009; Ryan et al., 2011; M. C. Singer, 2010; Sloan et al., 2009; Underwood, Boyd, Fletcher, & Lypson, 2004; Winslow, Berger, & Klingensmith, 2004). However, members of the public have strongly supported the 2003 and 2011 fatigue interventions, believing they will lead to decreased medical error (Blum et al., 2010). Further, experts in patient safety and fatigue have been confident that these changes are necessary and beneficial (Ulmer et al., 2009).

Encouragingly, prior studies have investigated the impact of the 2003 and 2011 ACGME fatigue interventions on organizational effectiveness indicators such as mortality (Fletcher, Reed, & Arora, 2011; Shetty & Bhattacharya, 2007) and cardiac arrest (Pepper et al., 2014), with some results showing improvements. However, it is essential to understand the drivers of these improvements. That is, in order to appropriately evaluate the intervention and identify both

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strengths and areas of weakness, we must better understand how reduced fatigue is changing the *performance* of employees within healthcare organizations, rather than simply effectiveness *outcomes*. Along these lines, Campbell (2012) makes an important distinction between effectiveness, defined as organizational outcomes (e.g., financial success, mortality, etc.), and performance, which is defined as "actions or behaviors that are relevant to the organization's goals," (Campbell, McCloy, Oppler, & Sager, 1993, p. 40).

Purpose of the Current Study

In this dissertation, I test the impact of a fatigue intervention (i.e., the 2011 ACGME intervention) on employees' job performance in United States hospitals. Further, I look at organizational change to examine the timing at which the 2011 ACGME fatigue intervention becomes most effective in improving job performance. While there is a proliferation of studies examining the impact of the fatigue intervention on effectiveness indicators (e.g., patient outcomes), this is the first known investigation to examine the impact on these particular performance variables, allowing for a better understanding of what may be driving improved effectiveness outcomes.

Additionally, many studies examining the 2011 fatigue intervention are a single-group, pre-post design. The current study improves upon this by using a control group as well as by examining the data longitudinally with two pre- and three post-intervention time points. Evaluating these effects over time allows for a better understanding of when the benefits of the fatigue intervention occur – information that is not currently known. This method is beneficial, as "mapping performance levels of individuals or groups [over time]… allows a picture to emerge of modal performance and variability in performance," (W. C. Borman, 1991, p. 279). In keeping with this logic, this dissertation also examines differences in baseline job performance

amongst different types of hospitals. This is important as prior studies have found that not all hospitals have the same baseline level of performance. For example, some have found that teaching hospitals (i.e., those that employ resident physicians) tend to have worse performance in comparison to non-teaching hospitals (Kahn et al., 2015; Rajaram et al., 2015).

Additionally, it is not currently known exactly when improvements due to the 2011 ACGME fatigue intervention occur. Some of the initial benefits of reduced resident fatigue may be offset as organizations undergo a trial and error period to learn how to adapt to this change, leading to additional improvement over time as organizations adjust. For example, Jena, Prasad, and Romley (2014) found that the 2003 ACGME fatigue intervention impacted mortality more in the long term than the short term. As such, it is important to examine the impact of the 2011 fatigue intervention across time and to examine the associated change in job performance over time.

Finally, it is likely that characteristics of the organizations impact the extent to which the fatigue intervention improves job performance. For example, Piening, Baluch, and Oliver Salge (2013) used organizational (i.e., hospital) size as a control variable when examining the impact of human resource systems, as "larger hospitals may have an advantage over smaller ones by having more resources…" (p. 934). Building off this logic, large organizations may also have more resources to adapt to the fatigue intervention. These types of questions can only be answered by examining multiple organizations of varying sizes, which the current study allows for.

In sum, this dissertation aims to answer the following overarching questions:

Question 1: How does employees' baseline job performance in intervention hospitals (i.e., hospitals with resident physicians) compare to that of control hospitals (i.e., hospitals without resident physicians)?

Question 2: How does employees' job performance change over time within organizations that undergo a fatigue intervention in comparison to those that do not undergo a fatigue intervention?

Question 3: Do organizational characteristics impact the magnitude and rate of change on employees' job performance after the intervention?

Question 4: Does job performance continue to improve over time after the initial post-intervention period?

These questions are further developed in the next section. As such, this dissertation contributes to both cognitive and organizational change theories and takes both a micro- and macro-level approach. The remainder of this dissertation discusses the literature review that has guided the theory behind this proposed study, the method for this study, the results, and a discussion of findings as well as implications.

CHAPTER TWO: LITERATURE REVIEW

Fatigue

The definition of fatigue has been ambiguous (Noy et al., 2011). At a general level, fatigue has been defined as "a biological drive for recuperative rest," (Williamson et al., 2011, p. 499). However, fatigue can be muscular (e.g., decreased muscle function after extended use of muscles), chronic (e.g., due to a medical condition), mental (e.g., poor cognitive processing induced by mental work), or physical (e.g., tiredness due to sleep deprivation) in nature (Dawson, Noy, Harma, Akerstedt, & Belenky, 2011). The current study focuses on the latter two types; i.e., physical due to sleep deprivation (engaging in consecutive wakefulness over a long period of time) and/or sleep restriction (obtaining only small amounts of sleep over several days and nights), as well as mental fatigue due to working long hours. These types will hereafter be referred to simply as "fatigue".

Fatigue occurs when one has had insufficient sleep (Williamson et al., 2011) and/or has worked long hours (Emery, 2012). An optimal amount of rest is between 6 and 10 hours within a 24 hour period (Owens, 2007). Thus, an insufficient number of hours of sleep is one cause of fatigue. Additionally, fragmented sleep, wherein one is interrupted or even simply anticipates being interrupted during sleep, also negatively impacts sleep quality and causes fatigue (Owens, 2007). Furthermore, duration of hours worked is a cause of fatigue (Emery, 2012). In particular, long work hours and multiple successive work days have been shown to be associated with decreases in performance on mental tasks and increases in error (Alluisi & Morgan, 1982).

Sleep deprivation and fatigue impact cognitive processes such as attention, memory, and decision making (Philibert, 2005). For example, fewer than 5 hours of sleep causes declines in cognitive performance including vigilance (Jewett, Dijk, Kronauer, & Dinges, 1999). Muraven

and Baumeister (2000) theorize that vigilance performance decreases over time as the one's self-control becomes depleted, which may be one of the mechanisms through which fatigue leads to poor cognitive performance. Additionally, it has been found that sleep-deprived surgeons performed slower on some tasks than surgeons who were legally under the influence of alcohol (Mohtashami, Thiele, Karreman, & Thiel, 2014). Similarly, Dawson and Reid (1997) found that, after 24 hours of sustained wakefulness, participants' performance on a hand-eye coordination tracking task was equivalent to the performance deficit that occurred at a blood alcohol concentration of 0.10%.

Numerous studies and literature reviews have noted effects of long work hours on medical errors (Baldwin, Daugherty, Tsai, & Scotti, 2003; Reed et al., 2010), accidents (Jagsi et al., 2005; Mustahsan et al., 2013), and surgical complications (Yaghoubian et al., 2008). For instance, Brandenberger et al. (2010) noted that residents performed significantly worse on psychomotor and cognitive skills after a 12-hour work shift in comparison to before a 12-hour work shift. Similarly, Olds and Clarke (2010) found that nurses who worked more than 40 hours per week had significantly higher rates of adverse events and errors, including needlestick injury, work-related injuries, patient falls with injury, nosocomial infections, and medication errors. Additionally, Landrigan et al. (2004) found a 36% increase in medical errors, including 57% more non-intercepted serious errors, 21% more medication errors, and a six-fold increase in diagnostic errors when comparing interns working shifts greater than or equal to 24 hours versus shifts that were limited to 16 hours. However, as previously mentioned, it is important to examine not just outcomes, but also the behaviors that can lead to these outcomes.

Job Performance

One such behavior is job performance, defined as "actions or behaviors that are relevant to the organization's goals," (Campbell et al., 1993, p. 40). That is, this dissertation defines job performance as the behaviors conducted by employees, rather than the outcomes of these behaviors. Further, job performance involves multiple behavioral episodes (Beal, Weiss, Barros, & MacDermid, 2005; Motowidlo, Borman, & Schmit, 1997). Additionally, job performance is dynamic and can change over time (Deadrick & Madigan, 1990; Ghiselli & Haire, 1960; Thoresen, Bradley, Bliese, & Thoresen, 2004).

Job performance is a multi-dimensional construct which has been said to be comprised of various factors such as task performance, organizational citizenship behaviors, and leadership, among others (Campbell, 2012). The wide array of dimensions that have been housed under this construct has led scholars to create taxonomies of job performance. In particular, Campbell (2012) reviewed and integrated the literature and other performance taxonomies and concluded that there were eight dimensions of job performance. These dimensions are: (1) technical performance, including tasks specific to a particular job, such as analyzing data, administering a medication, or driving a vehicle; (2) communication, defined as conveying information either verbally or in writing; (3) initiative, persistence, and effort, defined as completing organizational citizenship behaviors (OCBs) such as voluntarily taking on extra tasks; (4) counterproductive work behavior (CWBs), described as behaviors that have a negative implication for an organization (e.g., theft, absenteeism); (5) supervisory, manager, executive (i.e., hierarchical) leadership, which involves behaviors such as coaching, initiating structure, and encouraging subordinates; (6) management performance (hierarchical), including "actions that deal with obtaining, preserving, and allocating the organization's resources to best achieve its goals,"

(Campbell, 2012, p. 181); (7) peer/team member leadership performance, defined similarly to the factor of supervisory, manager, and executive leadership but with the behaviors being directed towards peers and team members as opposed to subordinates; and, (8) team member/peer management performance, which is similar to management performance but with the behaviors being performed by peers and team members rather than management.

Performance in Healthcare

This dissertation focuses on the first dimension in the aforementioned taxonomy, technical performance. In particular, this study will focus on technical job performance at the organizational level, as opposed to individual-level technical job performance. As such, it is important to first describe the tasks and duties that employees in this industry complete. In this section, I provide an overarching description of the technical tasks that resident physicians perform on the job.

Task analyses of physicians and residents (Overhage, Perkins, Tierney, & McDonald, 2001; Schultz et al., 2006; Victores, Coggins, & Takashima, 2014; Weinger et al., 1994) have broken down major job tasks into various categories, including direct patient care (e.g., giving medication), indirect patient care (e.g., conversing with a nurse about a patient), and miscellaneous tasks (e.g., walking). Some (e.g., Schultz et al., 2006; Victores et al., 2014) have broken these categories down into more fine-grained classifications by considering job task categories such as physicians' manual work (e.g., performing procedures, such as giving medication; washing hands), conversational tasks (e.g., conversing with patient, conversing with team members), observing (e.g., checking patient vitals on machine), documenting or reading (e.g., filling out patient charts, reading nurse documentation), sending orders, miscellaneous tasks (e.g., walking), and teaching or reading educational materials. Regardless of the level of

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granularity employed, conclusions of these types of studies show that a large proportion of physicians' time is spent providing patient care. As such, performing patient care activities is a major component of job behaviors expected of and exhibited by physicians.

One set of patient care tasks that resident physicians engage in includes starting and stopping antibiotics within a certain number of hours before and after a patient undergoes a surgical procedure. In order to best prevent surgical infection, it is essential that these antibiotics are given within one hour of surgery, and discontinued within 24 hours after surgery (Bratzler et al., 2005; Classen et al., 1992; Polk, Trachtenberg, & Finn, 1980; Smith et al., 2012; Stone, Hooper, Kolb, Geheber, & Dawkins, 1976). While the provision and timing of surgical antibiotics are important job performance behaviors for resident physicians, they can be difficult for these novice physicians and are susceptible to non-completion when conditions are sub-optimal. For example, Tan, Naik, and Lingard (2006) conducted a qualitative study investigating reasons why medical providers do not always adhere to surgical antibiotic guidelines. Frequently, medical providers listed reasons such as lack of awareness; for example, one anesthesia provider stated: "…with different surgeons and different procedures, it will mean that I have to be aware of every service, every procedure they do and which ones are indicated for prophylactic antibiotics," (Tan et al., 2006, p. 35). This indicates that this task can at times induce a high cognitive load, which may prohibit physicians who are low on attentional capacity (due to fatigue) from completing this action.

Another patient care activity that residents must engage in includes planning for patient discharge. Discharge planning is an important predictor of patient outcomes (Shepperd et al., 2013) and is an indicator of a high-performing hospital (Cherlin et al., 2013). However, fatigue may make resident physicians more susceptible to errors in planning for patient discharge, as

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fatigue can impact cognitive processes essential to planning and communication, including memory, attention, and reasoning (Lim & Dinges, 2008; McCarthy & Waters, 1997; Ryman, Naitoh, & Englund, 1985; Turner, Drummond, Salamat, & Brown, 2007).

Importantly, surgical antibiotic timing and discharge planning are not the only job performance behaviors resident physicians engage in. However, these facets of job performance will be the focus of this study, given their importance to patient and hospital outcomes and their susceptibility to non-completion and poor performance under conditions of resident fatigue. To further confirm the extent to which these job performance tasks were subject to non-completion when fatigued and represented high cognitive load tasks for resident physicians, a questionnaire was sent to physicians (see Appendices B and C). This questionnaire first introduced the concept of cognitive load. Then, it listed each of the job performance task behaviors used in this study and asked about the extent to which each task induced a high cognitive load (i.e., required significant mental effort) for (a) PGY-1 residents and (b) PGY-2 residents and above, where $1 =$ very low and $7 =$ very high. Further, the questionnaire also asked physicians about the extent to which a resident who is fatigued or sleep deprived would fail to perform each job performance task. For this set of items, respondents could indicate a number between 1 and 7, where $1 =$ not at all likely and $7 =$ very likely.

Six physicians ($n = 6$) completed the measure. All respondents practiced in the United States and had between 12 and 35 years of experience as a physician ($M = 21.17$ SD $= 8.77$). Agreement on the items in this questionnaire was calculated using the $r*_{WG(J)}$ agreement index (Lindell, Brandt, & Whitney, 1999) using both a uniform and a slightly skewed distribution (LeBreton & Senter, 2008). For cognitive load of PGY-1 residents, the $r*_{WG(J)}$ was .57 and .29 when using the uniform and slightly skewed distributions, respectively. This indicates that

agreement was weak to moderate. For cognitive load of PGY-2 residents and above, the $r^*_{WG(J)}$ was .67 and .48 when using the uniform and slightly skewed distributions, respectively, indicating moderate agreement. The $r^*_{WG(J)}$ for the fatigue items was .79 and .69 when using the uniform and slightly skewed distributions, respectively, indicating high agreement. Importantly, having a small number of judges (i.e., fewer than 10) and a small number of items can attenuate agreement scores (Cohen, Doveh, & Eick, 2001; Kozlowski & Hattrup, 1992). Thus, these agreement indices may be stronger in reality.

Results of the questionnaire suggest that surgical antibiotic timing and discharge planning were moderately high cognitive load tasks for PGY-1 residents, $M = 4.58$, SD = 0.96, Mdn = 4.88, and moderately low cognitive load tasks for PGY-2 residents and above, $M = 3.08$, SD = 1.21, Mdn = 2.88. Further, physicians suggested that it was somewhat likely that residents would fail to complete these job performance tasks when fatigued or sleep deprived, $M = 3.54$, SD = 0.66, Mdn = 3.63. This suggests that these job performance behaviors are both somewhat complex skills for residents and have the potential for improvement due to lessened fatigue. See Table 2 for information at the item level.

Table 2. Results of physician questionnaire.

Item	Cognitive load, PGY-1 resident	Cognitive load, PGY-2 resident and above	Subject to non-completion when fatigued
Ordering an antibiotic for an outpatient having surgery at the right time (within one hour before surgery)	4.50 (1.64)	2.67 (1.51)	3.17 (1.17)
Ordering an antibiotic for a surgery patient at the right time (within one hour before surgery)	4.33 (1.63)	2.50 (1.38)	3.00 (1.10)
Ordering to stop a surgery patient's preventative antibiotics at the right time (within 24 hours after surgery)	4.50 (1.05)	3.00 (1.10)	4.33 (1.21)
Giving a heart failure patient discharge instructions	5.00 (1.79)	4.17 (1.60)	3.67 (1.21)

Note. Values in table represent Mean(SD). $n = 6$. Scale for cognitive load items ranges from 1 (very low) to 7 (very high). Scale for fatigue items ranges from 1 (not at all likely) to 7 (very likely).

Relationship between job performance and fatigue. Predictors of job performance include knowledge, skill, and motivation (W. C. Borman, White, Pulakos, & Oppler, 1991; Campbell et al., 1993; Schmidt, Hunter, & Outerbridge, 1986). In particular, in order to effectively perform a job task, one must: (1) have the ability to perform the task, (2) be motivated to perform the task, (3) have the necessary resources to perform the task, and (4) be able to perceive which tasks must be performed (Murphy, 1989). Fatigue is likely to impact job performance by posing deleterious effects to one's cognition, which can impact one's ability to perform a task.

With this in mind, various theories have been posited that can explain the impact of fatigue on job performance. For instance, Kahneman's (1973) resource theory suggests that a person has only a finite amount of attentional capacity, and these attentional resources can become depleted. Fatigue due to working long hours or sleep deprivation can lead one to start with a lower attentional capacity, and can more quickly deplete attentional capacity. Further, in alignment with Fitts' (1964) and Fitts and Posner's (1967) theory of skill acquisition, Kahneman's (1973) resource theory proposes that skills can become more automated over time. Such automaticity reduces the attentional capacity that the skill requires (Kahneman, 1973), as well as frees working memory (Schulz, Endsley, Kochs, Gelb, & Wagner, 2013). However, novices, such as PGY-1 residents, must invest more cognitive effort including working memory (Endsley, 1997), increasing the negative effects of fatigue for this group. These theories and an integration between them will be further discussed in the next subsection.

Figure 1 displays the model for the current study. Each link in this model will be explained in the following subsections.
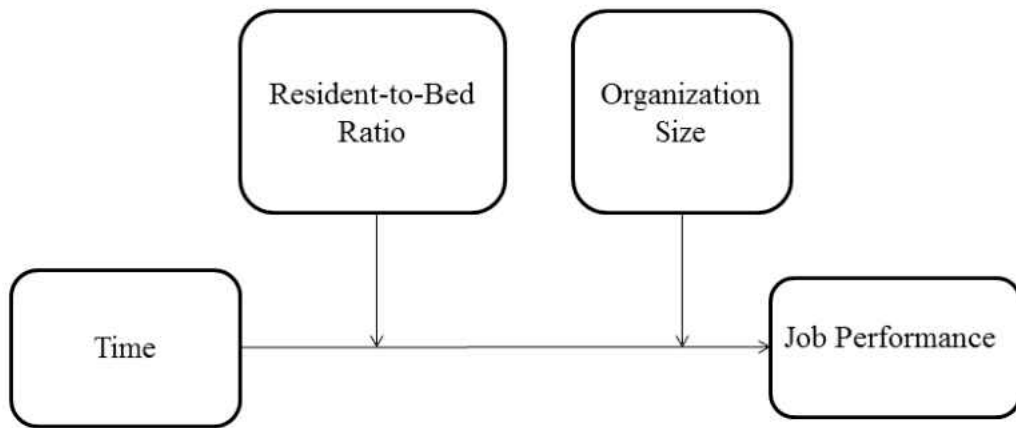
Figure 1. Model for the current study.

A Micro Perspective: Cognitive Theory

As previously stated, I examine hypotheses by taking both a micro and macro perspective. First, I discuss micro theories, investigating how fatigue can impact job performance via suboptimal cognition.

Dual process theories refer to theories in which phenomena can occur in two different ways. Along this line, scholars have discussed the idea that there are two forms of reasoning (e.g., Kahneman, 2003, 2011). Specifically, it is proposed that there is a rapid, intuitive and automatic form of reasoning, entitled System 1 (Kahneman, 2011). Additionally, there is said to be a deliberate, conscious, and more complex form of reasoning labeled System 2 (Kahneman, 2011). Kahneman (2011) suggests that System 1 is one's automatic and default mode of thinking, with people switching to System 2 when a problem is complex or something unexpected occurs. Being in System 1 mode is often considered ideal, as it allows people to engage in multiple tasks at once (e.g., driving while listening to the radio and engaging in a conversation). In contrast, System 2 requires more deliberate focus and is much less amenable to engaging in multiple tasks.

Most tasks do not simply and automatically fall into a System 1 or System 2 bucket for all people. Rather, reasoning about a particular task moves from a System 2 approach to a System 1 approach as a person gains knowledge and expertise with the particular task. Thus, one of the cognitive underpinnings of the two systems of reasoning is memory. As one gains expertise in a particular area, he or she develops and updates a knowledge structure in his or her long term memory (Glaser, 1999), facilitating improved System 1 reasoning. In particular, skill acquisition theory (Fitts, 1964; Fitts & Posner, 1967) suggests that there are three phases that one progresses through when learning a new skill. A person begins at a cognitive stage of skill

acquisition, wherein performance is slow and deliberate. One then moves into an associative phase wherein performance is less deliberate. Finally, one progresses into an autonomous phase wherein (s)he is an expert at the task and is able to devote fewer cognitive resources to the skill. Skill acquisition is typically a slow process, often occurring over thousands of hours or over a period of years of practice (Kahneman, 2011; Simon & Chase, 1973). As a person gains more experience and expertise with a particular task or subject, the person moves from a more deliberate phase of action to a more automatic phase wherein fewer cognitive resources are required (Fitts, 1964; Fitts & Posner, 1967). In terms of dual process theory, the person progresses from System 2 to System 1 reasoning as the skill is acquired (Kahneman, 2011). Novices must allocate more attention to a task than experts, who can perform the task without allocating much attentional capacity towards it (Kahneman, 2011). That is, novices must use more resources in comparison to experts.

Additionally, Kahneman (1973; 2011) suggests that people have a limited capacity for attention. For instance, Kahneman (2011) suggests the phrase "pay attention" is telling, in that it reaffirms the idea that there is a limited budget for attention. Attention is therefore considered to be the allocation of one's capacity to certain tasks or stimuli. Importantly, complex and dynamic environments—such as healthcare—can rapidly tax one's limited attention span (Endsley, 1997). Further, tasks can vary on the extent to which they require cognitive resources (Kahneman, 1973). More specifically, tasks can be automatic, wherein they do not require much attention. This is similar to the System 1 described by Kahneman (2011). Alternatively, tasks may be controlled, wherein they require high levels of attention to complete, similar to System 2 processes (Kahneman, 2011). As previously stated, a major driver of whether a task is automatic or controlled has to do with one's expertise with the task.

Because fatigue can limit attentional capacity, is an important consideration for job performance because it implies that one must prioritize the stimuli or tasks to which one should allocate his or her attention. This is particularly important for novices, such as PGY-1 residents, who must use more attentional capacity to deliberately complete job tasks, in comparison to experts who can successfully complete tasks automatically using less attentional capacity.

Specifically, there are four cognitive stages that a person must undergo in order to correctly carry out an action at the right time, place, and in the right order (Reason, 2008). These four stages include: (1) plan formulation, wherein one creates an intention to carry out an act at a certain place and time, in order to achieve a goal; (2) intention storage, wherein a person stores this intention in their memory and reactivates it at the right time and place; (3) execution, wherein one begins and performs the planned action; (4) monitoring, wherein one periodically checks to ensure that the action is proceeding as intended (Reason, 2008). Errors are defined as "those occasions in which a planned sequence of mental or physical activities fails to achieve its intended outcome, and when these failures cannot be attributed to the intervention of some chance agency," (Reason, 1990, p. 9). More specifically, Reason (1990) specifies that errors take on two primary forms: planning failures (i.e., mistakes) and execution failures (i.e., slips and lapses). Mistakes are failures in planning; that is, mistakes are defined as inadequate judgment or selection of processes of a goal or the steps needed to achieve a goal (Reason, 1990). Mistakes can therefore occur regardless of whether or not a series of actions goes according to plan (Reason, 1990). Slips and lapses on the other hand, are failures in carrying out a plan; thus, they occur due to a failure of the execution or storage phase of a series of actions, regardless of whether or not the plan was adequate (Reason, 1990).

While performance errors can occur at any level of expertise, they happen most often in the beginning (i.e., cognitive) phase of skill acquisition (Fitts & Posner, 1967; Reason, 1990). This may be because performance on complex tasks is particularly prone to effects of fatigue (Folkard & Monk, 1985), as fatigue depletes cognitive resources necessary for deliberate task performance such as reasoning, working memory, and attention (Lim & Dinges, 2008; McCarthy & Waters, 1997; Parasuraman, 1985; Ryman et al., 1985; Turner et al., 2007). For instance, Landrigan et al. (2004) found a six-fold increase in diagnostic errors for PGY-1 residents working shifts greater than or equal to 24 hours when compared to PGY-1 residents working shifts that were limited to 16 hours. Therefore, improving fatigue will likely improve job performance for these novice learners.

Figure 2 is a graphical representation of the process of fueling up a car. This process is conceptually similar to the cognitive processes underlying job performance. First, one's level of fatigue—which is higher pre-intervention—determines how much attentional capacity (i.e., gasoline) one has. This gasoline is poured into the car's gas tank to allow for task completion. However, different amounts of gasoline are necessary for sufficient task completion, depending on the task complexity.

When one has limited gasoline (i.e., attentional capacity) available, one can successfully complete only simple job performance tasks—tasks that are in one's System 1 arsenal. However, healthcare providers—including PGY-1 residents—are called upon to complete whatever job performance tasks are required for a patient, regardless of whether the provider is a novice or expert at the task, and regardless of whether or not (s)he is fatigued. This produces the potential for suboptimal job performance when a novice is required to complete a difficult job task while fatigued.

Expanding on this idea further, hospitals vary on the number of residents that are employed, and more importantly, the ratio of residents to patient beds (referred to throughout this paper as the *resident-to-bed ratio*). Those with a higher ratio should have a higher proportion of fatigued employees before the intervention, leading to poorer job performance at the organizational level. Returning to the car example, this is similar to the proportion of fatigued drivers on a given road in comparison to the number of passengers on the road. When there are more fatigued drivers, overall driving performance for a given road, across all drivers, is likely to be poorer in comparison to a road wherein very few of the drivers are fatigued. This increases the likelihood that poor performance will affect a given passenger on the road. As such, I hypothesize:

> *Hypothesis 1: Hospitals with a higher resident-to-bed ratio will have worse employee job performance before the intervention in comparison to hospitals with a lower resident-to-bed ratio.*

Type of car = Organizational size

Large

Small

Fatigued drivers on the road
Resident-to-bed ratio

Low

High

FATIGUED
Pre-intervention

NON-FATIGUED
Post-Intervention

Gas can =
Residents'
attentional
capacity pre- and
post-intervention

HIGH
Cognitive Phase; System 2

LOW
Associative Phase; System 1

Gas tank = Technical
performance resource
intensity
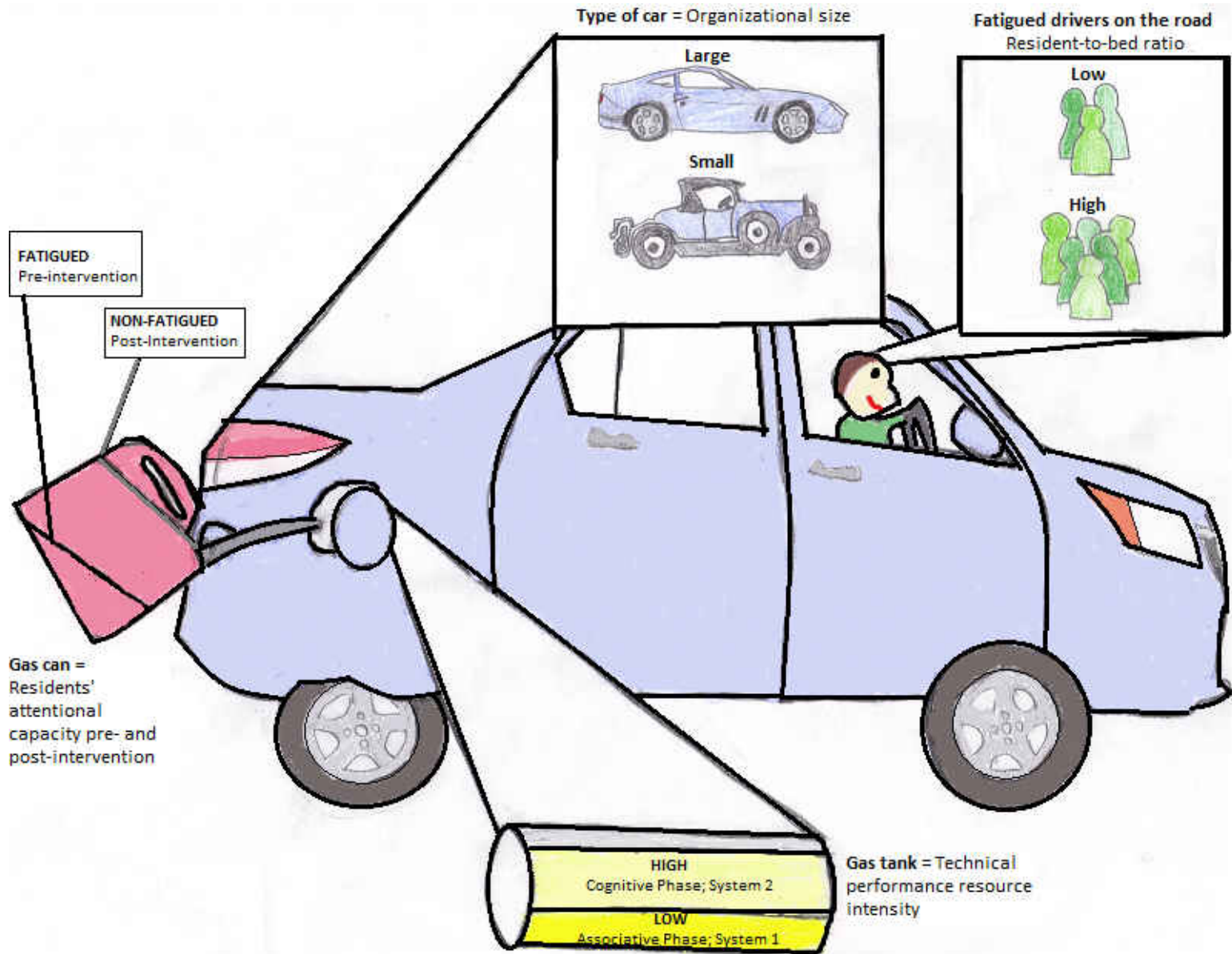
Figure 2. Integration of dual process theory (Kahneman, 2003; 2011), attentional capacity

(Kahneman, 1973; 2011), and skill acquisition theory (Fitts, 1964; Fitts & Posner, 1967). This

figure shows the idea that one's attentional capacity gasoline is lower when fatigued (i.e., pre-

intervention), starting them off with fewer resources to fill the technical performance resource

intensity gas tank. As will be explained, resident-to-bed ratio is represented by the number of

drivers on the road, and organizational size is represented by the type of car driven.

Further, given that the resident-to-bed ratio differs between hospitals, hospitals received different relative amounts of the fatigue intervention. The higher a hospital's resident-to-bed ratio, the proportionally greater impact the intervention should have, as it impacts a larger proportion of people and processes within the organization. Returning to the concepts in Figure 2, this is similar to the idea that roads with a higher proportion of fatigued drivers have greater room for improvement on driving performance in comparison to roads with proportionally fewer fatigued drivers. In some prior studies of ACGME fatigue interventions, researchers have found evidence for this. For example, Volpp et al. (2007) found that hospitals with a higher resident-to-bed ratio had greater improvements in mortality rates than hospitals with a lower resident-to-bed ratio after the 2003 ACGME intervention. As such, I hypothesize:

> *Hypothesis 2: Hospitals with a higher resident-to-bed ratio will have a greater improvement in employee job performance over time in comparison to hospitals with a lower resident-to-bed ratio.*

A Macro Perspective: Organizational Change

It is also important to consider the impact that the organization has on implementation of organizational interventions. Thus, I also take a macro perspective in this dissertation.

An important consideration when investigating the impact of an organizational intervention is organizational change. The organizational change literature distinguishes between two sources of organizational change: determinism, wherein change is stimulated by forces external to an organization, and managerial choice, wherein it is assumed that managers can choose the strategies used to anticipate change (Martins, 2011). The fatigue intervention that is the focus of this study falls more within the determinism bucket, as it was a mandate by an

organization external to individual hospitals. An important theory within the determinism bucket is neo-institutional theory, which posits that organizations (e.g., individual hospitals) adapt to their institutions (e.g., the healthcare industry) to achieve legitimacy (DiMaggio & Powell, 1983; Meyer & Rowan, 1977). According to neo-institutional theory, there are three forces that drive organizational change: coercive isomorphism, normative isomorphism, and mimetic isomorphism (DiMaggio & Powell, 1983). Particularly relevant to the current study is coercive isomorphism, which drives change due to demands of powerful, external forces (e.g., legal authorities, accrediting boards, etc.). Given the mandated nature of the fatigue intervention, the change undergone by these organizations is most likely coercive isomorphism. As such, in this case it is less important to focus on *whether* the organizations implemented the change; but rather, *how* organizations adapted to the change. Understanding what hospitals have done to adapt to this change is an important step in predicting how the change will impact performance over time.

Organizational characteristics may therefore moderate the effectiveness of an intervention, and one important characteristic is organizational size, which can be considered a proxy for organizational resources (Piening et al., 2013). Again returning to Figure 2, this can be thought of similarly to the type of car that the gasoline is fueling. While adding more gasoline (i.e., attentional capacity) to a car's gas tank can allow for improved performance, the impact of this gasoline on performance is impacted by the features of the car. For example, a brand new luxury vehicle with enhanced fuel economy features will allow for a stronger impact of the gasoline in comparison to an old 1990s gas-guzzling car.

As suggested by a recent study in the *Journal of Applied Psychology,* hospital size may be an important organizational characteristic (Piening et al., 2013). Specifically, "larger hospitals may have an advantage over smaller ones by having more resources…" (Piening et al., 2013, p. 934). More resources can allow for more and better options for hospitals to adjust to the changes necessary due to the intervention. For example, larger hospitals are likely to have a larger staff or a more sophisticated selection system (Piening et al., 2013), allowing for additional patient coverage by non-resident physicians after the intervention. Thus, larger hospitals are more likely to have more improvement and to improve more rapidly in comparison to smaller hospitals.

Hypothesis 3: Employees' job performance will improve (a) significantly more from pre-to post-intervention and (b) more rapidly in large hospitals, in comparison to small hospitals, and these effects will be more pronounced for hospitals with a higher resident-to-bed ratio.

Further, timing is a central feature of organizational change. While there is likely to be some immediate effect of the intervention, the effects may also continue to develop over time as employees and the organization adjust to new policies, procedures, and practices. At an organizational level, Lewin (1947) proposed that organizational change occurs in three phases: (1) unfreezing the organization and preparing it for change, (2) moving, or making the change, and (3) refreezing the organization into the new norms by modifying procedures and policies. At an individual level, there tends to be resistance and inertia when organizational change occurs (Scott, Ruef, Mendel, & Caronna, 2000). For instance, Jaffe, Scott, and Tobe (1994) propose four phases that people go through when responding to organizational change (1) denial, in which the necessity of the change is questioned, (2) resistance, in which the change is avoided, (3) exploration, wherein the new behaviors are attempted and compared to old behaviors, and finally (4) commitment, wherein the new behaviors are embraced. In anticipation of and in the

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early stages of the 2011 ACGME intervention, many healthcare providers seemed to be in the denial stage. For example, a qualitative study on fatigue culture found that surgeons believe that fatigue has only minor consequences and is an essential component to training residents (Coverdill, Bittner, Park, Pipkin, & Mellinger, 2011). Additionally, various editorials in the medical literature (e.g., Ryan et al., 2011; M. C. Singer, 2010) have lambasted the 2003 and 2011 reforms, and numerous survey studies (e.g., Abraham et al., 2006; Cohen-Gadol et al., 2005; Gallagher et al., 2005; Jagannathan et al., 2009; Underwood et al., 2004; Winslow et al., 2004) show that physicians have been resistant to both 2003 and 2011 reforms.

Regardless of physician denial and resistance, these changes were unavoidable, as residency programs' continued accreditation was contingent upon the implementation of the fatigue intervention on July 1, 2011. Along these lines, it is likely that the intervention was begun as mandated across all teaching hospitals. As previously stated, prior to the intervention, 94% of residency programs reported that their first-year residents did not currently adhere to at least some of the major standards required by the 2011 fatigue intervention (Antiel et al., 2010). Therefore, I expect to see an increase in job performance within the first year of the intervention.

However, as previously alluded to, there is likely a continued improvement over time, as employees and organizations continue on to more advanced phases of change (e.g., moving, refreezing, exploration, commitment). Further, the organizations can continue to perfect new policies, practices, and procedures over time. Various studies provide insight on the mechanisms hospitals have used to adapt to the fatigue intervention. For instance, Ferguson, Kellogg, Hutter, and Warshaw (2005) created a night float system in response to the similar 2003 ACGME changes and found that it was beneficial in maintaining high levels of resident surgical experience while simultaneously bringing resident work hours into the mandated guidelines.

Additionally, Long, Poe, Zimmerman, and Rose (2012) discussed the creation and use of a program that tracked duty hour noncompliance citations within a hospital and facilitated a hospital review and plan for correction for these citations. Blum, Shea, Czeisler, Landrigan, and Leape (2011) recommended the use of simulation-based training to boost resident learning curves, accounting for buffer time for educational opportunities and fulfilment of patient responsibilities when creating resident schedules, and budgeting for additional compensation for attending physician responsibility and time.

As the processes described above (i.e., introducing night float, developing noncompliance systems, developing simulation-based training, changing compensation systems) take time to implement and refine, the full benefits of the intervention may not be immediately apparent. Further, organizations may need time to procure the necessary resources (i.e., money, training, additional staffing) to implement these processes. It is likely that the organizations need time to adapt to the change and adjust any processes that are not working as expected. In essence, the first years may act as a trial period, allowing organizations to refine processes for the following years. This may lead to further improvements in job performance over time.

Alternatively, it is possible that job performance will decrease after the first post-intervention period. For example, it is well-known in the organizational training domain that in order for the impact of training to be sustained, organizations and managers must continue to reinforce policies, practices, and procedures that encourage use of trained behaviors (e.g., conducting refresher training, integrating training into performance appraisals, sending clear signs and messages that the training is rewarded, etc.) (Salas, DiazGranados, Weaver, & King, 2008). Without these sustainment efforts, the impact of training can decline sharply over time (Arthur, Bennett, Stanush, & McNelly, 1998). This logic has been extended to the broader topic

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of organizational change efforts, with one study finding that deliberate sustainment efforts must be enacted in order to maintain organizational change initiatives over time (Brimstin, 2014). However, the literature on the 2011 ACGME fatigue intervention is largely void of mention of such sustainment efforts. In the absence of sustainment efforts, it seems logical that job performance may decline over time after an initial improvement.

Therefore, while I expect an initial improvement in job performance, it is unknown whether job performance will continue to improve or will decrease after the first post-intervention period. Further, it is unknown whether improvement in job performance due to the intervention will be abrupt or gradual. As such, I pose the following questions:

Research Question 1: Does job performance improve or decrease after post-intervention year 1?

Research Question 2: Is change in job performance due to the intervention abrupt or gradual?

Table 3 lists the hypotheses in tabular format. In sum, I expect to find trajectories similar to that in Figure 3 and Figure 4.

Table 3. Hypotheses.

Overarching Question	Hypotheses
1. Difference in baseline job performance between hospitals	**Hypothesis 1**: Hospitals with a higher resident-to-bed ratio will have worse employee job performance before the intervention in comparison to hospitals with a lower resident-to-bed ratio.
2. Impact of intervention on job performance	**Hypothesis 2:** Hospitals with a higher resident-to-bed ratio will have a greater improvement in employee job performance over time in comparison to hospitals with a lower resident-to-bed ratio.
3. Organizational characteristics as moderators	**Hypothesis 3:** Employees' job performance will improve (a) significantly more from pre- to post-intervention and (b) more rapidly in large hospitals, in comparison to small hospitals, and these effects will be more pronounced for hospitals with a higher resident-to-bed ratio.
4. Change over time	**Research Question 1:** Does job performance improve or decrease after post-intervention year 1?
	Research Question 2: Is change in job performance due to the intervention abrupt or gradual?
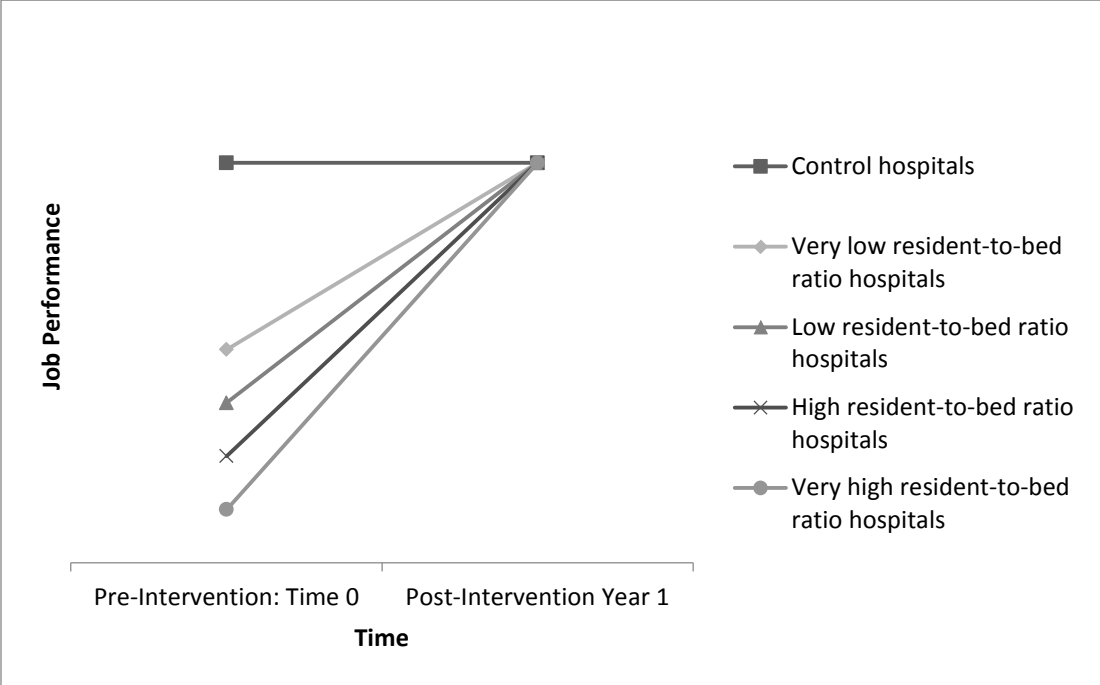
Figure 3. Hypothesized change trajectories from pre- to post-intervention, displaying change over time and the moderator of resident-to-bed ratio.
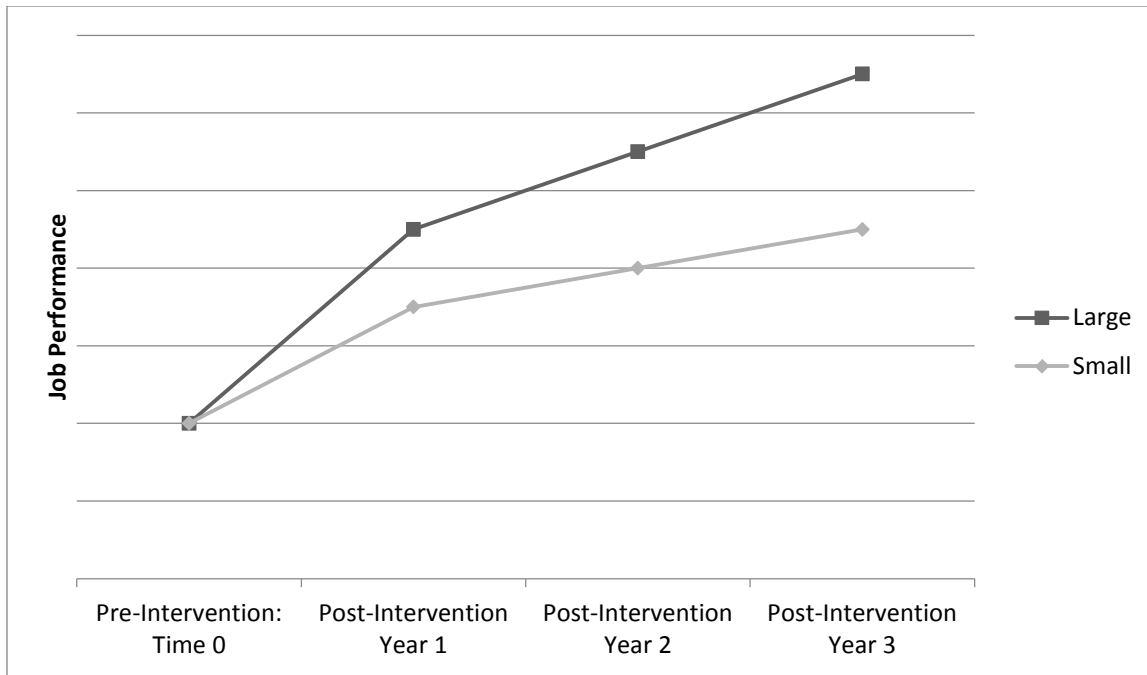
Figure 4. Hypothesized change trajectory for the post-intervention period, comparing small organizations to large organizations. Note: This graph assumes that job performance continues to improve after post-intervention year 1, and that change is abrupt and then gradual; however, these assumptions are tested in Research Questions 1 and 2.

CHAPTER THREE: METHODOLOGY

Sample and Data Cleaning

Public use data at the hospital level from Centers for Medicare and Medicaid Services (CMS; cms.gov) was used to examine these hypotheses. These datasets provide information on hospital characteristics, processes, and outcomes across the thousands of hospitals that accept Medicare payments in the United States. Upon investigation of the data, I found that many organizations reported results on the basis of only a few patients. This occurred most commonly when the total number of patients in a hospital who met the criteria was very few (e.g., perhaps there were only two patients at a hospital in a given year who were heart failure patients and were discharged; thus precluding a large sample size for this hospital for item 4 on the job performance scale). In order to improve the quality of the data and avoid cases based on small sample size having undue influence on results, I selected out cases that did not meet minimum sample size criteria. Because Time 1 was the most common year for small sample sizes, and because I found that hospitals who had small sample sizes in time 1 often had this same issue in subsequent time points, I selected out cases in the following manner: To be included in analyses, hospitals had to have at least a sample size on the 50th percentile for each of the four items on time 1. The 50th percentile sample size at time 1 was 136.50, 222.00, 212.00, and 98.00 for items 1-4, respectively. Selecting out cases in this manner leaves 1,277 hospitals for a total of 6,385 data points.

After selecting out cases with items computed on the basis of small sample sizes, 1,277 hospitals remained. Approximately forty-seven percent ($n = 594$) were control hospitals (i.e., had no resident physicians on staff) and 53.5% ($n = 683$) were intervention hospitals (i.e., employed resident physicians). Among intervention hospitals, there were 112.68 residents on average (SD

= 168.13, *Mdn* = 40.41). These descriptive statistics and all analyses described below were

conducted on the subset of 1,277 hospitals.

Measures

Job Performance

Job performance was operationalized as the extent to which four job performance

behaviors occurred, including: "Percentage of outpatients having surgery who got an antibiotic at

the right time (within one hour before surgery)," "percentage of surgery patients who got an

antibiotic at the right time (within one hour before surgery)," "percentage of surgery patients

whose preventative antibiotics were stopped at the right time (within 24 hours after surgery),"

and percentage of "heart failure patients given discharge instructions." These items covered

behaviors within the technical performance dimension of job performance. As previously stated,

the level of analysis was organizational job performance.

The information for these items was entered by each hospital into a system entitled CMS

Abstraction and Reporting Tool (CART; see CMS, 2015). From this system, the data were

submitted to CMS by each hospital. Scoring of these items was on a 1-100 scale, with numbers

representing the percent of eligible patients who met the criterion of interest.

Resident-to-Bed Ratio

To calculate hospitals' resident-to-bed ratio, I followed a process used by others (e.g.,

Patel et al., 2014). Specifically, I calculated the ratio of residents to patient beds. Patel et al.

(2014) defines the following criteria: 0 = control hospital; >0 to <0.05 = very low resident-to-bed

ratio hospital; 0.05 to <0.25 = low resident-to-bed ratio hospital; 0.25 to <0.60 = high resident-

to-bed ratio hospital; ≥0.60= very high resident-to-bed ratio hospital. Control hospitals were

coded as 0, very low resident-to-bed ratio hospitals were coded as 1, low resident-to-bed ratio hospitals were coded as 2, high resident-to-bed ratio hospitals were coded as 3, and very high resident-to-bed ratio hospitals were coded as 4. One-hundred seventy-four intervention hospitals (13.60% of all hospitals; 25.48% of intervention hospitals) had a very low resident-to-bed ratio, 287 (22.5%, 42.02%) had a low resident-to-bed ratio, 143 (11.2%, 20.94%) had a high resident-to-bed ratio, and 79 (6.2%, 11.57%) had a very high resident-to-bed ratio.

The information used for this calculation was obtained from annual Medicare Cost Reports (CMS, 2011). The 2011 cost report was used.

Organizational Size

Similar to previous hospital research in the applied psychology domain (Piening et al., 2013), organizational size was operationalized by the number of patient beds. Organizational size (i.e., number of beds) ranged from 32 to 2068, with an average of 337.40 (SD = 211.43) and a median of 282.00. Because there is no true 0 in the sample, organizational size was centered for analyses. The information used for this calculation was obtained from annual Medicare Cost Reports (CMS, 2011). The 2011 cost report was used.

<div align="center">

Analyses

</div>

Structure of Data

Following the logic of Raudenbush and Bryk (2002) and Anderson (2012), I used a piecewise coding structure. This allowed for comparison of different parts of the model, which is necessary when utilizing discontinuous growth modeling. The coding structure with data from two hypothetical participants is shown in Table 4. Specifically, the pre-intervention parameter was coded as 0, 1, 1, 1, 1. This was done because there was no theoretical reason to expect any

change in job performance in the pre-intervention period; rather, I expected job performance to

be stable during this time period. Thus, the coding scheme of 0, 1, 1, 1, 1 (in contrast to a

sequential set of numbers such as 0, 1, 2, 3, 4) allowed for examination of absolute change due to

the intervention rather than change relative to a trend in the pre-intervention period. The

transition parameter was dummy coded as 0, 0, 1, 1, 1 to indicate time before and after in the

intervention took place. The post-intervention parameter was coded as 0, 0, 1, 2, 3 to indicate

absence during the pre-intervention period. The distal post parameter was coded as 0, 0, 0, 1, 1 to

allow for examination of a second, more distal, transition in order to answer questions regarding

change over time. The abrupt transition (0, 0, 3, 3, 3) and abrupt post (0, 0 3, 6, 9) parameters

were used only in answering Research Question 2.

Table 4. Structure of the data for two hypothetical hospitals.

id	Time	Pre	Trans-ition	Post	Dis-tal Post	Abrupt Trans-ition	Abrupt Post	Mean of Job Perfor-mance Items 1-4	Org Size	Org Size Centered	Number of Residents	Number of Residents/ Number of Beds	Resident-to-Bed Ratio Categoric-al
1	1	0	0	0	0	0	0	92	353	321	0	0.00	0
1	2	1	0	0	0	0	0	93	353	321	0	0.00	0
1	3	1	1	1	0	3	3	95	353	321	0	0.00	0
1	4	1	1	2	1	3	6	96	353	321	0	0.00	0
1	5	1	1	3	1	3	9	97	353	321	0	0.00	0
2	1	0	0	0	0	0	0	91	1200	1177	750	0.64	4
2	2	1	0	0	0	0	0	92	1200	1177	750	0.64	4
2	3	1	1	1	0	3	3	95	1200	1177	750	0.64	4
2	4	1	1	2	1	3	6	96	1200	1177	750	0.64	4
2	5	1	1	3	1	3	9	99	1200	1177	750	0.64	4

Note. Org = organizational

Analysis of Hypotheses

This subsection repeats my hypotheses and describes how they were analyzed.

Hypothesis 1: Hospitals with a higher resident-to-bed ratio will have worse employee job performance before the intervention in comparison to hospitals with a lower resident-to-bed ratio.

Hypothesis 1 was analyzed using an ANOVA with Tukey post hoc tests to examine job performance at time 1 among hospitals at different resident-to-bed ratios.

Hypothesis 2: Hospitals with a higher resident-to-bed ratio will have a greater improvement in employee job performance over time in comparison to hospitals with a lower resident-to-bed ratio.

Hypothesis 2 uses discontinuous growth modeling and follows equations 1-6:

$$Y_{ti} = \pi_{0i} + \pi_{1i}PRE_i + \pi_{2i}TRANS_i + \pi_{3i}POST_i + \pi_{4i}DISTPOST_i + \varepsilon_{ij} \qquad (1)$$

$$\pi_{0i} = \gamma_{00} + \zeta_{0i} \qquad (2)$$

$$\pi_{1i} = \gamma_{10} + \zeta_{1i} \qquad (3)$$

$$\pi_{2i} = \gamma_{20} + \zeta_{2i} \qquad (4)$$

$$\pi_{3i} = \gamma_{30} + \zeta_{3i} \qquad (5)$$

$$\pi_{4i} = \gamma_{40} + \zeta_{4i} , \qquad (6)$$

where t= time, i =hospital, Yti= job performance at time t for hospital I; PRE=Pre-intervention, TRANS=Transition (i.e., the intervention), POST= Post-intervention (i.e., times 3-5), DISTPOST= Distal post-intervention (i.e., time 4 and 5).

I first computed the intraclass correlation coefficient (ICC) on the null model. Then, I used equations 1-6 to follow the steps outlined in Bliese (2013) and Bliese and Ployhart (2002)

to find the best-fitting model. That is, I tested a null model against a model where only the intercept is allowed to vary, against additional models each subsequently freeing additional parameters (intercept, pre, transition, post, distal post). Continuing the logic of Bliese (2013) and Bliese and Ployhart (2002), I chose the model that fits best, and used this model to test for autocorrelation and heteroscedasticity in within-group errors.

Next, I added level 2 predictors, as seen in equations 7-12:

$$Y_{ti} = \pi_{0i} + \pi_{1i}PRE_i + \pi_{2i}TRANS_i + \pi_{3i}POST_i + \pi_{4i}DISTPOST_i + \varepsilon_{ij} \qquad (7)$$

$$\pi_{0i} = \gamma_{00} + \zeta_{0i} \qquad (8)$$

$$\pi_{1i} = \gamma_{10} + \zeta_{1i} \qquad (9)$$

$$\pi_{2i} = \gamma_{20} + \gamma_{21}RBR + \zeta_{2i} \qquad (10)$$

$$\pi_{3i} = \gamma_{30} + \gamma_{31}RBR + \zeta_{3i} \qquad (11)$$

$$\pi_{4i} = \gamma_{40} + \gamma_{41}RBR + \zeta_{4i}, \qquad (12)$$

where t= time, i =hospital, Yti= job performance at time t for hospital I; PRE=Pre-intervention, TRANS=Transition (i.e., the intervention), POST= Post-intervention (i.e., times 3-5), DISTPOST= Distal post-intervention (i.e., time 4 and 5), RBR=Resident-to-bed ratio.

Specifically, I examined whether the interaction between resident-to-bed ratio and transition as well as the interactions between resident-to-bed ratio and post and between resident-to-bed ratio and distal post were significant in the predicted direction. This allowed me to determine whether treatment hospitals improve at these time points significantly more in comparison to control hospitals.

Hypothesis 3: Employees' job performance will improve (a) significantly more from pre-to post-intervention and (b) more rapidly in large hospitals, in comparison to small hospitals, and these effects will be more pronounced for hospitals with a higher resident-to-bed ratio.

To analyze hypothesis 3, I used equations 13-18 to look for significant main effects and interactions of organizational size:

$$Y_{ti} = \pi_{0i} + \pi_{1i}PRE_i + \pi_{2i}TRANS_i + \pi_{3i}POST_i + \pi_{4i}DISTPOST_i + \varepsilon_{ij} \quad (13)$$

$$\pi_{0i} = \gamma_{00} + \zeta_{0i} \quad (14)$$

$$\pi_{1i} = \gamma_{10} + \zeta_{1i} \quad (15)$$

$$\pi_{2i} = \gamma_{20} + \gamma_{21}TI + \gamma_{22}OS + \gamma_{23}(OS * RBR) + \zeta_{2i} \quad (16)$$

$$\pi_{3i} = \gamma_{30} + \gamma_{31}TI + \gamma_{32}OS + \gamma_{33}(OS * RBR) + \zeta_{3i} \quad (17)$$

$$\pi_{4i} = \gamma_{40} + \gamma_{41}TI + \gamma_{42}OS + \gamma_{43}(OS * RBR) + \zeta_{4i}, \quad (18)$$

where t= time, i =hospital, Yti= job performance at time t for hospital I; PRE=Pre-intervention, TRANS=Transition (i.e., the intervention), POST= Post-intervention (i.e., times 3-5), DISTPOST= Distal post-intervention (i.e., time 4 and 5), RBR= Resident-to-bed ratio, OS=organizational size (centered).

Research Question 1: Does job performance improve or decrease after post-intervention year 1?

Research Question 1 was answered by using equations 19-24, in particular by examining the significance and the direction of the distal post parameter and the interaction between distal post and resident-to-bed ratio in equation 24.

$$Y_{ti} = \pi_{0i} + \pi_{1i}PRE_i + \pi_{2i}TRANS_i + \pi_{3i}POST_i + \pi_{4i}DISTPOST_i + \varepsilon_{ij} \quad (19)$$

$$\pi_{0i} = \gamma_{00} + \zeta_{0i} \quad (20)$$

$$\pi_{1i} = \gamma_{10} + \zeta_{1i} \tag{21}$$

$$\pi_{2i} = \gamma_{20} + \gamma_{21}RBR + \zeta_{2i} \tag{22}$$

$$\pi_{3i} = \gamma_{30} + \gamma_{31}RBR + \zeta_{3i} \tag{23}$$

$$\pi_{4i} = \gamma_{40} + \gamma_{41}RBR + \zeta_{4i}, \tag{24}$$

where t= time, i =hospital, Yti= job performance at time t for hospital I; PRE=Pre-intervention, TRANS=Transition (i.e., the intervention), POST= Post-intervention (i.e., times 3-5), DISTPOST= Distal post-intervention (i.e., time 4 and 5), RBR= Resident-to-bed ratio.

Research Question 2: Is change in job performance due to the intervention abrupt or gradual?

To answer Research Question 2, I took multiple approaches. First, I compared two separate models: a gradual change model (which follows equations 1-6) and an abrupt change model (equations 25-29). This allowed me to compare the AICs, with the lowest AIC indicating the best fitting model. Next, I examined of graphs of the change trajectories to visually determine whether change was abrupt or gradual. Additionally, I examined the beta coefficients of the parameters to better understand the magnitude of change over time.

$$Y_{ti} = \pi_{0i} + \pi_{1i}PRE_i + \pi_{2i}ABRUPTTRANS_i + \pi_{3i}ABRUPTPOST_i + \varepsilon_{ij} \tag{25}$$

$$\pi_{0i} = \gamma_{00} + \zeta_{0i} \tag{26}$$

$$\pi_{1i} = \gamma_{10} + \zeta_{1i} \tag{27}$$

$$\pi_{2i} = \gamma_{20} + \zeta_{2i} \tag{28}$$

$$\pi_{3i} = \gamma_{30} + \zeta_{3i} \tag{29}$$

where t= time, i =hospital, Yti= job performance at time t for hospital I; PRE=Pre-

intervention, ABRUPTTRANS=Abrupt Transition (i.e., abrupt change at the intervention),

ABRUPTPOST=Abrupt change Post-intervention (i.e., times 3-5).

CHAPTER FOUR: RESULTS

Correlations

I first conducted correlations of each of the variables. See Table 5.

Table 5. Reliabilities and correlations among study variables.

	1	2	3	4	5	6	7
1. Job Performance, Time 1	.62						
2. Job Performance, Time 2	.77**	.52					
3. Job Performance, Time 3	.57**	.76**	.57				
4. Job Performance, Time 4	.48**	.60**	.73**	.54			
5. Job Performance, Time 5	.39**	.48**	.52**	.67**	.46		
6. Resident-to-bed ratio	-.06*	-.07*	-.06*	-.06*	-.05	-	
7. Organizational size (centered)	-.09**	-.06*	-.04	-.05	-.01	.44**	-

Note. *p <.05, **p <.01. Values in the diagonal represent Cronbach's alphas.

Baseline Job Performance

Hypothesis 1, which stated that hospitals with a higher resident-to-bed ratio would have lower baseline employee job performance in comparison to hospitals with a lower resident-to-bed ratio, was examined using a one-way ANOVA with Tukey post-hoc tests. This analysis was conducted with SPSS version 22 (IBM, 2013). The overall model was significant, $F(4, 1272) = 4.28$, $p < .01$. Further, Tukey HSD post-hoc tests revealed that hospitals with the highest resident-to-bed ratio had significantly worse job performance at baseline in comparison to all other hospitals (see Table 6). However, no other groups differed significantly on baseline job performance. Thus, Hypothesis 1 was partially supported.

Table 6. Results of Tukey HSD post-hoc comparisons for baseline job performance.

Reference Group	Comparison Group	Mean Difference
Control hospitals	Very low resident-to-bed ratio	0.26
	Low resident-to-bed ratio	0.10
	High resident-to-bed ratio	-0.22
	Very high resident-to-bed ratio	1.81**
Very low resident-to-bed ratio	Control hospitals	-0.26
	Low resident-to-bed ratio	-0.16
	High resident-to-bed ratio	-0.48
	Very high resident-to-bed ratio	1.55*
Low resident-to-bed ratio	Control hospitals	-0.10
	Very low resident-to-bed ratio	0.16
	High resident-to-bed ratio	-0.32
	Very high resident-to-bed ratio	1.71**
High resident-to-bed ratio	Control hospitals	0.22
	Very low resident-to-bed ratio	0.48
	Low resident-to-bed ratio	0.32
	Very high resident-to-bed ratio	2.03**
Very high resident-to-bed ratio	Control hospitals	-1.81**
	Very low resident-to-bed ratio	-1.55*
	Low resident-to-bed ratio	-1.71**
	High resident-to-bed ratio	-2.03**

Note. *p < .05, **p < .01.

Effect of Intervention Step 1: Level 1 Analyses

Hypotheses 2-3 and Research Questions 1 and 2 were tested using discontinuous growth modeling using the nlme package (Pinheiro, Bates, DebRoy, & Sarkar, 2014) in R (R Core Team, 2014). The first step of the discontinuous growth modeling process is to test models with constrained parameters against models wherein parameters are subsequently freed to vary. The best fitting model, indicated by the smallest -2 Log Likelihood and a significant p-value, is to be retained for successive analyses and subsequent hypothesis tests.

Before proceeding further, I examined the intraclass correlation coefficient, ICC(1), on the null model. This was done by dividing the intercept variance (between-hospital variance) by the sum of the intercept variance and the residual (within-hospital variance) (Bliese & Ployhart, 2002). I found that a moderate amount, 35%, of the variance in job performance over time can be attributed to hospitals (ICC[1]= .35).

Next, a model was fit with no free parameters (Model 1). This model was compared to a model wherein the intercept was permitted to vary (Model 2). Model 2 fit significantly better than Model 1 (see Table 7); thus, Model 3, which allowed the intercept and the pre-intervention period to vary, was tested against Model 2. Model 3 fit significantly better. Models 4, 5, and 6 similarly allowed these parameters as well as subsequent parameters (transition, post, distal post, respectively) to vary. Models 4 and 5 each fit significantly better than their predecessor; however, Model 5 and Model 6 failed to converge indicating that these two models may be overfit (Bliese, McGurk, Thomas, Balkin, & Wesensten, 2007). Further, these models still failed to converge when increasing the number of iterations. Therefore, comparisons with Models 5 and 6 are not meaningful. As such, I retained Model 4 as the best fitting model, thereby only allowing the intercept, pre-intervention, and transition parameters to vary in successive analyses.

Next, I tested for autocorrelation as well as heteroscedasticity in within-group errors on Model 4. Autocorrelation was not significant as the model with this term added did not converge. Heteroscedasticity was significant (see Table 8; p = .05). As such, a heteroscedasticity term will be added to subsequent models. Thus, Model 4 was used for subsequent hypothesis tests, and a heteroscedasticity term was retained. This is denoted as Model 4a.

Table 7. Tests for variability in level 1 model.

Model	Random Parameters	df	AIC	-2LogLik	Test	L.Ratio	*p*
1	None	6	31,267.47	31,255.48	-	-	-
2	Intercept	7	28,626.96	28,612.96	1 vs. 2	2,642.51	<.0001
3	Intercept, Pre	9	27,832.62	27,814.62	2 vs. 3	798.34	<.0001
4	Intercept, Pre, Transition	12	27,079.58	27,055.58	3 vs. 4	759.04	<.0001
5	Intercept, Pre, Transition, Post	15	26,615.52	26,585.52	4 vs. 5	470.06	<.0001
6	Intercept, Pre, Transition, Post, Distal Post	9	28,456.26	28,438.26	5 vs. 6	1,852.74	<.0001

Note. Models 5 and 6 failed to converge and thus the tests with these models are not meaningful comparisons.

Table 8. Test of heteroscedasticity.

Model	Random Parameters	df	AIC	-2LogLik	Test	L.Ratio	*p*
4	Intercept, Pre, Transition	12	27,079.58	27,055.58	-	-	-
4a	Intercept, Pre, Transition	13	27,077.66	27,051.66	4 vs. 4a	3.92	.05

Note. Model 4a denotes the model with the heteroscedasticity term added.

Effect of Intervention Step 2: Level 2 Analyses

First, I first examined the significance of the transition and post-intervention parameters. These parameters were both significant (see Table 9), $t(5082) = 10.10$, $p < .01$ for transition and $t(5082) = 7.71$, $p < .01$ for post-intervention, indicating that hospitals improve on employee job performance at the transition (i.e., intervention) and post-intervention periods. However, because the post-intervention and distal post-intervention parameters did not significantly vary between hospitals (i.e., Models 5 and 6 did not converge in Step 1 analyses), hypotheses were tested on variance only within the transition period from pre-intervention to post-intervention.

To test Hypothesis 2, which stated that hospitals with a higher resident-to-bed ratio will have a greater improvement in employee job performance over time in comparison to hospitals with a lower resident-to-bed ratio, I added the level 2 variable resident-to-bed ratio to the model. The parameter of resident-to-bed ratio was significant, $t(1275) = -2.51$, $p = .01$. Further, the interaction between resident-to-bed ratio and transition trended in the predicted direction (see Figure 5), $t(5081) = 1.56$, $p = .12$. As can be seen in Figure 5, hospitals with a resident-to-bed ratio improve more rapidly in comparison to hospitals with a lower resident-to-bed ratio (and hospitals with a zero resident-to-bed ratio, i.e., non-resident control hospitals). Because the interaction was not statistically significant, Hypothesis 2 was, however, not fully supported.

Interestingly, the pre-intervention parameter was also significant and had a coefficient larger than that of the transition and post-intervention parameters. The data indicated that hospitals saw a 2.06 percent increase in employee job performance during the pre-intervention period. This suggests that there may be something else, in addition to the intervention, that occurred over time and impacted job performance. This issue is further discussed in the discussion section.

Table 9. Parameters in Model 4a.

Parameter	b	Standard Error	df	t	p
Intercept	93.23	0.11	5082	862.31	< .01
Pre-intervention	2.06	0.07	5082	29.57	< .01
Transition	0.89	0.09	5082	10.10	< .01
Post-intervention	0.43	0.06	5082	7.71	< .01
Distal post-intervention	0.31	0.09	5082	3.34	< .01

Note. Model 4a denotes the model with a random intercept, and random pre-intervention and transition parameters, and with the heteroscedasticity term added.
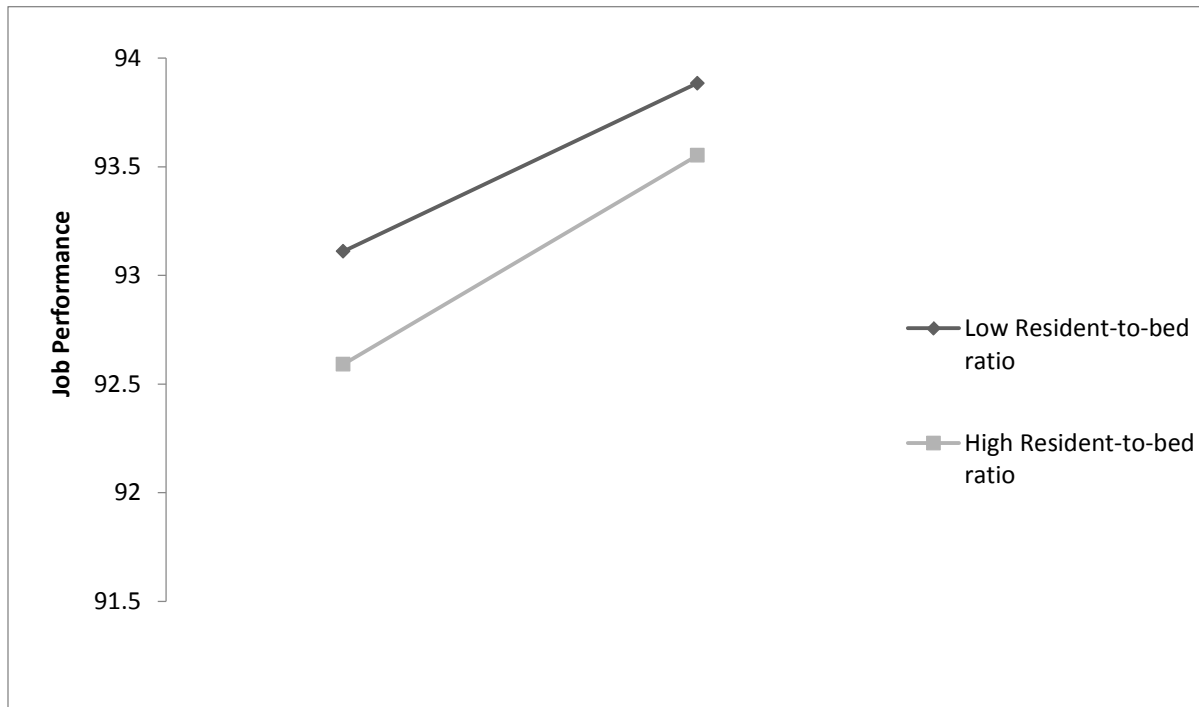
Figure 5. Interaction between resident-to-bed ratio and the transition parameter.

Hypothesis 3 proposed that job performance would improve (a) more for large hospitals in comparison to small hospitals, and (b) more rapidly in large hospitals in comparison to small hospitals, and that these effects would be greater for hospitals with a higher resident-to-bed ratio. To examine this hypothesis, organizational size was added as a parameter and an interaction between organizational size and transition was computed. Additionally, a three-way interaction between organizational size, transition, and resident-to-bed ratio was computed and added to the model. The parameter of organizational size was not significant, $t(1273) = -0.13$, $p = .90$. Further, neither the interaction between organizational size and transition [$t(5079) = 0.50$, $p = .62$], the interaction between organizational size and resident-to-bed ratio [$t(1273) = -0.92$, $p = .36$], nor the three-way interaction [$t(5079) = 0.53$, $p = .60$] were significant. Thus, Hypothesis 3a was not supported. Further, because tests conducted within the Level 1 analyses showed that the post-intervention slope did not significantly vary between hospitals, Hypothesis 3b was similarly not supported.

Research Question 1 asked whether job performance improves or decreases after post-intervention year 1. To answer this question, I tested the significance of a distal post parameter within the model and examined the direction of the effect. The parameter was significant, $t(5081) = 3.34$, $p = .00$, and positive, suggesting that job performance continues to improve after the first post-intervention period. However, because during Level 1 analyses the distal post parameter was found not to significantly vary between hospitals, I was not able to compute an interaction between resident-to-bed ratio and the distal post parameter to determine whether this improvement occurred only for intervention hospitals.

Research Question 2 sought to determine whether change in job performance due to the intervention is gradual or abrupt. To answer this question, I compared a gradual change model

against an abrupt change model (see Table 10). Because log likelihoods are only meaningful for nested models, I do not report them in this table. Rather, comparisons are based on the AICs, which show that the gradual change model has a better fit in comparison to the abrupt change model (AIC = 28,703.25 vs. 28,894.53, respectively; $p < .0001$).

In addition, I examined a line graph of the change process (see Figure 6 and Figure 7) and examined the beta coefficients of each parameter (see Table 9). It appears that there was an abrupt initial change from the pre-intervention period, followed by a more gradual continued improvement across the post-intervention period. The beta coefficients suggest the same (see Table 9): On average, hospitals increased 0.89 units at the transition period (an abrupt shift), and continued to improve, more gradually, in the post-intervention period and distal post-intervention period (0.43 and 0.31 units, respectively). Thus, it seems that change was largely gradual but that there was also an abrupt shift at the transition period.

Table 10. Gradual vs. abrupt change.

Model	Random Parameters	df	AIC
Gradual	Intercept, Pre, Transition	14	28,703.25
Abrupt	Intercept, Pre, Transition	13	28,894.53
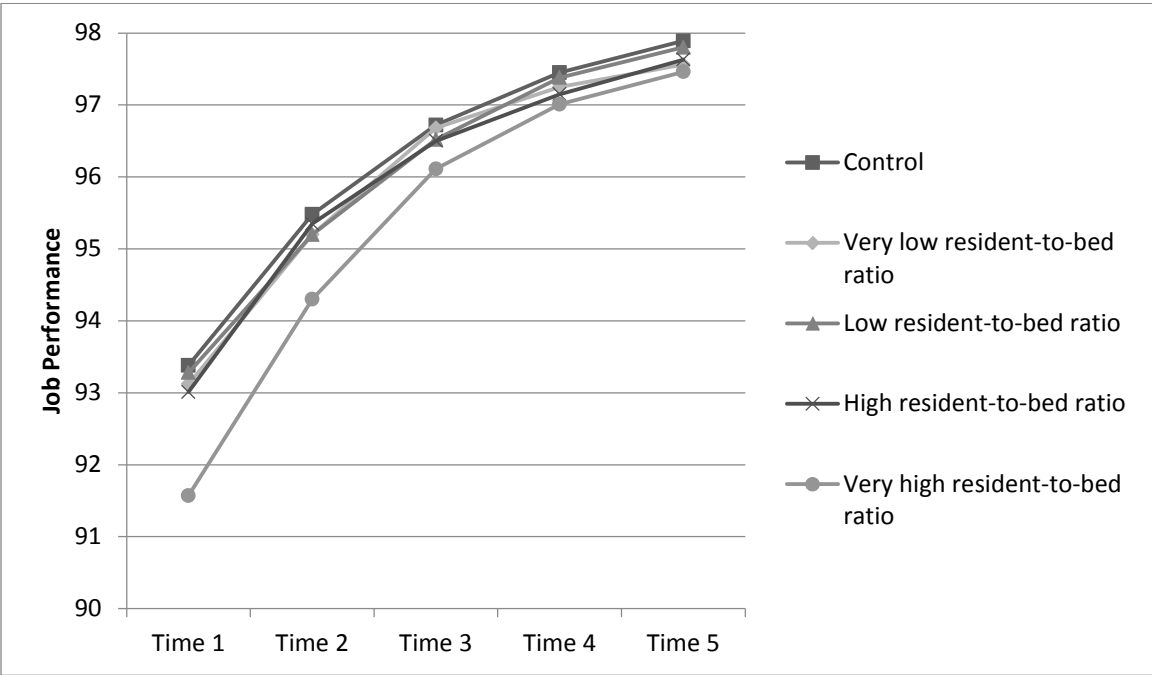
Figure 6. Line graph showing the change process across each of the five time points.
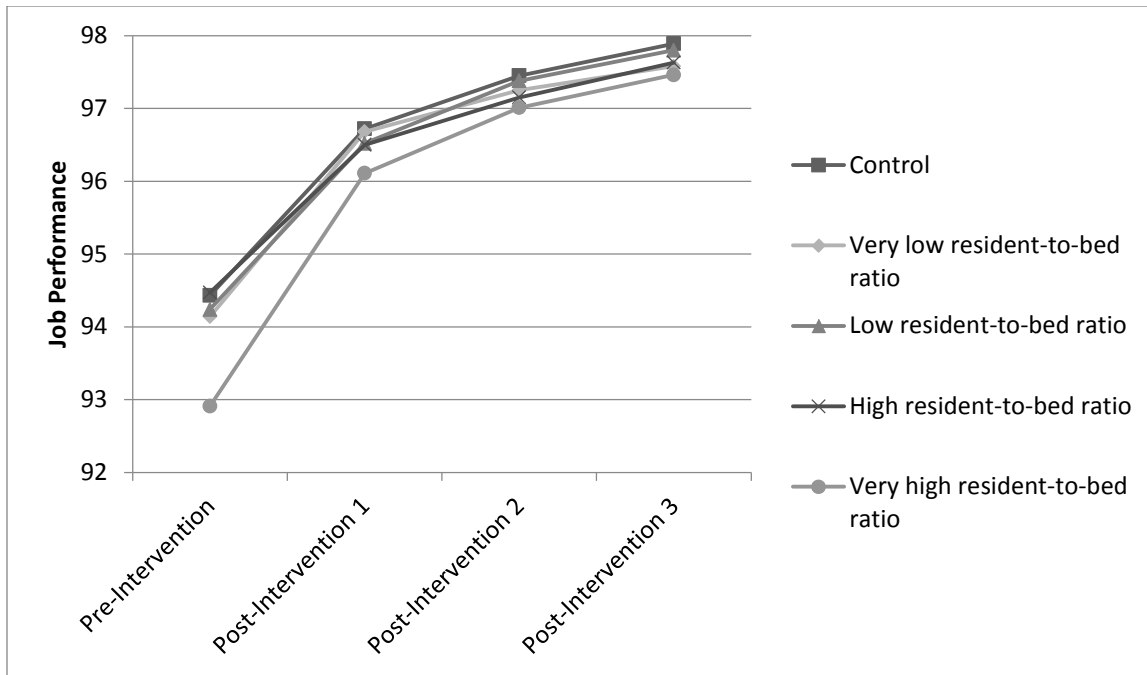
Figure 7. Line graph showing shift between pre- and post-intervention

Interestingly, according to Figure 6 and Figure 7, the change pattern held even for control hospitals, suggesting that something else that occurred over time played a major role in the improvement. However, as can be seen, hospitals with a very high resident-to-bed ratio had a lower initial intercept (which was found to be significant when examining Hypothesis 1), but seemed to have a steeper slope, almost catching up to the performance levels of the other groups after the intervention. This suggests that there may, in fact, have been a role of the intervention in improving job performance. As a summary, Table 11 displays the results of all hypothesis tests conducted.

Table 11. Model results.

Fixed Effects	Model 1		Model 2		Model 3	
	b	SE	b	SE	b	SE
Level 1 Model (π)						
Intercept	93.23**	0.11	93.43**	0.13	93.44**	0.23
Pre	2.06**	0.07	2.06**	0.07	2.06**	0.07
Transition	0.89**	0.09	0.80**	0.10	0.75**	0.16
Post	0.43**	0.06	0.43**	0.06	0.43**	0.06
Distal Post	0.31**	0.09	0.31**	0.09	0.31**	0.09
Level 2 Model (γ)						
Resident-to-Bed Ratio			-0.17*	0.07	0.01	0.13
Resident-to-Bed Ratio * Transition			0.07	0.05	0.00	0.09
Organizational Size					0.00	0.00
Organizational Size * Transition					0.00	0.00
Organizational Size * Resident-to-Bed Ratio					0.00	0.00
Organizational Size * Transition * Resident-to-Bed Ratio					0.00	0.00

Note. Model 1= Final level 1 model with heteroscedasticity term (i.e., Model 4a). Model 2= Examining significance of resident-to-bed ratio. Model 3= Examining significance of organizational size. *p < .05 **p < .01.*

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Exploratory Analyses

Quadratic Model of Time

Additionally, although not hypothesized, I examined a quadratic effect for the post-intervention parameter. There was a significant quadratic trend, $t(5082) = -3.34$, $p < .01$, which when entered into the model, altered the significance of the transition parameter, $t(5082) = 1.47$, $p = .14$. This analysis suggests that job performance may have improved gradually over the course of years 1-5. This alternative explanation is in contrast to the findings of Research Question 2, which noted an abrupt change at the time of the intervention, followed by a more gradual change throughout the post-intervention phase.

The former, non-quadratic results align more with theoretical rationale suggesting that performance will have an abrupt change between the pre-intervention period and the first post-intervention time period. Further, there is not a theoretical reason to expect gradual change in the post-intervention period without also the initial improvement due to the intervention. However, future research should explore this quadratic effect in more depth.

Comparing Control Hospitals to Very High Resident-to-Bed Ratio Hospitals

Because the transition parameter was significant, the interaction between transition and resident-to-bed ratio was marginally significant, and the line graphs (Figure 6 and Figure 7) seemed to indicate that hospitals with a very high resident-to-bed ratio improve on employee job performance over time significantly more than employees in hospitals at any other resident-to-bed ratio, I ran an exploratory regression to directly examine the change in control hospitals to that of very high resident-to-bed ratio hospitals. In particular, I ran a multiple regression using SPSS version 22 (IBM, 2013). I first selected only cases in which resident-to-bed ratio was

coded as 0 (control) or 4 (very high resident-to-bed ratio). Then, I entered resident-to-bed ratio, the transition parameter, and the interaction between resident-to-bed ratio and the transition parameter into a multiple regression, with job performance as the dependent variable. The overall model was significant, $F(3, 3350) = 284.85$, $p < .01$, $R^2 = .20$. The predictor of resident-to-bed ratio and transition were also significant, $t(3350) = -5.85$, $\beta = -.14$, $p < .01$ and $t(3350) = 25.79$, b = -.38, $\beta = .42$, $p < .01$, respectively. Furthermore, the interaction was significant in the predicted direction (see Figure 8), $t(3350) = 3.04$, b = .25, $\beta = .08$, $p < .01$. This supports the idea that the fatigue intervention significantly improved job performance. To further confirm these findings, I conducted an additional one-way ANOVA, with job performance at time 5 as the dependent variable and resident-to-bed ratio as the IV. I computed Tukey post-hoc tests to examine differences between hospital types. The overall model was not significant, $F(4, 1265) = 1.43$, $p = .22$. Further, Tukey HSD post-hoc tests revealed no significant differences in job performance at time 5 (see Table 12), suggesting that performance at time 5 was the same for both control hospitals and very high resident-to-bed ratio hospitals.
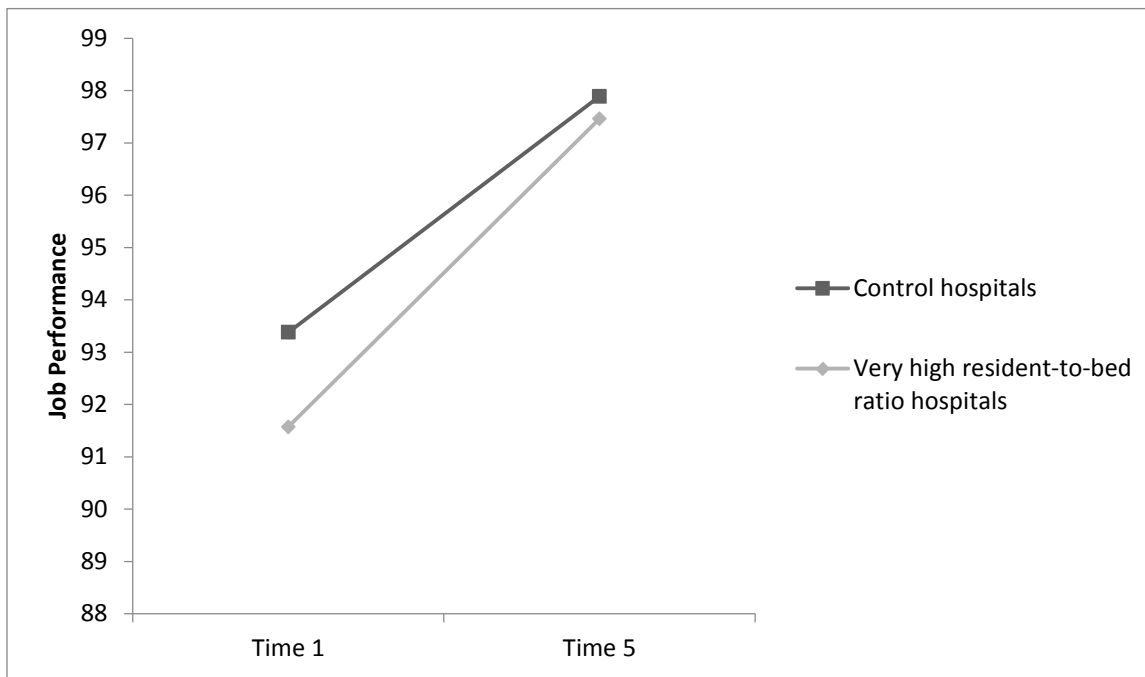
Figure 8. Exploratory interaction between resident-to-bed ratio and the transition parameter for control and very high resident-to-bed ratio hospitals only.

Table 12. Results of Tukey HSD post-hoc comparisons for time 5 job performance.

Reference Group	Comparison Group	Mean Difference
Control hospitals	Very low resident-to-bed ratio	0.04
	Low resident-to-bed ratio	0.19
	High resident-to-bed ratio	0.21
	Very high resident-to-bed ratio	0.61
Very low resident-to-bed ratio	Control hospitals	-0.04
	Low resident-to-bed ratio	0.15
	High resident-to-bed ratio	0.18
	Very high resident-to-bed ratio	0.57
Low resident-to-bed ratio	Control hospitals	-0.19
	Very low resident-to-bed ratio	-0.15
	High resident-to-bed ratio	0.02
	Very high resident-to-bed ratio	0.42
High resident-to-bed ratio	Control hospitals	-0.21
	Very low resident-to-bed ratio	-0.18
	Low resident-to-bed ratio	-0.02
	Very high resident-to-bed ratio	0.39
Very high resident-to-bed ratio	Control hospitals	-0.61
	Very low resident-to-bed ratio	-0.57
	Low resident-to-bed ratio	-0.42
	High resident-to-bed ratio	-0.39

Note. No comparisons were statistically significant at $p < .05$ or $p < .01$.

Comparing Amongst Resident-to-Bed Ratios

Finally, in order to examine differences within the resident-to-bed ratios themselves, I ran a discontinuous growth model wherein control hospitals were coded as a missing value. This allowed the model to compute the hypotheses on only intervention hospitals, to determine whether there was a significant difference amongst the varying resident-to-bed ratios. Further, resident-to-bed ratio was dichotomized, with very low and low resident-to-bed ratio hospitals coded as 0, and high and very high resident-to-bed ratio hospitals coded as 1. This allowed for a direct comparison of low and high resident-to-bed ratios.

Model 4a, previously defined above as allowing the pre and transition parameters to vary and including a heteroscedasticity term, was used for this analysis. The dichotomous resident-to-bed ratio variable was not significant, $t(1275) = -1.69$, $p = .09$. Further, the interaction between the dichotomous resident-to-bed ratio variable and the transition parameter was not significant, $t(5081) = 0.66$, $p = .51$. Thus, there was no significant difference for high versus low resident-to-bed ratios in job performance improvement after the intervention, when comparing the two directly.

CHAPTER FIVE: DISCUSSION

To summarize my findings, I return to the questions posed in the introduction chapter. Question 1 asked how employees' baseline job performance in intervention hospitals compared to that of control hospitals. Results of Hypothesis 1 showed that job performance of employees in very high resident-to-bed ratio hospitals was significantly worse in comparison to all other hospitals. These findings are in line with others that have found that hospitals with residents (i.e., intervention hospitals) tend to have worse performance in comparison to hospitals without residents (i.e., control) hospitals (Kahn et al., 2015; Rajaram et al., 2015). Given that intervention hospitals are comprised of more novice physicians, this is also aligned with skill acquisition theory (Fitts, 1964; Fitts & Posner, 1967) which posits that it takes time and practice for people to reach levels of optimal performance. Further, these results align with the idea that organizations with more fatigued employees should theoretically have worse performance, due to the cognitive limitations fatigue creates.

Question 2 considered how employees' job performance changed over time for organizations that underwent a fatigue intervention, in comparison to those that did not undergo a fatigue intervention. The results of Hypothesis 2 suggest that job performance improved over time for both groups. While in contrast to some studies showing improvements due to the 2011 ACGME fatigue intervention (e.g., Pepper et al., 2014), these findings are line with some other findings on the intervention. For example, Rajaram et al. (2014) found improvement in patient outcomes for both intervention and non-intervention hospitals. Patel et al. (2014) also did not find an impact of resident-to-bed ratio on patient outcomes. However, the two aforementioned studies both failed to directly compare control hospitals with the highest resident-to-bed ratio hospitals. The results of my exploratory analysis suggest that there may be an impact of the

intervention that is only apparent for very high resident-to-bed ratio hospitals. Furthermore, the aforementioned studies examine patient outcomes (e.g., mortality, complications) as a dependent variable, as opposed to job performance in the current study. Patient outcomes are likely affected by a multitude of other factors (e.g., patient health, age, etc.) which may make it difficult to truly understand the impact of the fatigue intervention for these variables.

Question 3 asked whether organizational characteristics impact the magnitude and rate of change on employees' job performance. Results of Hypothesis 3 suggested that the characteristic of organizational size did not influence job performance or the change in job performance at the transition period. Further, because the models with the post and distal post parameters as random effects did not converge, it was not possible to examine whether organizational size influenced job performance in these periods. While this finding is in opposition to the idea that organizations with more resources should be able to adapt to change better and more rapidly, perhaps organizational size is a double-edged sword. For example, with fewer employees needing to adapt to a change, and fewer processes impacted, smaller organizations may be able to implement a change process among employees more quickly in comparison to organizations with hundreds or thousands more employees. This may have washed out any effects that may have existed.

Finally, Question 4 asked whether job performance continued to improve over time after the initial post-intervention period. Results of Research Question 1 suggested that job performance continued to improve. Results of Research Question 2 showed that change in job performance was largely gradual, but with an abrupt change immediately after the intervention. These findings are in line with organizational change theories that suggest that organizations refreeze into new norms by modifying policies and procedures (Lewin, 1947), and that people

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within organizations take time to explore and commit to new behaviors after an organizational change (Jaffe et al., 1994).

In sum, the results of this study partially support the integration of theories presented in Figure 2. In particular, job performance increased post-intervention for all groups, but significantly more for groups at the highest resident-to-bed ratio. This suggests that while the fatigue intervention may have allowed for higher resident attentional capacity, leading to improved performance on difficult tasks, these effects may only be visible at the organizational level when there is a large proportion of staff whose fatigue levels are improved. The results of the physician measure suggest that the job performance items were difficult tasks for first-year residents, supporting dual-process and skill acquisition theories. However, parts of Figure 2 were not supported. In particular, organizational size was not a significant moderator, suggesting that the idea that organizations with more resources will fare better may not be true. The results of this study also align with organizational change theories which posit that change within organizations can be a gradual process that occurs over a long period of time.

It is important to consider the significant (and relatively large) improvement in job performance that occurred in the pre-intervention phase. This suggests that there may be something else that occurred over time, in addition to the intervention, that could have improved job performance. Notably, time 1 was the first time in which hospitals were required to publicly report these particular job performance behaviors. Perhaps the process of capturing and publicly reporting this data led organizational stakeholders to be motivated to implement additional processes and procedures targeted at improving these particular behaviors. Additionally, beginning October 1st, 2012 (i.e., between times 3 and 4 in this study), hospitals' Medicare

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reimbursements began to become partially contingent upon successful completion of the job performance behaviors in this study, among other behaviors (CMS, 2013). This may have incentivized aims to improve these behaviors, which may account for some of the improvement seen in the post-intervention period for all hospitals; however, it does not explain the improvement seen between times 1 and 3. Unfortunately, hospitals often have a host of changes occurring at one time, and it is typically impossible to tease out one specific intervention as the cause of any improvement. Thus, it is important to attempt to rule in the fatigue intervention as one potential cause of change in job performance. The large number of hospitals involved in this study (all which likely have different changes and interventions occurring at different times in addition to the fatigue intervention, rather than one change common to all hospitals)—as well as the exploratory analysis comparing the control group to the very high resident-to-bed ratio group—strengthen the case for the intervention as having some impact on job performance. Further, theory suggests that the fatigue intervention should have increased resident attentional capacity, allowing residents to better perform difficult tasks. As such, it makes theoretical sense for the fatigue intervention to be associated with improved job performance, particularly in very high resident-to-bed ratio hospitals, which had the greatest proportion of fatigued staff to patients and the greatest room for improvement. Additionally, the results of the physician measure support the idea that the job performance behaviors in this study were amenable to non-completion when a resident is fatigued. This provides further support for the legitimacy of the findings.

The results of this study can be compared with other studies of the 2011 ACGME fatigue intervention. In particular, while some single-hospital studies have found improvements in patient outcomes (Pepper et al., 2014), other studies across numerous U.S. hospitals have shown

that the intervention was not effective in improving mortality, morbidity, readmission rates, complications, or resident exam performance across hospitals (Patel et al., 2014; Rajaram et al., 2014). However, the aforementioned studies differ from this study in three ways: (1) First, this dissertation examined processes (i.e., job performance), in contrast to these prior studies which examined outcomes (e.g., mortality, readmission). This is an important difference because patient outcomes can be biased as they can be affected by a multitude of other factors in addition to the intervention, such as faulty equipment (Reason, 2000). In particular, the Swiss cheese model proposes that there are numerous defensive layers (e.g., alarms, locks, etc.) that prevent accidents from occurring, even when a performance error has occurred. However, the model posits that each of these defensive layers has numerous holes (like Swiss cheese) that open, shut, and change location. On occasion, holes in the various defensive barrier slices can line up, allowing penetration of all defensive layers. The model suggests that only in these circumstances will an error lead to an adverse patient outcome. For this reason, it is more optimal to examine process variables, such as job performance. (2) Second, this study uses discontinuous growth modeling, an arguably more advanced and appropriate way to model the data, in comparison to time-series designs and the difference-in-difference (DID) technique used by these prior studies. In particular, time-series designs should be used only when there are at least 8 time points pre and 8 time points post (Penfold & Zhang, 2013), rendering this design inappropriate, although it is used in one of the aforementioned papers. Further, DID designs—used in one prior study— compare only the mean level of post-intervention values to those of pre-intervention; whereas discontinuous growth modeling allows for modeling of more advanced concepts such as the rate of change. As such, the findings in this dissertation can be interpreted as an arguably more accurate estimation of the impact of the 2011 ACGME fatigue intervention across U.S. hospitals;

(3) Third, this dissertation examines organizational characteristics (i.e., organizational size) as a moderator, which the aforementioned studies failed to do.

Other studies that have examined the 2011 ACGME fatigue intervention within just one hospital have found encouraging results. For example, Pepper et al. (2014) found a significant decrease in transfers to the ICU due to a code blue from pre- to post-intervention. This study, conducted within a very high resident-to-bed ratio hospital, provides support for the legitimacy of the exploratory analysis conducted in this dissertation.

More broadly, other fatigue interventions are being examined in the literature, suggesting there is interest in improving fatigue within other workforces. One such intervention is "SleepTrackTXT", a text-messaging system that prompts behavior change of fatigued emergency medical services (EMS) workers (Patterson et al., 2014). This program is currently undergoing a trial to determine whether simple text message suggestions and reminders (e.g., "Try drinking a caffeinated beverage like coffee to stay awake,") can significantly improve perceived fatigue in this sample. Other fatigue interventions have been evaluated with other samples, with encouraging results. For example, a fatigue training program for truck drivers has been associated with positive reactions, improvements in knowledge, retention of this knowledge over time, and transfer of trained behaviors to the work place (Gander, Marshall, Bolger, & Girling, 2005). Others have discussed the necessity of fatigue interventions for nurses (Chen, Davis, Daraiseh, Pan, & Davis, 2014; Han, Trinkoff, & Geiger-Brown, 2014), and firefighters (Dawson, Mayger, Thomas, & Thompson, 2015).

Implications

There are some important implications of the current study. First, overall, findings suggest that employees at very high resident-to-bed ratio hospitals start out at a lower baseline

level of job performance (see Table 6). However, over time after the fatigue intervention, the average job performance of employees in these hospitals catches up to that of their peers in control and lower resident-to-bed ratio hospitals (see Figure 6 and Figure 7). Thus, while the effect of the fatigue intervention may not have been statistically significant across all hospitals, with the interaction between the intervention and the transition parameter only at marginal significance ($p = .12$, and see Figure 5), it is significant for hospitals with the highest resident-to-bed ratios in comparison to control hospitals. Results of an exploratory analyses support this interpretation (see Figure 8 and Table 12). This indicates that patients received significantly better care at very high resident-to-bed ratio hospitals post-intervention in comparison to pre-intervention—an important finding.

With this in mind, it seems reasonable to suggest that organizations with many fatigued employees have worse job performance. The idea that fatigue has negative implications for job performance has been suggested before (e.g., Kaplan & Tetrick, 2010); however, there are few studies that longitudinally examine the impact of a fatigue intervention on job performance. Further, the current suggests that fatigue does not just affect individuals, but that when there are enough fatigued employees, these effects can carry out to impact organizational-level outcomes. This is a finding that organizations should be concerned about. More broadly, sleep deprivation has also been found to be associated with unsafe performance in other industries, such as with construction workers (Powell & Copping, 2010), suggesting the findings in this dissertation have more widespread implications.

Additionally, the current study shows that it is important to conduct long-term longitudinal studies of organizational interventions. Continued improvement in job performance occurred as far out as three years from the introduction of the intervention. As such,

organizations should continue to measure the impact of organizational change interventions across many years. Importantly, however, sustainment processes such as refresher training should be implemented to ensure that the intervention continues to have an impact over time (Salas et al., 2008).

Finally, the current study indicates that organizational size (a proxy for organizational resources) does not seem to matter. While I was unable to investigate the particular processes that organizations underwent to adapt to the fatigue intervention, it seems that expensive and resource-intensive processes may not be necessary to successfully implement the intervention. Rather, smaller hospitals with presumably fewer resources can also adapt to the intervention.

Limitations

As with all studies, there are some limitations in the current study. First, the study was limited by the information available in the public use databases. Thus, I was unable to dig deeper to examine potential variables of interest, such as the processes that each hospital utilized to adapt to the fatigue intervention (e.g., introducing night float, changing compensation models, etc.). Furthermore, given that all components of the intervention went into effect at the same time, I was unable to examine whether specific components of the intervention (e.g., reduced work hours) were more impactful than others (e.g., naps).

Additionally, I was unable to examine variance in the post-intervention and distal-post phases because the models containing these parameters as random factors did not converge, suggesting that they did not significantly vary between hospitals. Bliese (2008) states that models with too many random factors can often fail to converge; however, I cannot be sure whether the failure in convergence is due to having too many random factors or due to lack of variance within the post and distal post parameters. In any case, this issue precluded the examination of

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parts of Hypotheses 2 and 3 and part of Research Question 1. As such, I was limited to examining variance in the transition period only.

Finally, I was only able to examine data at the hospital level, and therefore was unable to examine data at lower levels (e.g., hospital units, physician-patient dyads, etc.). This limitation is a function of the way the data is reported. While it would have been interesting to track each resident's performance over time, it is not possible to do so with the limited information in the datasets provided.

<div align="center">**Future Research**</div>

While the current study suggests that the fatigue intervention may have a small impact on job performance for hospitals with the highest resident-to-bed ratios, future research should examine which implementation processes (e.g., night float, etc.) are most optimal in adapting to this change. The current study was not able to examine this; yet, having a better understanding of this can allow for more prescriptive guidance to hospitals in regards to how to best implement and sustain the intervention.

Additionally, as previously mentioned, other studies have examined the impact of the fatigue intervention on patient outcomes (e.g., Patel et al., 2014; Rajaram et al., 2014). It would be interesting to test the causal chain to understand the extent to which the fatigue intervention impacts more proximal processes such as job performance, which in turn may improve patient outcomes. Limitations in the ways data were reported prevented me from doing this in the current study.

Furthermore, additional robust study designs (e.g., experiments) should be utilized to investigate the impact of the fatigue intervention. Currently, randomized controlled trials are

underway which may provide more insight as to some of the unanswered questions in this study (e.g., Northwestern University, 2016).

Finally, while the current study focused on technical performance, other dimensions of job performance should also be examined. Examining the impact of a fatigue intervention on communication, leadership, organizational citizenship behaviors (OCBs), and counterproductive workplace behaviors (CWBs) could yield some interesting findings. It is likely that, for example, fatigued employees may be more likely to commit CWBs. Particularly in the healthcare field, it would be intriguing to see how this plays out and how the fatigue intervention may improve CWB rates.

<center>**Conclusion**</center>

The 2011 ACGME fatigue intervention may have an impact on employees' job performance, but only very high resident-to-bed ratio hospitals outpace performance improvement in the non-intervention control group. More specifically, employee job performance at baseline in very high resident-to-bed ratio hospitals is significantly lower in comparison to that of other hospitals, but it improves post-intervention to reach the performance levels of other hospitals. However, additional research is needed to confirm these findings, as job performance improved over time for all groups—including within control hospitals. Thus, future studies examining change in job performance should take this into consideration and utilize a control group to determine whether any significant effects are due to the intervention or are simply an effect of time. Organizational size did not have any significant effects on change in job performance suggesting that the amount of resources a hospital has is not a significant predictor of intervention success. Finally, job performance continued to improve as much as three years

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post intervention. Thus, it is important to examine organizational interventions over a long

period of time. The findings of this study support cognitive and organizational change theories.

APPENDIX A: MEDICAL DEFINITIONS

Adverse event: "An unintended physical injury resulting from or contributed to by medical care rather than the underlying condition of the patient, that requires additional monitoring, treatment, or hospitalization or results in death. Not all adverse events are caused by errors," (Ulmer et al., 2009, p. 182)

At-home call: "A call taken from outside the assigned site. Time in the hospital, exclusive of travel time, counts against the 80 hour per week limit but does not restart the clock for time off between scheduled in-house duty periods," (ACGME, 2013, p. 2).

Attending physician: "An appropriately credentialed and privileged member of the medical staff who accepts full responsibility for a specific patient's medical/surgical care," (ACGME, 2011a, p. 1).

Duty hours: "…all clinical and academic activities related to the program; i.e., patient care (both inpatient and outpatient), administrative duties relative to patient care, the provision for transfer of patient care, time spent on in-house call, and other scheduled activities, such as conferences. Duty hours do not include reading and preparation time spent away from the duty site," (ACGME, 2013, p. 4).

Error: "…failure of a planned action to be completed as intended (i.e., error of execution) or the use of a wrong plan to achieve an aim (i.e., error of planning)," (IOM, 2000, p. 28). "An error of execution could be an error of omission of an essential step, a critical piece of data, etc.; could be caused by a poorly designed system requiring staff to 'work around' the design fault or miscommunications; an error of planning could result from misdiagnosis or lack of knowledge about the patient's medical problem. Some errors are caught and corrected before they harm the patient," (Ulmer et al., 2009, p. 182).

External moonlighting: "Voluntary, compensated, medically-related work performed outside the institution where the resident is in training or at any of its related participating sites," (ACGME, 2013, p. 4).

Faculty: "Any individuals who have received a formal assignment to teach resident/fellow physicians. At some sites appointment to the medical staff of the hospital constitutes appointment to the faculty," (ACGME, 2013, p. 4).

Fatigue management: "Recognition by either a resident or supervisor of a level of resident fatigue that may adversely affect patient safety and enactment of appropriate countermeasures to mitigate the fatigue," (ACGME, 2013, p. 4).

Graduate medical education (GME): "The period of didactic and clinical education in a medical specialty which follows the completion of a recognized undergraduate medical education and which prepares physicians for the independent practice of medicine in that specialty, also referred to as residency education. The term 'graduate medical education' also applies to the period of didactic and clinical education in a medical subspecialty which follows the completion of education in a recognized medical specialty and which prepares physicians for the independent practice of medicine in that subspecialty," (ACGME, 2013, p. 5).

Harm: See *adverse event*.

In-house call: "Duty hours beyond the normal work day when residents are required to be immediately available in the assigned institution," (ACGME, 2013, p. 5).

Intern: "Historically, a designation for individuals in the first year of GME. This term is no longer used by the ACGME," (ACGME, 2013, p. 6).

Internal moonlighting: "Voluntary, compensated, medically-related work (not related with training requirements) performed within the institution in which the resident is in training or at any of its related participating sites," (ACGME, 2013, p. 6).

Night float: "Rotation or educational experience designed to either eliminate in-house call or to assist other residents during the night. Residents assigned to night float are assigned on-site duty during evening/night shifts and are responsible for admitting or cross-covering patients until morning and do not have daytime assignments. Rotation must have an educational focus," (ACGME, 2013, p. 7).

One day off: "One (1) continuous 24-hour period free from all administrative, clinical and educational activities," (ACGME, 2013, p. 7).

Preventable adverse event: "An adverse event attributable to error…" (IOM, 2000, p. 28).

Resident: "Any physician in an accredited graduate medical education program, including interns, residents, and fellows," (ACGME, 2013, p. 8).

Residency: "A program accredited to provide a structured educational experience designed to conform to the Program Requirements of a particular specialty," (ACGME, 2013, p. 8).

Rotation: "An educational experience of planned activities in selected settings, over a specific time period, developed to meet goals and objectives of the program," (ACGME, 2013, p. 8).

Safety: "…freedom from accidental injury," (IOM, 2000, p. 28).

Sentinel event: "An unexpected occurrence (which may or may not result from an error) in a hospital patient's case, including actual or risk of death or serious physical or psychological injury," (Ulmer et al., 2009, p. 182).

Strategic napping: "Short sleep periods, taken as a component of fatigue management, which can mitigate the adverse effects of sleep loss," (ACGME, 2013, p. 9).

Supervising physician: "A physician, either faculty member or more senior resident, designated by the program director as the supervisor of a junior resident. Such designation must be based on the demonstrated medical and supervisory capabilities of the physician," (ACGME, 2011a, p. 1).

Transitions of care: "The relaying of complete and accurate patient information between individuals or teams in transferring responsibility for patient care in the healthcare setting," (ACGME, 2013, p. 10).

APPENDIX B: IRB APPROVAL FOR PHYSICIAN MEASURE

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Exempt Human Research

From: **UCF Institutional Review Board #1**
        FWA00000351, IRB00001138

To: **Megan E. Gregory**

Date: **August 18, 2015**

Dear Researcher:

On 08/18/2015, the IRB approved the following minor modification to human participant research that is exempt from regulation:

Type of Review:	Exempt Determination
Modification Type:	A revised version of the study measure has been uploaded in iRIS. A revised consent document, with questionnaire below it, has been approved for use.
Project Title:	Situation Awareness and Fatigue in Resident Physicians
Investigator:	Megan E Gregory
IRB Number:	SBE-15-11365
Funding Agency:	
Grant Title:	
Research ID:	N/A

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these changes affect the exempt status of the human research, please contact the IRB. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

Joanne Muratori

Signature applied by Joanne Muratori on 08/18/2015 03:04:44 PM EDT

IRB manager

APPENDIX C: PHYSICIAN MEASURE

EXPLANATION OF RESEARCH

Title of Project: Situation Awareness and Fatigue in Resident Physicians

Principal Investigator: Megan Gregory, M. S.

Faculty Supervisor: Eduardo Salas, Ph.D.

You are being invited to take part in a research study. Whether you take part is up to you.

- The purpose of this research is to determine the extent to which certain behaviors that occur in healthcare are representative of the construct of situation awareness, and to determine the impact on these behaviors when resident physicians are sleep deprived.
- You will be asked to fill out a brief questionnaire. This can be done in the location of your choice.
- This questionnaire should take approximately 20 minutes to complete.

You must be 18 years of age or older to take part in this research study and a U.S. healthcare provider.

Study contact for questions about the study or to report a problem: If you have questions, concerns, or complaints please contact Megan Gregory, Graduate Research Associate, (407) 882-2810 or by email at mgregory@ist.ucf.edu, or Dr. Eduardo Salas, Faculty Supervisor, (407) 882-1325 or by email at esalas@ist.ucf.edu.

IRB contact about your rights in the study or to report a complaint: Research at the University of Central Florida involving human participants is carried out under the oversight of the Institutional Review Board (UCF IRB). This research has been reviewed and approved by the IRB. For information about the rights of people who take part in research, please contact: Institutional Review Board, University of Central Florida, Office of Research & Commercialization, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246 or by telephone at (407) 823-2901.

Thank you for your interest in this questionnaire! This will ask about your job experiences as well as patient care behaviors that occur in hospitals. There are no right or wrong answers to these questions. Please answer using your best judgment based on your healthcare expertise. Your responses are confidential and will not be shared with your coworkers or bosses. This survey should take approximately 20 minutes to complete.

If you have any questions or concerns, please contact Megan Gregory at 407-882-2810 or mgregory@ist.ucf.edu.

Upon completion, please email your responses to mgregory@ist.ucf.edu. Alternatively, you can complete a web-based version of this survey at http://ucf.qualtrics.com//SE/?SID=SV_9O09rUqRGWkpvHT.

Thank you for your time. Your responses are valuable!

<u>PART 1</u>

Cognitive load is defined as the amount of mental effort one uses to complete a task. Typically, difficult tasks induce a higher cognitive load in comparison to simple tasks. However, what is difficult and simple differs depending on a person's expertise and experience with a particular task and can change with time and experience. For example, driving a car may induce a higher cognitive load for a new driver in comparison to a person who has been driving for 30 years.

Directions: On the next page is a list of nine behaviors that occur in healthcare. Please read each behavior and indicate the extent to which the behavior (a) is subject to non-completion under conditions of fatigue/sleep deprivation, (b) could induce cognitive load for a first-year resident and (c) could induce cognitive load for a resident in his/her second year and above.

Behavior	If a resident physician is sleep deprived/fatigued, how likely is it that (s)he would fail to perform this behavior? (Please rate 1-7, where 1=not at all likely and 7=very likely)	To what extent does this behavior induce cognitive load for a *first year* resident? (Please rate 1-7, where 1=very low and 7=very high cognitive load)	To what extent does this behavior induce cognitive load for a resident in their *second year or above*? (Please rate 1-7, where 1=very low and 7=very high cognitive load)	Comments/Explanation
Ordering an antibiotic for an outpatient having surgery at the right time (within one hour before surgery)				
Ordering an antibiotic for a surgery patient at the right time (within one hour before surgery)				
Ordering to stop a surgery patient's preventative antibiotics at the right time (within 24 hours after surgery)				
Ordering aspirin for an outpatient with chest pain or possible heart attack within 24 hours of arrival				
Giving a patient information about what to do about their recovery at home				
Giving a heart failure patient discharge instructions				
Giving a heart attack patient aspirin at discharge				

PART 2:

1. What is your profession?
   a. Physician
   b. Nurse
   c. Other (please list):_____

2. How many years of experience do you have in your profession? _____

3. Please indicate your discipline and/or your primary department (e.g., internal medicine, pediatrics, surgery, etc.):
   _____

4. If you are a physician, please answer the following question. Which of the following best describes you?
   a. Attending physician or equivalent
   b. Fellow
   c. Resident
   d. Other (please list):_____

5. Which of the following best describes the setting(s) in which you work? Check all that apply.
   __ Hospital
   __ Academic institution (e.g., medical school, nursing school, etc.)
   __ Private office
   __ Clinic
   __ Other (please list): _____

6. In which country do you practice?
   e. United States
   f. Other (please list): _____

Please email your responses to mgregory@ist.ucf.edu. Thank you!

APPENDIX D: IRB NOT HUMAN SUBJECTS LETTER

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901, 407-882-2012 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

From : **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To : **Megan E. Gregory**

Date : **August 28, 2015**

Dear Researcher:

On 08/28/2015, the IRB determined that the following proposed activity is not human research as defined by
DHHS regulations at 45 CFR 46 or FDA regulations at 21 CFR 50/56:

Type of Review:	Not Human Research Determination
Project Title:	EXAMINING THE IMPACT OF A FATIGUE INTERVENTION ON JOB PERFORMANCE: A LONGITUDINAL STUDY ACROSS UNITED STATES HOSPITALS
Investigator:	Megan E Gregory
IRB ID:	SBE-15-11540
Funding Agency:	
Grant Title:	
Research ID:	N/A

University of Central Florida IRB review and approval is not required. This determination applies only to the
activities described in the IRB submission and does not apply should any changes be made. If changes are to be
made and there are questions about whether these activities are research involving human subjects, please
contact the IRB office to discuss the proposed changes.

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

Joanne Muratori

Signature applied by Joanne Muratori on 08/28/2015 02:06:37 PM EDT

IRB manager

REFERENCES

Abraham, T., Freitas, M., Frangos, S., Frankel, H. L., & Rabinovici, R. (2006). Are resident

work-hour limitations beneficial to the trauma profession? *American Surgeon, 72*(1), 35-

41.

ACGME. (2011a). Glossary of terms related to resident duty hours.   Retrieved March 31, 2015,

from http://www.acgme.org/acgmeweb/Portals/0/PDFs/dh-GlossaryofTerms2011.pdf

ACGME. (2011b). Resident duty hours in the learning and working environment: Comparison of

2003 and 2011 standards.   Retrieved March 31, 2015, from

http://www.acgme.org/acgmeweb/Portals/0/PDFs/dh-ComparisonTable2003v2011.pdf

ACGME. (2013). Glossary of terms.   Retrieved March 31, 2015, from

http://acgme.org/acgmeweb/Portals/0/PFAssets/ProgramRequirements/ab_ACGMEgloss

ary.pdf

ACGME. (2015a). About ACGME.   Retrieved March 31, 2015, from

http://www.acgme.org/acgmeweb/tabid/116/About.aspx

ACGME. (2015b). ACGME fact sheet.   Retrieved March 31, 2015, from

http://www.acgme.org/acgmeweb/tabid/276/About/Newsroom/FactSheet.aspx

Alluisi, E. A., & Morgan, B. B. (1982). Temporal factors in human performance and

productivity. In E. A. Allusi & E. A. Fleishman (Eds.), *Human performance and

productivity: Stress and performance effectiveness* (Vol. 3, pp. 165-247). Hillsdale, NJ:

Lawrence Erlbaum Associates.

Anderson, D. (2012). Hierarchical linear modeling (HLM): An introduction to key concepts

within cross-sectional and growth modeling frameworks

Anglen, J. O., Bosse, M. J., Bray, T. J., Pollak, A. N., Templeman, D. C., Tornetta, P., 3rd, &
Watson, J. T. (2009). The Institute of Medicine report on resident duty hours. Part I: The
Orthopaedic Trauma Association response to the report. *Journal of Bone and Joint
Surgery (American Volume), 91*(3), 720-722. doi: 10.2106/jbjs.i.00070

Antiel, R. M., Thompson, S. M., Reed, D. A., James, K. M., Tilburt, J. C., Bannon, M. P., . . .
Farley, D. R. (2010). ACGME duty-hour recommendations: A national survey of
residency program directors. *New England Journal of Medicine, 363*(8), e12(11)-e12(16).
doi: 10.1056/NEJMp1008305

Arthur, W., Bennett, W., Stanush, P. L., & McNelly, T. L. (1998). Factors that influence skill
decay and retention: A quantative review and analysis. *Human Performance, 11*(1), 57-
101.

Auger, K. A., Sieplinga, K. R., Simmons, J. M., & Gonzalez Del Rey, J. A. (2009). Failure to
thrive: Pediatric residents weigh in on feasibility trial of the proposed 2008 Institute of
Medicine work hour restrictions. *Journal of Graduate Medical Education, 1*(2), 181-184.
doi: 10.4300/jgme-d-09-00067.1

Babyatsky, M. W., Bazari, H., & Del Valle, J. (2009). Response to the Institute of Medicine's
recommendations on resident duty hours: The medical residency program and GI
fellowship viewpoints. *Gastroenterology, 136*(4), 1145-1147. doi:
10.1053/j.gastro.2009.02.016

Baldwin, D. C., Daugherty, S. R., Tsai, R., & Scotti, M. J. (2003). A national survey of residents'
self-reported work hours: Thinking beyond specialty. *Academic Medicine, 78*(11), 1154-
1163.

Beal, D. J., Weiss, H. M., Barros, E., & MacDermid, S. M. (2005). An episodic process model of affective influences on performance. *Journal of Applied Psychology, 90*(6), 1054-1068. doi: 10.1037/0021-9010.90.6.1054

Bliese, P. D. (Producer). (2008). Discontinuous growth models. [PowerPoint slides]

Bliese, P. D. (2013). Multilevel modeling in R (2.5): A brief introduction to R, the multilevel package and the nlme package.

Bliese, P. D., McGurk, D., Thomas, J. L., Balkin, T. J., & Wesensten, N. (2007). Discontinuous growth modeling of adaptation to sleep setting changes: Individual differences and age *Aviation, Space, and Environmental Medicine, 78*(5), 485-492.

Bliese, P. D., & Ployhart, R. E. (2002). Growth modeling using random coefficient models: Model building, testing, and illustrations. *Organizational Research Methods, 5*(4), 362-387.

Blum, A. B., Raiszadeh, F., Shea, S., Mermin, D., Lurie, P., Landrigan, C. P., & Czeisler, C. A. (2010). US public opinion regarding proposed limits on resident physician work hours. *BMC Medicine, 8*, 33. doi: 10.1186/1741-7015-8-33

Blum, A. B., Shea, S., Czeisler, C. A., Landrigan, C. P., & Leape, L. (2011). Implementing the 2009 Institute of Medicine recommendations on resident physician work hours, supervision, and safety. *Nature and Science of Sleep, 3*, 47-85.

Borman, K. R., & Fuhrman, G. M. (2009). "Resident duty hours: Enhancing sleep, supervision, and safety": Response of the Association of Program Directors in Surgery to the December 2008 report of the Institute of Medicine. *Surgery, 146*(3), 420-427. doi: 10.1016/j.surg.2009.06.023

Borman, W. C. (1991). Job behavior, performance, and effectiveness. In M. D. Dunnette & L. M.

    Hough (Eds.), *Handbook of industrial and organizational psychology* (pp. 271-326). Palo

    Alto, CA: Consulting Psychologists Press.

Borman, W. C., White, L. A., Pulakos, E. D., & Oppler, S. H. (1991). Models of supervisory job

    performance ratings. *Journal of Applied Psychology, 76*(6), 863-872. doi: 10.1037/0021-

    9010.76.6.863

Brandenberger, J., Kahol, K., Feinstein, A. J., Ashby, A., Smith, M., & Ferrara, J. J. (2010).

    Effects of duty hours and time of day on surgery resident proficiency. *American Journal*

    of Surgery, 200(6), 814-818. doi: 10.1016/j.amjsurg.2010.06.009

Bratzler, D. W., Houck, P. M., Richards, C., Steele, L., Dellinger, E. P., Fry, D. E., . . . Red, L.

    (2005). Use of antimicrobial prophylaxis for major surgery: Baseline results from the

    National Surgical Infection Prevention Project. *Archives of Surgery, 140*(2), 174-182.

    doi: 10.1001/archsurg.140.2.174

Brimstin, J. A. (2014). *Sustaining change: A case study of sustaining a bottom-up change*

    initiative in a military training organization. ProQuest Information & Learning.

Brion, L. P., Neu, J., Adamkin, D., Bancalari, E., Cummings, J., Guttentag, S., . . . Ryan, R. M.

    (2009). Resident duty hour restrictions: is less really more? *Journal of Pediatrics, 154*(5),

    631-632.e631. doi: 10.1016/j.jpeds.2009.02.004

Britt, L. D., Sachdeva, A. K., Healy, G. B., Whalen, T. V., & Blair, P. G. (2009). Resident duty

    hours in surgery for ensuring patient safety, providing optimum resident education and

    training, and promoting resident well-being: A response from the American College of

    Surgeons to the Report of the Institute of Medicine, "Resident Duty Hours: Enhancing

Sleep, Supervision, and Safety". *Surgery, 146*(3), 398-409. doi:

10.1016/j.surg.2009.07.002

Campbell, J. P. (2012). Behavior, performance, and effectiveness in the twenty-first century. In

S. J. Kozlowski (Ed.), *The Oxford handbook of organizational psychology* (Vol. 1, pp.

159-194). New York: Oxford University Press.

Campbell, J. P., McCloy, R. A., Oppler, S. H., & Sager, C. E. (1993). A theory of performance.

In N. Schmitt & W. C. Borman (Eds.), *Personnel selection in organizations* (pp. 35-70).

San Francisco: Jossey-Bass.

Carek, P. J., Gravel, J. W., Jr., Kozakowski, S., Pugno, P. A., Fetter, G., & Palmer, E. J. (2009).

Impact of proposed Institute of Medicine duty hours: Family medicine residency

directors' perspective. *Journal of Graduate Medical Education, 1*(2), 195-200. doi:

10.4300/jgme-d-09-00003.1

Cedfeldt, A. S., English, C., El Youssef, R., Gilhooly, J., & Girard, D. E. (2009). Institute of

Medicine committee report on resident duty hours: A view from a trench. *Journal of*

Graduate Medical Education, 1(2), 178-180. doi: 10.4300/jgme-d-09-00031.1

Chen, J., Davis, K. G., Daraiseh, N. M., Pan, W., & Davis, L. S. (2014). Fatigue and recovery in

12-hour dayshift hospital nurses. *Journal of Nursing Management, 22*(5), 593-603. doi:

10.1111/jonm.12062

Cherlin, E. J., Curry, L. A., Thompson, J. W., Greysen, S. R., Spatz, E., Krumholz, H. M., &

Bradley, E. H. (2013). Features of high quality discharge planning for patients following

acute myocardial infarction. *Journal of General Internal Medicine, 28*(3), 436-443. doi:

10.1007/s11606-012-2234-y

Classen, D. C., Evans, R. S., Pestotnik, S. L., Horn, S. D., Menlove, R. L., & Burke, J. P. (1992). The timing of prophylactic administration of antibiotics and the risk of surgical-wound infection. *New England Journal of Medicine, 326*(5), 281-286. doi: 10.1056/nejm199201303260501

CMS. (2011). *Cost Report Files*. Retrieved from: http://www.cms.gov/Research-Statistics-Data-and-Systems/Downloadable-Public-Use-Files/Cost-Reports/Hospital-2010-form.html

CMS. (2013). Hospital value-based purchasing program Retrieved March 31, 2015, from https://www.cms.gov/Outreach-and-Education/Medicare-Learning-Network-MLN/MLNProducts/Downloads/Hospital_VBPurchasing_Fact_Sheet_ICN907664.pdf

CMS. (2015). CMS abstraction and reporting tool (CART).

Cohen-Gadol, A. A., Piepgras, D. G., Krishnamurthy, S., & Fessler, R. D. (2005). Resident duty hours reform: Results of a national survey of the program directors and residents in neurosurgery training programs. *Neurosurgery, 56*(2), 398-403.

Cohen, A., Doveh, E., & Eick, U. (2001). Statistical properties of the rWG(j) index of interrater agreement. *Psychological Methods, 6*, 297-310.

Coverdill, J. E., Bittner, J. G., Park, M. A., Pipkin, W. L., & Mellinger, J. D. (2011). Fatigue as impairment or educational necessity? Insights into surgical culture. *Academic Medicine, 86*(10 Suppl), S69-72. doi: 10.1097/ACM.0b013e31822a6b40

Dawson, D., Mayger, K., Thomas, M. J. W., & Thompson, K. (2015). Fatigue risk management by volunteer fire-fighters: Use of informal strategies to augment formal policy. *Accident Analysis and Prevention, 84*, 92-98. doi: 10.1016/j.aap.2015.06.008

Dawson, D., Noy, Y. I., Harma, M., Akerstedt, T., & Belenky, G. (2011). Modelling fatigue and the use of fatigue models in work settings. *Accident Analysis and Prevention, 43*, 549-564.

Dawson, D., & Reid, K. (1997). Fatigue, alcohol and performance impairment. *Nature, 388*, 235-237.

Deadrick, D. L., & Madigan, R. M. (1990). Dynamic criteria revisited: A longitudinal study of performance stability and predictive validity. *Personnel Psychology, 43*(4), 717-744. doi: 10.1111/j.1744-6570.1990.tb00680.x

DiMaggio, P. J., & Powell, W. W. (1983). The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American Sociological Review, 48*, 147-160. doi: 10.2307/2095101

Emery, S. (2012). *Work hours, workload, and fatigue in nurse anesthetists.* Boston College. Available from CINAHL

Endsley, M. R. (1997). The role of situation awareness in naturalistic decision making. In C. E. Zsambok & G. Klein (Eds.), *Naturalistic decision making* (pp. 269-283). New York: Routledge.

Ferguson, C. M., Kellogg, K. C., Hutter, M. M., & Warshaw, A. L. (2005). Effect of work-hour reforms on operative case volume of surgical residents. *Current Surgery, 62*(5), 535-538. doi: 10.1016/j.cursur.2005.04.001

Fitts, P. M. (1964). Perceptual-motor skill learning. In A. W. Melton (Ed.), *Categories of human learning* (pp. 381-391). New York: Academic Press.

Fitts, P. M., & Posner, M. I. (1967). *Human performance*. Belmont, CA: Brooks/Cole Publishing Company.

Fletcher, K. E., Reed, D. A., & Arora, V. M. (2011). Patient safety, resident education and resident well-being following implementation of the 2003 ACGME duty hour rules. *Journal of General Internal Medicine, 26*(8), 907-919. doi: 10.1007/s11606-011-1657-1

Folkard, S., & Monk, T. H. (1985). *Hours of work: Temporal factors in work scheduling*. New York: Wiley.

Gallagher, S. F., Ross, S. B., Haines, K., Shalhub, S., Fabri, P. J., Karl, R. C., & Murr, M. M. (2005). Realistic expectations and leadership in the era of work hour reform. *Journal of Surgical Research, 126*(2), 137-144. doi: 10.1016/j.jss.2004.11.027

Gander, P. H., Marshall, N. S., Bolger, W., & Girling, I. (2005). An evaluation of driver training as a fatigue countermeasure. *Transportation Research, 8*(1), 47-58. doi: 10.1016/j.trf.2005.01.001

Ghiselli, E. E., & Haire, M. (1960). The validation of selection tests in the light of the dynamic character of criteria. *Personnel Psychology, 13*, 225-231. doi: 10.1111/j.1744-6570.1960.tb01352.x

Glaser, R. (1999). Expert knowledge and the processes of thinking. In P. Murphy, M. Selinger, J. Bourne, & M. Briggs (Eds.), *Subject learning in the primary curriculum* (pp. 261-275). New York: Routledge.

Han, K., Trinkoff, A. M., & Geiger-Brown, J. (2014). Factors associated with work-related fatigue and recovery in hospital nurses working 12-hour shifts. *Workplace Health & Safety, 62*(10), 409-414. doi: 10.3928/21650799-20140826-01

104

IBM. (2013). SPSS Statistics (Version 22).

IOM. (2000). *To err is human: Building a safer health system*. Washington, D.C.: National Academy Press.

Jaffe, D., Scott, C., & Tobe, G. (1994). *Rethinking commitment: How to revitalize yourself, your work, and your organization*. San Francisco: Jossey-Bass.

Jagannathan, J., Vates, G. E., Pouratian, N., Sheehan, J. P., Patrie, J., Grady, M. S., & Jane, J. A. (2009). Impact of the Accreditation Council for Graduate Medical Education work-hour regulations on neurosurgical resident education and productivity. *Journal of Neurosurgery, 110*(5), 820-827. doi: 10.3171/2009.2.jns081446

Jagsi, R., Kitch, B. T., Weinstein, D. F., Campbell, E. G., Hutter, M., & Weissman, J. S. (2005). Residents report on adverse events and their causes. *Archives of Internal Medicine, 165*(22), 2607-2613. doi: 10.1001/archinte.165.22.2607

Jena, A. B., Prasad, V., & Romley, J. A. (2014). Long-term effects of the 2003 ACGME resident duty hour reform on hospital mortality. *Mayo Clinic Proceedings, 89*(7), 1023-1025. doi: 10.1016/j.mayocp.2014.05.001

Jewett, M. E., Dijk, D. J., Kronauer, R. E., & Dinges, D. F. (1999). Dose-response relationship between sleep duration and human psychomotor vigilance and subjective alertness. *Sleep, 22*(2), 171-179.

Johns, M. W. (1991). A new method for measuring daytime sleepiness: The Epworth Sleepiness Scale. *Sleep, 14*(540-545).

Kahn, C. N., Ault, T., Potetz, L., Walke, T., Chambers, J. H., & Burch, S. (2015). Assessing

    Medicare's hospital pay-for-performance programs and whether they are achieving their

    goals. *Health Affairs, 34*(8), 1281-1288. doi: 10.1377/hlthaff.2015.0158

Kahneman, D. (1973). *Attention and effort*. Englewood Cliffs, NJ: Prentice-Hall.

Kahneman, D. (2003). A perspective on judgment and choice: Mapping bounded rationality.

    American Psychologist, 58(9), 697-720.

Kahneman, D. (2011). *Thinking, fast and slow*. New York: Farrar, Straus and Giroux.

Kaplan, S., & Tetrick, L. E. (2010). Workplace safety and accidents: An industrial and

    organizational psychology perspective. In S. Zedeck (Ed.), *APA handbook of industrial*

    and organizational psychology (pp. 455-472). Washington, DC: American Psychological

    Association.

Kozlowski, S. W. J., & Hattrup, K. (1992). A disagreement about within-group agreement:

    Disentangling issues of consistency versus consensus. *Journal of Applied Psychology, 77*,

    161-167.

Landrigan, C. P., Rothschild, J. M., Cronin, J. W., Kaushal, R., Burdick, E., Katz, J. T., . . .

    Czeisler, C. A. (2004). Effect of reducing interns' work hours on serious medical errors in

    intensive care units. *The New England Journal of Medicine, 351*(18), 1838-1848. doi:

    10.1056/NEJMoa041406

LeBreton, J. M., & Senter, J. L. (2008). Answers to 20 Questions about interrater reliability and

    interrater agreement. *Organizational Research Methods, 11*(4), 815-852.

Lewin, K. (1947). Frontiers in group dynamics. *Human Relations, 1*, 5-41.

Lim, J., & Dinges, D. F. (2008). Sleep deprivation and vigilant attention. *Annals of the New York Academy of Sciences, 1129*, 305-322. doi: 10.1196/annals.1417.002

Lindell, M. K., Brandt, C. J., & Whitney, D. J. (1999). A revised index of agreement for multi-item ratings of a single target. *Applied Psychological Measurement, 23*, 127-135.

Long, T. R., Poe, J. D., Zimmerman, R. S., & Rose, S. H. (2012). A citation tracking system to facilitate sponsoring institution oversight of ACGME-accredited programs. *Journal of Graduate Medical Education, 4*(4), 500-504. doi: 10.4300/jgme-d-11-00313.1

Martins, L. L. (2011). Organizational change and development. In S. Zedeck (Ed.), *APA handbook of industrial and organizational psychology* (Vol. 3, pp. 691-728). Washington, DC: APA.

McCarthy, M. E., & Waters, W. F. (1997). Decreased attentional responsivity during sleep deprivation: Orienting response latency, amplitude, and habituation. *Sleep, 20*(2), 115-123.

Meyer, J. W., & Rowan, B. (1977). Institutional organizations: Formal structure as myth and ceremony. *American Journal of Sociology, 83*, 340-363.

Mohtashami, F., Thiele, A., Karreman, E., & Thiel, J. (2014). Comparing technical dexterity of sleep-deprived versus intoxicated surgeons. *JSLS: Journal of the Society of Laparoendoscopic Surgeons, 18*(4). doi: 10.4293/jsls.2014.00142

Motowidlo, S. J., Borman, W. C., & Schmit, M. J. (1997). A theory of individual differences in task and contextual performance. *Human Performance, 10*(2), 71-83. doi: 10.1207/s15327043hup1002_1

Murphy, K. R. (1989). Dimensions of job performance. In R. F. Dillon & J. W. Pellegrino (Eds.), *Testing: Theoretical and applied perspectives* (pp. 218-247). Santa Barbara, CA: Praeger.

Mustahsan, S. M., Ali, S. M., Khalid, F., Ali, A. A., Ahmed, H., Hashmi, S. A., . . . Feroz, F. (2013). Sleep deprivation and its consequences on house officers and postgraduate trainees. *Journal of the Pakistan Medical Association, 63*(4), 540-543.

Niederee, M. J., Knudtson, J. L., Byrnes, M. C., Helmer, S. D., & Smith, R. S. (2003). A survey of residents and faculty regarding work hour limitations in surgical training programs. *Archives of Surgery, 138*(6), 663-669. doi: 10.1001/archsurg.138.6.663

Northwestern University, American College of Surgeons, American Board of Surgery, & Accreditation Council for Graduate Medical Education. (2016). Flexibility in duty hour requirements for surgical trainees trial - "the FIRST Trial".

Noy, Y. I., Horrey, W. J., Popkin, S. M., Folkard, S., Howarth, H. D., & Courtney, T. K. (2011). Future directions in fatigue and safety research. *Accident Analysis and Prevention, 43*, 495-497.

Olds, D. M., & Clarke, S. P. (2010). The effect of work hours on adverse events and errors in health care. *Journal of Safety Research, 41*(2), 153-162. doi: 10.1016/j.jsr.2010.02.002

Overhage, J. M., Perkins, S., Tierney, W. M., & McDonald, C. J. (2001). Controlled trial of direct physician order entry: Effects on physicians' time utilization in ambulatory primary care internal medicine practices. *Journal of the American Medical Informatics Association, 8*(4), 361-371.

Owens, J. A. (2007). Sleep loss and fatigue in healthcare professionals. *Journal of Perinatal and Neonatal Nursing, 21*(2), 92-100. doi: 10.1097/01.JPN.0000270624.64584.9d

Papp, K. K., Stoller, E. P., Sage, P., Aikens, J. E., Owens, J., Avidan, A., . . . Strohl, K. P.

    (2004). The effects of sleep loss and fatigue on resident-physicians: A multi-institutional,

    mixed-method study. *Academic Medicine, 79*(5), 394-406. doi: 10.1097/00001888-

    200405000-00007

Parasuraman, R. (1985). Sustained attention: A multifactorial approach. In M. I. Posner & O. S.

    Marin (Eds.), *Attention and human performance* (pp. 493-511). Hillsdale, NJ: Lawrence

    Erlbaum Associates.

Patel, M. S., Volpp, K. G., Small, D. S., Hill, A. S., Even-Shoshan, O., Rosenbaum, L., . . .

    Silber, J. H. (2014). Association of the 2011 ACGME resident duty hour reforms with

    mortality and readmissions among hospitalized Medicare patients. *JAMA, 312*(22), 2364-

    2373. doi: 10.1001/jama.2014.15273

Patterson, P. D., Moore, C. G., Weaver, M. D., Buysse, D. J., Suffoletto, B. P., Callaway, C. W.,

    & Yealy, D. M. (2014). Mobile phone text messaging intervention to improve alertness

    and reduce sleepiness and fatigue during shiftwork among emergency medicine

    clinicians: Study protocol for the SleepTrackTXT pilot randomized controlled trial.

    Trials, 15, 244-244. doi: 10.1186/1745-6215-15-244

Penfold, R. B., & Zhang, F. (2013). Use of interrupted time series analysis in evaluating health

    care quality improvements. *Academic Pediatrics, 13*(6), S38-S44.

Pepper, D. J., Schweinfurth, M., & Herrin, V. E. (2014). The effect of new duty hours on

    resident academic performance and adult resuscitation outcomes. *American Journal of

    Medicine, 127*(4), 337-342. doi: 10.1016/j.amjmed.2013.12.007

Philibert, I. (2005). Sleep loss and performance in residents and nonphysicians: A meta-analytic examination. *Sleep, 28*(11), 1392-1402.

Piening, E. P., Baluch, A. M., & Oliver Salge, T. (2013). The relationship between employees' perceptions of human resource systems and organizational performance: Examining mediating mechanisms and temporal dynamics. *Journal of Applied Psychology, 98*(6), 926-947.

Pinheiro, J. C., Bates, D. M., DebRoy, S., & Sarkar, D. (2014). nlme: Linear and nonlinear mixed effects models (Version 3.1-118). Vienna: R Foundation for Statistical Computing. Retrieved from http://CRAN.R-project.org/package=nlme

Ployhart, R. E. (Producer). (2014). Emerging questions in longitudinal research. [PowerPoint slides]

Polk, H. C., Jr., Trachtenberg, L., & Finn, M. P. (1980). Antibiotic activity in surgical incisions. The basis of prophylaxis in selected operations. *JAMA, 244*(12), 1353-1354.

Powell, R., & Copping, A. (2010). Sleep deprivation and its consequences in construction workers. *Journal of Construction Engineering & Management, 136*(10), 1086-1092. doi: 10.1061/(ASCE)CO.1943-7862.0000211

R Core Team. (2014). R: A language and environment for statistical computing (Version 3.1.2). Vienna: R Foundation for Statistical Computing. Retrieved from http://www.R-project.org/

Rajaram, R., Chung, J. W., Jones, A. T., Cohen, M. E., Dahlke, A. R., Ko, C. Y., . . . Bilimoria, K. Y. (2014). Association of the 2011 ACGME resident duty hour reform with general

surgery patient outcomes and with resident examination performance. *JAMA, 312*(22), 2374-2384. doi: 10.1001/jama.2014.15277

Rajaram, R., Chung, J. W., Kinnier, C. V., Barnard, C., Mohanty, S., Pavey, E. S., . . . Bilimoria, K. Y. (2015). Hospital characteristics associated with penalties in the Centers for Medicare & Medicaid Services hospital-acquired condition reduction program. *JAMA, 314*(4), 375-383. doi: 10.1001/jama.2015.8609

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods* (2nd ed.). Thousand Oaks, CA: Sage.

Reason, J. (1990). *Human error*. New York, NY: Cambridge University Press.

Reason, J. (2000). Human Error: Models and management. *BMJ: British Medical Journal, 320*(7237), 768-770. doi: 10.2307/25187420

Reason, J. (2008). *The human contribution: Unsafe acts, accidents and heroic recoveries*. Surrey, England: Ashgate.

Reed, D. A., Fletcher, K. E., & Arora, V. M. (2010). Systematic review: Association of shift length, protected sleep time, and night float with patient care, residents' health, and education. *Annals of Internal Medicine, 153*(12), 829-842. doi: 10.7326/0003-4819-153-12-201012210-00010

Rosen, I. M., Bellini, L. M., & Shea, J. A. (2004). Sleep behaviors and attitudes among internal medicine housestaff in a U.S. university-based residency program. *Academic Medicine, 79*(5), 407-416.

Ryan, R. M., Brion, L. P., Aucott, S. W., Juul, S. E., Parker, T. A., Savich, R. D., . . . Campbell, D. E. (2011). Organization of Neonatal Training Program Directors Council responds to

the ACGME 2010 proposed standards. *Journal of Perinatology, 31*(4), 296-297. doi: 10.1038/jp.2010.160

Ryman, D. H., Naitoh, P., & Englund, C. E. (1985). Decrements in logical reasoning performance under conditions of sleep loss and physical exercise: The factor of sentence complexity. *Perceptual and Motor Skills, 61*(3 Pt 2), 1179-1188. doi: 10.2466/pms.1985.61.3f.1179

Salas, E., DiazGranados, D., Weaver, S. J., & King, H. (2008). Does team training work? Principles for health care. *Academic Emergency Medicine, 15*(11), 1002-1009.

Schmidt, F. L., Hunter, J. E., & Outerbridge, A. N. (1986). Impact of job experience and ability on job knowledge, work sample performance, and supervisory ratings of job performance. *Journal of Applied Psychology, 71*(3), 432-439. doi: 10.1037/0021-9010.71.3.432

Schultz, K., Slagle, J., Brown, R., Douglas, S., Frederick, B., Lakhani, M., . . . Carayon, P. (2006). *Development of a job task analysis tool for assessing the work of physicians in the intensive care unit.* Paper presented at the 50th Annual Human Factors and Ergonomics Society Meeting, San Francisco, CA.

Schulz, C. M., Endsley, M. R., Kochs, E. F., Gelb, A. W., & Wagner, K. J. (2013). Situation awareness in anesthesia: Concept and research. *Anesthesiology, 118*(3), 729-742. doi: 10.1097/ALN.0b013e318280a40f

Scott, W. R., Ruef, M., Mendel, P. J., & Caronna, C. A. (2000). *Institutional change and healthcare organizations.* Chicago: University of Chicago Press.

Shepperd, S., Lannin, N. A., Clemson, L. M., McCluskey, A., Cameron, I. D., & Barras, S. L.

(2013). Discharge planning from hospital to home. *Cochrane Database of Systematic*

Reviews, 1, 1-89. doi: 10.1002/14651858.CD000313.pub4

Shetty, K. D., & Bhattacharya, J. (2007). Changes in hospital mortality associated with residency

work-hour regulations. *Annals of Internal Medicine, 147*(2), 73-80.

Singer, J. D., & Willett, J. B. (2003). Modeling discontinuous and nonlinear change. In J. D.

Singer & J. B. Willett (Eds.), *Applied longitudinal data analysis: Modeling change and*

event occurence (pp. 189-242). New York: Oxford University Press.

Singer, M. C. (2010). The future of otolaryngology training threatened: The negative impact of

residency training reforms. *Otolaryngology and Head and Neck Surgery, 142*(3), 303-

305. doi: 10.1016/j.otohns.2009.12.010

Sloan, S., Krishnamurthy, M., Lyon, D. T., Mitri, G., Chyshkevych, I., & Livert, D. (2009).

Work hour regulations: Do we need further changes now? A survey of internal medicine

faculty and residents. *Journal of Graduate Medical Education, 1*(2), 201-207. doi:

10.4300/jgme-d-09-00009.1

Smith, B. P., Fox, N., Fakhro, A., LaChant, M., Pathak, A. S., Ross, S. E., & Seamon, M. J.

(2012). "SCIP"ping antibiotic prophylaxis guidelines in trauma: The consequences of

noncompliance. *Journal of Trauma and Acute Care Surgery, 73*(2), 452-456. doi:

10.1097/TA.0b013e31825ff670

Stone, H. H., Hooper, C. A., Kolb, L. D., Geheber, C. E., & Dawkins, E. J. (1976). Antibiotic

prophylaxis in gastric, biliary and colonic surgery. *Annals of Surgery, 184*(4), 443-452.

Tan, J. A., Naik, V. N., & Lingard, L. (2006). Exploring obstacles to proper timing of

    prophylactic antibiotics for surgical site infections. *Quality and Safety in Health Care,*

    15(1), 32-38. doi: 10.1136/qshc.2004.012534

Thoresen, C. J., Bradley, J. C., Bliese, P. D., & Thoresen, J. D. (2004). The big five personality

    traits and individual job performance growth trajectories in maintenance and transitional

    job stages. *Journal of Applied Psychology, 89*(5), 835-853. doi: 10.1037/0021-

    9010.89.5.835

Turner, T. H., Drummond, S. P. A., Salamat, J. S., & Brown, G. G. (2007). Effects of 42 hr of

    total sleep deprivation on component processes of verbal working memory.

    Neuropsychology, 21(6), 787-795. doi: 10.1037/0894-4105.21.6.787

Ulmer, C., Miller Wolman, D., & Johns, M. M. E. (2009). *Resident duty hours: Enhancing sleep,*

    supervision, and safety. Washington, D.C.: The National Academies Press.

Underwood, W., Boyd, A. J., Fletcher, K. E., & Lypson, M. L. (2004). Viewpoints from

    generation X: A survey of candidate and associate viewpoints on resident duty-hour

    regulations. *Journal of the American College of Surgeons, 198*(6), 989-993. doi:

    10.1016/j.jamcollsurg.2003.12.027

Victores, A. J., Coggins, K., & Takashima, M. (2014). Electronic health records and resident

    workflow: A time-motion study of otolaryngology residents. *The Laryngoscope, 125*,

    594-598.

Volpp, K. G., Rosen, A. K., Rosenbaum, P. R., Romano, P. S., Even-Shoshan, O., Canamucio,

    A., . . . Silber, J. H. (2007). Mortality among patients in VA hospitals in the first 2 years

following ACGME resident duty hour reform. *JAMA, 298*(9), 984-992. doi:
10.1001/jama.298.9.984

Weinger, M. B., Herndon, O. W., Zornow, M. H., Paulus, M. P., Gaba, D. M., & Dallen, L. T.
(1994). An objective methodology for task analysis and workload assessment in
anesthesia providers. *Anesthesiology, 80*(1), 77-92.

Whang, E. E., Perez, A., Ito, H., Mello, M. M., Ashley, S. W., & Zinner, M. J. (2003). Work
hours reform: Perceptions and desires of contemporary surgical residents. *Journal of the
American College of Surgeons, 197*(4), 624-630. doi: 10.1016/s1072-7515(03)00602-1

Wickens, C. D., Hutchins, S. D., Laux, L., & Sebok, A. (2015). The impact of sleep disruption
on complex cognitive tasks: A meta-analysis. *Human Factors, 57*(6), 930-946.

Williamson, A., Lombardi, D. A., Folkard, S., Stutts, J., Courtney, T. K., & Connor, J. L. (2011).
The link between fatigue and safety. *Accident Analysis and Prevention, 43*, 498-515.

Winslow, E. R., Berger, L., & Klingensmith, M. E. (2004). Has the 80-hour work week increased
faculty hours? *Current Surgery, 61*(6), 602-608. doi: 10.1016/j.cursur.2004.06.013

Yaghoubian, A., Saltmarsh, G., Rosing, D. K., Lewis, R. J., Stabile, B. E., & de Virgilio, C.
(2008). Decreased bile duct injury rate during laparoscopic cholecystectomy in the era of
the 80-hour resident workweek. *Archives of Surgery, 143*(9), 847-851. doi:
10.1001/archsurg.143.9.847