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Vigilance of Certified Registered Nurse Anesthetists

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Don’t cry because it’s over, smile because it happened.

—Theodor Geisel “Dr. Seuss”

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ABSTRACT

Vigilance of certified registered nurse anesthetists (CRNAs) is an integral component of the care they provide patients under general anesthetic. The practice of CRNAs is important as the official seal of the American Association of Nurse Anesthetists (AANA). On the seal, Morpheus, the god of dreams, is shown holding the Lamp of Learning, by the light of which he keeps vigil (Hirter & Van Nest, 1995). As the patients remain unconscious under general anesthesia, CRNAs remain the patients' eyes and ears remain responsive to their needs. The CRNA must remain attentive to the patient's needs by continuously monitoring the patient in the operating room and constantly communicating with the operating room staff. Complete focus must be maintained to avoid any mishaps or adverse events. In essence, CRNAs must remain focused and vigilant when caring for their patients.

The importance of vigilance is essential and undeniable for optimal patient outcomes, but the process has yet to be defined and understood. Fourteen CRNAs participated in phone interviews in this study. CRNAs practicing in both hospital and ambulatory settings were included. Through data analysis, using constant comparison, a model emerged that explained vigilance in the CRNA process. The core category was Using Senses, and the model had seven subcategories. The categories below reflected stages in the process model.

The process begins with the CRNA's care of the patient (Being Alert). This is when the CRNA assumes care of the patient, maintains a high level of alertness, and does not get mentally fatigued. Being alert allows the CRNA to be ready to care for their patients. When CRNAs are

alert, they are attentive and engaged (Being Attentive and Engaged) in watching over their patients. This allows the CRNA to be constantly aware and pay attention to their patients. Being attentive and engaged allows the CRNA to be focused (Focusing) on every aspect of patient care. Unfortunately, the operating room is a dynamic environment, where distractions, such as music, conversation, and technology can distract clinicians from being engaged in the care of their patients. These distractions can, but do not always, occur. When they do occur, the CRNA redirects their attention and begins to focus, which allows CRNAs to use their senses to look, listen, and feel (Looking, Listening, and Touching). Using the senses of looking, listening, and feeling, the CRNA can pick up on events or look for cues that can help continue or improve care by anticipating changes at random intervals during the case. By using their senses and picking up on cues, the CRNA knows what is going on with the patient (Know What Is Happening).

The findings of this study have implications for nurse administrators. This theory will be informative and helpful for hospital administrators, as they may want to implement a policy similar to that which the aviation industry developed for pilots reporting for duty. In regard to nursing research, the Institute of Medicine ([IOM], 2003) has used the phenomena of vigilance and surveillance interchangeably, but the processes are not interchangeable. There is a distinction between these two concepts. This study provides a link between the two phenomena. Vigilance is a link to the process of surveillance and studying it will help the researcher expound upon the previous surveillance research in nursing.

CHAPTER 1

INTRODUCTION

The United States has an advanced healthcare system and is moving forward every day to improve patient care. Yet, it is estimated that up to 17% of hospitalizations are affected by one or more adverse events, with up to 71% potentially preventable (Slawomirski, Auraaen, & Klazinga, 2017). Healthcare is a high-risk industry in which adverse events can lead to patient harm and potential death. In 1999, the Institute of Medicine (IOM) was the major leader in patient safety when it released "To Err Is Human" (Kohn, Corrigan, & Donaldson, 2000). The publication did not put blame or shame on any healthcare worker, but rather brought attention to adverse events as a learning tool for healthcare workers to build upon. This was the spark to ignite the focus on patient safety. In her *Notes on Hospitals,* Florence Nightingale (2014) mentions how the hospital environment would allow nature to work in the direction of health and it should do the sick no harm.

As healthcare has evolved, adverse events continue to burden patient care. Unsafe care and patient harm are not just the result of human fallibility, but also, principally, the result of system failures. Harm is deemed preventable through the improvements of clinical practice, and nowhere is this more critical than in the operating room, where the anesthesia provider is in complete control of the patient's survival of the surgery. The anesthesia provider remains the eyes and ears of the patient when the patient cannot verbalize his or her problems. In 1985, the Anesthesia Patient Safety Foundation was developed as a way to improve patient care by recognizing potential hazards in the specialty of anesthesia.

The recognition of potential hazards and adverse events were turned into learning opportunities for anesthesia providers to understand the importance of attention and vigilance when patients are under their care (Holzman, Polk, Webre, & Zeitlin, 1991). The Anesthesia Patient Safety Foundation has led to the development of new and safer anesthesia practices, though they are geared more to physicians' practices. The Foundation only recently has focused on the impact of technology and distractions that can be detrimental to patient care. The Foundation refers to vigilance passively and is mentioned in the literature (Weinger, Gonzales, Slagle, & Syeed, 2004; Weinger, & Slagle, 2001; Weinger & Smith, 1997), yet no one has defined the process of vigilance.

In the advent of new anesthesia techniques, drugs, and enhanced training, anesthesia-mortality risk has declined from about 1 death in 1,000 anesthesia procedures in the 1940s to 1 in 10,000 in the 1970s and to 1 in 100,000 in the 1990s and early 2000s (Li, Warner, Lang, Huang, & Sun, 2009). Anesthesia care is the safest it has ever been; yet adverse incidents still occur. Even though the numbers have dropped dramatically, there still remains potential adverse risk that patients can succumb to under general anesthesia. Currently, anesthesia deaths have declined to about 1 death in every 300,000 anesthetics provided (Dutton, 2012).

According to a 1999 report from the IOM, anesthesia care is nearly 50 times safer than it was in the early 1980s, with identifying safety problems and promoting research to improving care (IOM, 1999). The report provided evidence that the healthcare profession needed to find ways to improve the quality of care; yet there have not been any significant improvements made in reducing mistakes and errors (Leape et al. 2009). In the operating room, the source of frequent adverse events is mainly its inherently complex structure, such as increased case load demands, pressures to perform, and conflicting priorities when caring for patients (Wheelock et al., 2015).

Errors are largely avoidable in healthcare, but they occur due to a system problem or lack of attention/experience of the clinician. The Harvard Medical Practice study highlighted errors occurring in hospitals and stated that over 5% of patients admitted to hospitals in New York suffered an adverse event as a consequence of the care they received (Brennan et al., 1991). More recently, 10 hospitals in North Carolina were examined for errors. Of over 2,000 hospital admissions, there were 364 preventable events that were deemed "harms" (Landrigan et al., 2010). Medication errors and communication problems are major contributors to adverse events in healthcare. When errors and bad decision-making occur, healthcare can have catastrophic effects on patients, such as potential death. Therefore, it is of utmost importance that complete focus and attention be maintained when caring for patients.

One example of the importance of vigilance in anesthesia is relieving colleagues for small breaks for mental refocus and to avoid drug errors. The best way to "treat" drug errors is prevention. Errors are estimated to occur with an incidence of 3 to 16% in hospitalized patients (Daverio, Fino, & Luca, 2015). Wrong medication (due to syringe swap), overdose (due to pump misuse and dilution error), incorrect administration route, under-dosing, and omission are common causes of medication errors that occur perioperatively. Drug omission, calculation mistakes, and medication errors can occur during preparation, administration, or record keeping (Anderson, 2018; Dhawan, Tewari, Sehgal, & Sinha, 2017).

Certified registered nurse anesthetists (CRNAs) have been providing anesthesia care to patients for over 150 years (American Association of Nurse Anesthetists [AANA], 2017), and it is estimated that they provide approximately 43 million anesthetics each year in the United States (AANA, 2017). Once there were anesthesia providers, nurses were better suited to the task of anesthesia because they were more likely to keep their minds strictly on it, whereas interns, used

as anesthesia providers when anesthesiologists were not identified as practitioners yet, were more interested in what the surgeons were doing (Bankert, 2004). CRNAs are highly educated, highly trained, and certified to provide highly volatile drugs to patients so they can withstand surgery.

The practice of CRNAs is important as noted on the official seal of the AANA. Adopted in 1940, it is the "Watchful Care of the Sleeper by the Light of the Lamp of Learning." It was derived from the ancient legend about Hypnos, the God of Sleep, who fostered sleep and pleasant dreams with poppies. Morpheus, the God of Dreams, was delegated to watch over Hypnos as he slept and fend off harm and ensure pleasant dreams. On the seal, Morpheus is shown holding the Lamp of Learning, by the light of which he keeps vigil (Hirter & Van Nest, 1995). As the patients remain unconscious under general anesthesia, CRNAs remain the eyes and ears of the patient. They remain responsive to the needs of the patient shown though subtle indications, such as changes in vital signs or changes in volume status, like bleeding or decreased urine output. The CRNA must remain attentive to the patient's needs by continuously monitoring the patient in the operating room and constantly communicating with the operating room staff. Complete focus must be maintained to avoid any mishaps or adverse events. In essence, CRNAs must remain focused and vigilant when caring for their patients.

Vigilance has been referred to as a state of readiness to detect and respond to small changes occurring at random intervals in the environment (Jorm & O'Sullivan, 2012. Vigilance is a phenomenon that plays an essential role in our daily lives. The requirement for attention is present in every part of daily living. Nowhere is it more essential than in healthcare, where human lives are affected by the results of vigilance. Vigilance is an essential component to providing safe patient care. Specifically, it is assumed that every anesthesia provider caring for a

patient keeps his or her utmost attention and focus on the patient. This is especially important since patients under general anesthesia cannot communicate their needs.

There still remains no uniform definition of vigilance as it differs among professions. The meaning can be similarly understood amongst many disciplines, though there is no consensus to a working definition that can be used throughout. In fact, the IOM has used the phenomena of vigilance and surveillance interchangeably when, in fact, the meanings are not interchangeable. Vigilance is defined as a state of readiness to detect and respond, which is an important concept in anesthesia, while surveillance is defined as a process of watching over (Schmidt, 2010). Vigilance is a quality characteristic that is obtained with years of training clinical practice, not developed overnight by just reading it in a book. Therefore, vigilance is the basis of nurse anesthetists' practice.

The issue is that anesthesia providers monitor and assess patients throughout their surgery; yet providers cannot remain vigilant for long periods of time. It is human nature to eventually divert one's attention and allow for distractions to occur or fatigue to take over. Unfortunately, mishaps and clinical events occur in the operating room due to human error. Practitioners are human, make poor monitors over a sustained amount of time, and can be distracted very easily. A single distraction can increase the risk of error by 12% in healthcare (Beyea, 2014). Even when complete focus is occurring, the human mind can be distracted or wander, affecting reaction time. These errors occur and can vary from things such as syringe swapping to inadvertent anesthesia gas flows and misplaced endotracheal tubes. It is important to prevent these errors from ever occurring and recognize immediately when it happens. These events occur mostly due to the lack of attention and vigilance from the CRNA.

The more important question is how does the vigilance of the anesthesia provider affect

patient care and patient outcomes? Healthcare is evolving with advancements in technology, but as more technology is implemented with automation, the role of the anesthesia provider shifts more to the monitor, placing the provider in more of a passive role. A long-standing finding concerns the propensity for automation to exacerbate vigilance decrement, meaning a decrease or lack of vigilance, when individuals' roles shift from active controller to supervisor of automation. Consequently, people perform poorly in responding to rare failures of highly automated systems (Parasuraman, Sheridan, & Wickens, 2000). Automation performs well in boring, monotonous tasks, but human performance can suffer due to a decrease of vigilance and fatigue. Automation provides a solution by relieving people of monotonous tasks but simultaneously introduces the potential to make boring tasks even more boring. The challenge is keeping the individual engaged while automation is involved.

Vigilance in CRNAs remains vital to their patients' well-being and the success of their outcomes. CRNAs are constantly bombarded with stimulation, such as conversations, noise, music, alarms, pagers, and demands from surgeons in the operating room environment (Campbell, Arfanis, & Smith, 2012). They must remain attentive at all times while providing critical patient care. The AANA acknowledges the importance of vigilance in clinical practice as a standard of nurse anesthesia practice, noting that continuous clinical observation and vigilance are the basis of safe anesthesia care (AANA, 2017).

The importance of vigilance is undeniable. What is missing is an understanding of what the process of practicing vigilance is. Vigilance has been examined over multiple disciplines in the literature, but the process of how to be vigilant has never been researched in the profession of nurse anesthesia. Therefore, it is essential to understand the foundations of vigilance, specifically in anesthesia. Because of the lack of research in this area, a qualitative research approach using

grounded theory will be used. It is important to examine the process of how nurse anesthetists remain vigilant because without knowing the process, it cannot be understood. Without understanding the process, designs to improve or increase vigilance cannot occur.

The aim of this research is to conceptualize the process of how nurse anesthetists remain vigilant over their patients. The goal is to comprehend vigilance when it is stated in anesthesia practice, but has yet to be defined. Grounded theory refers to a set of systematic inductive methods for conducting research aimed toward theory development by collecting and analyzing data (Glaser & Strauss, 1967). The resulting theory is built upon strong empirical data. This area of research will bring attention to and shed light on a new understanding of vigilance provided by nurse anesthetists.

The results will inform the nursing practice of vigilance and improve awareness of it, while filling in gaps in the literature about the vigilance of CRNAs. This can affect patient care in order to optimize positive outcomes. Although there has been one qualitative research study that involved CRNAs, "Keeping Vigil Over the Profession" (Schreiber & MacDonald, 2010), which examined the profession of CRNAs, there has not been any specific research on the clinical actions of vigilance over patients. Therefore, there are no conclusions that can be reached about how CRNAs maintain vigilance over their patients.

This phenomenon of vigilance has a major role in clinical practice and, therefore, is essential when providing anesthesia care. This is something that CRNAs misunderstand, but there is an expectation that they will practice it. The results of this research will contribute to the science of nursing and bring vigilance to the attention of providers. During an era in which technology, texting, and social media are distractions, patient outcomes can be negatively

affected. This research can bring an understanding of the process of vigilance, which will influence the way CRNAs practice anesthesia.

Understanding the process is essential for the progress of nurse anesthesia practice. This topic is essential for nursing practice and should be common practice for all clinicians caring for patients. This research will finally provide concrete meaning and understanding to something that is not taught, yet is understood as “clinical awareness” (Weinger & Smith, 1997) in the field of anesthesia. The results will advance the profession and improve patient care and patient safety.

CHAPTER 2

LITERATURE REVIEW

A literature review was conducted to analyze vigilance research in aviation, psychology, medicine, nursing, and the specialized area of anesthesia. These areas were selected because of the importance of the topic and the impact vigilance has on the profession. This review of the research literature was performed to determine the deficits and gaps in the existing literature, to provide supporting evidence for the research question, and to analyze the current state of knowledge of vigilance. A summary was compiled to identify gaps in vigilance research and to justify the need for research in the area of anesthesia and the proposed study.

Aviation

This literature search was performed on vigilance to better understand the background, understanding, and meaning of the phenomenon in various disciplines. Aviation was selected as the first discipline because of the importance and impact it can have on the aviation profession. This profession has parallels to anesthesia in that both professions are responsible for keeping people safe, and their actions and inactions can have detrimental and catastrophic effects. In the search for vigilance in aviation, Google Scholar and CINAHL were the search engines used. Typing vigilance in the keywords section in Google Scholar, resulted in over 30,000 citations, while with CINAHL, the results produced over 3,000 citations. As with research, a random sampling is indicative of a population. Therefore, a random sample of the literature search results was done from 1990 to 2018 to obtain data and studies in aviation. When researching vigilance in aviation, the exact term vigilance did not show up in titles, but rather indicators emerged from

the literature that are contributing factors affecting vigilance, such as workload, complacency, and fatigue.

The first psychological testing center for pilots can be dated back to the First World War, which focused on pilots' and aviators' ability to perform during a time of war. This is also where the National Research Council started to examine the psychological problems in aviation. One of the first psychological studies examined in-flight training and emotional stability, looking at pilots' responses to noises (Koonce, 1984). This led to further psychological studies examining a pilot's ability to cope with high altitude flight. Reaction times, emotional stability, and altitude flying ability were all examined to determine a pilot's fitness for flying during the time of war.

During peacetime, American and European researchers began to administer tests to help identify the characteristics of those aviators who were successful. Most important were the power of quick adjustment to a new situation and good decision-making. As World War Two began, there was a surge in research, specifically around fatigue, vigilance, target detection, and equipment to improve aviation. Around the same time, commercial aviation began along with the use of aviation for transportation of goods, including mail. During this time, several universities, such as Ohio State University, started investing time and research into aviation-related problems. Thomas Gordon (1949) researched how the commercial airlines went about selecting their pilots. Pilots' test scores and years of experience did not have any correlation with the selection process.

From the 1950s to the late 1980s, there is a gap in the literature, with a lack of studies for an unknown reason. Then emerged the air traffic controllers and the workload stressors they endure on the job. The air traffic controllers themselves became of greater interest along with the advancement of technology, such as new displays and computers, to help share workloads.

Rapid advances in technology have revolutionized the way air traffic controllers and flight crew interact with each other and perform their duties. Cockpit instruments that were once completely manual are now assisted by computers and sensors. The overall purpose for air traffic controllers, pilots, and flight staff is to ensure the safe and efficient management of complex air traffic and transportation (Wickens, Mavor, & Megee, 1997). To avoid any type of catastrophic event or error, pilots and controllers are responsible for a number of different responsibilities simultaneously, such as flight paths, distances, speed, and weather conditions. These responsibilities can affect not only the safety, but also the outcomes of many lives. As with anesthesia patients, passengers relinquish control to highly trained individuals to ensure their safety. Therefore, complete focus and attention must be given to the task and distractions and monotony that can occur with repetitive conditions must be avoided.

A survey of 138 air traffic controllers at four European Air Navigation Services revealed that there is a gap between the interpretation and perception of what vigilance is (Straussberger, 2006). Air traffic controllers see vigilance as the active, preplanning behavior undertaken to avoid potential accidents. While preplanning is an important element of vigilance, the authors failed to explain the continuous process of monitoring and assessing the situation.

The aviation industry has researched pilot fatigue and decision-making for years, for the most part, because when there is an error or deviation from planned operations, the results can be catastrophic not only for the passengers, but for those of the surrounding residential areas below. Fatigue is one of the biggest factors that affect a pilot's ability to remain vigilant when operating an aircraft (Olaganatghan, Holt, & Luedtke, 2017). Fatigue has been defined as a transient state associated with difficulties in maintaining task-directed effort and attention during sustained performance (Belenky et al., 2003; Thomas & Ferguson, 2010). This has been identified as a

major contributor to incidents in aviation and documented by the National Transportation Safety Board (NTSB), such as in the Asiana Airline accident in San Francisco (NTSB, 2013).

Long, unpredictable hours; interrupted sleep patterns, and circadian rhythm disruptions can all affect the focus and attention of aviation pilots and crew members. Irregular work hours can affect the biological programming of the human body, and these disruptions affect the vigilance and attention of the flight crew. It is estimated that anywhere from 4–25% of mishaps or errors are due to fatigue, resulting in poor decisions, while about 70% of pilots admitted to experiencing fatigue and even some to dosing off at some period during a flight (Caldwell & Caldwell, 2005). Fatigue affects our physical ability to stay alert and attentive, while also affecting emotional ability and the psychological thought process (Caldwell & Caldwell, 2005).

Drury, Ferguson, and Thomas (2012) examined fatigue and the negative affective states in pilots. In this study, Drury and colleagues examined the emotional state of pilots as they experienced fatigue, specifically, their heightened emotional activity (HEA), which is defined as the affective responses to perceived environmental threats encountered (Drury et al., 2010). The researchers wanted to know if there was a relation between HEA and fatigue. Trained interviewers used five emotional markers (confusion, disagreement, unease, frustration, and stress) to observe flight crews' responses to threats encountered during their work routines. They observed 302 flight operations and obtained 535 HEAs. The findings demonstrated that when crew members' sleep was restricted, there was an increase in HEA. This is important because this is when errors that can occur with emotional states are increased leading to potential adverse events.

Over the past two decades, attention studies have become recognized as vitally important to human factors, especially in aviation, because of the growing use of automation in modern

airplanes. Such automation requires less action but more monitoring on the part of the crew, who must retain the ability to act when necessary. This type of monitoring activity requires a great deal of attention and vigilance.

Attention to detail in the aviation field is required for the safety of the crew and passengers. Maintaining vigilance for critical events such as changes in altitude deviations are important components for air traffic control operations, but there are few studies about this (Wickens et al., 1997). Pilots and air traffic controllers must remain sharp and responsive to any change or event. Time efficacy, the ability to perceive time, has proven to affect an air traffic controller's reaction time and situational awareness, leading to fewer mental mistakes (Yang, Rantanen, & Zhang, 2009). Technology has helped the aviation industry to evolve to improve outcomes and decrease errors with simulated environments to mimic real situations and increase attention to vigilance.

All of the research done in aviation is performed in a laboratory or simulated setting. Participants sit and watch for abnormal events, waiting for their performance to decline over time. The issue arises when the subjects do not perform their routines as they would in the real setting.

Casner, Geven, Recker, and Schooler (2015) questioned the simulated setting when they examined 16 pilots in a simulated environment to assess whether vigilance was affected during a flight path and approach to landing. During this simulation study, pilots were asked to perform two important phases in aviation called the "arrival phase" and the "approach phase." In the arrival phase, pilots must call out a series of altitudes they must cross to designate their location. In the approach phase, actions are less predictable when the planes arrive in a busy air space and air traffic controllers must communicate to either ascend or descend in a busy traffic space.

During these actions, the pilots were asked questions to determine if mind wandering was occurring.

The results of Casner and colleagues' (2015) study provided evidence that pilots did engage in mind wandering at times and missed 25% of the callouts they were required to perform, even though their performance overall did not deteriorate. They were able to engage in other cockpit activities for pilot monitoring, helping to redirect focus, and providing evidence that mind wandering does occur but does not affect the monitoring and engagement of an exercise.

Technology has helped to advance the way aviation is performed. It has helped to reduce some of the stressors pilots may experience with normal, routine flight duties. Automation, more specifically the autopilot, has aided in relieving the immediate attention of pilots. This is seen as a positive benefit to aviation pilots, but research has shown that automation does not only supplant human activity, but rather it changes it in ways that were not intended or anticipated by its designers (Parasuraman & Riley, 1997).

Parasuraman and Manzey (2010) referred to automation as complacency, defined by the National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System as satisfaction resulting in a non-vigilant state (Billings, Lauber, Cooper, & Ruffell-Smith, 1976). The core feature of complacency leads the pilot to monitor the automated system and removes the constant physical manual maneuvers demanded for flying an aircraft. The benefits that automation provides, such as lower workload and increased efficiency, may negatively affect human performance (Parasuraman & Manzey, 2010).

Casner and Schooler (2013) examined the effects of automation on the thoughts and focus of pilots while in flight. In another study, 18 airline pilots were asked to fly a simulated

flight approaching LaGuardia airport, crossing over particular landmarks as they normally would. During the simulation, the airplane automation was put in two different modes, a lower lever automation, in which the plane would fly in a vertical fashion, or a higher level automation in which the plane would fly altering the vertical altitude when needed. Pilots were asked periodically during the simulation what they were thinking about: the task at hand, task-related thoughts, or task-unrelated thoughts. The results provided evidence that pilots using the higher level automation had fewer task-at-hand thoughts compared to the lower level automation. Also, pilots overall reported a higher percentage of task-unrelated thoughts when using either automation, peaking at 25% of the time. Again, this shows that there is a higher reliance on automation with a greater potential of mind wandering.

A factor influencing automation complacency is automation reliability and thinking that automation will not have the ability to make errors or fail. One problem is that some studies have examined the failure of automation at multiple time points during a study, which underrepresents any real situation. Molloy and Parasuraman (1996) examined what happens when there is only a single failure, similar to what could possibly happen in a real- life scenario. In this study, participants either performed a multiple task battery, a two-dimensional tracking, and engine fuel management monitoring task, while performing in either a single or multi-task condition. An automation failure occurred either early or late in the study session. Findings provided evidence that when performing a single task, study subjects were able to recognize the failure whereas only half of the subjects recognized the failure when they were multi-tasking. Even more subjects missed the failure when it occurred later in the session as opposed to the beginning of the session.

Bailey and Scerbo (2007) followed up on the Molloy and Parasuraman (1996) study by examining and assessing the impact of system reliability, monitoring complexity, operator trust, and experience with system on automation-induced complacency. Participants operated a manually controlled flight task while monitoring several simulated aircraft displays for failures. The ability of operators to detect a single automation failure during three sessions was also assessed. Results indicated that realistic levels of system reliability severely impaired an operator's ability to monitor effectively. Further, as the system experience increased, operator-monitoring performance declined. The results also indicated that the complexity of the task heavily influenced operator monitoring, with poorer performance associated with more cognitively demanding tasks. Finally, results from both studies indicated that operator trust increased and monitoring performance decreased as a function of increasing system reliability.

The integration of autopilot programs has lessened the burden of multi-tasking events that must be performed while navigating airplanes. These programs of automation have also relieved the stress of air traffic controllers guiding the planes for safe runway maneuvers. Metzger and Parasuraman (2005) tested the reliance of automation among 12 air traffic controllers in a simulated environment. The experiments examined the effects of using an aircraft-to-aircraft conflict precision aid on workload and performance in a simulated flight experience. The experiment required controllers to recognize conflicts among aircraft distances with the aid of a “conflict probe” automation program. Results showed that controllers recognized fewer conflicts when the automation program failed than when the process was performed without any automation, providing evidence that conflict detection was increased when done manually rather than with the help of any automation program.

In another study, Hitchcock and colleagues (2002) examined the cerebral blood flow and stress measures to predict subsequent vigilance performance. A short battery of three high-information-processing demand tasks were used. The study utilized a simulated air traffic control display in which two planes, represented by black lines, flew over a city, symbolized by a red circle. Normally, the planes were on a non-collision course, one passing over the center of the city and one on a tangent to the city. Critical events for detection were cases in which the planes flew on a collision path over the center of the city. Participants indicated their detection of collision paths by pressing the spacebar on a computer keyboard. Correct detections correlated with increased cerebral blood flow volumes, which were indicated via Doppler to the left and right hemispheres of the brain. The results showed that when blood flow is increased to the brain, the brain is receiving more oxygen and, therefore, improving vigilance activities.

Fatigue is another indicator that affects the attention and vigilance of individuals. Fatigue is experienced during strenuous activities, complete focus over an extended period of time, or is due to a lack of sleep or a lack of restful sleep (Caldwell & Caldwell, 2005). It not only affects individuals physically with delayed response times, but also emotionally and psychologically with how they handle stress. The recognition and understanding of fatigue are extremely important.

Pilot fatigue, while rare, is one of the most significant problems in aviation because of the potential catastrophic effects it can have on the flight crew and passengers as well as bystanders below. Fatigue has been prevalent among pilots because of their unpredictable work hours, sleep deprivation along with circadian rhythm changes, changes in sleep patterns, and the heavy workload, also known as “time on task.” Official statistics indicated that 4–8% of aviation mishaps occur when fatigue is involved (Kirsch, 1996), while the US Army estimates that

number to be at 4% (Caldwell & Gilreath, 2002). Sleep experts agree that fatigue, including sleepiness and tiredness, is the largest identifiable and preventable cause of accidents in transport operations (Akerstedt, 2000). It is estimated that after 17 hours without sleep, performance can be equated to a blood alcohol level of 0.05%, and that value doubles after 24 hours (Williamson & Feyer, 2000).

Numerous research studies have examined the effects that fatigue can have on aviation pilots. Reis, Mestre, and Canhao (2013) examined the prevalence of fatigue in airline pilots. An anonymous survey was conducted asking Portuguese airline pilots to complete a Fatigue Severity Scale along with additional questions concerning perception of fatigue by pilots. The findings showed that there was 89.3% of pilots' feeling of overall fatigue, including mental fatigue, but this increased to 94.1% prevalence when switching in between long and short flight times.

Reis, Mestre, Canhao, Gradwell, and Paiva (2016) followed up the previous study by examining pilot fatigue and sleep complaints. A questionnaire was developed to focus on sleep and fatigue; flight schedule; and socio-economic data, such as family life, including children. Out of 1,498 pilots to whom the survey questionnaire was distributed, 435 responded (32% response rate). The findings showed that the prevalence of sleep complaints was 34.9%. Daytime sleepiness was experienced by 59.3% and severe sleepiness by 13%. Overall fatigue was reported at 90.6%. The study confirmed that a significant number of pilots experienced overall fatigue.

Previous research showed that fatigue is an experience that most aviation pilots have battled. Powell, Spencer, Holland, and Petrie (2008) decided to examine if there was a relation between the length of and time of day to determine if and when fatigue was experienced. Flights involving two pilots were selected, ranging from 3 to12 hours of duty time. Pilots completed the

Samn-Perelli fatigue ratings, which is a subjective scale that was completed at the end of each shift for a 12-week period. The researchers collected 3,023 ratings comprising 26% single-pilot duty/flights and 74% two-pilot duty/flights. Findings provided evidence that the time of day had a significant impact on fatigue, with the highest levels occurring between 2:00-6:00 am. Fatigue was also rated higher when at the end of the double duty as compared to the single duty/flight, leading to the conclusion that flight times can negatively affect a pilot's ability to function.

Powell, Spencer, and Petrie (2010) followed up by examining the effects of short- and long-duration flights with an additional day's layover. Two different flight duties were investigated: one flight flying from Auckland to Brisbane and one flight from Auckland to Los Angeles. Both flights were allotted a one-day layover before returning from their departure city. Pilots were asked to complete reaction time tasks, the Samn-Perelli Fatigue Scale, and the Karolinska Sleepiness Scale on both the departure and return flights. Findings showed that on the flight to Brisbane, the additional day layover resulted in a reduction of fatigue, sleepiness, and reaction time. The flight to Los Angeles had no significant effect with the extra day layover.

Jackson and Earl (2006) examined the prevalence of fatigue among commercial pilots. There were 162 pilots who completed an anonymous questionnaire involving aviation factors, flight experience, and an 11-item chronic fatigue scale. Of the 162 pilots who completed survey, 75% reported having experienced severe fatigue (scored >4 on 11-item scale), 81% reported their fatigue to be worse than two years ago. Eighty percent felt their thought processes were reduced due to fatigue. This study demonstrated that 75% of pilots feel fatigued to severely fatigued when operating a plane.

Thomas, Gast, Gruber, and Craig (2015) performed a study examining if there was a difference in fatigue of aviation pilots on shorter and longer flights. This study examined the

varying levels of fatigue and workload on pilot performance along with determining if there is any technology to help detect symptoms of fatigue. Thirty-two airline pilots participated in a simulation. They were assigned to one of two groups: one 6.5 hours "long haul" flight and four consecutive 0.5 to 1.5 hours "short haul" flights in a simulated environment. Subjects were also attached to an EEG monitor along with EKGs and eyeglasses to monitor eye movements. Authors' findings showed that subjective fatigue ratings accurately reflected rested and fatigued conditions, though the task did not vary between the two Psychomotor Vigilance Tasks, response times, and lapse times.

In 1980, the National Aeronautics and Space Administration (NASA) Research Center developed a fatigue/jetlag program to study fatigue in response to a congressional letter. The letter described the importance and advancement of the space program, while also recognizing the importance of safety and avoidance of catastrophic events. In their research on fatigue and sleep, NASA officials were able to conclude that the amount of sleep required to function properly in aviation is eight hours (Rosekind, Neri, & Dinges, 1997).

It is during the automation portion of flights that the flight crew experience slow brain activity, which was described as vigilance lapses or decreased focus (Wright & McGown, 2004). This is when the lack of attention can result in potential issues such as changes in altitude or speed and misdirection. For example, Northwest Airlines Flight 188 overflew its destination in Minneapolis due to distractions. After takeoff from San Diego, the two pilots cruised on autopilot, they opened their laptops, worked on the company's new computerized scheduling program, and remained distracted. They overflew their destination by 150 miles (National Transportation Safety Board [NTSB], 2010). Luckily, no harm was done other than an added 20 minutes to the flight time, but this is an example of distracted events.

Similar to lack of attention, because of fatigue, two pilots flying from Honolulu to Hilo, Hawaii, fell asleep for at least 18 minutes while in the air on Hawaii Airline Flight 1002. The plane flew past the airport and out to sea before air traffic controllers were finally able to reach the pilots overflying their destination by 48km and losing contact with air traffic controllers for 26 minutes (NTSB, 2008). The plane landed safely, but upon investigation, it was discovered that one of the pilots suffered from sleep apnea and was constantly fatigued.

American Airlines Flight 1420's mishap error that led to the death of 11 people occurred due to fatigue. This was because of the pilots' failure to deploy the spoiler system during bad weather. The pilots acted in a reckless manner due to fatigue (NTSB, 1999). Another example is Air France Flight 447 from Rio de Janeiro to Paris, which crashed into the Atlantic Ocean. The complete cause is unknown as the autopilot was disengaged, but one of the pilots could be heard on the black box tape stating he had had only one hour of sleep in preparation for the 11-hour flight.

These examples of mishaps led the Federal Aviation Administration to revise their procedures for flight time and rest for aviation pilots. Currently, aviation pilots must have a minimum of eight to nine hours; otherwise, the pilot is unable to perform his or her work activity while the plane is moving under its own power before, during, or after flight. The new rules state that there must be a rest time of 10 hours, including eight hours of un-interrupted sleep. Pilots must have 30 consecutive hours free on a weekly basis. At the beginning of each shift, a pilot is required to affirm his or her fitness for duty. If they state they are unfit, the airline must immediately remove them from duty. This puts the responsibility on both the pilot and airline to confirm that pilots are fit and able to take on the responsibility of ensuring safety to everyone on board. In 2010, Congress mandated a Fatigue Risk Management Plan for airlines to comply with

in accordance with the Federal Aviation Administration (2011). Required training measures are mandated every two years related to sleep fundamentals and mitigating fatigue.

Aviation has focused and performed research on vigilance because of the drastic impact it can have on the industry and human lives. Safety and guidelines have been developed to provide safety to passengers. The next section will focus on psychology.

Psychology

Psychology was selected as the next discipline to explore as it was the first to be associated with the research topic of vigilance. This literature search was different from the previous search in aviation. There are many psychology studies that examine vigilance and attention. In the literature search for vigilance, Google Scholar and CINAHL were the search engines used. Typing "vigilance" in the keywords section in Google Scholar produced over 100,000 results. This was further narrowed down by typing in "psychology studies between the years of 2010 to 2019." This produced 10,000 results of either citations or publications. In a similar search using another database, PsycINFO, the search term "vigilance" produced over 20,000 results. A random sample was taken from the results to provide a summary of the literature.

The beginning part of this section begins with the historical work on vigilance. A history of vigilance will be followed by a discussion of Dr. Raja Parasuraman, a leader in the research on vigilance. His interest in vigilance spurred further research on the topic and will be broken down by specific categories.

The history of vigilance can be dated back decades to when Dr. Henry Head, an English physician, first applied the concept of vigilance to human behavior. He was the first researcher to apply a definition to the phenomena he observed while conducting research as a neurologist. He

referred to vigilance as the extent to which activities of a particular portion of the central nervous system exhibit any signs of integrative and purposive adaptation (Head, 1924).

Norman Mackworth (1947) performed one of the early research studies on vigilance back in World War II. In his investigation, Mackworth used a simulated radar display known as the "clock test," showing the effect of time on task. Subjects were asked to examine a clock pointer moving along a circular blank-faced clock and identify when the pointer changed its distance of movement, that is, how far it moved at one time. This experiment continued for a total of two hours, and the changes occurred infrequently in an unpredictable manner (Mackworth, 1947; Warm, 1984).

The results of Mackworth's (1947) study of vigilance performance provided evidence supporting the idea that attention and focus can decline over a period of time. The phenomenon known as the vigilance decrement emerged, which is a decrease in the ability of an observer to recognize and act upon rare target events embedded amongst distractor events over time (Thomson & Hasher, 2017). Mackworth's (1947) research led to future research examining distractors and contributors to vigilance performance, such as length of time with tasks, boredom, increased number of interruptions, and difficult tasks.

In the literature on vigilance, there still remains a gap in understanding the essence of vigilance and what the process is. Vigilance has been researched and examined in psychology and has been conceptualized as either the anticipation of, or a response to, a stimulus; yet no one has examined the process of it. The variability in understanding vigilance is what has made it very difficult to solidify a definition that can be used across all professions.

There is no consistent definition of vigilance in the psychology literature. Various meanings of vigilance involve observing an individual. There are synonyms, such as readiness or

anticipation of something (Arthur, 1987), while other definitions express vigilance as the action of constant monitoring. With his research, Mackworth defined vigilance as a state of readiness to detect and respond to certain small changes occurring at random time intervals in the environment (Mackworth, 1947). Davies and Parasuraman (1982) defined vigilance as a state of maximum physiological and psychological readiness to act. Weinger and Smith (1997) defined vigilance as a state of readiness to detect and respond to changes in the monitored environment. Warm (1984) referred to vigilance as the ability of organisms to maintain their focus of attention over prolonged periods of time. A definition of vigilance in the field of psychology is defined as the ability to maintain concentrated, sustained attention over prolonged periods of time (Warm, Parasuraman, & Matthews, 2008).

Raja Parasuraman

Dr. Raja Parasuraman is known as the leader in the field of vigilance research. Dr. Parasuraman made profound contributions to the areas of vigilance (Hancock., Baldwin, Warm, & Szalman, 2017). In the review of the literature, he was cited numerous times, leading to a review of his studies and research that proceeded following his untimely passing. These studies are presented here in the order of importance with Parasuraman's initial studies. In his many years of research, Parasuraman examined how human attention, memory, and vigilance affected performance when people work with automated systems. This literature search focused on some of his research work involving vigilance, including other current studies by other researchers involving vigilance. Following his taxonomy, initial psychology research relied heavily on visual and auditory studies. As time progressed, more technological research was performed to understand vigilance in human subjects. A debate remains as to what exactly vigilance is and

how to research it. A gap remains in the literature because as vigilance has been defined and researched, no one has been able to conceptualize the process of vigilance.

After Mackworth's initial research on vigilance, investigation of the topic remained stagnant with few studies until the late 1970s, when Parasuraman took a particular interest in understanding the human effects of vigilance. He is considered the greatest researcher on the subject of vigilance, an innovator, and profound thinker (Hancock, Baldwin, Warm, & Szalma, 2017). His desire was to understand the inherent neurological limitations to vigilance and awareness of the neuroergonomic opportunities (Hancock, 2017). The problems with previous vigilance studies were that there was a short duration to response time at was not taken into account (Davies & Tune, 1969) and that signals were difficult to discriminate compared to non-signal stimuli (Audley, 1973.

Parasuraman's research on vigilance can be dated back to 1976 with his original work on response to latencies in vigilance (Parasuraman, 1976). Latency is the time interval between the stimulation and response. In two separate experiments, Parasuraman examined 30 male subjects and their responses to latencies associated with four categories of response. All four categories of response (correct detections, false alarms, correct rejections, and omissions) were recorded during the performance of a 45-minute task. In the first study, signal probability was altered, and subjects were exposed to two separate signal rates, low or high, and asked to respond to either bright or dim flashes. The results showed that latencies associated with responses of correct detections increased and false detections decreased, whereas those associated with correct rejections and omission errors decreased. Results also showed that over time, correct signal detections increased, while false alarms decreased.

In the second study, Parasuraman was concerned with sensitivity changes resulting from changes in event rate in which the signals were either regular or irregular along with high and low rates for the subjects. Results showed a reduction in sensitivity associated with an increased event rate and effects of responses to signals, such as correct detections and omissions, while leaving the other responses to non-signals, correct rejections, and false alarms unchanged. Results were similar to the first study, and as time progressed, correct detections increased, while false alarms decreased.

In both studies, it was observed that while the latencies associated with positive responses increased with time on task, the latencies of negative responses decreased with time on task. These results were consistent and, therefore, assumed an inverse relation between response latency and distance from the criterion.

In one of his early research studies, Parasuraman (1979) sought to differentiate between two causes for the vigilance decrement, similar to an earlier study performed by Broadbent and Gregory (1965), in which they examined the effect of divided attention. Subjects were presented with both visual and auditory displays of digits and letters to be memorized. In his study, Parasuraman posed two research questions: To what degree does a decline in a subject's ability to distinguish targets from non-targets in a response criterion contribute to the vigilance decrement, and how do factors such as event rate and memory load affect their respective contributions? In this study using auditory noises, Parasuraman (1979) varied the type of discrimination tasks, successive versus simultaneous auditory discrimination, in which the successive task necessarily imposed a memory load, and a high- or low-event rate, in which the high-event rate was known to worsen detection. He found that the former cause of perceptual sensitivity only plays a role with high-working memory load and high-event rate. Otherwise, the

decrement was caused by a change in response criterion. More specifically, his results suggested that the group in the successive-discrimination task with a high-event rate showed changes in observer's ability to discriminate, while all other groups' vigilance decrement was caused by changes in response criteria.

Parasuraman decided to conduct a follow-up study to clarify which factor controls the sensitivity decrement using three visual vigilance tasks at high-event rates, comparing successive and simultaneous discrimination. In this study, he found that sensitivity declined in the successive-discrimination (high-memory load) task, but not for either of the simultaneous tasks, confirming his hypothesis that memory load and event rate are the critical factors in controlling changes in sensitivity on vigilance tasks. There is a strong distinction between successive and simultaneous discrimination such that a sensitivity decrement can be obtained for either a visual or an auditory task, but only for successive-discrimination tasks combined with a high-event rate (Parasuraman, 1979).

The original vigilance taxonomy, also known as the Parasuraman taxonomy, refers to a framework for distinguishing between the contribution of perceptual sensitivity and response criteria in the vigilance decrement. This taxonomy holds that the vigilance decrement results from a decrease in perceptual sensitivity only during tasks that load memory and have rapid event rates. Parasuraman and Davies (1977) created a 2x2 matrix in which the axes were event rate (high or low) and task type (simultaneous or successive) comparisons. This matrix served to find the fundamental source of the sensitivity (*d*') reduction where the sensitivity *(d')* reduction is the form of vigilance decrement. It was evident that sensitivity decrement occurred in combinations of conditions with high-event rates in conjunction with a taxed memory of the observer found in successive tasks (Parasuraman & Davies, 1977).

Further research into vigilance and decrement helped support the original vigilance taxonomy produced by Parasuraman and Davies (1977). Over two decades later, a meta-analysis examining the decrement in vigilance was performed to understand the root cause of it. J. See, Howe, Warm, and Dember (1995) reviewed vigilance studies attempting to refine the vigilance taxonomy. From the analysis, J. See and colleagues concluded that the results of Parasuraman and Davies' research were correct, that vigilance decrement was from high-event rates and a taxing memory, though the distinction between simultaneous and successive events was difficult to define. The authors found that both successive and simultaneous tasks were taxing to the subject and resulted in decrement of vigilance. They also concluded that the vigilance decrement appeared to be associated with a decrease in the observer's ability to discriminate critical signals from non-signals not just in a high-event, successive discrimination task, but also in a multitude of other situations. When a sensitivity decrement did occur, the result was substantial.

The shift from active control to supervisory control means that vigilance is becoming an increasingly vital component of human operator performance in a wide array of work environments. One big issue with maintaining vigilance is the ability to focus on something for a period of time. Concentrating for long periods of time can be exhausting and concentration deteriorates, that is, there is vigilance decrement. Vigilance decrement is defined as deterioration in the ability to remain vigilant for critical signals with time, as indicated by a decline in the rate of the correct detection of signals (Parasuraman, 1986).

Vigilance decrement has been researched by psychologists in many experiments in waiting for a stimulus or event to occur short and long durations. It is most commonly associated with long periods of monitoring to detect a weak target signal. Under most conditions, vigilance decrement becomes significant within the first 15 minutes of attention (Teichner, 1974), but a

decline in detection performance can occur more quickly if the task demand conditions are high. This occurred in inexperienced and expert subjects. Vigilance is hard work, requiring the allocation of significant cognitive resources and inducing various levels of stress (Parasuraman & Davies, 1977; Warm et al., 2008).

Vigilance research is becoming more important with the advancement of technology in many professions. The individual has been transitioned from the operator to more of an observer, watching monitors and equipment for long periods of time. There have been challenges in vigilance research since the very first studies. New distractors and situations have been examined to understand the effects on vigilance and attention. Researchers have investigated vigilance by using a proxy of research techniques, such as noise, fatigue, simulated environments, measurements of catecholamine levels, and Doppler blood flows, to examine the subjects' vigilance and focused attention. There remain inconsistencies with interpreting the results of studies and how vigilance has been researched. Regardless, vigilance is the principal element of human performance in a variety of activities in many professions, such as aviation, the military, transportation, and healthcare. All play a pivotal role in daily living and affect people's lives.

The bigger problem is how vigilance research can be translated into real-life situations. For example, Yanovich, Hadid, Erlich, and Morgan (2015); Mahoney, Hirsch, Hasselquist, Lesher, and Lieberman (2007); Casner, Geven, Reckcr, and Schooler (2014); and Cummings, Mastracchio, Thornburg, and Mkrtchyan (2016) all performed studies in simulation, but these results cannot be considered conclusive because they cannot be replicated or translated into real-life situations. Also, a controlled situation exposes subjects to the Hawthorne effect, in which people react differently because they know they are being watched, examined, and recorded. It

can provide a learning experience, but it does not guarantee certainty to the actions of the individual in real situations.

Age/Motivation

Age and occupational experience play a factor in vigilance and attention. As with healthcare, where experience is important, age can play a vital role with vigilance on individual performance. Brache, Scialfa, and Hudson (2010) examined the vigilance and disparities with age in response to simulation of industrial inspection (Brache et al., 2010). The effects showed that adults remained at a constant vigilance throughout the simulation, while teenagers' vigilance decreased with time. The study did not assess for boredom or monotony during the simulation, which can affect the level of vigilance in individuals.

Berardi, Parasuraman, and Haxby (2001) examined the overall vigilance and sustained attention decrements in healthy, aging individuals to determine if there was a difference with age. Sixty-two subjects, all with similar backgrounds and educational levels, volunteered for the study in which the participants were divided into three groups: young (21 subjects), middle age (21), and older subjects (20). The subjects were asked to respond to a computer screen flashing numbers at random and asked to only respond when the number 0 (target) appeared on the screen and not to respond to the numbers 1 to 9 (non-target). The vigil lasted for two hours with intermittent 10-minute rest periods. The results of the study showed that during a high-event rate, visual digit discrimination task, the overall level of vigilance was equivalent across all age groups, although a trend of lower overall vigilance in older subjects was observed. There was no significant difference.

Motivation and expectations of certain tasks can affect the individual tasks. Dember, Galinsky, and Warm (1992) hypothesized that the level of commitment and vigilance would be

affected in subjects who were given a choice of hard or easy tasks to perform. In their study, half of the subjects were offered the choice to perform a hard- or easy-signal salience task, and the other half of the subjects were not given the choice and randomly assigned to a group. Over the 40-minute vigil, the detection rate of the choice subjects remained more stable than those with no choice; therefore, they concluded that intrinsic motivation can affect vigilance performance.

Shaw and colleagues (2013) were interested in individual differences in subjects in relation to vigilance. They enrolled 105 subjects randomly into either simultaneous or successive vigilance tasks. The researchers then wanted to test to see if a trait such as personality, ability, or affect state might predict a person's experience with the vigilance task. Researchers concluded through their results that cognitive ability and stress were good predictors of vigilance, while personality traits were weak predictors of vigilance.

Dember and colleagues (1992) believed that motivation can really affect vigilance in individuals. When there is a high desire to obtain or achieve something, there is more motivation to be vigilant and focus attention on the goal. Research now is examining brain stimulation and processing information. It was thought that with a lack of stimulation, vigilance can decrease due to a lack of perceived importance (Warm et al., 2008).

Environmental Elements

Environments can affect thought processes and the ability to function. As technology advances, we find ourselves multi-tasking, while also being exposed to secondary elements such as noise and conversations as we function every day. We learn to adapt and function as these elements are around us. Helton, Matthews, and Warm (2009) looked at the exposure to noises while concentrating on performing tasks. Helton and colleagues (2009) used similar elements by having subjects identify the letter O or D on a screen while exposing them to noises such as

recorded jet engines. They concluded that the subjects exposed to the loud noise of engines did not underperform, but rather performed better than the subjects who did not have any noise exposure. The noise stressors did not affect the vigilance of individuals, but actually enhanced their focus, improving their results. This finding conflicted with Parasuraman's previous studies that vigilance is affected by distractions.

Fatigue/Breaks

While environmental elements may not affect vigilance, time or duration can decrease it over time. Hockney (1978) examined the impact of breaks on vigilance decrement. Subject were first asked to complete the Dundee Stress State Questionnaire (DSSQ) and then asked to perform a vigilance task, to monitor and decide between two lengths of a line on the monitor without a break. Then separate subjects were asked to perform the same task with a break included. Results showed that vigilance was better in subjects who received a break, though vigilance decrement returned to being even with those without a break (Hockney, 1978). The takeaway is that breaks can improve vigilance, which is why anesthesia providers require regular breaks away from patient care, if possible, as do those in other professions, such as in aviation for pilots and air traffic controllers.

Results of a rest and brief mental break study provide evidence that they have positive effects on vigilance. Ariga and Lleras (2011) followed Hockney's research and hypothesized that deactivating task goals with breaks for periods of time would benefit subjects and help to decrease vigilance decrement and maintain focus. In their study, they proposed a new account of vigilance decrement that they defined as "goal habituation" (p. 440), in which cognitive control systems have difficulties in maintaining a goal active for a prolonged period of time. In this study, 84 students participated and were randomly assigned to one of four groups: a control

group that just performed the vigilance task of identifying short pixel lines compared to the normal length; a no-switch group, which performed the vigilance task along with memorizing four numbers asked at the end of the task; a switch group, which performed the vigilance task viewing a monitor for random numbers to appear; and a number-ignored group, which performed the vigilance task and ignored anytime their four numbers were asked. The results showed that when the cognitive control system had to occasionally engage in the memory task during the vigil switch condition, observers' sensitivity remained high throughout and there was no vigilance decrement. Although sensitivity declined over time when the control system was equally loaded with memory information but did not have an opportunity to activate the memory-task goal until the end of the vigilance task, that is, the no-switch condition, and, thus, showed that mental breaks can help benefit vigilance.

Helton and Russell (2014) confirmed the Ariga and Llera (2011) findings by examining the role of rest and task interruptions. They subjected 236 subjects to two different experiments. In experiment one, subjects were asked to monitor a screen and hit the space bar whenever the oval displayed on the screen was far away from target and not respond if it was near. During a visuospatial session, an interruption occurred, and the subjects were randomly placed into one of three groups: Group one was able to take a complete rest and do nothing; group two was subjected to another short alphanumeric vigilance task, detecting the letter O on the screen when a series of the letter D was presented; and group three just continued with the vigilance task previously administered. The results showed that the complete rest group did the best, followed by the alphanumeric group, and then the continuous group.

In experiment two, 521 subjects were subjected to five interruptions: complete rest, a visuospatial continuous task, an alphanumeric task, a verbal-match task, and a letter-match task.

The results were similar to the first experiment in which the subjects who rested did the best, and those completing the continuous visuospatial task did the worst. The verbal match and alphanumeric groups had similar results. The researchers concluded that brief periods of rest have beneficial effects during vigilance tasks (Helton & Russell, 2014).

Vigilant tasks require observers to monitor displays over extended periods for an occasional critical event to occur. The event probability is low, averaging 2–5% (Parasuraman, Warm, & Dember, 1987). Stuss, Shallice, Alexander, and Picton's (1995) interpretation of vigilance decrement is that, when signals are separated by long events, subjects lose their ability to focus on the task at hand. The repetitive tasks of vigilance can lead to mindless lack of attentional focus and failure of signal detection.

Tasks/Stress

In one study, Grier, Warm, Dember, Matthews, and Galinsky (2003) examined the effects of a traditional and a modified vigilance task to examine vigilance decrement along with the perception of the workload tasks using either the NASA-TLX Task Load Index or Dundee Stress State Questionnaire (DSSQ). Sixty-four subjects participated in a 50-minute vigil, separated into five consecutive 10-minute periods of watch. Half of the subjects were placed in a standard vigil condition in which the subjects were to examine a screen displaying dots; they were to indicate if the dots were spaced equally apart by doing nothing (neutral event) or unequally apart by pressing a button (critical event). The other half of the subjects were placed in the modified vigil condition, in which subjects were to press the button if a neutral event occurred and do nothing if a critical event occurred. Following the vigil, subjects were asked to complete a questionnaire about workload. The results of this study did not support the premise that vigilance tasks in both the standard and modified vigil do not promote a mindless lack of attentional focus. The

responses of the questionnaires provided evidence that the tasks in this study induced a high level of work and were stressful.

Previously presented research provides evidence that vigilance decrement declines over time with exposure to a task. In one study, researchers examined the opposite. The sustained attention to a response task (SART) study (Dillard et al., 2014) examined the effects of SART, the act of promoting mindlessness in vigilance performance as a root of detection failures in vigilance compared to the traditional vigilance format (TVF). In this study, 45 individuals were randomly assigned to one of three groups, TVF, SART, or a passive control, and were asked to examine a monitor involving flight paths and determine if the planes were going to collide (critical signal) or have a safe flight path (neutral signal). Only 12 critical signals occurred within the 40-minute session. The TVF group was allowed 1,000ms to determine if there was a critical signal or not. In the SART group, subjects were credited if they did not respond to a critical signal, but rather responded to a neutral detection. In the passive control group, no signals were given. The results showed that in the TVF group, performance efficiency showed a significant decline over time in terms of signal detections and workload. The SART group response declined, not due to mindlessness, but rather the result of difficulty in continuously initiating motor responses to a flow of neutral events with a consequent increase in the false alarm rate. The authors concluded that the results of this study provided evidence that the SART is not an engine of mindlessness in vigilance.

Head and Helton (2014) investigated the changes in performance over four sessions of a modified SART study. Generally, when SART is administered, participants are instructed to respond quickly to noncritical events. In this study, 18 subjects were asked to monitor a computer screen with four empty boxes. In a circular pattern, a number would appear in one box

at 1,000ms and the participants were instructed to respond to numbers 1 to 9 except for 8. Subjects were instructed to press a button on a joystick for a response. The subjects were then asked to complete a Dundee Stress State Questionnaire (DSSQ) to assess affect, motivation, and cognition. Results showed that as participants became more skilled at selecting the stimuli in the boxes, their response time decreased, and errors increased. The more practice the participants had with the tasks, the greater the speed of response at the expense of commission accuracy. This study provided further evidence that motor performance became more fluid and the response rate increased leading to more commission errors.

Cummings and colleagues (2013) researched the attention span of pilots flying unmanned aerial vehicles. Subjects were placed in a low-task load, computerized simulation for a total of four hours with low stimulation and random events occurring. Results showed that even top-performing subjects were distracted over one third of the time. Cummings and colleagues (2013) researched the attention span of pilots flying unmanned aerial vehicles. One great problem with vigilance is the exposure to low frequency of signals. Whether it is security or surveillance of environments, observers must remain attentive and focused on the task. Therefore, periods of breaks are useful to help refocus those observing. A sensory display format can result in more threat detections, fewer false alarms, and faster target-acquisition times achieved (Gunn et al., 2005).

Stress and the demands of work can affect the way individuals interact and respond in their environment. As with providing anesthesia, a variety of stressors can interfere with decision-making and vigilance. Tiwari, Singh, and Singh (2009) examined a low- and high-task demand condition in which the subjects were exposed to a certain number of events during the testing period to determine whether the box on the screen was 3.5/cm or 3.0/cm in size. The

high-task demand experienced 30 events per minute while the low-task demand experienced 15 events per minute. All subjects were asked to complete a multi-dimensional stress state questionnaire. Results showed that the high-task demand group committed more errors with slower reaction times. All participants reported fatigue and depletion of focus following the study (Tiwari et al., 2009). This finding is consistent with that of Guastello (2014), who determined vigilance decrement derives from a high workload and stress.

Warm and colleagues (2008) compared successive and simultaneous vigilance tasks that support an attention resource theory of vigilance. Subjective reports also show that the workload of vigilance was high and sensitive to factors that increase processing demands. Researchers found that successive tasks are more demanding of attention resources than simultaneous. Neuroimaging studies using transcranial Doppler sonography provide strong, independent evidence for resource changes linked to performance decrement in vigilance tasks. Finally, physiological and subjective reports confirmed that vigilance tasks reduce task engagement and increase distress and that these changes rise with increased task difficulty.

Neuroergonomics

Parasuraman (2014) performed extensive research examining the brain and neuroergonomics to assess brain activity and function. Neuroergonomics is the study of the human brain in relation to performance at work and in everyday settings, specifically examining neuroimaging. Neuroergonomic studies have provided evidence that over time observers in vigilance tasks lose information-processing resources and experience fatigue. Parasuraman examined the effects of multitasking in everyday life. Multitasking can pose a threat to safety. Parasuraman mentions the effects of driving while conversing on the telephone as an example. He cites Horrey and Wickens (2006) as an example of how driving performance degrades when

conversing on the phone. The authors cite that the performance deterioration was attributed to competition for central attention resources rather than any motor interferences (Horrey & Wickens, 2006).

Researchers have examined the brain more extensively with less invasive technology that can display brain activity. In their study of cerebral lateralization of vigilance, Helton and colleagues (2010) examined 57 subjects who were randomized into three groups watching a visual display: hard vigil, in which letters were exposed at a rate of 40ms with a brighter, luminescent background screen; easy vigil, in which the letters were exposed at a rate of 42ms with a darker contrast background screen, making it easier to detect the letters; and a control group. Sensors were placed in their heads to determine brain and cerebral activity. Subjects had to determine if the screen displayed the letter O, D, or D backwards. The results showed that for the easier, high-salience conditions, cerebral oxygenation was lateralized, but it was not lateralized in the higher low-salience conditions. While there was a significant decline in perceptual sensitivity over periods of watch for both salience conditions, performance was significantly worse overall in the low-salience condition. Both vigilance tasks did increase overall cerebral oxygenation relative to the control group. Therefore, they did place processing demands on the brain beyond the mere act of simply looking passively at the same images on the visual display with no work imperative.

Funke, Warm, and Matthews (2017) provided further evidence of the effects of neuroergonomics by examining the cerebral blood flow and oculomotor effects of fatigue. They recruited 36 participants to take part in one of three vigilant conditions: 12 participants were placed in a spatial certainty, 12 were placed in a spatial uncertainty (uncertain about where in the field of view critical signals for detection appear), and 12 served as a control group. The vigil

lasted for 50 minutes separated by five continuous 10-minute periods. Collision flight paths were to be detected among all three groups. The results showed that the signal detection was poorer in the spatial uncertainty group and correlated with a decrease in cerebral blood flow and increased eye closure. The conclusion supported that vigilance tasks involving spatial uncertainty are more neurophysiologically taxing than those in which spatial uncertainty is not a factor.

Another study examined the cerebral hemodynamic effect on target-specific resource allocation during vigilant tasks. Shaw and colleagues (2013) examined the cerebral blood flow of subjects during a vigil in which the subjects monitored simulated flight paths of planes. Thirty participants were asked to monitor a flight path of planes during a 50-minute vigilance session and then asked to respond to a critical and noncritical event. A transcranial Doppler was used to monitor and assess cerebral blood flow during the session. Results showed that signal detections and cerebral blood flow decreased over time. In addition, the results showed an increase in cerebral blood flow when signals were detected, which was not present with missed signals. This study reconfirmed that cerebral blood flow is affected during vigilant tasks.

Taking it one step further, Nelson, McKinley, Golob, Warm, and Parasuraman (2014) examined the effects of transcranial direct stimulation (tDCS) with enhancing stimulation. Transcranial stimulation can be used to modulate the activity of the brain and might be effective treatments for neurally mediated disorders and attention. Previous research provided evidence that tDCS can accelerate learning and enhance performance in a range of cognitive tasks (Parasuraman & McKinley, 2014). Twenty-five military personnel volunteered to participate in a vigilance task examining a simulated air traffic controller task. They were asked to examine planes flying in a circular pattern and were asked to detect critical events in which, if the planes were to fly in an opposite direction, it would result in a potential crash. The study examined the

subjects' abilities to discriminate between hit rates and false alarms. A tDCS was used to deliver a direct current to the precortex area of the brain at either 10 minutes or 30 minutes after the start of the vigilance task.

A transcranial Doppler was used to assess blood flow velocity (Warm & Parasuraman, 2007) as well as a cerebral oximeter to measure blood oxygenation. The study aimed to investigate the role of the prefrontal cortices during sustained attention, and whether prefrontal stimulation using tDCS can diminish the vigilance decrement. Unlike previous studies of vigilance, which have used either frontal lesion or neuroimaging methods, this study directly manipulated cortical functioning in the prefrontal cortices. Further, the researchers attempted to use tDCS not simply as a basic science exploratory technique but also as a possible method for interventions in operational performance. The vigilance task reproduced behavioral and physiologic effects typically observed in similar experiments (Helton et al., 2007; Warm & Parasuraman, 2007), with decreased hit percentages, increased reaction times, and decreased blood flow velocity in the middle cerebral artery.

Another neuroergonomic approach to examining mental fatigue is to evaluate the effects from physical fatigue. Mental fatigue is known to influence muscle fatigue (Taylor, Amann, Duchateau, Meeusen, & Rice, 2016). Mehta and Parasuraman (2014) examined the effects of mental fatigue on the development of physical fatigue. Twelve participants in the research were first asked to handgrip a metered device at maximal strength three consecutive times. Following a time of rest, the same subjects were asked to handgrip the device at 30% of their maximal handgrip strength until exhaustion. While gripping the device subjects were given a subtraction task, in which they were given a three-digit number and asked to count backwards by seven. Cerebral oxygenations, muscular response time, and self-reports from the subjects were

collected. The results revealed that the concurrent mental and physical fatigue condition resulted in lower cerebral oxygenation levels in the bilateral, pre-frontal cortex at exhaustion compared with the physical fatigue conditions alone. This indicated an increased cerebral perfusion during the time of activity, resulting in the feeling of fatigue and exhaustion at the end of the study. This study provided evidence that both physical and mental demands can lead to greater fatigue.

Sleep deprivation is commonplace in modern society, but its far-reaching effects on cognitive performance are only beginning to be understood from a scientific perspective. There is a consensus that insufficient sleep leads to a decreased response time and an increased variability in performance, including alertness, attention, and vigilance, perception, memory, and executive functions (Killgore & Weber, 2014). Neuroimaging evidence has implicated the prefrontal cortex as a brain region that may be particularly susceptible to the effects of sleep loss and function. Prefrontal functioning has yielded inconsistent findings within the context of sleep deprivation. Emerging evidence suggests that some aspects of higher level cognitive capacities remain degraded by sleep deprivation despite restoration of alertness and vigilance with stimulant countermeasures (Killgore & Weber, 2014), suggesting that sleep loss may affect specific cognitive systems above and beyond the effects produced by global cognitive declines or impaired attention processes.

Sleep, rest, memory, and psychological aspects in general all have a direct impact on vigilance (De Koninck, 1997). Oken, Salinsky and Elsas (2006) examined complex neural systems, such as neurotransmitters, that not only impact sustained attention, but also the sleep wake cycle (Oken et al., 2006). Brain systems such as the hypothalamus; serotonin system; norepinephrine system; and cholinergic system, including the thalamic and cortical systems, all have an impact on a person's attention and ability to focus, while the reticular formation,

thalamic, prefrontal cortex, and forebrain all have key roles in the overall level of vigilance (Parasuraman et al., 1998). These systems all affect the focus and attention of individuals. Sleep deprivation, and even motivation, are all factors that can affect one's attention and focus.

The environment that individuals are exposed to today is not necessarily directed at discovering information, but at selecting and processing incoming information (Pirollo, 2007). The surrounding environment imposes a continuous stream of stimulation. There is now a need to understand how the exposure of today's environment can really affect vigilance. Adaptation to our environment, such as to automation, can bring an evolutionary difference to how individuals practice vigilance. Multitasking has become a common action in society that will affect the individual's ability to refocus to one source or topic.

Healthcare

Healthcare is a complex, chaotic, and high stakes profession that affects patients every day. Whether it be physicians or nurses, all play a role in the care of patients and have an impact on their outcomes. Therefore, it is essential that practitioners maintain focus and attention to the care of their patients. Literature reviews were performed of following categories: medicine, nursing, and anesthesia, which are separated by professions and later by the specialty of anesthesia.

Medicine

The next discipline for this literature review focuses on the field of medicine. For the literature search on vigilance, Medline was the search engine that was used to specifically focus on the medical literature. When typing "vigilance" into the search, over 13,000 results were produced. There was an advanced search performed in which criteria were narrowed down to humans, focusing only on literature in the English language. Index Medicus was a subset citation

used to narrow the literature to medicine- related papers. Adults, 18 years and up, were the age group that was selected in order to narrow the search results to a manageable volume of literature. This still resulted in over 9,000 publications. Key words, such as "alertness" and "attention," which are used synonymously with vigilance, as well as "physicians" were used in the advanced search section. The results produced a total of 87 publications. A further search, adding "resident physicians" to involve training physicians, narrowed the search results to 20 publications. The focus was narrowed because resident physicians during training learn to train with focus and prioritization. Physician anesthesiologists will be described under a separate subheading because of the specialty focus in this study.

Medicine has recognized the importance of vigilance and the impact it has on patient care and patient outcomes. There are many factors in medicine specifically that affect the vigilance of the practitioner. In the literature retrieved, sleep, alertness, and distractions were highlighted.

Before examining the research studies pertaining to vigilance, the landmark case of Libby Zion is presented. This case resulted in a change in physician-training practices that directly or indirectly can be related to vigilance and the associated concept of sleep (Asch & Parker, 1988). The effects of sleep, or lack thereof, have affected everyone at some point in their lives. Libby Zion was a college student who was rushed to the emergency room following a tooth extraction and spiking high, uncontrolled fevers. She was admitted to a New York teaching hospital and died within eight hours of admission. Upon admission and transfer of care from the emergency department to the patient floor, Libby Zion received meperidine, a pain medication, and anti-shivering medication for her febrile shivers that interacted with her depression medication, phenelzine, which resulted in her demise.

After her demise, the New York Health Commissioner appointed an advisory commission, known as the Bell Commission (Holzman & Barnett, 2000), to investigate and provide recommendations for supervision and link this to physicians in training. In 1987, the finding included the recommendation of an 80-hour limit on weekly resident hours, a maximum of 24 consecutive hours on duty, and a requirement for the presence of senior physicians to be present in the hospital (Philibert & Taradejna, 2011). In 1988, the Accreditation Council for Graduate Medical Education (ACGME) adopted the Task Force's report and examined the hourly duty requirements of residents. In 1989, the Review Committee for Internal Medicine instituted an 80-hour weekly limit, averaged over four weeks, to become effective in July 1989. By the early 1990s, six specialties, including internal medicine, the largest accredited specialty, had established a weekly duty-hour limit (ACGME, 2019).

In 1999, the Institute of Medicine released "To Err Is Human: Building a Safer Health System," specifying that 44,000 to 98,000 preventable deaths occur in hospitals per year. This prompted the ACGME to explore sources of error in resident training. The report highlighted medical errors that occur. In 2001, the ACGME authorized the formation of a Work Group on Resident Duty Hours and the Learning Environment focused on developing standards for resident duty hours. In 2003, ACGME instituted a comprehensive approach that included standards for resident hours and institutional oversight.

In 2010, a Task Force of Quality Care and Professionalism, part of the ACGME, presented recommendations for enhancing the 2003 resident duty-hour standards. A key aim was to expand the focus beyond duty hours and to set forth new standards for supervision, safety, and professionalism. In 2011, new rules stated that residents should have 10 free hours off duty with eight hours between scheduled duty shifts and at least 14 hours free post 24-hour call shifts. The

ACGME recognized the need to improve patient care and medical learning, which led to changes. These changes appear to be beneficial to improving the residency and learning environment while providing safe and effective care. As with the pilots, sleep can affect performance and decision-making.

Sleep is vital to proper functioning in daily activities and professional responsibilities. Much like the aviation industry, in medicine lack of sleep can result in errors, such as near misses and sentinel events, which can have detrimental effects. As in aviation, these errors affect human lives. One of the first studies performed in medicine that examined sleep loss was performed by Friedman, Bigger and Kornfeld (1971), who examined the effects of sleep deprivation in 14 medical interns when they were examining electrocardiogram results. The medical interns served as their own controls. Each subject was tested when he or she was rested, having had an average of seven hours of sleep, and then again when they were sleep deprived, having had an average of 1.8 hours of sleep. The results showed that the sleep-deprived interns responded more slowly and had more errors when interpreting the electrocardiogram results. Their mood was also significantly affected; they stated increased sadness, decreased vigor, and decreased social affection.

This was an original study (Friedman et al., 1971) that provided evidence that sleep had an important effect on performance of interns, and it was conducted at a time when there were limited or no measures or guidelines that physician training/residency programs could follow in regards to sleep and work hours. However, this practice of long work hours changed after the Libby Zion incident in 1984.

As sleep can improve function, another question is whether short, mental breaks improve the tasks. There are beneficial effects to short breaks for mental adjustment and refocusing on the

task at hand. In surgery, a high performance has to be maintained over a sustained period of time. Engelmann, Kirschbaum, and Dingemann (2011) examined the effects of intraoperative breaks on mental and somatic operator fatigue during laparoscopic surgery. Surgeons' focus and attention should be optimal for the success of surgery and optimal patient outcomes. In their study, Engelmann and colleagues (2011) recruited seven surgeons performing 51 operations that were randomized into two groups: conventional conduct or intermittent pneumoperitoneum, which is the carbon dioxide gas injected into the patient's abdomen during laparoscopic procedure to insufflate the abdomen that aides the surgeon in viewing in the abdomen.. The conventional conduct group performed surgery as usual, while the intermittent pneumoperitoneum group performed 25 minutes of surgical care followed by a five-minute break period, releasing the pneumoperitoneum carbon dioxide gas. Saliva samples were taken before, during, and after the surgery to test for stress hormones and amylase levels of the surgeons. The results provided evidence that cortisol, which is a stress hormone, was elevated greater than 22% in surgeons operating without a break compared to those who had a break. There were also fewer intraoperative events with the intermittent pneumoperitoneum group compared to the conventional conduct group, which yielded a higher level of amylase peaks in surgeons, which is alpha-amylase, a useful biomarker that can be used in assessing stress. The authors concluded that work breaks during complex laparoscopic procedures can reduce stress and preserve performance.

Zheng and colleagues (2011) followed the Engelmann study with their own study, examining the surgeon's vigilance in the operating room. In this study, Zheng and colleagues introduced eye-tracking technology to study the vigilance of surgeons while performing a simulated laparoscopic operation. In this study, participants were asked to perform a simulated

laparoscopic procedure while monitoring the patient's vital signs on another screen. The researchers hypothesized that the frequency with which the surgeon checked a monitor for the patient's vital signs was a function of his or her clinical experience and that the frequency with which the surgeon checked the anesthesia monitor was based on the preoperative patient's condition before surgery. This means that the more comorbidities, the more frequently the surgeon would check on the patient. Before the procedure, the surgeon was told whether the patient was healthy and stable or had a mild cardiac condition.

In this study, participants were divided into two separate groups: a novice group of junior residents and an expert group consisting of senior residents, fellows, and attending surgeons. A total of 10 novice participants and 13 expert participants were recruited for the study. The results showed that the expert group took longer to complete the laparoscopic procedure than the novice group, and the expert group made more errors per case, although the differences were not significant. In contrast, the expert group scanned the vital signs of the patient and the anesthetic level of the patient more often than the novice group. The results also showed that the novices tended to focus their eyes on a limited area of the operative field, seldom moving their eyes around the surgical environment for other visual input. The authors concluded that using eye-tracking technology to measure a surgeon's vigilance during an operation was useful. Eye-tracking observations can lead to inferences about a surgeon's behavior for patient safety (Zheng et al., 2011).

Healthcare is a 24-hour/7 days a week enterprise that always remains open to patient care. During this time, healthcare workers continue to work shifts that can affect their attention and focus when they are caring for patients. These hours can consist of long, extended shifts or

off-hours shifts that can affect the circadian rhythm. The following are some studies that focus on the effects of sleep in regard to performance during clinical work.

One major factor that can affect patient care is alertness. Smith-Coggins and colleagues (2006) examined improving alertness and performance in emergency department physicians and nurses. In their study, a total of 49 physicians and nurses working three consecutive 12-hour night shifts in an academic emergency department were selected for the study. Subjects were randomly selected for either a control group with no nap or an intervention group consisting of a 40-minute nap around 3 a.m. A group of tests was performed to assess any differences between the groups; the Psychomotor Vigilance Task, Probed Recall Memory Task, CathSim intravenous insertion task, and a Profile of Mood States were performed to assess the subjects at the end of their shifts. The Psychomotor Vigilance Task (Loch et al. 2004) was a 10-minute test of simple visual reaction time. The Probed Recall Memory Task was a memory task in which subjects have 30 seconds to memorize six word pairs. The CathSim intravenous insertion was a virtual reality, computer-based simulation for inserting an IV catheter in a patient. The Profile of Mood States was a questionnaire with six scales of mood and emotion, such as anger, confusion, depression, fatigue, tension, and vigor.

The results showed that the subjects in the nap group slept for a total of 24.8 minutes. The psychomotor difference occurred at the end of the work shift at 7:30 a.m. in the group that had no naps, when their reaction time was slower. There were no differences between groups for Memory Recall. The other difference was noted with the simulated catheter insertion. The nap group was able to insert the catheter about 13 seconds faster than the control group. The authors concluded that subjects who napped had a faster reaction time and fewer vigilance lapses and rated themselves less fatigued. Another study by Shea and colleagues (2014) confirmed similar

results that medical interns who were allowed to have protected nap periods had fewer attention lapses on the Psychomotor Vigilance Test.

In another study, Rollinson and colleagues (2003) examined the effects of four consecutive night shifts on performance of interns in the emergency department. Twelve interns were selected and three standardized, neuropsychological tests were performed: the Delayed Recognition Span Test, which looks at visual capacity; the Continuous Performance Test, which examines attention function; and the Santa Ana Form Board Test, which examines psychomotor speed. The results showed that the only significant impact was in the Delayed Recognition Span Test, which showed a significant deterioration from the beginning of the shift to the end of the shift, showing a decrease in visual memory capacity by 18%.

A subsequent study followed examining the deterioration of neurobehavioral performance in residents with exposure to extended duration work shifts, working 24–30 scheduled, consecutive hours every other shift for three weeks, (Anderson et al., 2010). Researchers concluded that response times deteriorated with time on the residents' work shifts, and performance deteriorated the more night shifts the residents worked. These results provided evidence that the disruption in day and night work can affect an individual's ability to perform at a high capacity.

Lack of sleep is not an uncommon experience in the medical profession. Depending on the specialty, residents can be expected to remain awake and attentive for periods great than a normal work shift. Reimann, Manz, Prieur, Reichmann, and Ziemessen (2009) examined the cognitive performance in sleep-deprived neurology residents. In their study, 38 neurology residents at a German university hospital participated in a prospective, single-blinded comparison study. The residents were divided into three groups: a 24-hour overnight, on-call

duty group; a night-shift group; and a regular day-shift group, which was used as a control. Participants underwent a series of tests at the beginning and at the end of their shifts. A self-rated sleepiness scale questionnaire was administered along with a Paced Auditory Serial Addition Test, which is a cognitive performance test requiring subjects to perform addition problems, and the Pupillary Sleepiness Test, which measures pupillary oscillations over a period of time. The results showed that sleepiness was reported and increased in residents after night shifts and overnight on-call shifts when compared to the regular day shifts. The residents did not show any deficits in cognitive performance in any of the three groups. This contradicts previous research, showing that there is a decline in cognitive function following overnight, on-call, and night shifts.

Along with sleep, distraction was another key indicator in the literature regarding vigilance. Distractions can lead to interruptions by breaking the focus and attention on a particular task. This can be vital and potentially harmful in certain instances during patient care. K. C. See, Phua, Mukhopadhyay, and Lim (2014) performed a simple observational study to examine the frequency, sources, and severity of distractions in the intensive care unit (ICU). In their study, independent paired observers shadowed eight residents and three fellows in 38 separate shifts over a 100-hour span in a medical ICU. Distractions were defined as breaks in attention, evidenced by observed behavior such as orienting away from a task or responding verbally. K. C. See and colleagues graded the severity of distraction on the following scale: no effect on activity; momentary pause, but activity resumes during distraction; complete pause, activity resumed only after the distraction ceases; and the physician abandons the activity and attends to the distraction. The last two distractions were considered to constitute a major distraction.

The total number of distractions that occurred during the study was 444 (K. C. See et al., 2014). A total of 107 (24.1%) distractions were prolonged, lasting greater than five minutes. More senior physicians were distracted than junior physicians, but the difference was not statistically significant. The results showed that both nurses and physicians were equally likely to distract the residents and fellows. The greatest activities performed during the interruptions were entering notes, writing orders, and conducting rounds. The severity of the 444 distractions were as follows: 13 had no effect on activity, 136 resulted in momentary pause, 210 resulted in a complete pause, and 85 resulted in abandonment of the current activity. The results provided evidence of the high frequency of distractions that occur in the ICU. These distractions can divert attention away from patient care.

In another study, Mamykina and colleagues (2017) examined interruptions through an observational study in a pediatric intensive care unit (PICU). The main goal of this study was to examine the purpose of interruptions in the PICU as they occurred in the context of a real-world setting. Trained observational researchers observed 34 clinicians, 21 nurses, and 13 residents in a one-hour session. Researchers recorded all interruptions experienced and initiated by residents and nurses in the PICU, noting the sources as human or nonhuman causes. Interruptions were defined as any intrusion of a secondary, unplanned, and unexpected task that leads to discontinuity in task performance.

Results showed that out of the 34 observations, 559 interruptions were observed (Mamykina et al., 2017). The interruptions were broken down to internal clinical (241), such as clinicians not involved in the same patient care; team (172), such as clinicians involved with the same patient care; phone/pager (54), such as phone calls or pages requiring attention; device alarms (24), such as interruptions with alarms from equipment; external clinical (37), such as

external clinicians and consultations; patient/family (23), such as interruptions originated by patient family members; and nonclinical (8), such as nonfamily members and hospital services. The authors concluded that interruptions averaged 10 per hour and affected both residents and nurses throughout their clinical shifts, affecting workflows, mental concentration, and ability to document in the electronic health record.

Wheelock and colleagues (2015) performed a study examining the effects of distractions in the operating room on stress, workload, and teamwork. Two researchers, one surgeon and one behavioral scientist, examined 90 surgical cases and observed for distractions and teamwork during the case. The surgical staff completed the NASA-Task Load Index and State Trait Anxiety Inventory scales to assess their stress during the case. The results showed that distractions were observed in 98% of the cases, averaging about 10 times a surgical case. The most prevalent types of distraction were by those external to the case, such as nurses entering the operating room and conversations irrelevant to the surgical case. The most "intense" distractions were related to wrong or missing equipment. Distractions led to impaired teamwork. Surgeons reported higher levels of stress and workload than other team members.

Disruptions, which are a form of distractions, have the potential to increase the risk of surgical errors and complications. Wiegmann, ElBardissi, Dearani, Daly, and Sundt (2007) examined surgical errors and their relationship to surgical flow disruptions in cardiovascular surgery. An observer recorded events during 31 cardiovascular surgeries at one medical center. Results showed that most errors observed were minor. Sixty percent of errors were recognized immediately, such as improperly suturing an anastomosis, while 40% were not recognized immediately but corrected when recognized. Disruptions consisted of teamwork problems, equipment problems, extraneous distractions, and the subjects' ability to remain fully engaged

mentally during a case. The results of the study indicate that surgical errors occur on a regular basis.

Another study examined disruptions in the operating room. Zheng, Martinec, Cassera, and Swanstrom (2008) performed a quantitative study examining disruptions in the operating room during laparoscopic gastric surgery. A video aided observational field study was conducted to examine disruptive events. Twelve surgical cases were observed, averaging an estimated 123 minutes. The results showed that, on average, a total of 114 disruptive events were recorded, consisting of conversations, instrument changes, position changes, shift changes with nurses, phones, pagers, and extraneous disruptions. Results also showed that disruptive events caused a four-minute delay for each case per hour.

Interruptions and distractions occur in all settings. As technology advances and becomes incorporated into daily living, it has also been involved with improving patient care and communication amongst caregivers. These technologies are developing a blurry line between personal and professional responsibilities. Cell phones and mobile devices have improved and provide a unique way to store private information, such as text messages and phone numbers, while allowing access to information and educational material. While improving our lifestyles, mobile devices can act as a deterrent and a distraction.

Nerminathan, Harrison, Phelps, Scott, and Alexander (2016) examined the effects of doctors' use of mobile devices in the clinical setting. The researchers used a mixed methods approach to examine doctors in both pediatric and adult teaching hospitals. First, a survey was sent to 117 participants and completed by 109 physicians (93% participation rate). The survey results showed that 91% of physicians owned a smart phone, and 88% used their smart phones in the clinical setting. Most participants reported using their devices for learning or educational

purposes. Thirty-eight participants stated that distraction from patient care was a hindrance to their use of mobile devices for learning. Ten percent of participants recalled a negative comment received from patients when they were using their mobile devices.

Following the survey (Nerminathan et al., (2016), a focus group revealed four themes: knowledge of existing standards and code of conduct, such as hospital policy; factors influencing their use, such as mobile devices have become a routine aspect of medical care; individual decisions to use their mobile devices, such as for medical photography; and employed strategies to enable use, such as deciding when it is appropriate to use their devices and when to avoid use. The study confirmed that mobile devices are incorporated in the care of patients. Physicians are making their own decisions as to the appropriate use and settings in which to use their devices. The authors concluded that there is a need for guidelines for acceptable and ethical use that respects patient privacy.

In the review of the literature, medicine has given no specific definition for vigilance, but the common themes were sleep, fatigue, and distractions, which are factors that can influence or affect vigilance. The literature review in medicine indicates that vigilance is a phenomenon that has limited research studies. It remains difficult to understand a phenomenon with limited research on the topic. Medicine is a profession in which patient outcomes and the care they receive are determined by other individuals, similar to aviation. Thus, understanding vigilance and how to practice it is critical to the profession of medicine and healthcare overall.

Nursing

The next discipline for this literature review on medicine is the field of nursing. For the literature search on vigilance, CINAHL was used to specifically focus on the nursing literature. The search term “vigilance” produced over 200 results. An advanced search performed in which

criteria were narrowed to academic journals and nursing practice produced 12 articles. The following js a summary of the literature. Certified registered nurse anesthetists will be described under a separate subheading because of the specialty focus in this study.

Vigilance is an important topic to the field of nursing. Attentive care should be required of nurses, and sometimes that care falls short. It is essential that nurses follow guidelines to help direct their practice. The American Nurses Association (ANA) provisions state that nurses will remain committed to the care of their patients and preserve their integrity and safety (ANA, 2003), but they do not mention vigilance. Vigilance is more than just maintaining the safety of the patient. It entails constant, assertive, and holistic attention to the patient throughout their care. Vigilance can be viewed as the central component and foundation of what nursing is.

In the medical literature, various definitions have been used to give meaning to the word vigilance. In nursing, vigilance is defined as intensive watchfulness to identify changes in a patient's status (Gieb, 2003) or a state of watchful attention of maximal physiological and psychological readiness to act, detect, and react to danger (Hirter & Van Nest, 1995) or watching over the profession (Schreiber & MacDonald, 2010).

Nurses have maintained that vigilance has been embedded in the discipline since the time of Florence Nightingale (Meyer & Lavin, 2005), and that nursing vigilance requires both caring and expertise. In their study, Meyer and Lavin used historical and theoretical bases to define vigilance as the essence of caring in nursing. They were able to summarize the framework of nursing, in which the nursing knowledge base is the foundation that leads to professional nursing's vigilance, which, in turn, leads to informed actions. Nursing care is based upon caring for the patient holistically and watching over patients in their time of need. This can be witnessed

in a variety of settings, from the emergency room to the intensive care unit to the operating room.

Johansson and Wiklund-Gustin (2016) performed a qualitative study aimed to describe how nurses working in a psychiatric ward experienced caring encounters with patients suffering from substance use disorders. Six nurses were interviewed in reflective group dialogues, and their discussions were transcribed and analyzed. A common thread was conceptualized as a theme, multifaceted vigilance, which described how nurses delivered care while being attentive to their patients' behaviors.

Carr (2014) performed a qualitative, ethnographic study to explore and understand the experience of vigilance from family members' perspectives. Carr examined eight family members staying with their loved ones in the neurology and rehabilitation units. Informal, semi-structured interviews and observations were performed. Five categories of meaning emerged from the data analysis: commitment to care, resilience, emotional upheaval, dynamic nexus, and transition. These categories of meaning provided a description of the vigilance of family members. These data were used to develop a middle-range theory of vigilance and provided guidelines for nursing interventions when family members stay with their hospitalized loved ones.

Critical care environments remained the prominent environment where the topic of vigilance appeared. The literature referred to nursing vigilance in the critical care unit. Rogers, Hwang, Scott, Aiken, and Dinges (2006) examined the work patterns of nurses and their minimizing adverse events. Data were obtained from a random sample of critical care nurses in the United States. Nurses eligible for the study were mailed two 14-day logbooks to fill out. Information collected included the hours worked, the time of day worked, overtime hours, days

off, and sleep-wake patterns. A total of 502 nurses provided data for the study, a final response rate of 43.7%. Respondents stated they consistently worked longer than scheduled and for extended periods. Longer work duration increased the risk of errors and near errors and decreased nurses' vigilance. Rogers and colleagues concluded that nurses should be limited to working 12 consecutive hours during a 24-hour period and 40 hours a week. Research has shown that critical care nurses working more than 12-hour shifts were significantly more likely to make errors and have less vigilance than nurses working shorter shifts.

Along with vigilance and monitoring, surveillance, which has been used as a synonymous term, has been identified as an important quality and safety intervention for patient care and outcomes. The World Health Organization ([WHO], 2005) referred to vigilance as the process of paying close and continuous attention whereas surveillance is defined as the systematic ongoing collection, collation, and analysis of data. Vigilance and surveillance are used in association to underline that vigilance is associated with the methods of surveillance (WHO, 2005). Surveillance is an important nursing intervention used in every practice to prevent complications, medical errors, and adverse outcomes (Henneman, Gawlinski, & Giuliano, 2012). Schmidt (2010) conducted a qualitative research study to fill the gap in the literature. A basic social process of "making sure" emerged as a way that nurses watch over their patients (Schmidt, 2010). This study provided a theoretical basis for the way nurses watch over their patients. While this is important for the profession of nursing, the specialty of nurse anesthesia requires more intense focus as the patient cannot verbalize cues. The nurse anesthetist must remain vigilant during the entire surgical procedure because critical events can lead to catastrophic outcomes.

Vigilance is the backdrop against which professional activities are performed as it is always part of the nurse's thinking process (Meyer & Lavin, 2005). Vigilance remains a part of

nursing for patient safety reasons, ensuring adequate and quality care to patients (American Association of Critical Care Nurses, 2002). Meyer and Lavin (2005) wrote an article about professional vigilance, describing it as the essence of caring in nursing. Nursing vigilance contributes to patient safety by using two types of nursing diagnoses, central and surveillance. Central diagnoses indicate the need for the nurse to plan and implement interventions for the achievement of outcomes. Surveillance diagnoses are those that recognize patient risks that are anticipated by the nurse, who remains ready to act in the event of occurrence. The goal is to improve patient safety. Nursing has encouraged emphasis in vigilance, but there has been little research performed on the topic.

Although vigilance is recommended in many research abstracts as a solution to various problems, when the articles are reviewed, there is no information on how to operationalize vigilance, no definition of the term, nor any evidence that being vigilant is a successful response to any of the problems for which it is recommended. Little research has been conducted specifically on vigilance as a concept of primary interest for nurse anesthesia. An investigation of how to use vigilance in healthcare has potential to improve patient safety and outcomes. The only known example of nursing vigilance was provided from a study that examined women suffering migraine headaches and concluded that vigilance emerged as a process that allowed preservation of self (Meyer & Lavin, 2005).

Meyer (2002) performed a qualitative study using her grounded theory methodology to explore the process of vigilance in women who suffered from migraine headaches. Twenty-two women were interviewed, and the basic social problem identified for women with migraines was the need to maintain function when faced with unpredictable bouts of pain and associated distress. One way women maximized their daily function was through the exercise of vigilance.

Vigilance in these women was conceptualized as the art of watching out. Watching out, the core category, had four processes: assigning meaning to what is, calculating the risk, staying ready, and monitoring the results. While informative, there still remained a gap as to how clinicians remain vigilant watching over their patients.

Kooken and Haase (2014) performed a study examining oncology nurses' lived experience of vigilance. They wanted to understand the role of nurse vigilance in preventing errors. They performed a phenomenological, qualitative study to understand the lived experience of oncology nurses. Seven nurses were identified by patients and family members as being vigilant, and they were interviewed about their experiences of vigilance. After data collection and analysis, four theme categories, similar to those in Meyer's study (2002) emerged: Nurses use vigilance to keep patients safe, vigilance is incorporated into expert practice over time, barriers impede nurses' abilities to be effectively vigilant, and nurses expect patients and families to participate in vigilance partnerships with them because it enhances the nurses' abilities to be vigilant. The overall results of this study indicated that vigilance is a complex phenomenon.

In the review of the literature, evolving themes or concepts were mentioned in regards to vigilance. Attention must be present in order for vigilance to take place. The literature referred to vigilance as being synonymous with attention. Some researchers used attention and vigilance interchangeably. The nursing literature alluded to the thought that in order for vigilance to be present, the individual must focus and remain attentive to an event or an object. The literature review provides examples of how the phenomenon of vigilance has been researched, but a large gap remains with research and understanding the process of nurses remaining vigilant over patients.

Anesthesia

This section of the review of literature is different from the previous sections because this section will consist of the review of literature in the specialty of anesthesiology and nurse anesthesia. This is separated from the medicine and nursing section specifically because of the specialty and the area of focus for this dissertation. Anesthesia recognized the importance of vigilance and the potential effects it can have on patient care. The word vigilance is embedded in the official seal of the American Society of Anesthesiologists, while the official seal of the American Association of Nurse Anesthetists includes Morpheus, the God of Dreams, holding the Lamp of Learning, by the light of which he keeps vigil. To date, there still remains no research study that focuses on understanding the process of vigilance in anesthesia.

Ovid and Pubmed were used as search engines when examining the literature about vigilance in anesthesiology. Another search engine used to search vigilance was the Wiley Online Library, which resulted in a total of 61 results. With Google Scholar, 160,000 search results were generated.

Based on the search results, a sample of the most relevant articles was selected for this literature review. Of all the articles in healthcare, anesthesia providers were the first to recognize the importance of vigilance with patient care. Anesthesiologists, similar to aviators, work in a critical profession in which their actions impact patient outcomes. Summarizing the field of medicine literature search, “sleep” and “distractions” were used as keywords to narrow the results. The studies examining these indicators in medicine are limited. Similar keywords were used in the literature search of nurse anesthesia. Most important is that the field of nurse anesthesia has not examined this topic other than the Schreiber and MacDonald (2010) research publication.

The word vigilance is embedded in the official seal of the American Society of Anesthesiologists. It is considered the "Holy Grail" of the anesthesia profession (Aronson & Cook, 1998). It has not been defined by the society, but yet it is "understood as clinical awareness" (Weinger, Herdon & Gaba 1997). Memory tasks, decision-making, and vigilance are the most vulnerable to compromise (Weinger et al., 1997). The American Society of Anesthesiology has researched fatigue and its effects on clinical production and patient care, but they have never examined vigilance as a specific topic affecting patient care in the operating room.

One of the first studies of vigilance in anesthesia examined the effects of automatic blood pressure devices on the vigilance of anesthesia residents (Kay & Neal, 1986). In this small study, two different anesthesia programs had two separate techniques for monitoring blood pressure. Program A used a manual blood pressure cuff, requiring auditory monitoring, while Program B used an automated blood-pressure-monitoring technique. Recognizing an issue with auditory monitoring from a clamp on the stethoscope took an average of 40 seconds less than recognizing an issue with the automated monitoring. The authors concluded that the impact of the automated system negatively affected vigilance.

One of the first studies examining activities and attention in anesthesia, the "Ergonomics of Anesthesia," was performed by Drui, Behm, and Martin (1973). The researchers examined how anesthesiologists spent their time during a surgical procedure in the operating room. The practice of anesthesia is unique because there are many activities that the provider must participate in, such as communication with the surgical staff, monitoring the patient, drawing up and administering medications, along with assessing fluid management. One major finding was

that anesthesiologists were distracted over 42% of the time after analyzing the filmed surgical case.

DeAnda and Gaba (1990) examined first- and second-year anesthesia residents in a comprehensive anesthesia simulation environment. While performing in the simulated cases, it was documented that 132 unplanned incidents occurred during 19 simulations. Ninety-six (73%) of the incidents were considered simple incidents, and 36 (36%) were considered critical incidents, such as human errors, equipment failures, and fixation errors. The results showed that most incidents in anesthesia are due to human error. The data indicated that while most incidents are simple and do not progress into more serious incidents, human error remains ubiquitous, and that formal training and education should include recognition of events and the responses to them, in addition to prevention.

Campbell, Arfanis, and Smith (2012) further examined distractions and interruptions in anesthesia practice. Researchers examined distractions and interruptions in a variety of 30 anesthetic cases in a United Kingdom hospital. Out of the 424 distracting events that occurred, 92 (22%) had negative effects ranging from repeated procedure attempts, changes in vital signs, and brief periods when the patient was unattended. The researchers did provide examples that anesthesia providers have many responsibilities during the care of patients.

Another study, performed by Chang and colleagues (2013), examined the neurocognitive effects on faculty anesthesiologists following an overnight call shift. The study examined 11 faculty anesthesiologists who took overnight call at a level-1 trauma center. The primary objective of the study was to examine the effects of an overnight call shift on cognitive function in comparison to the performance of the same tasks after a night in which the participants did not have to work overnight. Four neurocognitive tests were administered to the 11 faculty

anesthesiologists: the Hopkins Verbal Learning Test, which is a verbal learning and memory task; the Dual N-back Task, which is a working memory task; Connor's Continuous Performance Test, which is an impulsivity and vigilance task; and delayed recall of the Hopkins Verbal Learning Test. These tests were administered at baseline and immediately post-call. The authors hypothesized that sleep loss and stress due to fatigue during a call shift would result in impairment of neurocognitive performance in the post-call. There was a significant impairment in verbal learning and memory following the Hopkins Verbal Learning Test, but there were not any significant differences in any other of the tests administered. There was a higher rating of sleepiness post-call. The authors concluded that following a call shift, performance on learning and memory was significantly reduced.

In examining anesthesia residents, Bartel, Offermeier, Smith, & Becker (2004) examined the effects of attention and working memory in resident anesthetists after night duty. The aim of the study was to investigate the effects of a single period of night duty on measures of attention and working memory in a group of anesthesia residents. Thirty-three residents participated in the study. The Stanford Sleepiness Scale was a subjective questionnaire to assess the feeling of sleepiness followed by four reaction time tasks increasing in difficulty: simple, complex, sequential 1 task, and sequential 2 task were administered for a total of 35 minutes in duration. The main result from the study was that sleep deprivation induced important psychomotor deficits in 52% of the residents participating in the study following the simple reaction-time test.

In another study researching vigilance in anesthesia residents, Loeb (1994) examined and measured the response times of eight residents to detect a simulated abnormal value on the physiologic monitor. The anesthesia residents were studied during 60 surgical procedures. Responses to 439 abnormal values were analyzed. Fifty-six percent of the detections were made

within 60 seconds, although 16% of the abnormal values were undetected during the five minutes that these were displayed. During induction, the time when the patient is put to sleep, the response times and missed events were the highest due to multitasking and the high-work demand.

In another study, by Weinger, Gonzales, Slagle, and Syeed (2004), vigilance was examined when teaching of anesthesia took place during surgical cases. It was observed that anesthesiologists who were teaching took a significantly longer time to react to alarms. Teaching reduced attention during important phases of anesthesia, including the induction stage: putting the patient to sleep, and the emergence stage, waking the patient up from anesthesia (Weinger et al., 2004). It is important to note that Weinger and Slagle (2001) examined years of experience in relation to performance, and they concluded that as clinicians gain experience, they could accomplish critical tasks and avoid distractions. Clinicians can dissociate important compared to non-important duties.

In anesthesia, much like in aviation, the most important moments are induction and emergence. Following induction and when the patient is asleep during surgery, there are lull times when the patient is under general anesthesia and monitoring occurs, also known as maintenance, when there is not much, if anything, for the anesthesia provider to do other than monitor the patient and assess their vital signs. Therefore, anesthesia providers can still monitor the patient, while performing other tasks, such as drawing up medications or documenting things to which their attention can be momentarily diverted.

Slagle and Weinger (2009) examined the reaction times of anesthesiologists to alarms when reading in the operating room. The results showed that reading and non-reading periods showed no significant difference in reaction time among groups studied and observed. This study

was supported by McGrath, Taenzer, Karon, and Blike (2016), who examined the use of laptops and mobile devices during the maintenance phase of anesthesia, also defined as surveillance monitoring (McGrath et al., 2016). While multitasking, such as using a laptop or mobile device, during the low-task maintenance phase of anesthesia, with brief glances at vital signs, subjects reported a decrease in boredom and suggested it might not reduce, but enhance vigilance, contradicting previous vigilance studies in psychology (Jorm & O'Sullivan, 2012). The authors concluded that there is no evidence to support the ban of electronic devices such as laptops and mobile devices, and their impact on vigilance and patient care would need to be further researched.

For anesthesia providers, both visual and auditory changes in the operating room have important roles in the changes in the surgical case. For example, when examining the surgical field, significant bleeding can inform the anesthesia provider that the patient's vital signs may change and require an intervention, such as fluid replacement. Auditory noises also play a role in the status of the patient. Changes in beeps of the pulse oximeter or heart rate can inform the anesthesia provider of changes in vital signs.

Stevenson, Schlesinger, and Wallace (2013) researched the effects of divided attention, looking at the effect of operating room noise to the perception of the beeps with the pulse oximeter. Anesthesia residents were given a visual task of responding to color changes on the computer screen by raising their left hands while listening to the pulse oximeter beeping. They were to indicate changes of the pulse oximeter tone by raising their right hands and, therefore, they were to maintain both auditory and visual detections simultaneously. The results showed that visual attention load had a significant effect on being able to detect audible changes in the

pulse oximetry beeping, meaning that when more visual concentration was applied, the resident's auditory ability suffered detection ability (Stevenson et al., 2013).

The maintenance phase of anesthesia allows the anesthesia provider the time to perform tasks, such as drawing up medications or reviewing the patient's chart. Wax, Lin and Reich (2012) wanted to know the effects that electronic medical records had on the overall patient status during a surgical case. Wax and colleagues (2012) examined if there was variability in vital signs when the anesthesia provider used an electronic medical record that automatically documented vital signs during a procedure and required no physical exertion or attention for documentation. The study examined when the anesthesia provider had the electronic medical record on the computer screen compared to when the provider was distracted, looking at something else. The results showed that there was no hemodynamic variability in the patient's vital signs according to whether the medical record was on the computer screen or not. This is one of the first studies done in healthcare in which technology could have been the distraction and provided the opportunity for an adverse event; yet there was no harm or changes in the patient while under general anesthesia (Wax et al., 2012).

It is clear that clinicians with their unaided senses are far from infallible monitors; yet, there is little information on what vigilance in the operating room entails and how it affects the anesthesia provider's performance. As technology advances in medical care, the way providers document and interact with patients during care will also change. Now, information is readily accessible with the touch of a finger that can improve split-second decisions.

Multitasking has been a way of life for most people, but multitasking during patient care can potentially have harmful effects. Anesthesia providers, much like pilots, experience a time of low stimulation when things are coasting along fairly easily. This is the time that more than 90%

of anesthesia providers admit to some form of boredom, potentially leading to severely decreased vigilance. There is no doubt that reading or computer usage gives the appearance of being less attentive, even if there are no measurable effects.

Karcz, Lee, Chhibber and Eaton (2013) distributed an 18-item questionnaire to members of the American Association of Clinical Directors for the American Society of Anesthesiologists asking about the impact of electronic distractions in the operating room. Over half of respondents admitted to being distracted in the operating room. The results of the survey suggest that use of electronic devices is prevalent, with the majority of respondents expressing concern over significant patient safety risk.

The anesthesiology literature indicates that vigilance is a complex phenomenon that individuals process differently. This complex environment of healthcare further muddies the understanding of vigilance due to dynamic factors, such as what occurs in the operating room.

In comparison to the literature specifically in anesthesiology, the nursing anesthesia literature has limited research in the area of vigilance. The first article published on the topic of vigilance analyzed the concept of vigilance in anesthesia. Hirter and Van Nest (1995) performed a concept analysis of vigilance, recognizing its role in anesthesia for safety in the anesthesia environment. Five defining attributes for vigilance were watchfulness, alertness, attention, diligence, and readiness to act. Alertness and fatigue were attributes recognized in the medicine and psychology sections. Although the concept analysis provided information in regards to vigilance, there still remains a gap in the literature of examples and the impact on patient care. The authors concluded that vigilance is a vital part of the role of nurse anesthetists.

A study by Betza, Jurewicz, and Neyens (2016) examined the anesthesia maintenance and vigilance. In an observational study, Davies and Tune (1969) examined the maintenance

phase, the period of time when the patient is under anesthesia during the surgery. Two researchers observed three recorded bariatric surgeries involving the student nurse anesthetists and certified registered nurse anesthetists (CRNAs). The aim of the study was to identify tasks associated with anesthesia maintenance and transition between anesthesia tasks. The observers examined monitoring compared to no-monitoring tasks during the maintenance phase of anesthesia. The results showed that student nurse anesthetists spent 71% of their time doing monitoring tasks during the maintenance phase. They performed a vigilance task of continuously monitoring the patient and displays while also documenting on the electronic medical record. The CRNAs spent 41% of their time monitoring and 23% of their time interacting with the electronic medical record. The results showed that about 30% of the time nurse anesthetist students faced away from the patient and were not performing monitoring tasks. The CRNA instructor spent more time faced away and not monitoring the patient. This could be due in part to trusting the student or providing independence to their training.

The only qualitative research study examining vigilance documented in the anesthesia literature was performed by Schreiber and Macdonald (2010), titled "Keeping Vigil Over the Profession." This qualitative study did not examine vigilance in the clinical setting, but rather vigilance of the profession. This was a grounded theory study that examined how CRNAs remain vigilant in regard to the practice environment. Eighteen interviews were conducted and data collected at the AANA Congress. From the data collection, three contextual categories emerged: establishing public credibility through regulatory and educational standards, political vigilance and taking action in governmental and policy arenas and tending the flock through a continuous information loop between local and administrative/political levels. Although informative, the results of the qualitative study did not provide a true understanding of the process of vigilance in

anesthesia practice. This further provides evidence of the need for a qualitative study to understand the process of vigilance in anesthesia practice. The gap in the literature remains because in order to research a phenomenon further, we must understand the process of how it occurs. Therefore, a qualitative research study of vigilance is needed and required to fill in the gap in the literature.

In conclusion, the literature revealed that vigilance has been researched in a variety of disciplines and affects human function, yet there is no understanding of the process of how individuals are vigilant. In review of the literature from aviation, psychology and healthcare, there appear commonalities, such as fatigue and distractions, from the findings that impact decision-making and responses to events. In order to improve these commonalities, there needs to be an understanding of the process of vigilance. The term vigilance has been stated without a true working definition and process. Research in understanding the process can help guide nurse anesthetists to improve their practice and, in essence, to improve patient care. The literature review provides evidence to support the need to explore vigilance in nurse anesthesia care.

CHAPTER 3

METHODS

The purpose of this study is to conceptualize the process of how certified registered nurse anesthetists (CRNAs) remain vigilant over their patients. There remains a gap in the literature about how CRNAs care for their patients and keep them safe during anesthesia. To date, there has never been any qualitative research examining the process of vigilance in CRNAs. Although there has been one qualitative research study that involved CRNAs, "Keeping Vigil Over the Profession" (Schreiber & MacDonald, 2010), this study focused on the profession of CRNAs and not the clinical actions of vigilance over patients. Therefore, there are no conclusions that can be reached about how CRNAs maintain vigilance over their patients.

Grounded theory provides a set of systematic inductive methods for conducting research aimed toward theory development. The resulting theory is built upon strong empirical data. This area of research brings attention to, and sheds light on, a new understanding of the process of vigilance performed by CRNAs. The results inform and improve the practice of vigilance in nursing, while filling in gaps in the literature about the vigilance of CRNAs. This can affect patient care in order to optimize positive outcomes.

This phenomenon of vigilance has a critical role in CRNAs' practice. This is something that can be misunderstood, but there is an expectation that it will be practiced. The results of this research contribute to the science of nursing and bring vigilance to the attention of providers. Using the grounded theory method will yield a theoretical model to explain the process of being vigilant. Therefore, it is essential to understand the process of how CRNAs care for their patients

in order to improve their practice. The specific areas that will be addressed in this chapter are research design, setting, sample size, data collection and management, data analysis, rigor, and ethical considerations.

Research Design

For this qualitative research study, a naturalistic design was used because the focus is on the process of how CRNAs care for their patients. The naturalistic research design provided a focus for studying the social behavior of individuals. It involved exploring how CRNAs practice anesthesia and remain vigilant over their patients. There is at this point no understanding of how this process occurs. In this study, the purpose was to conceptualize the vigilance process of CRNAs. This design used qualitative methods to engage with participants with in-depth interviews using guiding questions to gain an understanding of how they are vigilant over their patients (Frey, Botan, & Kreps, 1999). This approach helped identify patterns and behaviors to help further understand the process that CRNAs perform when caring for their patients.

Since the focus is on CRNAs, a grounded theory method was used because it is a systematic approach that enables researchers to identify concepts and build theory from qualitative data (Corbin & Strauss, 2008). CRNAs can recognize these concepts in their practice and relate this middle-range theory to clinical practice. Grounded theory examines the social process of behavior and identifies what is occurring (Glaser, 2001). In open-ended interviews, the data gave rise to categories that led to conceptualization as the core process of grounded theory (Glaser, 2001). The primary research question was, “What is the process a nurse anesthetist uses to be vigilant and ready to detect and respond to changes occurring during a surgical case?”

Setting

The operating room was used as a reference point to which the practice of vigilance is performed by the CRNAs. The interview setting was determined after the participants agreed to participate, either in person or via telephone interview.

Sample and Sample Size

Participants were CRNAs. The inclusion criteria for this study were licensed CRNAs, who are individuals who have completed a certified nurse anesthesia degree program, and are board certified in the specialty of anesthesia by the American Association of Nurse Anesthesia (AANA). This was defined as working as a CRNA without restrictions on the number of hours worked. Their practice must have included performing general anesthesia. For the purpose of this study, CRNAs practicing in both hospital and ambulatory settings were included. There was a decision made to include CRNAs without any years of practice restriction because vigilance is a core process of practice. This decision provided a wide range of data from CRNAs.

For the purpose of this study, there were two exclusion criteria for the selection of participants. Students were not to be considered because students do not have the same scope of practice as CRNAs and cannot practice independently within the scope of their license, and CRNAs in orientation were excluded because they are not currently practicing under their license. Retired CRNAs were not to be considered because they are no longer practicing under their licenses.

The sample size was determined by examining previous qualitative, grounded theory research studies. After performing a random sample and examining qualitative research studies from 2008–2019, which had sample sizes ranging from 15–23 participants, the estimated sample size of 19 participants was selected for this study. The final sample size was determined based on

the saturation of categories. The goal of qualitative research should be the attainment of saturation. Saturation occurs when adding more participants to the study does not result in additional perspectives or information. Glaser and Strauss (1967) recommend the concept of saturation for achieving an appropriate sample size in qualitative studies.

Recruitment

Participants were recruited by posting the research topic and summary on AANAConnect. This is a social media site organized by the American Association of Nurse Anesthetists (AANA) where CRNAs can post discussions, research ideas, and make social connections with other CRNAs across the country. In order to post something, a member must log in at the AANA website and navigate to the site. There is a code of conduct that opens up prior to any ability to post anything. If a violation of the code of conduct occurs, the CRNA is allowed up to three violation warnings before the CRNA's access to the site is revoked. All members of the AANA have access to this site, but the number of participants on the site is unknown.

A posting titled "Seeking Participants for Vigilance Research Study" was posted on the website. Following approval, recruitment flyer information was posted, describing the purpose of the research study, along with the inclusion and exclusion criteria. Sappleton and Lourenco (2016) discussed how recruitment online can be improved by the titling of the subject line. Using the term "seeking" should attract CRNAs willing to participate. A snowball effect was anticipated to occur through networking and that other CRNAs will be willing to participate in the study.

Data Collection and Management

Ideally, this study would have been conducted as face-to-face interviews. If any participants were willing to travel and meet in person, a quiet conducive environment would have been provided for the interview. Once participants had provided consent in person, the interview could have started immediately. If a participant was unable to perform a face-to-face interview, the study was conducted over the phone in an interview format. The consent was mailed to the participant, and upon receiving back the consent form, a date and time was determined for the phone interview. The beginning of the interview was used to establish a rapport with the participants to make them feel comfortable and relaxed. To start the interview, basic demographic information were gathered, such as the nurse anesthetist's age, number of years as a nurse anesthetist, work experience, day/shift worked, and examples of anesthesia cases performed during a normal daily shift.

The length of interviews varied among participants. A stipend was offered because CRNAs were hypothesized to want to eagerly tell their story in hopes of improving patient care. The goal was to obtain adequate data for analysis. Qualitative researchers gather information by initiating a question, allowing subjects to speak freely, and listening carefully. A tree-and-branch method of questioning was used to help guide the conversation. This method can be done in a chronological order to construct the history of the interviewee's anesthesia care (Rubin & Rubin, 2005).

Using the tree-and-branch approach (Glaser & Strauss, 1967) allowed the researcher to divide the research questioning into appropriate sections. Data collection began with an open-ended, initial question and remained broad; and it then led to probing questions as new topics

and patterns emerged to allow for the discovery of what, when, and how in regard to vigilance. Below are examples of the questions.

1. Tell me about a typical or recent case in which you cared for a patient under general anesthesia?
2. How do you monitor your patients during a surgical case?
3. How do you recognize changes in the anesthesia environment and your patient?
4. What things detract or distract from your caring and monitoring your patient?
5. What things facilitate your caring for and monitoring your patient?

During each interview memos were written in a notebook, which were later transcribed and stored in the computer. Theoretical sampling is the process of data collection for generating theory though the data. This is an ongoing process that can help answer any further questions that arise during data collection. Theoretical sampling continues moving back and forth between interviews and data collection and analysis until data saturation is reached.

All interviews were digitally recorded via a recording device. Upon the conclusion of the interview, the digitally recorded interview was downloaded into a password-protected folder on a personal computer located in a home office and electronically sent to a transcription service, where the interview was transcribed as a Word document and sent back on a secure password-protected email address network for data analysis. The transcriptions were verified by listening to the recorded conversations and comparing these to the typed transcriptions. The participants were identified only by numbers that corresponded to their interview numbers. For example, interview #1 was participant #1. The transcriptions, consent forms, and all interview data were stored in a locked cabinet in my home office.

Data Analysis

Data were analyzed using the constant comparative method (Glaser & Strauss, 1967). Data analysis was supervised by the dissertation chair. After the initial interview, the transcribed interview was analyzed and coded. A constant comparative analysis method was performed as the interviews continued and further data were collected and coded. Coding consisted of naming conceptually what was happening in the data (Glaser, 1978). The codes conceptualized the patterns within the data. The data analysis proceeded first using an open-coding method followed by an axial-coding method.

Open coding was done following each interview so that codes identified were incorporated into the analysis of the next interview. Open coding involved examination of the transcribed interview line by line, using words, phrases, and sentences as units of analysis to identify codes (Glaser & Strauss, 1967). The data analyzed in each new transcript were compared with codes from previous interviews to identify anything that appeared similar to previous data.

Following the open-coding process, axial coding was done. In axial coding, the group of open codes were examined and conceptual categories emerged (Glaser & Strauss, 1967). The goal was to discover a core category and process from the data. Memos are the theorizing write-up of ideas about codes and their relationships (Glaser, 1978). These were used to initiate new or follow-up questions to explore. Memos were employed to enhance the research by making reflective notes to compare to interviews and help further explain the new emerging data. Memos also provided further ideas to incorporate during future interviews to examine new categories and provide support of the categories.

Rigor

Rigor refers to the precision with which a study is conducted to enhance the quality and trustworthiness of the findings produced from the research. Glaser and Strauss (1967) defined rigor as a process to gain an understanding of what the data convey. Rigor in qualitative research is associated with consistent data collection and allowing the data to represent the emerging social process described. With the inclusion of rigor, Glaser and Strauss (1967) describe the importance of credibility and plausibility. Credibility is accuracy of the study or believability. This is confirmed by seeing the process described in the interview and data from the beginning, middle, and end of the process. Lincoln and Guba (1985) suggest another approach for establishing credibility, leaving an audit trail, so that data analysis can be reviewed. Plausability is the meticulous process for how the data were collected and coded. Process will be detailed and described during analysis. Transferability refers to the degree to which the results of qualitative research can be generalized or transferred to other contexts or settings. This cannot occur until the results are complete. It is up to the reader to determine where this middle-range theory can be applied to another discipline and fit (Speziale & Carpenter, 2007).

Ethical Considerations

The Institutional Review Board (IRB) at Loyola University Chicago reviewed and approved this research proposal. A signed informed consent form was obtained from all participants prior to the beginning of any research or interviews. The consent forms were stored in a locked cabinet. All questions the participants had were answered prior to beginning data collection. Participants were informed of their right to refuse to participate, the right to not answer any specific questions asked, or the right to withdraw from the study at any time, without any consequences.

Confidentiality was maintained throughout the research process. The participants' identities were in the form of numbers, and their recordings and transcripts were identified the same way to maintain anonymity for any identifying information that was disclosed during the interview. All identifiers were redacted from the transcripts in order to maintain privacy. There was no anticipated risk to participating in this study, and participants were to be reminded of their right to withdraw at any time

CHAPTER 4

RESULTS

The purpose of this chapter is to present the study findings to explain the basic social process of vigilance performed by certified registered nurse anesthetists (CRNAs). The sample, process, and model; the core category; and conceptual categories and their properties will be presented. Properties of categories will be exemplified by direct quotes from participants.

Sample

Fourteen certified registered nurse anesthetists (CRNAs) participated in phone interviews. The participants (8 females and 6 males) were board certified practicing CRNAs who provided general anesthesia in their clinical practice, without restrictions on the number of hours worked. Participants had a mean average of 15.7 years in practice as CRNAs, with a standard deviation of 8.9 years. The clinical environments of the participants varied from independent practice to supervised practice by anesthesiologists. The practice settings consisted of rural hospitals, academic teaching institutions, and surgical centers consisting of inpatient and ambulatory surgical cases. There was a decision made to include CRNAs without any years of practice restriction because vigilance is a core process of practice. Years of practice should not matter because vigilance is practiced by every CRNA caring for their patients. This approach provided a wide range of data from CRNAs. Students were not considered because they do not have the same scope of practice as CRNAs and cannot practice independently as they are not board certified as anesthesia providers. Retired CRNAs were not considered because they are no longer practicing under their licenses.

Process and Model

The data indicated that the process of vigilance performed by CRNAs is the process of ***using senses***. The process is illustrated in Figure 1. (Below)

Using Senses

(core category)

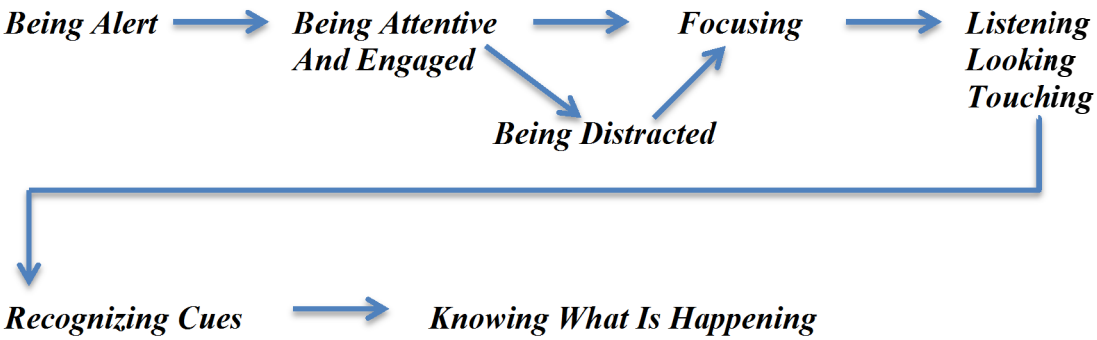

Figure 1. The process of vigilance by CRNAs, Using Senses

Basic Social Process

The data indicated that, in the process CRNAs used in being vigilant over their patients, ***using senses*** (core category) was employed to provide safe and effective care while the patient is under general anesthesia. The process begins with the CRNA ***being alert*** to care for the patient. This is when the CRNA assumes care of the patient and maintains a high level of alertness and does not get mentally fatigued. Being alert allows the CRNA to be ready to care for their patients. When a CRNA is alert, the CRNA positions him- or herself for the next conceptual category, in which they are ***being attentive and engaged*** in watching over their patient and the surgical case. The CRNA is constantly aware and pays attention to his or her patient. Being attentive and engaged keeps the CRNA ***focusing*** on every aspect of patient care. The operating room is a dynamic environment, where ***being distracted*** with things such as music, conversation,

and technology can pull clinicians away from being engaged in the care of their patients. These distractions can, but do not always, occur. If the distractions do not occur, then the CRNA maintains their focus. If distractions do occur, the CRNA recognizes and redirects their attention and returns to focusing on the patient. Thus by focusing, the CRNA uses their senses ***by looking, listening, and touching***. By looking listening and touching, the CRNA puts a picture together of the care of their patient under general anesthesia. This puts them in a position to look for and ***recognize cues*** that can help continue or improve care by anticipating changes at random intervals during the case. When the CRNA picks up on cues, the CRNA ***knows what is happening***.

The process by which CRNAs remain vigilant over their patients starts with the CRNA initiating care by being aware at the start of the case and concludes at the end of the case and transfer of care. In the presentation of findings, the core category (using senses) is followed by seven conceptual categories, and the properties of the category, which are italicized (properties). Quotations from the participants are used to represent and illustrate the properties of the associated category. At the end of each quotation, the participant number and page number of the interview are provided in brackets. The chapter concludes with a discussion of the necessary elements used to demonstrate methodological rigor of the study.

Core Category

Using Senses

The data indicated that in the process of CRNAs being vigilant over their patients, they are ***using senses*** (core category) in order to provide safe and effective care while the patient is under general anesthesia. The role of the CRNA is vital to the survival and well-being of the

patient throughout the perioperative process. This begins upon meeting and assuming care of the patient and concludes at the handoff to the nurse in the recovery room.

During this process under the care of the CRNA, the patient is placed under general anesthesia where they rely on the CRNA to be the eyes and ears, responding to critical events to maintain the well-being of the patient. The CRNA assumes complete care and control of the patient. The important role of the CRNA, as discovered in the data, is to use their senses to identify and respond to the needs of the patient. ***Using senses*** emerged as the process by which CRNAs care for and watch over their patients.

Using senses reflects the key component of what makes the CRNA vital to the care of patients under general anesthesia. While the patient is under general anesthesia, they are unable to vocalize any discomfort or issue. They are however able to provide cues, such as changes in their vital signs or appearance, which is when a trained CRNA uses their abilities to detect and respond to small changes occurring at random intervals during the surgical case. CRNAs are trained to perform a technique referred to as circle checks, in which a CRNA begins by looking at the patient, checking to make sure things are appropriate and continuing this examination moving over to the anesthesia machine and concluding by looking at all of the monitors. This technique is done every few minutes during the surgical procedure to ensure things look appropriate and everything is stable in the eyes of the CRNA. One participant below described how an alarm or just performing the common circle check would allow them to pick on some things occurring during the case.

> Sometimes it's the alarm that catches my attention, depending on what I'm doing in the case. So yeah, sometimes it's the alarm. And it's sometimes just me doing my circle checks we call them. [1.5]

The same participant again stated that as a CRNA, she is constantly monitoring everything that is occurring during the surgery:

> Well, what does monitoring mean? Well, it doesn't just mean physical monitors. It's you, as the nurse anesthetist, as the constant monitor. [1.13]

Using senses as a CRNA involves monitoring and watching for anything occurring during the surgical case. The CRNA is attentive to the welfare of the patient. Another participant stated:

> I mean, we only chart five-minute intervals. But I still have it set at two and a half. I'm still watching for any changes. [2.4]

The same participant compared anesthesia to attaching to the patient and experiencing what the patient is experiencing so they can respond to the patient's needs and act as a "watchdog" when the patient cannot respond to changes during the surgical case:

> Years ago, somebody told me that doing anesthesia is kind of hooking up to the patient's nervous system for a while because you are their watchdog. [2.5]

The same participant later described the process of using senses by phrasing it as being adjoined to their patient:

> But I just feel like that is part of what keeps me in line or in a sense kind of adjoined to that patient in a way that's kind of difficult to describe. [2.5]

CRNAs require extensive education and training. From their training, CRNAs apply their knowledge to every patient they care for. Another participant described providing anesthesia as a complete process using senses:

> You're constantly aware of everything that's happening around you. It's a full sensory experience as well as you're thinking cognitively about your patient, your case, always adjusting for surgical demands, surgeon preferences, patient physiology, and pathophysiology. [4.4]

CRNAs care for only one patient because it requires constant focus and attention to the needs of the patient during the surgical procedure. Another participant described ***using senses*** as getting tuned into the case and picking up on subtle events:

> But I think we all get tuned in to the monitor beeps and we know that if it beeps a way, we hear it go down a little bit, and then you realize, Okay, what's going on? What's happening? [5.4]

Patients give their trust to CRNAs to keep them safe under general anesthesia and in return, they ask that CRNAs provide effective care. CRNAs remain alert to events occurring during surgery. During the interviews, the data showed how CRNAs use their senses for the detailed care they provide:

> In our practice, we're very accustomed to hearing slight changes in heart rate, as well as changes in oxygen saturation. [11.6]

Using senses emerged from the data when CRNAs discussed the care they provided to their patients under general anesthesia. They assumed a sense of ownership of their patients, where they respected and honored the responsibility that patients gave to them with trusting their abilities to keep them safe. The core category of using senses demonstrated the process of how CRNAs are vigilant over their patients.

Being Alert. The first category of the theory, ***being alert,*** reflects the CRNA's focus on the care they provide for their patients. This is the beginning of the process when the CRNA assumes care of the patient. ***Being alert*** means being awake, being responsive and functioning at a high level. Properties of ***being alert*** are *maintaining alertness* and *staying in the game,* while properties mentioned that negatively impact alertness were "*fatigue"* [1.9] and "*mentally fogged"* [9.6], which can affect the care of the patients/. In order to provide safe and effective care, CRNAs described the need to "*maintain alertness*" [4.8] and "*stay in the game*" [1.13]. By being alert, a CRNA is ready to respond and care for patients under general anesthesia. ***Being alert*** is an important component of anesthesia as clinicians work in a variety of settings and various work hours.

One participant explained the importance of fighting fatigue and maintaining alertness:

> If I'm feeling a little fatigued, sometimes for me, getting up, walking around, just taking in the room from a different perspective is helpful for maintaining alertness. [4.8]

There are moments when a CRNA may feel fatigued or tired and utilize mobility as a way to combat the fatigue feeling. Another participant described the action of walking around the room allowed them to be alert during surgery:

> That's why I walk around to make sure there's nothing hidden behind the drapes or on the floor that I'm not seeing from the head of the bed. The walking around process is also just for me to kind of to stay alert in the situation. [9.6]

Furthermore, being alert can be tiring, especially with the unpredictable and unscheduled work hours that CRNAs experience. Therefore, fatigue can have a negative impact on ***being alert***. Another participant stressed the importance of not becoming fatigued:

> If you're on a long shift, a 12-, a 24- or a 16-hour, then if there is staff and you can take a break so that you just don't get fatigued mentally. And I think sometimes stepping out allows you to kind of reset and refocus. [1.9]

It can be challenging for CRNAs to combat fatigue. The same participant expressed the importance of not only avoiding fatigue, but also maintaining a state of alertness:

> So you're the constant monitor. However, to monitor means you have to pay attention. And like I said earlier, I call it staying in the game and that's what I always tell students. [1.13]

Participants expressed the importance of being alert. When CRNAs are alert, they position themselves for the second category of the process, ***being attentive and engaged.***

Being Attentive and Engaged. The second category of the theory, ***being attentive and engaged,*** reflects the importance of paying attention and being observant while being invested and involved in the care of the patient. The CRNA becomes an interactive participant, engaging during the process, anticipating the needs of the patient, while being ready to respond appropriately. Properties of ***being attentive and engaged*** are *constantly aware, being more attentive, and being in the game.* One participant described ***being attentive and engaged*** as being

"constantly aware" [9.6] of what is going on with the patient throughout the perioperative process. When CRNA are attentive, they remain ready to respond to the needs of the patient. One participant described being attentive as paying attention:

> So you're the constant monitor. However, to monitor means you have to pay attention. [1.13]

Another participant mentioned the evolution of their practice throughout their career. CRNAs begin to evolve their practice through experience and learning. The participant mentioned how more attentive they are in their practice now compared to their earlier career:

> Oh, I definitely think I'm more attentive in the last part of my career compared to the beginning of my career. [2.10]

CRNAs provide powerful medications that help alleviate pain. Unfortunately, these medications can have adverse effects that can impact patient outcomes and, therefore, caution and attention are required when prescribing and administering medications. For example, another participant described being more attentive to the care of their patient because of the patient's comorbidities that can affect pain management:

> I was a little bit more concerned about pain, balancing with basically too much narcs in her system as far as apnea and stuff. So, I was a little bit more hands-on, a little bit more attentive. [10.3]

Alarms provide a safety mechanism for the CRNA, bringing attention to an abnormality that may not be recognized immediately. As the same participant mentioned being attentive to medication administration, the participant commented on ***being attentive and engaged*** to the operating room environment regardless of alarms:

> I don't turn anything off [in regard to monitors]. I leave everything set. But no, I mean I stay pretty aware, pretty attentive. [10.3]

Another participant describes being involved in the care of the patient. Participating in the care of the patient, the CRNA must engage by being ready to respond to the needs of the patient, symbolized by being in the game:

> And even though you think you're in the game most of the time you are, but if you're tired, you're probably not making the best decisions. [1.10]

In anesthesia, providers have multiple tasks to complete in regard to administering medications, charting, and assessing the patient. The same participant also described the challenges of multitasking with charting on the electronic medical record and having to reengage and focus on the patient during the surgical case. It was switching from one action to another:

> When I had computer charting, I felt like a lot of times I was disengaged at certain points during the case. And I felt like I had to push myself to reengage and become involved and make sure that I was doing what I should be doing. [10.6]

During surgery, the CRNA can multitask with things such as drawing up and administering medications and documenting vital signs. The surgeon, while not knowing these actions of the CRNA, may think that the CRNA is not engaged in the surgery. Therefore, the CRNA may need to communicate with the surgeon to let him/her know they are still engaged with the surgical case. One participant described staying engaged to let other clinicians know the CRNA is following along during the surgical case:

> "Hey what's going on?" It's more of I just engage and to let them know that, "Hey I'm up here. What do you guys got going on down there?" so that they know to tell me what's going on. [10.3]

Participants expressed the importance of ***being attentive and engaged*** as it puts them in a position to be aware of the status of the patient and the progress of the surgical case. Unfortunately, there are instances when their attention can be diverted away from the patient. If this does occur, then the CRNA would experience the third category in the process, ***getting distracted.*** There are instances when the CRNA does not experience any distractions. If the

CRNA does not experience any distractions, the CRNA progresses to the fourth category in the process, ***focusing*.**

Getting Distracted. The third category of the theory, ***getting distracted***, reflects the potential incidents that can lure the CRNA attention away from the care of their patients. This would include anything that prohibits the CRNA from providing care to the patient. Properties of ***getting distracted*** are *losing track, getting drawn away, distracting conversations, music in the operating room* and *using cellphones* during the surgical case. The operating room is a very dynamic environment. "There are tons of distractions," [6.5] in the operating room that can take away the focus of CRNAs, "distracting from care" [2.7]. The patient remains unconscious, while under general anesthesia, unable to respond to events occurring during the surgical case. The CRNA must remain attentive to respond to the needs of their patient. Distractions can lead to potential adverse or sentinel events.

There are distractions that can and do occur. Surgeons will usually request that music be played to prevent the monotony of surgery. One participant described how music in the operating room distracted them:

> They had a particular surgeon who enjoyed his music that was so loud that it interfered with my ability to hear alarms or tones of the pulse oximeter. And I complained about it many times. In fact, a couple of times I went over and just turned the radio down. But I think that's one thing that certainly distracted me from taking care of the patient. And that's one thing I find bothersome. [2.7]

Distractions can interrupt or lure a CRNA's attention away from the task at hand. These can be mild or major distractions that can impact care. One participant described being drawn away when trying to prepare for the next surgery by setting up syringes and airway supplies, while still providing general anesthesia to a patient:

> That's something that can, if you have a big set up, you can be making syringes, drawing up drugs, doing things for your next case. You got to be more aware of what you're doing

> so you don't spend so much time doing one thing you're not looking at your patient. Those are kind of the big things where you tend to get drawn away from what you should be focusing on. [13.3]

Another participant described distractions occurring while charting on the electronic medical record. The participant referred to being drawn away from the patient:

> Because people have to spend more time typing and staring at screens than to looking at their patients. So, it's taking away from the provider/patients relationship and putting their faces into more screens than necessary. [7.4]

Every day is different and dynamic in the operating room, which can bring different challenges and distractions. Some distractions can be from conversations occurring during surgery. One participant discussed that there are distracting conversations that occur every day:

> In the OR, there are tons of potential distractions. And every day is different, depending on what room you're in, who the surgeon is, who the staff is. So just in the room environment you have some people who like to talk, talk, talk and will come up above the drapes [where anesthesia is located in the operating room during surgery] and they'll talk to you. [6.5]

Communication is essential during a surgery. During the surgical case, conversations of non-surgery topics may arise. These conversations may seem harmless, but they can lure CRNA's attention away from care. One participant recognized that conversation can be distracting and knowing when to stop it:

> I think we all know when to stop having personal conversations during an OR case. You may have to tell a colleague that now is not an appropriate time to be talking. [9.8]

As healthcare evolves, technology is becoming more incorporated into the care of patients. Electronic medical records have organized patient information into one concise appropriate place. Other technologies, such as cellphones, have made information accessible to look up and reference. These also allow the opportunity for distractions. One participant described having mobile phones in the operating room:

> But I've had a few people come in and you can see them looking at their phones while the case is going on. I would think that would fall into that distraction [category]. [3.10]

Another participant described the importance of avoiding distractions such as cell phone use and zeroing in on the caring for the patient:

> I mean, some people will text and say they need a break, or they need something like that. But we try to really hone in on not using phones. [6.6]

Participants described different distractions in the operating room. These distractions can lure CRNAs away from remaining vigilant over their patients. One participant recognized that conversations can be distracting and reported telling a colleague "now is not an appropriate time" [9.8] to talk. This provided evidence that the CRNA recognized a distraction and redirected their attention, positioning them for the fourth category, **focusing.**

Focusing. The fourth category of the theory, ***focusing,*** reflects the important ability of CRNAs to pick up on particular details or insights that may impact the care and outcomes of the patient. Two separate pathways led to the category of focusing. When the CRNA is ***being attentive and engaged***, it leads to the CRNA's ***focusing*** on the care of the patient. There can be instances when the CRNA may get distracted in the dynamic environment of the operating room and redirect their attention to the patient. Properties of ***focusing*** consist of *focused on the patient* and *focused on one aspect.*

One participant described ***focusing*** as a high priority in their care:

> So it's always been high on my priority list to make sure that I'm focused on the patient as really the last advocate between that patient and something, some sort of adverse event. That's my job. That's why I'm there. [6.9]

Another participate described being focused on the care of the patient entirely. It is important to recognize and respond to changes in the environment. This participant described the importance of focusing when an abnormal vital sign appears on the monitor. This can be an indicator of a

change that occurred, such as the depth of anesthesia. During the surgical case, the depth of anesthesia can change depending on the surgical stimulation and duration of the surgical case. Therefore, it is imperative that the CRNA remain focused on the anesthesia provided on the overall care of the patient:

> Focused on something [depth of anesthesia] going down or something going up or something negative [potentially] happening. [7.6]

The same participant expressed the importance of not focusing on one thing, but the entire surgical case. The participant described that the CRNA must stay focused on the entire surgery. Vital signs can change because of the amount of anesthesia delivered, but these can also change if there is significant blood loss or potential injury to blood vessels and nerves.

> That would be the only other thing I could think about would be if you get so focused on trying to fix one thing, and something else is going wrong, you're going to miss that other thing going wrong, and it becomes critical. [7.6]

Participants described the patient as their priority. Focusing allowed the CRNA to recognize any subtle changes in the status of the patient. This leads to the fifth category of the process, ***looking, listening, and touching.***

Looking, Listening, and Touching. The fifth category of the theory, ***looking, listening and touching,*** reflects the important ability of CRNAs to examine or pick up on information relayed from the sounds or tones of the monitors, while physically interacting with the patient. In the operating room, visualization (***looking***), is an important action in which CRNAs can understand and gauge events of the surgical procedure and anticipate the needs of the patient. CRNAs look at their patients and the monitor to evaluate vital signs and also look at the surgical field. ***Listening*** is an important component for CRNAs because during a surgical procedure, CRNAs are multitasking, checking, and assessing the patient and vital signs, while also administering and titrating medications. The CRNA monitors the surgical case and moves

around the operating room checking for any blood loss and suctioning of fluids. In doing so, the beeps of the vital sign and anesthesia monitors (***listening***) provide indications of the patient's status during the surgical case. ***Touching*** is important because it allows CRNAs to be close to their patients. CRNAs are positioned at the head of the bed, an arm's length away from the patient, allowing them to assess the patient, such as their temperature. CRNAs work in a tight environment where location and access to the patient is important to patient care. Properties of ***looking*** are looking at the vital signs, looking at the monitor, looking into the surgical field. Properties of ***listening*** are listening to the beeps, hearing more suction sounds, and listening to the conversation. Properties of ***touching*** are touching the patient's head and touching the skin.

The CRNA looks around to retain vital information during the surgical case. For example, the anesthesia monitor and the vital sign monitor display important information that the CRNA can process to decide if an intervention is required. One participant stated the importance of looking at vital signs and the anesthetic level of the gases administered to make sure nothing has changed:

> I look at all of my vital signs. I look at my end tidal, if I'm running gas. I look at all the ventilator settings, make sure nothing has changed make sure the patient is ventilating OK. [13.4]

The same participant described making sure things are all right. This refers to the circle check that CRNAs perform by ***looking*** around their environment, the patients and all monitors to make sure things are working appropriate and the participant is comfortable with how the patient appears during the delivery of anesthesia care. This is learned from CRNAs extensive training:

> [During the circle check] I'll just kind of look at things and make sure everything is all right [with the patient during surgery]. [13.5]

Scanning the field helps the CRNA to see and anticipate any possible changes that may not appear immediately in the vital signs. One participant described the importance of particularly ***looking*** at the surgical field:

> I do try to stand up every 10 to 15 minutes just to look into the surgical field and make sure I'm not missing something that they're saying or more so that something is going on that they're not telling me that they're unaware of from an anesthesia point of view. [8.6]

The patient's vital signs are the best indicator on the stability of the patient. Another participant described the process of ***looking*** at the monitor even though the tones of the heart rate and pulse oximeter did not change:

> Even though the tones of the monitor did not change, I still look at the screen that I have with my patient's vital signs. [14.7]

Furthermore, another participant described ***looking*** at the monitor for details of the patient's status. When discussing how he assessed the vital signs on the monitor, the participant stated that he checks to make sure the wave forms of the heart rate and pulse oximeter appear correctly to confirm the correct display. When surgeons use some surgical devices, the device can interact with vital sign readings, displaying an abnormal electrocardiogram and heart rate even though the vital signs are normal. The waveform can display the interaction between devices.

> The second way would be with monitors, just looking at my waveforms to make sure that they are waveforms that I expect them to look like. [1.4]

CRNAs remain active during surgery, always assessing and reassessing. This includes walking around the operating room, examining the surgical field and suction containers for any fluid or blood loss. In doing so, the CRNA has a keen ear for the beeps and tones on the monitor as well as any suctioning that provide insightful information on the status of the patient. Changes in tones can indicate changes in vital signs. The CRNA relies on their ability to hear in certain

instances when he/she cannot directly see the monitor or environment. One participant described ***listening*** to the monitor:

> It's always listening to what's happening with your pulse oximeter since that's going to give you changes in oxygenation as well as changes in heart rate. [4.5]

The tone of the beeps can describe the heart rate and oxygen saturation. These tones are indicators of the stability of the patient's vital signs. Changes in these tones can help advise the CRNA that there are changes in the patient. Another participant described the changes in pitch or tone of the beeps on the monitor. When discussing the tone changes, this participant described how the change in tone occurs prior to any changes in vital signs displayed:

> Typically, the first one is the pulse oximeter changes, whether it's the change in the pitch or the tone for saturation, or the change in the rate, the heart rate, speed up or slow down. Or sometimes the pitch may come, the change may come a little bit earlier, if you listen for it close enough, a change in the blood pressure and then the saturation will fall after that. [8.7]

The sound of suctioning can be an indicator for fluid loss or blood loss. This could result in potential changes in vital signs and allows the CRNA to anticipate changes. Another participant described the importance of ***listening*** to the surgical field for the sound of suctioning. This participant was describing how during the course of the surgical case, conversations that were once loud and interactive start to soften and noises such as suctioning getting louder, getting the attention of the CRNA:

> Maybe if they're getting quiet or if I hear more suction sounds, is that an indication of increased blood loss? [9.6]

Another participant expressed similar data in regard to suctioning:

> Suctions, hearing a bunch of suctions going into the machine is certainly a heads up. I listen to also the conversation of the surgeon. Also, the tone of their voice. They may ask the music to get turned down or turned off, which is a real tip-off because if they can't listen to their music obviously something is going on. They may ask for somebody else to be called to the room, for example, or ask what maybe like a vascular surgeon or

> somebody is doing in another room, or are they around, or something like that, which I see a tip-off that maybe something is going on. [14.4]

In anesthesia, proximity to the patient is also important. The CRNA can assess the patient and provide interventions such as inserting additional intravenous catheters, airway management, or medication administration. One participant described ***touching*** as being within an arm's reach:

> I try to bring everything close to me at about 45 degrees. So if I'm touching the patient's forehead, I can reach, I can keep one hand on the head, but yet be able to reach all of the pieces of the anesthesia machine and the back table. Just in case I need something, it was all within an arm's reach. [8.6]

Another participant described ***touching*** as assessing the temperature of the patient:

> She was getting up above 37 degrees. I started peeling blankets off her. I'm like, hey, this is really odd because I don't even have the temp turned on. But I'm pulling stuff off her. I'm touching her skin to feel it. And I'm looking at her skin to see if she looked flushed. [10.4]

There are instances when technology fails and CRNAs move back to the basics when assessing patients. This involves ***touching*** the patient to determine their heart rate and blood flow to areas of the body by checking pulses. Another participant described touching as an assessment tool when equipment fails:

> And it's pretty interesting when your blood pressure cuff is not working that you're immediate reaction is to feel the pulse and say, listen, I got palpable radial pulse. We're doing okay. This isn't the end of the world type of thing. So touch is important, but I would probably rank it as visual, audio, and then touch as the last sensory that we use. I'm not doing much as far as taste goes. [11.6]

Participants stated that they engage in ***looking, listening and touching*** to understand how their patients are doing and to pick up on subtle changes in the patient throughout the surgical case from anywhere in the operating room. This leads to the fifth category in the process, ***recognizing cues.***

Recognizing Cues. The sixth category of the theory, ***recognizing cues***, reflects indicators that provide information to the CRNA during the surgical case. ***Looking, listening and touching*** all provide data for a CRNA to pick up on recognizing cues to treat the patient. Properties of ***recognizing cues*** consist of *social cues, physical cues,* and *verbal cues.* Recognizing cues can guide the actions of the CRNA to keep the patient safe. Cues can either be verbal [11.6], physical [9.8], or social [9.6]. There are many noises in the operating room. Some noise provides cues to clinicians. One participant described cues that occur in the room. When discussing auditory cues, this participant described the noises in the room that get the CRNA's attention.

> When the vaporizer gets low you get an auditory cue that you need to refill it. And then the [suctioning] cues from the room, the suction canister, all that stuff. [8.5]

The same participant described an example of cues in the room that provide valuable information. The tone and pitch of the pulse oximeter provide valuable information about the patient:

> Or sometimes the pitch may come, the change may come a little bit earlier, if you listen for it close enough, a change in the blood pressure and then the saturation will fall after that. So if you listen for the pulse oximeter, those three pieces that really gives you a lot of cues to the patient. [8.7]

The participant described the changes in tones that provide cues about vital signs. There can be environmental actions that provide cues, in which people in the operating room will respond to. For example, the same participant described the action of dimming the lights providing a cue for people to speak softer or stop talking. When talking about ***recognizing cues***, this participant stated that if conversations and noise in the room were too loud, he would dim the lights as an indicator for everyone in the room to stop and focus on the care of the patient.

> Because people just have this natural tendency to want to whisper when the lights are turned down. And that really helped a lot, and it was a cue for people that I didn't even have to say anything just because of our natural tendency to kind of talk softer when the lights are dim. [8.8]

There are many forms of cues that occur. Cues could be noises or tones of voices to indicate the progress of surgery. At any instant, negative events can occur and cues provide information to the CRNA about what is occurring during surgery to the patient. One participant described other indicators in the operating room:

> We use a lot of social cues in the operating room. So if everyone is kind of talking and things are going very well, it's a very happy environment. But if I get a sense that the surgeon either is getting quiet or getting concerned for the operation, I may just look on my end, are there things that I can be doing to make his job easier for that particular instance? [9.6]

Similarly, the same participant stated:

> I think we all know when to stop having personal conversations during an OR case when the patient is awake. And if not, you may have to tell a colleague that now is not an appropriate time to be talking [when the patient is anxious and restless] giving a physical cue that you don't want to talk right now because of what's going on in the operating room. [9.8]

The participants stated how ***recognizing cues*** communicates many things in the operating room. It provides the CRNAs with an understanding of the case, along with any problems or changes that need to be addressed by the CRNA. This leads to the final category in the process, ***knowing what's happening.***

Knowing What's Happening. The seventh category of the theory, ***knowing what's happening***, reflects how the CRNA responds to the information provided from ***recognizing cues*** and assembles a picture from their knowledge and experience to ***know what is happening*** to the patient during the surgical case. This is important because it helps to direct the actions and care the CRNA provides to the patient. Properties of ***knowing what is happening*** are *aware what's going on* and *what is happening.* ***Knowing what is happening*** allows the CRNA to be aware of what's going on [9.8].

One participant stated that by looking at the anesthesia monitor and the electronic medical record, they are able to get an idea of how the patient is doing and how the patient is responding to surgery. With this information, adjustments to medication administration or ventilation changes can be made. When discussing assessing this patient, the participant described looking for trends of the patient's vital signs during surgery. The depth of anesthesia varies during surgery and titrating the anesthesia to the patient's needs is important. He stated after he titrates the anesthesia, he glances at the monitor to assess the effects but also what is displaying on his monitor:

> I try to be aware of what's going on across the screen. What's happening during the operation? If I hear the surgeon talking socially with his assistant or the OR nurse, and if they stop talking, I often am curious why they're no longer talking. [9.6]

Another participant stated the importance of knowing what's happening with changes in the patient. There can be many causes for vital signs to change. Understanding the events that could cause the changes is important:

> Oftentimes, you'll hear a change in the heart rate, the audible pulse rate, or the oxygen saturation tone. But you have to keep vigilance in the way that you correlate that to what's happening on the surgical field so that, for instance, if the heart rate goes up, is it because they're putting some local with epinephrine in? Or is it because the patient is light under anesthesia? Or they're getting more intense stimuli? So you have to rule out what's going on in order to treat the appropriate way. [2.5]

Likewise, another participant stated the importance of monitoring the surgical field and understanding what is going on during certain points in the surgery help to prepare and anticipate any events that occur:

> I mean, I'm continuously assessing all the vital signs, parameters, and monitoring what's happening in the surgical field, trying to anticipate the needs of the surgeon, anticipate the needs of the time demands of the case so that I can be ready to wake the patient up at an appropriate time. [4.3]

Another participant stated that they know what's happening by examining the waveform of the vital signs on the monitor. By glancing at the monitor and seeing patterns on the monitor, the participant is able to know if the patient is receiving adequate anesthesia and the vital signs are stable. She has an understanding of how the patient is doing:

> Just looking at the wave forms [on the monitors] to make sure they're wave forms that I expect them to look like [1.3]

The standard practice in anesthesia is to monitor the blood pressure every five minutes. One participant felt better taking an automated blood pressure every two-and-a-half minutes than the standard five-minute interval because he felt better with knowing how the patient is doing under the depth of anesthesia that he is administering.

> So I just feel more comfortable setting it for two-and-a-half minutes so that I'm forewarned. I think when they say brain death occurs in three minutes, and you set your blood pressure cuff for five, it tells me that there's something that can be happening and you may not even be aware of it. [2.3]

The same participant mentioned how it is important it is to look at the monitor and the surgical field and compare both with anything abnormal such as vital signs. There are things that occur in the surgical field that can cause the patient's vital signs to be out of the normal range. This CRNA mentions how it is important to know what is going on that may impact the vital signs.

> But you have to keep vigilance in the way that you correlate that to what's happening on the surgical field so that, for instances, if the heart rate goes up, is it because they're putting some local with epinephrine in? Or is it because the patient is light under anesthesia? Or they're getting more intense stimuli? [2.4]

One participant describes how it is important to continuously monitor the patient because it is important to anticipate the needs of the patient. This prepares the CRNA to be ready for anything.

> I mean, I'm continuously assessing all the vital signs, parameters, and monitoring what's happening in the surgical field, trying to anticipate the needs of the surgeon, anticipate

> the needs of the time demands of the case so that I can be ready to wake the patient up at an appropriate time. [4.3]

The same participant described how she is able to know what is happening by listening to the pulse oximeter. She can be anywhere in the room and has the ability to know what is happening to the patient by the tone of the pulse oximeter.

> It's always listening to what's happening with your pulse oximeter since that's going to give you changes in oxygenation as well as changed heart rate. And after a while, that listening, you can literally be anywhere in the room, attending to something else, and you're always listening to that sound. [4.3]

Another participant described how the changes in the pulse oximeter along with walking around the room provide information about what is happening during the surgical case. It provides a complete picture of what is going on during the case and how to treat the patient. For example, if the heart rate increases and the blood pressure decreases and the CRNA observes a large amount of blood in the suction canister, they know that the changes are due to a volume deficit and the patient will require some fluid resuscitation.

> What's really important is the modulation for the pulse oximeter as well, so I can hear, even if I'm not looking at the monitor, I can hear a heartbeat, and I can get a sense for what the pulse oximeter number is based upon the modulation. Because I'm not always staring at the monitor. I'm always looking around the room, talking to the surgeon, talking to the OR staff. I also walk around the room. If it's a case where I'm worried about blood loss, I may just kind of get up once in a while and just take a look at the different gauze, sponges we use, and look at the suction canister, see how much irrigation the surgeon or the OR staff has been using. [9.3]

When participants ***know what is happening***, it allows the CRNA to complete the process of vigilance of the CRNA. It is the final category, and all of the categories entail the core category of ***using senses***.

Summary

The results from this study defined the process of how CRNAs stay vigilant for their patients by ***using senses***. This is the first time the process is described and provides an

understanding of the particular actions needed for the safe care of patients when under general anesthesia. The next section will describe the assessment of rigor of this vigilance study.

Assessing Rigor

Rigor is defined as a structured process to gain an understanding of what the data convey (Glaser & Strauss, 1967). Rigor in qualitative research is associated with methodological dedication to the process and the emerging data (Glaser & Strauss, 1967). Glaser and Strauss (1967) emphasized the theory must satisfy four criteria: fit, workability, relevance, and modifiability. Emerging from the data, new categories were generated, leading to an understanding and discovery of a particular phenomenon and generate a theory. The criteria are addressed in this section along with confirming rigor of the study.

The theory must fit the substantive area in which it will be used. The theory must be generalizable so it can be applied in several situations within the substantive area, while also being clear to understand. It is important that it is clear and understood by individuals using the theory (Glaser & Strauss, 1967). The generated theory of vigilance fits and works will work in the substantive area as it was developed from the data of CRNA participants describing how they remain vigilant over their patients. This theory of vigilance was developed inductively from participants that have lived the experience, illustrated by examples of data (Glaser & Strauss, 1967). As new categories emerged, they were compared with other categories to develop broader conceptual categories. As the theory developed, constant comparative analysis was performed to evaluate the data and confirm that the categories fit the data. This was confirmed by seeing the process described in the interview and data from the beginning, middle, and end of the process.

The theory is described clearly and concisely for the participants, CRNAs and other healthcare practitioners and individuals, to understand. Workability refers to the ability to

explain and interpret what happened in the data and integration of the categories into the core category. Workability is related to how well a theory accounts for the participants' responses (Glaser & Strauss, 1967). Workability was demonstrated by taking the final theory and assessing whether it was representative of the accounts from the participants. The theory explains the process of vigilance. Direct quotes from participants were provided to support the conceptual categories (Glaser & Strauss, 1967; Rubin & Rubin, 2005). The interviews were reexamined and the vigilance process was clearly evident in participant accounts.

Grab is the ability of a topic to attract the attention of a person, while relevance is synonymous with importance, appealing to people (Glaser, 1978). It is considered that relevance is connected with grab in the sense that if a topic is important and appeals to an individual, then it will attract their attention. The theory of vigilance is relevant and has grab for participants and CRNAs and in the substantive field because it addresses the need to understand the process of how CRNAs remain vigilant over their patients. This theory confirms relevance because it is important to anesthesia care and patient outcomes. Understanding the process of vigilance provides the framework to conduct future research and improve anesthesia care. This theory provides a process that has never been developed conceptually and was therefore poorly understood. This theory provides missing information to the substantive area. This theory provides the foundation for future research. As this theory is utilized and tested, it can be modified as new information emerges.

Chapter Summary

This chapter presented the findings of the process of how CRNAs remain vigilant over their patients under general anesthesia during a surgical case. The core category, using senses, and the seven categories and the properties of those categories were presented. The participant

interviews provided confirmation of the process by which CRNAs remain vigilant over their patients. The components of a grounded theory study were described as essential to the development of the theory of vigilance by CRNAs. The following chapter will discuss how the findings will contribute to knowledge and implications for nurse anesthesia education, research, and clinical practice.

CHAPTER 5

DISCUSSION

The purpose of this chapter is to discuss the key findings of the grounded theory study of the process of vigilance by certified registered nurse anesthetists (CRNAs) and how these findings relate to previous findings in the literature. Vigilance remains an essential component to the care provided by CRNAs, yet it has never been researched from the clinical perspective. In order to research a topic, one must understand the process. There was a qualitative research study examining vigilance documented in the anesthesia literature performed by Schreiber and MacDonald (2010) titled "Keeping Vigil Over the Profession." This qualitative study did not examine vigilance in the clinical setting, but rather vigilance of the profession. Although informative, the results of the qualitative study did not provide a true understanding of the process of vigilance in anesthesia practice. This further provides evidence of the need for this study to understand the process of vigilance in anesthesia practice. The model, core category and seven conceptual categories, are discussed with previous literature findings from this research study. In conclusion, the chapter will refer to any limitations of the study and implications for anesthesia and nursing practice, education and future research. Below is the reproduced model from Chapter four.

Using senses allows the CRNA to be ready to care. The process begins with the CRNA's accepting responsibility of the patient (***Being Alert***). This is when the CRNA assumes care of the patient and maintains a high level of alertness. Being alert for their patient. When CRNAs arealert, they are attentive and engaged (***Being Attentive and Engaged***) in watching over their

patients. This aware and pay attention to allows the CRNA to be constantly their patients. By being attentive and engaged, the CRNA is prepared to focus (***Focusing***) on every aspect of patient care.

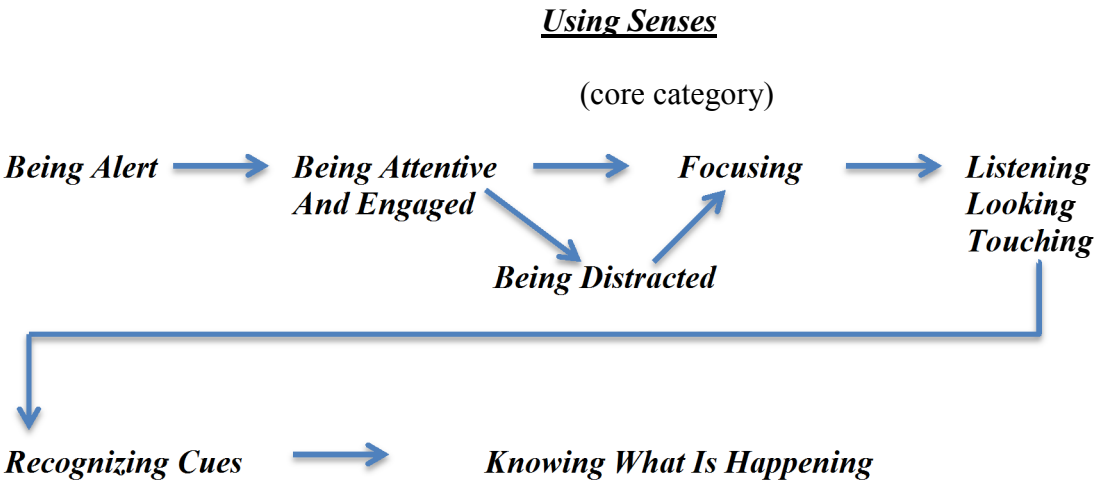

Figure 2. The process of vigilance by CRNAs, ***Using Senses***

Unfortunately, the operating room is a dynamic environment, where distractions (***Being Distracted***), such as music, conversation, and technology can draw clinicians away from being engaged in the care of their patients. These distractions can, but do not always occur, affecting the CRNA. If the distractions do not occur, then the CRNA maintains their focus. If they do occur, the CRNA redirects their attention and returns to focus on the patient. Thus, by focusing, the CRNAs use their senses to look, listen, and feel (***Looking, Listening and Touching***). By using their senses of looking, listening, and feeling, the CRNA begins to gather information about the patient and the surgical case. This puts them in a position to recognize cues (***Recognizing Cues***) that can help continue or improve care by anticipating changes at random intervals during the case. When CRNAs pick up on cues, they get a sense of what is going on (***Knowing What Is Happening***).

The process by which CRNAs remain vigilant over their patients starts with the CRNA's initiating care by being alert and concludes with the CRNA's knowing what is happening.

Core Category

Using Senses

Using senses emerged as the core category in the process by which CRNAs remain vigilant over their patients. Participants expressed using their senses by using phrases like "hooking up to the patient's nervous system" and "accustomed to hearing slight changes." Anesthesia is a profession that requires full attention and awareness of what is going on during the surgery while anticipating and preparing for unintended situations. Another participant described ***using senses*** in the most complete way when caring for a patient under general anesthesia. This participant "expressed being constantly aware of everything that is happening. It's a full sensory experience." This is how CRNAs practice, being constantly aware of everything going on. This allows the CRNAs to make decisions in the best interest of the patient. This reflects a key component of what CRNAs do.

In review of the literature, the core category can be linked to the theory of empiricism. Empiricism can be traced back to the 17th-century philosopher John Locke, who describes the human mind as a blank slate, tabula rasa, on which experience builds knowledge (Dawes, 2017). Empiricism is based on the idea that what is known is verified through the senses. The origin of all knowledge is sense experience, and that experience is necessary for the generation of knowledge (Hossain, 2014)). It emphasizes the role of experience and evidence, especially sensory perception, in the formation of ideas and argues that knowledge is based on experience (Dawes, 2017). The process of ***using senses*** is gained from the years of training that

CRNAs undergo to become board certified and continues into their practice as CRNAs. CRNAs use their knowledge and experience to care for patients under general anesthesia.

The methodology that is associated with empiricism is the scientific method, and because the belief is that the senses can be used to verify reality, observation is the preferred method of gathering data (Monti & Tingen, 1999). Carper (1978) developed her nursing theory, patterns of knowing, and referred to empirical patterns in her theory as knowledge from research and objective facts, gathered and obtained through evidence- based research, which is the scientific method. The purpose of nursing science is to develop and advance the profession by generating knowledge that explains practice. Therefore, the empiricist philosophy is necessary if the science of nursing is to generate theory (Monti & Tingen, 1999). This is evident with research of the process of vigilance in this qualitative study.

Carper's theory of knowing (1978) was referenced in a case study of CRNAs supporting palliative care in a patient with terminal cancer (Wolf, 2013). The author references CRNAs as better suited because of their ability to provide theory-based nursing care as well as an anesthesia-knowledge base. CRNAs can provide the care that is imperative for end-of-life care. The knowledge base and skill set of the CRNA may be even more applicable to palliative sedation in the rural setting, where specialty care providers are not as available. The CRNA can proceed with the knowledge and practice foundations that few others can provide. CRNAs are able to use their expertise and experience to care for and comfort the patient, such as recognizing discomfort and providing empathy to the patient.

One qualitative study by Meyer (2002) explored the process of vigilance in women who suffered from migraine headaches. The core category of watching out is described, when women had to be aware of instances when they experienced bouts of migraines in unexpected times. The

term watching out referred to women's using their senses to recognize the onset of migraine headaches about to occur. Meyer discovered that women maximized their daily function to watch out for migraines. This core category does not align with the core category that emerged in this study.

Wilber (1967) referred to a sixth sense for anesthetists. In the article, Wilber refers to the sixth sense as a system between physiological and clinical monitoring. In this system, information is communicated from the patient to the anesthetist in an information exchange system using a monitor to display the patient's blood pressure, heart rate, temperature, and respirations. At the time of Wilber's article, monitors displaying these vital signs were being introduced into clinical practice. Wilber refers to the sixth sense as the monitor displaying analytic information throughout the case.

The literature does not mention anything about CRNAs using senses to care for patients. This emerged as a core category, yet it is surprising that there is not much in the literature on this topic. This core category emerged as something important to anesthesia clinical practice, yet nothing is mentioned in the standards of practice for the American Association of Nurse Anesthetists. This is something that could be assumed, similar to how nurses are educated to observe, auscultate, and palpate upon examination of their patients; yet there is no specific standard of practice stating these actions are required by nurses.

Being Alert

The basic social process of being vigilant begins with ***being alert*** when the CRNA assumes care of the patient. Participants in this study described the importance of staying alert during a case. CRNAs must find ways to stay alert; one participant described it as "staying in the game" and trying not to get "mentally fatigued." By being alert, a CRNA is ready to provide the

psychomotor responses required to care for patients under general anesthesia. Hirter and Van Nest (1995), in their concept analysis of vigilance, described alertness as one of their five defining attributes, thus providing further evidence of its importance in the process of vigilance.

In the review of the literature, there was no mention on ***being alert***. Much of the studies that examined being alert reflect patient alertness, not the anesthesia provider's alertness. When broken down to the provider, there are scant research studies examining alertness in the anesthesia provider or CRNA. There was extensive literature on fatigue, which is the opposite of being alert. Fatigue is important because of the implications to clinical and patient care.

The death of Libby Zion is the best example of how fatigue impacted the attention of a clinician, leading to a sentinel event. The lack of sleep, fatigue, affected the resident who cared for Libby Zion. He had been working long hours when she was admitted to his care, leading to the prescription of a medication that resulted in her demise. The Libby Zion case resulted in a change in physician-training practices that can be directly related to vigilance and the associated concept of sleep (Asch & Parker, 1988). After concluding that fatigue played a role in decision-making, leading to her demise, the Accreditation Council for Graduate Medical Education (ACGME) recognized the importance and impact that fatigue can have on clinicians and patient care, leading to restricting work hours for residents (ACGME, 2019).

The human requirements for sleep are often offset by the unpredictable and sometimes long hours of the anesthesia profession. Disturbances to sleep homeostasis and the circadian rhythm affect alertness and performance, including the need for sleep (Howard, Rosekind, Katz, and Berry, 2002). Fatigue can set in and clinicians must find ways to combat it. By being alert, CRNAs are able to perform tasks appropriately and with fewer mistakes. CRNAs are ethically responsible for adhering to the American Association of Nurse Anesthetists (AANA) Code of

Ethics for the Certified Registered Nurse Anesthetist by assuring they are well rested and fit for duty.

The importance of ***being alert*** is reflected in the standards of care for the AANA (AANA, 2020) as Standard #13 concerning wellness. This standard refers to CRNAs being physically and mentally able to perform the duties of the role. Specifically, this standard highlights patient safety, encompassing fatigue and work schedule effects and the implication to the practice of nurse anesthesia. Personal obligations, scheduling needs, and the commute to a job should be considered prior to accepting a position. A national survey examining call shifts in CRNAs by Domen, Connelly, and Spence (2015) revealed that out of the 325 CRNAs who participated, 82% reported experiencing call-shift fatigue, and 28% reported committing a medical error because of fatigue. Poor quality sleep along with inadequate recovery of that poor sleep leads to an increased fatigue and decreased alertness and impaired performance (Harrington, 1978).

Specific clinical skills of importance to the practice of anesthesiology deteriorate as a result of fatigue. Denisco, Drummond, and Gravenstein (1987) examined fatigue on performance in a simulated anesthesia environment. In this study, 21 anesthesia residents were tested for their ability to detect significant changes in variables such as flow meter settings and vital signs monitoring in the presence of a concurrent distraction. Residents were tested after a night without clinical responsibility, meaning rested, and after 24 hours of in-house call, associated with fatigue. When tested post call shift, residents scored significantly worse on the psychomotor vigilance task than when rested. The authors concluded that a fatigued clinician is less likely than a rested clinician to detect important changes in monitored variables.

Anesthesia providers are required to deliver critical around the clock care to a variety of patients. Howard and colleagues (2002) reviewed fatigue in anesthesia providers. The authors

cited the safety risks, performance changes, and health issues associated with fatigue. They stated that even a lapse in performance from fatigue can lead to "microsleeps," when an individual has a brief uncontrolled spontaneous episode of sleep. Excessive fatigue can result in changes physical health and in the circadian rhythm of individuals (Howard et al., 2002).

The literature associates fatigue with decreased performance and increased errors. Barker and Nussbaum (2011) examined the relationship between mental and physical fatigue and performance in nursing students. Sixteen nursing students participated in a simulated environment performing nursing work tasks in a laboratory setting, such as patient transportation, data entry, vital sign recording and assessments, and medication preparations and distributions. High and low levels of fatigue were induced the students performing the tasks. Physical fatigue had a significant negative effect on performance, while mental fatigue resulted in a decreased performance, but not significantly. The authors concluded that nursing fatigue and performance have implications for patient and provider safety and warrant future studies.

The literature cites a correlation of fatigue and performance in clinicians. Smith-Coggins and colleagues (2006) confirmed the performance effects when they examined improving alertness and performance in emergency department physicians and nurses. The authors concluded that subjects who napped had a faster reaction time and fewer vigilance lapses and rated themselves less fatigued. Similarly, CRNAs try to avoid fatigue to remain alert when caring for their patients. Alertness is supported by the Smith-Coggins and colleagues (2006) study that resulted in fatigued clinicians experiencing more errors and mistakes when performing procedures than when not fatigued.

Oken, Salinsky, and Elsas (2006) examined the systems impacting vigilance, alertness, and sustained attention. In their paper, the authors used the three terms interchangeably, although

they are not really interchangeable. The authors examined how alertness to the environment has multiple underlying brain processes and related psychological constructs. An in-depth review of a number of neural systems, specifically neurotransmitters, directly affect alertness. These systems directly modulate the alertness systems related to motivation and stress. The authors concluded that the multiple factors affecting alertness are not one dimensional, but rather multifactorial.

The psychology and aviation literature provided some insightful results that could be applied to nurse anesthesia. In aviation, Caldwell and Caldwell (2005) estimated that anywhere from 4–25% of mishaps or errors are due to fatigue, resulting in poor decisions, while about 70% of pilots admitted to experiencing fatigue and even some to dosing off at some period during a flight. Fatigue affects our physical ability to stay alert and attentive, while also affecting emotional ability and the psychological thought process.

In psychology, Drury, Ferguson, and Thomas (2012) examined fatigue and the negative affective states in pilots and their heightened emotional activity (HEA), which is defined as the affective responses to perceived environmental threats encountered (Drury et al., 2012) They observed 302 flight operations and obtained 535 HEAs. The findings demonstrated that when crewmembers' sleep was restricted, there was an increase in HEA. This is important because errors that can occur with emotional states are increased leading to potential adverse events. This was confirmed by Engelmann, Kirschbaum, and Dingermann (2011), who examined the effects of intraoperative breaks on mental and somatic operator fatigue during laparoscopic surgery, concluding that work breaks during complex laparoscopic procedures can reduce stress and preserve performance. In anesthesia, breaks allow the clinician to maintain focus.

One study was able to draw a correlation between the impact of fatigue and performance by comparing fatigue to alcohol consumption and performance. Dawson and Reid (1997) examined the effects of fatigue and alcohol on performance impairment. Forty subjects participated in two counterbalanced experiments. In the first study, subjects were subjected to being awake for 28 hours and given a psychomotor test every two hours. In the second test, subjects were asked to consume 10–15 g of alcohol at 30-minute intervals to achieve a blood alcohol concentration of 0.10%, and a psychomotor test was administered. The results of both studies were compared, and the results showed a correlation between the performance effects of sleep deprivation and intoxication.

Twenty-four hours of continuous wakefulness psychomotor function was equivalent to a blood alcohol concentration of 0.1%. It is clear that the effects of moderate sleep loss on performance are similar to moderate alcohol intoxication. If it is wrong for clinicians to show up for work intoxicated per institutional policy, then this study provides evidence that fatigue should be treated in a similar manner. The AANA standard #13, wellness, addresses the issue of substance use disorder and recognizes the implications to patient safety.

Being alert is important for CRNAs because it allows them to begin the process of caring for their patients and allows them to ***be attentive and engaged*** for their patients.

Being Attentive and Engaged

In the basic social process of ***being attentive and engaged***, participants described this process as being "constantly aware" of what is going on during surgery. One participant stated the need for "attention" in order to anticipate the needs of the patient. Another participant referred to "being in the game," meaning being engaged in the care of the patient. During the original analysis of categories, attentive and engaged were separate categories, but were merged

into one category because of the importance of both during the process of vigilance. This was confirmed when examining both processes. One can be attentive, yet not engaged in an event, but if one is engaged, then that person is attentive to the needs of the patient.

One of the first studies on attention was first recognized and performed by Norman Mackworth (1947) during World War II with his "clock test," providing evidence that attention could decrease over time. Parasuraman's research (1976) on vigilance can be dated back to his original work on response to latencies in vigilance, providing evidence that over time, correct signal detection decreased. He was the one to coin the term "vigilance decrement," meaning attention and engagement decreased over time (Parasuraman, 1976).

Hirter and Van Nest (1995), in their concept analysis of vigilance, described attention as one of their five defining attributes. This concept analysis provides evidence that attention is important to the process of vigilance. In the current study, one participant referred to being "pretty attentive" when treating a patient for pain. This coincides with how CRNAs practice clinically. Anesthesia is a unique profession that allows highly educated clinicians to administer medications that can be potentially lethal if administered incorrectly. Correct dosing is vital to the outcome of patients. Administering and titrating pain medications is important to make the patient comfortable, while also recognizing adverse effects that may occur. Therefore, it is essential to be attentive to all medications administered to patients.

In this study, another participant described "engaging" with the surgeons to maintain communications during the surgical case. This communication occurs constantly to determine the flow of the case, any potential delays or complications, while anticipating any needs of the patient. Engaging in communication allows the entire surgical team to follow the flow of the case.

In the search of the literature, there was scant information in regard to engaging and most of the literature refers to disengagement. One study of engagement was found in the nursing literature. Dempsey and Assi (2018) examined the impact of nurse engagement on quality, safety, and the experience of care. The authors discovered that the triple aim of improving health and patient care couldn't be accomplished without the engagement of nurses. Nurses find meaning in their role caring for others and the connection of caring and patient outcomes.

Other studies examined the effects of disengagement. In the current study, another participant refers to "disengaging" during computer charting because the information was being automatically transferred to the computer and removing the action of documenting required by the CRNA. This can potentially lead to decreased recognition of abnormal vital signs of the patient. Metzger and Parasuraman (2005) described a process of reliance on automation and not recognizing conflicts with flight paths by air traffic controllers. The results of this study provided evidence that highly trained air traffic controllers can disengage during reliance on automation when given the opportunity. Automation allows one to disengage from responsibilities, leading to potential negative effects, which is similar to anesthesia providers using electronic medical records to document vital signs during a surgical case.

Disengagement was confirmed by the Casner and Schooler (2013) study that examined the effects of automation on the thoughts and focus of pilots while in flight. Eighteen airline pilots were asked to fly a simulated flight. The results provided evidence that pilots using the higher level automation had fewer tasks-at-hand thoughts compared to the lower level automation. Also, pilots overall reported disengaging, with a higher percentage of task-unrelated thoughts, when using the automation function. This shows that there is a higher reliance on

automation with a greater potential of mind wandering. This is similar during the surgical case when there are moments of less activity from anesthesia other than just monitoring the patient. Similarly, Cummings and colleagues (2013) examined the attention span of pilots flying unmanned aerial vehicles and discovered that when given the opportunity, less activity resulted in mind wandering. Similarly, less procedural activity and just monitoring in anesthesia resulted in disengaging during the surgical case.

Disengagement was confirmed by the Casner and colleagues (2014) study, examining the disengagement of pilots in a simulated setting. The results showed that pilots engaged in mind wandering at times and missed 25% of the callouts they were required to perform, even though their performance overall did not deteriorate. The pilots disengaged in the mission and engaged in other cockpit activities for pilot monitoring, helping to redirect focus, thus, providing evidence that mind wandering does occur, but does not affect the monitoring and engagement of an exercise.

The second conceptual category**,** ***being attentive and engaged***, is important for CRNAs because it allows them to continue the process of caring for their patients and recognize instances of ***being distracted***.

Being Distracted

The operating room is a dynamic environment in which many scenarios can occur. Normally, the surgical case proceeds as planned with no issues. Unfortunately, this environment invites an opportunity to ***be distracted***, as music and conversations can, but do not always occur. Being distracted can seem harmless, helping to pass time, but detracts the CRNA away from their role and responsibility. In this study, ***being distracted*** emerged as a category because participants described the action of being pulled away from care of the patient. There is a fine

line between ***being distracted*** and distractions. In the review of the literature, ***being distracted*** did not emerge, but the literature contained the topic of distractions.

Advanced technology and alarms have improved anesthesia safety, but situations do occur when the CRNA is distracted from care of the patient. These are opportunities that leave the patient vulnerable to potential harmful events. One participant described a distraction as "getting drawn away" from what they should be focusing on, while another participant described music in the operating room as "being too loud to hear the alarms on their monitor."

The operating room is a very dynamic environment where distractions and interruptions occur. Pape and Dingman (2011) performed a pilot study examining distractions that occurred during induction of anesthesia, an action of putting the patient to sleep under general anesthesia. The number of interruptions and distractions were observed, and the results showed that conversations and noise were the largest contributors of interruptions. The authors also noted that there were 7.5 interruptions per 9 minutes, equating it to about 68 interruptions an hour. This pilot study examined only the induction process of anesthesia and not the entire anesthetic case, but jt highlights the distractions that occur during critical moments of anesthesia.

Distractions can inhibit clinicians from the care of their patient. This is important in all clinical settings, including the operating room. The American Association of periOperative Registered Nurses (AORN) recognized that distractions and noise contribute to the complexity of the care environment (Feuerbacher, Funk, Spight, Diggs, & Hunter, 2012). In order to limit the number of distractions in the operating room environment, AORN published a position statement on managing distractions and noise during perioperative patient care (AORN, 2020). The position statement focuses on recognizing and minimizing potential distractions. This must be

important since the AORN recognized the need to publish a position statement, but the AANA has nothing published in their standards of care addressing this issue.

The practice of anesthesia is unique because it involves multitasking while watching over the patient. In the literature, Drui and colleagues (1973) discovered that anesthesiologists were distracted over 42% of the time. Campbell, Arfanis, and Smith (2012) researched distractions and interruptions in anesthesia practice. The researchers discovered that when examining 30 entire anesthetic cases, they found that the anesthesia providers experienced over 400 interruptions, with 22% of these delaying or impairing care to the patient. This supports the idea that distractions can lead to harmful effects. K. C. See, Phua, Mukhopadhyay (2014) confirmed that distractions draw the attention away from patient care with their observational study that examined the frequency, sources, and severity of distractions in the intensive care unit (ICU). Four hundred and forty-four distractions occurred with a total of 107 (24.1%) distractions lasting longer than five minutes, pulling the clinician away from care.

In the current study, another participant described that noises in the operating room, such as music, can "distract from taking care of the patient." This is supported by an observational study by Mamykina and colleagues (2017) examining interruptions such as beepers and conversations in the PICU, concluding that interruptions resulted in interruptions in workflow and mental concentration. There are many noises in the operating room that can distract the attention of CRNAs. Helton, Matthews, and Warm (2009) examined exposure to noises in subjects concentrating on performing tasks. The researchers wanted to examine if noise would be a distraction to decision making. The researchers concluded that the subjects exposed to the loud noises performed better, enhanced their focus, and were not distracted, improving their results

over the subjects who did not have any noise exposure. This contradicts previous studies discovering that noises are distracting.

Technology has improved the access to medical records and information in a way that never existed before. Technology can lead the CRNA to being distracted. This advancement in technology has shifted the practice of anesthesia to a supervisory role. One participant stated that they "spend more time typing and staring at the electronic medical record screens than to looking at their patients." So it's taking away from the provider/patient relationship and "putting their faces into more screens than necessary." Wax, Lin, and Reich (2012) examined the effect of clinicians' not paying attention to the electronic medical record and looking away at another screen on the same computer. The authors could not conclude any hemodynamic changes or adverse outcomes when the clinicians were not looking at the medical record. Even though there were not any negative outcomes, this provides evidence that technology can be a distraction to patient care.

Cellphones have become an activity of daily life and there is an increase of mobile device dependence and internet addiction due to accessibility and multimedia resources (Peraman & Parasuraman, 2016). Cellphones provide instant access to information and communication. While these devices have helped to advance daily activity, cell phones can provide a high level of distraction. The American Association of Nurse Anesthetists (AANA) recognized the use of mobile technology during anesthesia care and provided a position statement (AANA, 2015) stating that the association supports the integration of mobile technology per institutional policy. With loose, nonuniversal institutional policies and regulations concerning cell phones in the operating room, these devices can be a distraction resulting in a high level of distraction that can direct the CRNAs' attention away from patient care. One participant described "seeing

colleagues on their phones while the case was going on." There remains limited research on the effects of cell phones in the operating room, but Nerminathan, Harrison, Phelps, Scott and Alexander (2016) surveyed physicians and the use of smartphones while in the clinical setting. Over 30% of participants stated that smartphones led to being distracted from patient care.

Most recently, Avidan, Yakobi, Weissman, and Levin (2019) examined cell phone activity in the operating room causing distractions to the operating room staff. Observing 52 surgeries, the researchers observed 205 cell phone calls, including both incoming and outgoing calls, resulting in 30 staff distractions. These occurred mostly by surgeons speaking on the phone with the distractions lasting for a mean time of 43 seconds. The authors concluded that the number of cell phone calls in the operating rooms during elective surgery was lower than expected and caused short-lived distractions, mainly to the operating surgeons. They recommended that surgeons turn off their cell phones before surgery. In some instances, CRNAs communicate on the phone with other clinicians about the patient or transfer of care.

Snoots and Wands (2016) published an article on the use of electronic devices by CRNAs and the effect on patient safety. The authors performed a literature search on the implications for practice. Snoots and Wands stated that inappropriate use of personal electronic devices is underreported and understudied. The authors refer to use of these devices as ethically blurred boundaries, stating that there is a critical need for further research in order to analyze safety risks.

Zheng, Martinec, Cassera, and Swanstrom (2008) performed a quantitative study examining disruptions in the operating room during laparoscopic gastric surgery.
The results showed that, on average, a total of 114 disruptive events were recorded, consisting of conversations, instrument changes, pagers, and extraneous disruptions causing a delay in care.

Another study by Wheelock and colleagues (2015) examining the effects of distractions in the operating room resulted in an average of about 10 distractions per surgical case. The most prevalent types of distraction were by those external to the case, such as nurses entering the operating room and conversations irrelevant to the surgical case. The most "intense" distractions were related to wrong or missing equipment. Distractions led to impaired teamwork.

Being distracted sometimes occurs, but does not always occur. If ***being distracted*** does not occur, then the CRNA can maintain their ***focus*** on care. If being distracted does occur, the CRNA redirects their attention and begins to ***focus*** on their patient.

Focusing

The social process of ***focusing*** emerged from the data as another important conceptual category during the participant interviews. Two separate pathways led to the category of ***focusing***. When the CRNA is being attentive and engaged, it leads to the CRNA ***focusing*** on the care of their patient. Another pathway is when the CRNA is being distracted and they must refocus their attention to care of their patient. One participant stated that their priority was to "focus on the patient." In a review of the literature, there is scant amount of literature examining the topic of ***focusing***. In this study ***focusing*** is a specific conceptual category, specific to this vigilance model. The category of focusing is an action centered on the patient, focusing on the patient. In a refined search, patient-centered care was used because the focus is centered on the patient in this study.

In the review of the literature, patient-centered care was coined as one of the six aims for high-quality care from the Institute of Medicine (IOM) in Crossing the Quality Chasm (IOM, 2001). The book produced from the IOM made an urgent call for fundamental change to close the quality gap. The IOM refers to patient-centered as encompassing qualities of compassion,

empathy, and responsiveness to the needs, values, and expressed preferences of the individual patient (IOM, 2001). The goal of patient-centeredness is to customize care to the specific needs and circumstances of individuals, to modify the care to respond to the person. This is similar to the care the CRNA provides to a patient under general anesthesia. Not all patients are the same, and they require care tailored to their needs.

The AANA recognized the importance of patient-centered care as it is listed as standard number one for the standards of practice that guide CRNAs in clinical practice. These standards include: Standard 1, Respect the patient's autonomy, dignity, and privacy, and support the patient's needs and safety. The CRNA has a responsibility to the patient with providing safe and adequate anesthesia care, and Standard 11: Transfer of care, where the AANA refers to a document of patient-centered perianesthesia communication. The document refers to a commitment of safety to the patient and appropriate documentation to transfer care. There is a paragraph that refers to providers using their clinical judgment and situational awareness throughout the patient care process, understanding the perception of elements in the environment with comprehension of their meaning, and the projection of their status in the near future. (AANA, 2020, Endsley, 1995)

Johnston and Cooper (1997) recognized the need for change in healthcare focused more centrally on the patient. In their paper titled "Patient Focused Care: What Is It?" the authors highlight that patient-focused care is a construct that simplifies the care at the bedside focusing on the patient. The authors stated that focusing the care processes on the patient improves the welfare and outcomes of the patient. Similarly, the CRNA focuses care on the patient leading to a successful outcome.

Lauver and colleagues (2002) refer to individualized interventions as part of patient-focused care. Individualized interventions are customizable to particular patients and their situations. Core concepts are identified, and an outline is developed prior to any intervention. The interventions are customizable and finite, so no two interventions may be the same. The authors stated that individualized interventions are focused on specific patient needs. Similarly, CRNAs customize their anesthesia care by focusing on the needs of the patient, incorporating the past medical history to provide safe and adequate anesthesia.

Sullivan, Wallis, and Lloyd (2004) examined the effects of patient-centered care on seclusion in a psychiatric intensive care unit. The aim was to identify changes in nursing practice centered more on patients at risk for seclusion. The study used a pre-intervention and post-intervention design to examine the effects. The nursing staff was educated on risk assessment for violence along with workshops for de-escalation techniques. The authors concluded that there were no differences between pre- and post-intervention seclusion, but there was a difference in the amount of time the seclusions occurred and the amount of Haloperidol used, a drug used to sedate patients. The authors concluded that introduction of patient-focused care had a positive impact on patient care.

Kjornsberg, Karlsson, Babra and Wadensten (2010) examined the opinions of nurses in regard to patient-focused care. In a patient focused-care model, nurses are encouraged to provide more individualized care that responds to the needs of the patient. The aim of the study was to investigate the opinions of six registered nurses about their organizational change to patient focused care. A qualitative research design was performed using open-ended questions. Results had overall positive attitude towards patient-focused care, stating that the model focuses on the right thing, the patient. Participants stated a change in their attitudes towards work, more patient

focused. Participants felt closer to their patients, getting to know them and individualizing their care.

Bonner (2007) examined how expert and non-expert nephrology nurses focused on their patients. A total of 17 nurses participated, 11 of whom were experts, defined as having training in nephrology, and six non-experts, defined as not having training and education in nephrology. The results of this qualitative study increased an understanding of what an expert nurse focuses on when giving nursing care as compared to a non-expert nurse. From the study, one category, being patient focused, emerged as consisting of three dimensions: being there, keeping a close eye, and protecting the patient. There were contrasting differences between the expert nurses and non-expert nurses, such as the non-expert nurse was more focused on task duties and the expert nurses were entirely focused on optimal nursing care to patients with renal disorders. Being patient focused allowed the nurses to provide care essential to the patient's needs. The overall results provided evidence that nurses are focused on the care they provide their patients. Similarly, CRNAs remained focused on the care of their patients.

As CRNAs ***focus*** on their patients, they begin to utilize their skills and look, listen and touch the patient. These skills are taught and finely tuned prior to graduation in anesthesia school and before becoming board certified in anesthesia as a certified registered nurse anesthetist.

Looking, Listening, and Touching

The social process of looking, listening, and touching emerged as actions important to CRNAs in order understand and gauge events of the surgical procedure while anticipating the needs of the patient. CRNAs are always performing a circle check, looking at the patient, their monitors, and the surgical field. One participant stated, "looking at their patient's vital signs and

ventilator to make sure things have not changed." Another participant stated that they look at things to "make sure everything is all right."

CRNAs are always using their ability to ***look*** or scan the environment to make sure everything is OK. There is a circle-check process that the CRNAs perform in which they can gather information to make informed decisions about how to treat their patients. The process begins by scanning the patient, proceeding to the anesthesia monitors, and then the surgical field, recognizing fluid and blood loss in the field and suction canisters. Zheng and colleagues (2011) performed a study using an eye tracker technology on surgeons performing a simulated surgery. The results provided evidence that experienced surgeons scanned the surgical field and patient's vital signs rather than just focusing on one thing as the novice resident surgeons did. Similarly, CRNAs scan the surgical field and the anesthesia monitors. The act of looking provides a valuable understanding of the patient's status and surgical case.

The social process of ***listening*** is an important skill of the anesthesia provider because the practice of anesthesia involves multitasking and there are moments when the CRNA may not be able to see the monitor for vital signs or into the surgical field. The tones of the pulse oximeter, beeps of the heart rate, or suctioning from the surgical field can provide information to the CRNA on the status of the patient. One participant stated, "always listening to what's happening with your pulse oximeter since that's going to give you changes in oxygenation as well as changes in heart rate." This allows the CRNA to walk around the room to look at the surgical field, bloodied surgical pads, and suction canisters. Whether it be administering medications or walking around the room, the tones and pitches of the monitors and alarms provide the CRNA with critical information without seeing the monitor or alarming the CRNA to look at the monitor.

Stevenson, Schlesinger, and Wallace (2013) examined residents' ability to determine auditory changes when performing a visual task. Even though the residents were unable to differentiate audible changes when given a visual test, this could be because they are still training in their residency and not board certified with authority to practice independently. This provides evidence that training and experience are important for CRNAs to be able to pick up on auditory changes in the monitor beeps to determine the status of the patient. When caring for a patient, CRNAs may walk around the room to determine blood loss and fluid loss. The tones of the beeps provide valuable information about the patient to the CRNA.

The Joint Commission (JC) requires that health care facilities comply with a set of National Patient Safety Goals established for improving outcomes and care. Goal #6 on that list is to make improvements to ensure that alarms on medical equipment are heard and responded to on time (Joint Commission, 2020). Goldman and Robertson (2004) in an article published in the *Journal of the Anesthesia Patient Safety Foundation* stated that the argument supporting the use of audible alarm signals is straightforward: Audible alarm signals can enhance vigilance by directing the clinician's attention to out-of-bounds parameters. Despite the limitations of current clinical alarm systems, anesthesiologists have embraced one clinical alarm sound that is an information signal, the pulse oximeter tone. The authors stated that while there is no mandate that the pulse oximetry tone is required for anesthesia, pulse oximetry has become the de facto standard of care for intraoperative monitoring, and the pulse tone is the one monitor that is always heard (Goldman & Roberston, 2004). Anesthesia providers are keenly aware of changes in the patient's status just by the tones of the pulse oximeter.

Monitoring the patient under general anesthesia is a standard of care, but the use of alarms is still not considered a standard of care (American Association of Nurse Anesthetists,

2020, American Society of Anesthesiologists, 2020). Alarms were designed to alert healthcare workers to adverse clinical events. De Man and colleagues (2014) examined the effect of audible alarms on response times to adverse events in a simulated environment. Twenty anesthesiologists participated in two scenarios, high-pitched audible alarm and alarm-free conditions, in which four adverse events, atrial fibrillation, decreasing oxygen saturation, ST segment elevation on the monitor, and an occlusion of an intravenous line occurred. This study showed that response times to adverse events were similar in the absence or presence of an audible alarm.

Auditory skills are essential for health care providers and take time to perfect (Pellico, Friedlaender, & Fennie, 2009). Pellico and colleagues (2009) examined the impact of music auditory-training for nursing students in an accelerated master's entry program on their competence in detecting heart, lung, and bowel sounds. Seventy-eight students were randomized to receive either traditional assessment teaching or music auditory training and administered a pre- and posttest following the intervention. The students assigned to the music group were exposed to a two-hour music session that replicated the aural phenomena of the body's heart, lung, and bowel sounds. The results showed that students in the music group demonstrated a significant improvement in detecting sounds and a 50% increase in detecting abnormal sounds. This study supported a previous study by Stern and colleagues (2001) that examined medical student improvement of cardiac auscultation after the introduction of CD-ROM case studies. In addition to traditional training, the results provided evidence that multimedia tools improved the quality of the assessment skills of medical students.

The social process of ***touching*** is important because it allows the CRNA to be close to their patient, within an arm's reach, to watch over their patients. It also allows the CRNA to assess the patient, such as their temperature and provides the ability to check pulses for perfusion

in situations where a blood pressure cuff may fail. Kay and Neal (1986) examined techniques for blood pressure monitoring and discovered the manual blood pressure monitoring compared to automated blood pressure monitoring was more accurate for assessing the patient.

When patients are admitted to the hospital and evaluated, nurses use a process similar to that of CRNAs when assessing their patient known as inspection, palpation, percussion, and auscultation (Toney-Butler & Unison-Pace, 2019). Nurses inspect their patients from head to toe and all areas of the skin. Nurses touch the patient's body for abnormalities and skin temperature. Nurses listen for abnormal sounds, including the abdomen, heart, and lung sounds. In doing so, nurses are able to obtain pertinent information about the patient which helps with the direction of care. In the review of the literature on touching, there is scant research or literature on the topic.

The next conceptual category*, recognizing cues*, is important for CRNAs because it allows them to continue the process of caring for their patients and apply the information of ***looking, listening and touching*** to ***recognizing cues***.

Recognizing Cues

Cues are indicators that provide information to the CRNA during the surgical case. ***Recognizing cues*** can guide the actions of the CRNA to keep the patient safe. The capacity for cues to guide the decision-making process is evident in experienced decision makers (Klein, 2008). The review of the literature included an article by Offedy (1998), who examined 20 nurse practitioners working alongside general practitioners to explore decision-making issues. This was a pilot study consisting of semi-structured interviews followed by observations in clinical practice. Results of the study provided evidence that important factors relating to decision making include: the ability to recognize patterns in clinical situations and the ability to

concentrate on complex, and sometimes masked, cues. This supports the data that emerged in this study on how recognizing patterns and cues impact decision-making.

In her paper "Thinking Like a Nurse," Tanner (2006) does not use the term cues, but in her clinical judgment model, she refers to noticing, which is a function of the nurse's expectations of a situation. This stems from the nurse's knowledge and pattern recognition. She uses the term patterns when referring to the decision making of nurses. Tanner (2006) states that there are three interrelated patterns of reasoning used by experienced nurses in their decision-making process, which are analytic processes, intuition, and narrative thinking. Analytic processes are processes used to breakdown a situation into elements of clinical data. Intuition is characterized as an understanding of a clinical situation from previous experience. Narrative thinking involves trying to understand and make sense of a situation. These patterns allow the nurse to make decisions for patient care.

Cues are a process of clinical reasoning (Levett-Jones et al., 2010). Levett-Jones and colleagues (2010) described clinical reasoning as the process by which nurses collect cues, process information, and come to an understanding of the patient. The authors describe cues as identifiable physiological and psychosocial changes experienced by the patient, perceived through history and assessment and a specific body of knowledge. The authors also state that effective clinical reasoning depends on the nurse's ability to collect the right cues and take action at the right time. This supports the category of recognizing in this study, as it is vital for the CRNA to distinguish among important cues of the patient.

The NCLEX testing has focused on improving the assessment of entry level nursing by utilizing a clinical judgment model. Clinical judgment is an intellectual process that is more than just nursing knowledge; it involves the active use and application when making judgments on

patient care (Tanner, 2006). For this reason, it is now more important to assess entry-level nurses on this skill set and prepare them for good clinical judgment. Phaneuf (2008) stated that nurses deal with a wide range of issues related to patients. Understanding how nurses collect and use cues during decision-making can enable educators to better develop skills such as decision-making and clinical reasoning and may help to improve new graduate nurses' performance on this important aspect of nursing practice (Hoffman, Aitken, & Duffield, 2009).

Hoffman and colleagues (2009) examined the comparison of novice and expert nurses' cue collection during clinical decision-making. The study was an empirical, descriptive study that employed methods from the information-processing theory, both think aloud and verbal protocol analysis, to trace decision-making comparing cue usage and clustering during the decision-making of four novice and four expert nurses caring for patients post abdominal aortic aneurysm repair. The results provided evidence that expert nurses collected a wider range of cues than novice nurses, helping to identify patient status when making decisions.

It is essential for nurses to have the skillset to make correct and reliable clinical judgments. Muntean (2015) researched factors that influence decision-making. He discovered that experience, knowledge, and cue recognition are all related; cue recognition depends on knowledge, which is gained through years of experience (Muntean, 2015). He proposed a conceptual process model to assess nursing clinical judgments with recognizing cues as the first process, followed by generating hypotheses, judging hypotheses, taking action, and evaluating outcomes.

From Muntean's research, Dickison and colleagues (2016) proposed a framework for designing a theory-based assessment to measure a higher order cognitive construct for nursing clinical judgment. The assessment model of nursing clinical judgment is multilayered, with

recognizing cues and analyzing cues influencing decision-making. In this study, recognizing cues, similar to Dickison and colleagues' framework (2016), allows the CRNA to know what's going on to make appropriate decision-making.

Recognizing cues is seen as an important skillset for nursing. The National Board of Certification for CRNAs (NBCRNA) is currently in the process of developing simulation tools to assess the skills of CRNAs for recertification. Clinical scenarios are presented, and the assessment decision-making skills of the CRNA are assessed. The decision-making skills involve ***recognizing cues*** in order to make decisions for the optimal patient outcomes.

Cue-based processing has been investigated in psychology for effects in tasks. Small, Wiggins, and Loveday (2014) examined the cue-based processing and completion of vigilance tasks in a simulated environment involving power transmission. Twenty-five participants were classified into two groups on the basis of their capacity for cue-based processing in the context of power transmission control. The results identified a relationship between the levels of cues and response latency over tasks. The higher the level of cues, the faster the response time, while the lower the level of cues, the slower the response time. This provided evidence that cues lead to a positive response time. Similarly, cues can help CRNAs gather information and respond in a timely manner and respond to the needs of the patient.

Wiggins and O'Hare (2003) examined cue-based training in pilots in regard to deteriorating weather conditions. The aim was to investigate the extent to which pilots can be taught to recognize and respond appropriately to cues associated with weather conditions. Sixty-six licensed pilots were divided into two groups: a cue recognition group and a control group in a simulated environment. Results indicated that the control group pilots were significantly more likely to continue a flight path, while the cue recognition pilots diverted their flight with cue

recognition based on weather. Thus, they showed that cues allowed the pilots to change their flights paths for more appropriate flight paths. When CRNAs care for patients under anesthesia, they must recognize different cues during the surgical case and change their plan of care, tailoring it to the safety and well-being of the patient.

As the CRNA is ***recognizing cues***, the he/she uses the information and ***know what is happening***.

Knowing What's Happening

Knowing what is happening is the final category that emerged from the data. The ***cues*** provided information and allowed the CRNA to know what's happening to the patient. This is important because it helps to direct the actions and care the CRNA provides to the patient. Participants referred to "being aware of what's going on" and "what's happening on the surgical field." In reviewing the literature, one qualitative study by Schmidt (2010) examined the basic social process of making sure that is used by registered nurses as they watch over their patients. In his study, the basic social process of making sure begins with knowing what's going on as the first category. Participants described the necessity of knowing everything along with the awareness and integration of the dimensions of care (Schmidt, 2010).

There was limited literature in using the category ***knowing what is happening.*** In further review of the literature, naturalistic decision-making was reviewed because the framework emphasized the role of experience in enabling people to rapidly categorize situations to make effective decisions in the real world (Klein, 2008). Further research led to a concept analysis paper on decision making (Johansen & O'Brien, 2016) in which the term clinical reasoning emerged as an attribute of decision-making.

Clinical reasoning encapsulates the category of knowing what's happening as it is defined by Levett-Jones and colleagues (2010) as a logical process of "five rights" by which nurses collect cues, process information, come to an understanding of a patient's problem or situation, plan and implement interventions, evaluate outcomes ,and reevaluate. Clinical reasoning is not a linear process, but rather a collection of clinical events. This is how the CRNA is able to know what's happening.

Simmons (2010) defined clinical reasoning as a complex cognitive process that uses formal and informal thinking processes and strategies to gather and analyze patient information, evaluate the information, and arrive at potential actions. This process relies on the use of critical thinking, experience, and knowledge to make reasoned judgments. Clinical reasoning not only requires knowledge, but a level of experience and expertise (Linn, Khaw, Kildea, & Tonkin, 2012). In this current study of vigilance, only board certified CRNAs participated; student registered nurse anesthetists were excluded because CRNAs have a level of expertise different from that of students.

Benner, Hughes, and Sutphen (2008) refer to clinical reasoning as situated in a practice-based form of reasoning that requires knowledge. It also requires practical ability to discern the relevance of evidence behind scientific and technical knowledge and how it applies to the patient. This is the practice of nurse anesthesia in which CRNAs use both their knowledge and expertise to understand what is going on and determine if any actions are required for the patient.

The terms are worded differently, but the meaning is similar. Clinical reasoning is similar to the category of knowing what's happening for the process of vigilance that CRNAs use in their practice every day. It follows the same process of knowledge and application to the clinical situation as knowing what's happening. This supports the category that emerged in this study.

Unique Findings

A unique finding that emerged was how ***distractions*** consisted more of music and conversations rather than personal electronic devices. Smart phones have revolutionized the way we communicate and interact through text messages and emails. Smart phones are devices that everyone relies on to function in daily living. These devices not only provide phone services, but also allow for communication via text and email along with gaming and web surfing. Surprisingly, smart phone devices were not mentioned often by participants as a big ***distraction*** since the devices are commonly used. Rather, electronic medical records were mentioned as a ***distraction*** in regard to charting and documenting vital signs. Surprisingly, electronic medical records have been available for over a decade, and yet some clinicians still find these distracting. This could be related to inexperience with using the electronic medical records or lack of familiarity with computers.

Another unique finding is the standard of practice guidelines by the AANA (2020) for the use of electronic devices in the operating room. The AORN (2020) recognized that electronic devices serve as a distraction with sounds and inappropriate use, which may affect outcomes. The AANA (2020) outlines the scope of practice and provides a code of ethics, which delineates expectations for patient care but does not discourage the use of electronic devices while providing anesthesia. It is surprising that it is not recognized as a distraction since the CRNA has a direct impact on patient outcomes. Strayer, Drews, and Crouch (2006) point out that the National Highway Traffic Safety Administration equates texting and driving with driving after consuming four beers. Driving requires full attention, as does anesthesia. Alcohol consumption and providing anesthesia is not only discouraged, but also recognized as a patient safety issue. The distraction of electronic devices shows up also, but surprisingly, in the position statement for

mobile information technology, the AANA recognizes the potential distraction, but does not outright discourage the use of personal electronic devices.

Another unique finding of this study is that the vigilance process begins when the CRNA assumes care of the patient and concludes with handing the patient over to another clinician, such as a recovery room nurse. This is unique because clinicians describe vigilance occurring while the patient is under general anesthesia in the operating room, but the results provide evidence that vigilance is something that occurs throughout the perioperative process.

Limitations

A limitation of this study is the sample of participants willing to be interviewed for this research topic. Recruitment involved advertising on the AANA Connect website. Therefore, this study captured only participants on the AANA Connect website. There are members of the AANA that selectively participate on the website and members who do not. CRNAs who do not engage in the website may practice differently, and future research could determine if this is the case.

Participation was voluntary, and years of clinical experience were not limited as long as the CRNA was currently practicing. Participants had a mean average of 15.7 years in practice as a CRNA with a standard deviation of 8.9 years. The lowest number of year in practice was 3.5 years by one participant followed by 10 years for the next lowest participant. All of the CRNAs, with the exclusion of one, had practiced using paper charting at some point in their career. It would be interesting to see how new CRNAs, who did not use paper documents but rather electronic medical records would participate and answer the guiding questions, especially when it comes to distractions of the electronic medical records.

Another limitation was that the study examined the vigilance of CRNAs providing general anesthesia. CRNAs provide monitored anesthesia care (MAC) sedation for procedures not requiring the patient to be completely asleep. Under MAC sedation, patients are not rendered completely, unconscious, nor do they require a breathing device to support their airway. Patients are sedated, but have the ability to breath on their own and react to stimulation differently. It would be interesting to perform another study examining the process of vigilance of CRNAs providing MAC sedation for procedures and compare the processes of both studies.

Implications for Nursing Practice

The basic social process of how CRNAs remain vigilant over their patients has implications for nursing practice. The findings of this study indicate that the vigilance process begins when the CRNA assumes care of the patient and concludes with handing the patient over to another clinician, such as a recovery room nurse. When CRNAs assume care of the patient, similar to pilots stating that they are fit for duty, they acknowledge that they are alert to begin care of their patient. Participants stated the importance of being vigilant over their patients.

In the AANA standards of nurse anesthesia practice, standard #13 refers to wellness of the CRNA both physically and mentally. The AANA should be interested in refining this standard to have specific understanding of the expectations of CRNAs. For example, the National Sleep Foundation (2020) cites that sleep deprivation can have similar effects on your body as drinking alcohol. Being awake for 18 hours straight makes one drive as if one had a blood alcohol level of .05 (.08 is considered intoxicated), and being awake for a total of 24 hours is similar to someone driving with a blood alcohol level of .10. This can make it hard to pay attention to the road, and negatively impact making fast decisions. Similarly, Strayer and colleagues (2006) refer to the National Highway Traffic Safety Administration's equating texting

and driving with driving after consuming four beers, which impacts decision making. The AANA may want to set a standard of care in regard to the number of clinical hours a CRNA is to practice and a required amount of time off and rest.

As a profession that prides itself with improving patient safety, there needs to be steps implemented to improving the profession's safety. Cultural attitudes are difficult to change, especially in a profession as self-reliant as nurse anesthesia. A significant shift is necessary for universal recognition of potential fatigue-related risks along with approaches to improving performance.

Implications for Nursing Administration

Understanding the process of how CRNAs remain vigilant over their patients is important to nursing administration. The process begins with the CRNA being alert, prepared to take care of a patient. This theory will be informative and helpful for hospital administration, as they may want to implement a policy similar to that which the aviation industry took with pilots reporting for duty. There are steps that could be implemented that would be valuable for administrators. One step is to implement an education program regarding vigilance and the detrimental effects of fatigue, along with countermeasures. This program could involve alertness strategies and institutional policies. In addition, by expressing the effects of fatigue in terms of a blood-alcohol equivalent (Dawson & Reid, 1997) administrators can quantify the impact it can have on patient care.

Administrators would also find it valuable to develop a program involving work/rest schedules in anesthesia and departments requiring individuals to work call shifts similar to those that have been implemented in the aviation profession. When pilots show up for work, they state that they are fit for duty and have the required amount of rest/time off. The pilots are ready and

prepared to safely fly the plane. Anesthesia has been compared to the aviation industry in respect to safety and impact of outcomes (Welch, 2007). As stated previously, fatigue and texting can impact decision making of CRNAs similar to the effects of being under the influence of alcohol. In order to provide anesthesia safely, administrators may want to implement a policy on the length of clinical shifts for CRNAs followed by a required time-off rest period to help decrease incidents of fatigue. Anesthesia providers are accessible 24 hours a day and seven days a week. Therefore, it is important that CRNAs report for duty appropriately prepared.

In addition, administrators may want to implement or strengthen a policy for personal electronic devices in the operating room. As cited earlier, texting can be comparable to consuming alcohol and affect decision-making. Therefore, recognizing this as another distraction, a policy could help avoid further distraction and improve fitness for duty.

Implications for Nursing Education

The basic social process that emerged from this study has implications for nursing education, specifically nurse anesthesia education. Findings from this study will help direct the process of educating student registered nurse anesthetists during their education and training. This study provides the framework to use as guidance for students to understand what a CRNA does every case in their practice. It provides the steps and process of how CRNAs practice when caring for patients, specifically, how vigilance begins prior to the start of the surgical case. This is different from prior thoughts that vigilance only occurs when the patient is under general anesthesia. This understanding teaches students that the process of vigilance occurs throughout the perioperative process. The framework paints the picture of what the students should be learning and practicing as they progress through their training to become board certified.

The study findings have implications for nurse educators in simulation. Prior to entering the operating room, students are required to perform anesthesia in a simulated environment to assess and refine their skills. The simulated environment is a good place to practice this framework of vigilance. This framework and then be transferred to the clinical setting when students are required to perform in clinical rotations in the operating room This theory will then provide a framework in which the clinical supervising CRNA, can assess and evaluate how the student is progressing in their training and debrief their students on their daily performance. The student registered nurse anesthetist can be evaluated objectively.

Implications for Nursing Research

This is the first study examining vigilance of anesthesia providers and more specifically, of CRNAs. In order to further research a topic, one must understand the social process that occurs. Therefore, this grounded theory study was required in order for future research to be performed. The results of this study will guide future research in the anesthesia profession. Future studies could examine the difference between novice and expert CRNAS. Distractions were a category in this study. Participants reported different various distractions in the operating room. Another study would be to examine the varying levels of distractions that remove the CRNAs from practicing vigilance.

The IOM (1999) has used the phenomena of vigilance and surveillance interchangeably but, the processes are not. There is a distinction between these two concepts. In this study, vigilance is defined as a state of readiness to detect and respond to small changes occurring at random intervals in the environment (Jorm & O'Sullivan, 001.), while surveillance is defined as a process of watching over (Schmidt, 2010). While having similar attributes, they are different and highlighted in the process of vigilance and Schmidt's (2010) process of making sure. In this

study, the process of vigilance ends with knowing what is happening and the surveillance process begins with knowing what's going on (Schmidt, 2010). Therefore, vigilance is a link to the process of surveillance. It is important to develop a measure to operationalize vigilance. This study will also help expound upon the previous surveillance research in nursing. In doing so, a link will be developed between vigilance and surveillance.

Conclusion

The theoretical model of the basic social process of how CRNAs remain vigilant over their patient consists of a core category and seven conceptual categories. The core category and seven conceptual categories provide an explanation of the process of vigilance. In this final chapter, previous scholarly research findings were discussed and compared to the findings of this study. Unique findings and limitations that emerged were addressed and discussed. This chapter concluded with the implications to the nursing profession, administration, education, and research from this substantive theory. This theory will specifically help guide the future of nurse anesthesia.

APPENDIX A

CONSENT FORM

Participant's Name: _____

PROJECT TITLE: How do Certified Registered Nurse Anesthetists remain vigilant over their patients?

RESEARCHER: Timothy Finn, CRNA, PhD in Nursing Candidate

THE APPROVAL FOR THIS PROJECT EXPIRES ON

Participant Information

PRINICIPLES CONCERNING RESEARCH: You are being asked to take part in a research project. It is important that you read and understand the principles that apply to all individuals who agree to participate in the research project described below:

1. Taking part in the research is entirely voluntary.

2. You will not benefit from taking part in the research but the knowledge obtained may help others.

3. You may withdraw from the study at any time without anyone objecting and without penalty or loss of any benefits to which you are otherwise entitled.

The purpose of the research, how it is to be done, and what your part in the research will be is described below. Also described are the risks, inconveniences, discomforts and other important information, which you need to make a decision about whether or not you wish to participate. You are urged to discuss any questions you have about this research with the staff members.

PURPOSE OF RESEARCH: The purpose of this dissertation study is to understand the process of how Certified Registered Nurse Anesthetists remain vigilant over their patients. This study is being completed as part of the degree requirements for the Doctor of Philosophy degree at Loyola University Chicago

Approximately 15 people will participate in this research.

DESCRIPTION AND EXPLANATION OF PROCEDURES: If you agree to participate in this study, you will be asked to participate in an audiotaped in person or telephone interview with Timothy Finn, the investigator for this study. You will be asked to answer questions about clinical experiences as a Certified Registered Nurse Anesthetist. The interview should last between 30 and 60 minutes and will be conducted at a place convenient for you and the interviewer.

The interview will be tape-recorded. You may refuse to answer any question asked, ask to have the tape recorder shut off at any time, take a break during the interview, or end the interview at any time. After the interview is completed, the audiotape will be transcribed verbatim. Any names or identifying information disclosed during the interview will be deleted from the completion of the study. The information obtained during your interview will be combined with information obtained in the other interviews conducted in the course of the study.

RISK/BENEFITS: There are no foreseeable risks to you associated with participation in this study beyond those experienced in daily life. There are no direct benefits to you associated with participation in this study. It is hoped that the information gained from this study will increase our understanding of vigilance of Certified Registered Nurse Anesthetists and fill a significant gap in the nursing literature.

ALTERNATIVES: You do not have to participate in this research.

COMPENSATION: There is no compensation for this study.

CONFIDENTIALITY: Any identifying information disclosed during interview will be deleted from the transcribed record of the interview and replaced with general terms to preserve confidentially. The signed consent forms will be stored separately from the audiotapes and transcribed interviews. All consent forms, audiotapes, and transcribed interviews will be kept in locked file cabinets.

Your records from this study will be considered confidential to the extent permitted by law. A number will be assigned to each interview transcript. Authorized Loyola University Chicago employees, the Department of Health and Human Services, or other agencies may review the research records from this study and must follow the same rules of confidentiality. The dissertation advisor may review the audio tapes, will work with the investigator on data analysis, and will have access to the transcripts.

The results of this study will be submitted for publication and may be presented at professional conferences. Quotations from selected interviews may be used as examples in publications or presentations, but no identifying information will be presented with those quotations.

VOLUNTARY PARTICIPATION: Participation in this study is voluntary. If you decide to participate, you can withdraw your participation at any time without penalty, or refuse to answer any question asked during the interview.

If you ever questions regarding your participation in this study at any time, you may contact Timothy Finn (tfinn1@luc.edu, or (617) 201-2715 investigator for this study or Dr. Lee Schmidt (lschm3@luc.edu or (773) 508-3466), dissertation chairperson.

If you ever feel that you have been injured by participating in this study or if you have any questions concerning your rights as a research participant, you may contact either Kenneth

Micetich, MD, Chair of the Institutional Review Board for the Protection of Human Subjects-Loyola University Chicago Health Sciences Division, at 708-216-2633 or Elaine Fluder, MSN, Director of the Human Research Subjects Protection Program at 708-216-4608.

Although you have the right to revoke this authorization, you accept that such revocation will not apply to any uses and disclosures of your information that are described in the Loyola University Health System Notice of Privacy Practices or otherwise allowable under any Federal or State laws.

CONSENT:

You will receive a signed copy of this informed consent document.

You have been fully informed of the above described research program with its possible benefits and risks. Your signature below indicates that you are willing to participate in this research study and agree to the use and disclosure of information about you as described above. You do not give up any legal rights by signing this consent document.

_____ _____

Participant's Signature **Date**

_____ _____

Witness Signature **Date**

APPENDIX B

PROTOCOL OUTLINE

Protocol Title: **How do certified registered nurse anesthetists remain vigilant over their patients?**
Protocol Version: **1**
Protocol Date: **7/20/2019**
Principal Investigator: **Lee Schmidt, PhD, RN, Associate Professor, Marcella Niehoff**
Research Team: **N/A**

I. Abstract

Vigilance is defined as a state of readiness to detect and respond to small changes occurring at random intervals in the environment (Jorm and O'Sullivan, 2012). It is an essential component to providing safe patient care. It is assumed that every anesthesia provider caring for a patient gives his or her utmost attention and focus to the patient. This is most important in the operating room where the patient is rendered unconscious and relies on the nurse anesthetist to care for and respond to their every need.

Vigilance in Certified Registered Nurse Anesthetists (CRNAs) remains vital to their patient's well being and the success of the patient's outcome. Nurse anesthetists are constantly bombarded with stimulation, such as conversations, noise, music, alarms, pagers and demands from surgeons in the operating room environment. The CRNA must remain attentive at all times, while providing critical patient care. The importance of vigilance is undeniable, what is missing is an understanding of what is the process in practicing vigilance. The American Association of Nurse Anesthetists acknowledge the importance in anesthesia practice, noting that the continuous clinical observation and vigilance are the basis of safe anesthesia care.

For this qualitative research study, a naturalistic design will be used because the focus is on the process of how CRNAs care for their patients. The naturalistic research design provides a focus for studying the social behavior of individuals. This design will explore how CRNAs practice anesthesia and remain vigilant over their patients. There is at this point no understanding of how this process occurs. Therefore, the purpose of this research is to conceptualize the vigilance process of CRNAs. This design uses qualitative methods to engage with participants with in-depth interviews using guiding questions to gain an understanding of how they are vigilant over their patients (Frey, Botan, & Kreps, 1999). This will identify patterns and behaviors to help understand the process that CRNAs perform when caring for their patients.

A grounded theory method will be used as the systematic approach will enable concepts to be identified and assist with theory building from the data provided (Corbin & Strauss, 2008). Grounded theory examines the social process of behavior and identifies what is occurring (Glaser, 2001). In open-ended interviews, the data will give rise to categories that will lead to conceptualization as the core process of grounded theory (Glaser, 2001). The primary research question is, "What is the process a nurse anesthetist uses to be vigilant and ready to detect and respond to changes occurring during a surgical case?"

II. Background and Significance/Preliminary Studies

Vigilance is an essential component to providing safe and effective care to patients. Vigilance is defined as a state of readiness to detect and respond to small changes occurring at random intervals in the environment (Jorm & O'Sullivan, 2011). Anesthesia was the first profession in healthcare to recognize the importance of vigilance and the potential effects it can have on patient care. The word vigilance is embedded in the official seal of the American Society of Anesthesiologists, while the official seal of the American Association of Nurse Anesthetists includes Morpheus, the God of Dreams, holding the Lamp of Learning, by the light of which he keeps vigil. It is considered the "Holy Grail" of the anesthesia profession (Aronson & Cook, 1998). To date, there still remains no research study that focuses on understanding the process of vigilance in anesthesia.

Vigil has not been defined by either anesthesia societies, but yet it is "understood as clinical awareness" (Weinger, Herdon & Gaba 1997). Memory tasks, decision-making, and vigilance are the most vulnerable to compromise (Weinger et al., 1997). The American Society of Anesthesiology has researched fatigue and its effects on clinical production and patient care, but they have never examined vigilance as a specific topic affecting patient care in the operating room. Campbell and colleagues (2012) further examined distractions and interruptions in anesthesia practice. Researchers examined distractions and interruptions in a variety of 30 anesthetic cases in a United Kingdom hospital. Out of the 424 distracting events that occurred, 92 (22%) had negative effects ranging from repeated procedure attempts, changes in vital signs, and brief periods when the patient was unattended. The researchers did provide examples that anesthesia providers have many responsibilities during the care of patients.

As technology has advanced, medical records have transitioned to a computer-based system. While simplifying the medical record, it has removed the responsibility of an anesthesia provider being forced to examine the monitors. Wax and colleagues (2012) wanted to know the effects that electronic medical records had on the overall patient status during a surgical case. Wax, Lin, and Reich (2012) examined if there was variability in vital signs when the anesthesia provider used an electronic medical record that automatically documented vital signs during a procedure and required no physical exertion or attention for documentation. The results showed that there was no hemodynamic variability in the patient's vital signs whether the medical record was on the computer screen or not. Though no changes were detected does not mean that errors and mishaps cannot occur.

The issue is that anesthesia providers monitor and assess patients throughout their surgery; yet providers cannot remain vigilant for long periods of time. It is human nature to eventually divert one's attention and allow for distractions to occur or fatigue to take over. Unfortunately, mishaps and clinical events occur in the operating room due to human error. Practitioners are human, make poor monitors over a sustained amount of time, and can be distracted very easily. A single distraction can increase the risk of an error by 12% (Beyea, 2014). Even when complete focus is occurring, the human mind can be distracted or wander, affecting reactions to events.

Vigilance in CRNAs remains vital to their patients' well being and the success of their outcomes. CRNAs are constantly bombarded with stimulation, such as conversations, noise, music, alarms, pagers, and demands from surgeons in the operating room environment (Campbell et al, 2012). They must remain attentive at all times while providing critical patient care. The AANA acknowledges the importance of vigilance in clinical practice as a standard of nurse anesthesia practice, noting that continuous clinical observation and vigilance are the basis of safe anesthesia care (AANA, 2015).

To date there has not been any research examining vigilance in the clinical environment for the profession of nurse anesthesia. The only qualitative research study examining vigilance documented in the nurse anesthesia literature was performed by Schreiber and MacDonald (2010) titled "Keeping Vigil Over the Profession." This qualitative study did not examine vigilance in the clinical setting, but rather vigilance of the profession. Therefore, it is essential to understand the process of vigilance in order to improve patient care and guide future research.

III. Study Aims

The specific aim of this study is to understand the process of how Certified Registered Nurse Anesthetists (CRNAs) remain vigilant over their patients. In order to improve patient care, it is important to understand the process of vigilance.

IV. Administrative Organization

This study will be conducted ideally in a face-to-face person interview. If unable to perform a face-to-face interview, a phone interview will be performed.

V. Study Design

a. For this qualitative research study, a naturalistic design will be used because the focus is on the process of how CRNAs care for their patients. The naturalistic research design provides a focus for studying the social behavior of individuals, exploring how CRNAs remain vigilant over their patients.

b. Participants will be comprised of CRNAs. The inclusion criteria for this study will be licensed CRNAs, who are individuals who have completed a certified nurse anesthesia degree program and are board certified in the specialty of anesthesia by the American Association of Nurse Anesthesia (AANA). This is defined as working as a CRNA without restrictions on the number of hours worked. Their practice must include performing general anesthesia. Exclusion criteria are students because they do not have the same scope of practice as CRNAs and cannot practice independently within the scope of their license. Retired CRNAs will not be considered because they are no longer practicing under their license.

c. The sample size was determined by examining previous qualitative grounded theory research studies. After performing a random sample and examining qualitative research studies from 2008–2019, a sample sizing ranging from 15-23 participants, but the final sample size will be determined based on the saturation of categories.

d. The goal of qualitative research should be the attainment of saturation. Saturation occurs when adding more participants to the study does not result in additional perspectives or information. Glaser and Strauss (1967) recommend the concept of saturation for achieving an appropriate sample size in qualitative studies.

VI. Study Procedures

a. Subject selection procedures

i. The inclusion criteria for this study will be licensed CRNAs, who are individuals who have completed a certified nurse anesthesia degree program and are board certified in the specialty of anesthesia by the American Association of Nurse Anesthesia (AANA) providing general anesthesia.

1. Participants will be recruited by posting the research topic and summary on AANAConnect. This is a social media site organized by the American Association of Nurse Anesthetists (AANA), where CRNAs can post discussions, research ideas, and make social connections with other CRNAs across the country.

2. If a face-to-face interview is arranged, then consent will be obtained immediately prior to the interview. If a telephone interview is performed, then consent will be required prior to the interview phone call.

3. Myself, prior to the beginning of all interviews, will obtain consent.

4. A flyer will be advertised on a link posted on the AANAConnect website. Upon clicking the link, participants will be presented with the flyer advertisement for the study with instructions with how to proceed.

5. A flyer describing the purpose and contact information with how to proceed with participation.

ii. Screening procedures

1. The only screening required will be that participants are Certified Registered Nurse Anesthetists that provide general anesthesia.

b. Study Intervention

Not Applicable

c. Study Assessments and Activities

Study activities will involve a 30-60 minutes interview of all participants.

VII. Safety Monitoring Plan

Not applicable

VIII. Analysis Plan

Data will be analyzed using the constant comparative method (Glaser & Strauss, 1967). The dissertation chair will supervise data analysis. After the initial interview, the transcribed interview will be analyzed and coded. A constant comparative analysis method will be performed as the interviews continue and further data are collected and coded. Coding consists of naming conceptually what is happening in the data (Glaser, 1978).

Open coding will be done following each interview so that codes identified are incorporated into the analysis of the next interview. Open coding involves examination of the transcribed interview line by line, using words, phrases, and sentences as units of analysis to identify code (Glaser & Strauss, 1967). The data analyzed in each new transcript are compared with codes from previous interviews to identify anything that appears similar to previous data. Following the open-coding process, axial coding will occur. In axial coding, the group of open codes will be examined and conceptual categories will emerge (Glaser & Strauss, 1967). The goal is to discover a core category and process from the data.

Memos are the theorizing write-up of ideas about codes and their relationships (Glaser, 1978). These can be used to initiate new or follow-up questions to explore. Memos are employed to enhance the research by making reflective notes to compare to interviews and help further explain the new emerging data. Memos also provide further ideas to incorporate during future interviews to examine new categories and provide support of the categories.

APPENDIX C

IRB APPROVAL LETTER

LOYOLA UNIVERSITY CHICAGO
Health Sciences Division
Institutional Review Board for the Protection of Human Subjects
2160 South First Avenue
Maywood, IL 60153

08/19/2019

NOTICE OF EXPEDITED APPROVAL OF A RESEARCH PROJECT

Investigator	**Schmidt, Lee**
LU Number	**212669**
Title	**The Vigilance Process of Certified Registered Nurse Anesthetists**
Date of Initial Review	**08/15/2019**
Type of Review	**Expedited**
Action of Initial Review	**Expedited Approval**
Re-Review Date	**08/15/2020**
Informed Consent Document required?	**YES**
# of Participants	**20**
Participants Compensated?	**NO**
IRB Number	**212669081519**
Date of Approval	**08/15/2019**
Frequency of Review	**Annual**
Date of First Review	**08/15/2020**

Conditions of Approval

1. The study is of minimal risk and qualifies for expedited review 45CFR46.110, b-1, HHS Secretary Category:
(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.
2. Annual Review is required as the research involves the use of a consent document. The IRB requires annual review of research where participants are enrolled using an IRB Approved consent document.
3. You are required to use the consent document attached as 212669r3.081519, version date: 08/15/2019 (see project summary). The redlined consent document is attached as 212669r so that you can easily see the changes we have made.
PLEASE REVIEW THE CONSENT. IF YOU WISH TO MAKE CHANGES, SUBMIT AN AMENDMENT.

ITEMS SUBMITTED FOR REVIEW

- **08/07/2019 Protocol**
- **08/07/2019 212669.080719**
- **08/07/2019 Recruitment Flyer**
- **08/15/2019 Interview Guide**
- **08/15/2019 212669r (Redline Version)**
- **08/15/2019 212669r3.081519 (Approved Consent Doc) (ICD: 08/15/2019)**

APPENDIX D

RECRUITMENT MATERIAL

Seeking Certified Registered Nurse Anesthetists for Vigilance Study

- WHO: Certified Registered Nurse Anesthetists providing general anesthesia.

- PURPOSE: To understand the process of how Certified Registered Nurse Anesthetists remain vigilant over their patients.

- WHY: In order to improve anesthesia practice and patient care, we must understand the process of being vigilant.

- HOW: Phone or one-on-one interview (approximately 30 minutes)

- CONTACT: If interested please contact Tim Finn 617-201-2715 or by email tfinn1@luc.edu

APPENDIX E

GUIDING QUESTIONS

1. Tell me about a typical or recent case in which you cared for a patient under general anesthesia?
2. How do you monitor your patients during a surgical case?
3. How do you recognize changes in the anesthesia environment and your patient?
4. What things detract or distract from your caring and monitoring your patient?
5. What things facilitate your caring for and monitoring your patient?

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