MEASURES OF PHYSIOLOGICAL AND PSYCHOLOGICAL STRESS IN
NOVICE HEALTH PROFESSIONS STUDENTS DURING A
SIMULATED PATIENT EMERGENCY

By

JANET WILLHAUS

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To the Faculty of Washington State University:

The members of the Committee appointed to examine the dissertation/thesis of JANET WILLHAUS find it satisfactory and recommend that it be accepted.

Suzan Kardong-Edgren, Ph.D., Chair

Renee Hoeksel, Ph.D.

Celestina Barbosa-Leiker, Ph.D.
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ABSTRACT

By Janet Willhaus, Ph.D.
Washington State University
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Chair: Suzan Kardong-Edgren

Learning to provide emergency care alone and with others in the clinical environment imposes unexplored stresses on novice caregivers. It is unclear whether this stress inhibits or promotes performance and learning. Many academic health professions programs incorporate simulation as a method for teaching patient care emergencies. This study employed a modified switching replications design to explore the relationships and differences between psychological, physiological, and performance measures in health professions students who participated in acutely stressful health care simulation scenarios. Twenty-seven volunteer participants recruited from nursing, medicine, pharmacy, physical therapy, occupational therapy, and speech therapy were assigned to teams in either a simulation treatment or a control group. Teams participated in two simulations scenarios in which a fallen patient required assistance. Subjects in the simulation treatment groups received a standardized training module called the First Five Minutes® between simulation experiences. Mean heart rate, maximal mean heart rate, salivary alpha amylase levels, and salivary cortisol levels were compared at intervals before, during, and after each simulation scenario. Psychological stress was evaluated using the Stressor Appraisal Scale
(SAS). Team performance during scenarios was scored by independent evaluators using a skills checklist adapted from a standardized commercially available training module, The First Five Minutes™. Performance scores improved in both groups during the second simulation. Mean performance scores of the simulation intervention teams ($M = 14.1$, $SD = 1.43$) were significantly higher ($t = 4.54$, $p < .01$) than the performance scores of the control teams ($M = 10.6$, $SD = .96$). Psychological and physiological measures did not significantly predict performance. Psychological and physiological indicators were reactive to the simulations across time, but did not differ significantly between the control and simulation intervention groups.

This investigation explored the multi-dimensional nature of stress (psychological and physiological) that health professions students experience while learning. Simulation intervention did significantly improve group performance, but did not mitigate individual participant stress. Future research should include study with teams of working professionals to determine whether performance and stress measures differ with experience and expertise.
# TABLE OF CONTENTS

ACKNOWLEDGEMENT .......................................................................................................................... iii

ABSTRACT ........................................................................................................................................ iv

CHAPTER 1 ........................................................................................................................................ 1

INTRODUCTION ................................................................................................................................. 1

  Introduction ...................................................................................................................................... 1

  Problem Statement ......................................................................................................................... 1

  Background and Significance .......................................................................................................... 2

  Statement of the purpose, definition of terms and research questions ....................................... 5

  Conclusion ..................................................................................................................................... 7

CHAPTER 2 ........................................................................................................................................ 8

LITERATURE REVIEW ....................................................................................................................... 8

  Introduction .................................................................................................................................... 8

  Theoretical Framework ................................................................................................................... 8

  Psychological measures of stress ................................................................................................... 9

  Physiological stress ........................................................................................................................ 11

  Physiological Measures of Stress .................................................................................................. 12

  Simulation in health professions education .................................................................................. 14

  Simulation and stress measures in health professions education .............................................. 15

  Conclusion ...................................................................................................................................... 23

CHAPTER 3 ........................................................................................................................................ 24

STUDY DESIGN ............................................................................................................................... 24

  Introduction ..................................................................................................................................... 24

  Sample and recruiting, power analysis ......................................................................................... 24

  Independent variable ..................................................................................................................... 26

  Dependent variables ...................................................................................................................... 26

  Simulation Scenario ....................................................................................................................... 29

  Procedure ...................................................................................................................................... 29

  Analysis Plan ................................................................................................................................. 31

CHAPTER 4 ........................................................................................................................................ 34
TABLES

Table 1 ................................................................................................................................. 37
Table 2 .................................................................................................................................. 39
Table 3 .................................................................................................................................. 39
<table>
<thead>
<tr>
<th>FIGURES</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>34</td>
</tr>
<tr>
<td>Figure 2</td>
<td>38</td>
</tr>
<tr>
<td>Figure 3</td>
<td>41</td>
</tr>
<tr>
<td>Figure 4</td>
<td>42</td>
</tr>
<tr>
<td>Figure 5</td>
<td>43</td>
</tr>
<tr>
<td>Figure 6</td>
<td>44</td>
</tr>
<tr>
<td>Figure 7</td>
<td>45</td>
</tr>
</tbody>
</table>
CHAPTER 1

INTRODUCTION

Introduction

Health professions students describe learning in health care environments as stressful (Loureiro, Severo, Bettencourt, & Ferreira, 2011; Khajehei, Ziyadlou, Hadzic, & Kashefi, 2011). In an effort to prepare health professions students for the stress of clinical work, many academic health care programs have incorporated simulation as one method for teaching and learning about patient care experiences, however, even simulated patient care can cause participants to verbalize feelings of anxiety, inadequacy, or incompetence (Leighton & Scholl, 2009; Gantt, 2013).

Problem Statement

Teaching activities designed to simulate the care of patients impose unexplored levels of stress on the learner and it is unclear whether this stress inhibits or helps with learning. The risk of not fully understanding the effects of stress could lead to inadequate training for emergencies or impair learning (LeBlanc, 2009). Some studies show improved performance of health professions students under stressful training conditions while others show just the opposite effect (LaBlanc & Bandiera, 2007; LeBlanc, MacDonald, McArthur, King, & Lepine, 2005). Two contrasting perceptions have emerged in the practice of health education. The belief that stress enhances learning coexists with the belief that learning occurs best in environments free of stress. Neither approach is evidence based and only minimally explored (LeBlanc, 2009). Our current lack of understanding about the effects of stress on health professions students impedes best practices in teaching and learning.
When confronted by an acutely stressful situation, healthcare workers should be able to utilize normal physiological stress changes such as increased heart rate to help them spring into action. This kind of reaction to acute stress, known as the “General Adaptation Syndrome” (Selye, 1998), initiates human physiological responses designed to help assure survival (Motzer & Hertig, 2004). Increased heart rate, catecolamine secretion, and cortisol secretion are all part of the natural human adaptation process designed to boost physical performance in times of acute stress. How a person responds to stress is in part determined by personal appraisal of whether the stressor is a challenge or a threat (McEwen, 1998).

**Background and Significance**

The acute stress response occurs during moments of crisis and exerts both physiological and psychological effects on a person. There is little known about how acute, time-limited stress effects the care provided by healthcare professionals in patient care emergencies. Although one could logically assume that the acute stress response would create increased heart and respiration rate, it is difficult to collect in-situ measurements during a true patient emergency without interfering in patient care. Often true patient emergencies are also accompanied by odors, alarms, and loud voices. How this distracting environment effects the caregiver has not been fully explored.

The Transactional Theory of Stress and Coping (Lazarus & Folkman, 1984) explains that human adaptation to intensely demanding situations grows over time and making responses more automatic. Therefore, a health professions student would exhibit different physiological and psychological responses to an acute emergency than an expert caregiver. *Psychological stress* is an appraisal relationship between the person and an environment that is considered
taxing, dangerous, or requires more resources than are available (p. 19). During the appraisal process the person determines why and to what extent the event is considered stressful. *Coping* is the process of managing the demands of the person-environment relationship in light of the stressful event (p. 19).

Because it is potentially inappropriate to investigate the nature and physical processes experienced by a health care provider during a true patient care emergency, this process can be best studied using simulations in a lab setting. *Simulation* is a technique to replace or amplify real experiences with guided experiences to evoke or replicate substantial portions of the real world in an interactive manner (Gaba, 2004). Simulation in healthcare education is gaining popularity as a teaching method in schools of medicine, pharmacy, and nursing. The development of computerized mannequins, known as high fidelity simulators (HFS), which can mimic breathing, sweating and even bleeding has increased the use of simulation teaching methods. The HFS can replace real patients in student practice sessions and provides opportunities for teaching and learning without fear of harming a real patient. Simulation teaching and learning opportunities called scenarios are developed from case histories or potential patient care experiences. The HFS is programmed to exhibit varying signs of health or illness within a scenario. Other scenarios may call for the use of actors or role players, known as a standardized patients (SP) to provide experience in interactions with a real people. Both HFS and SP scenarios often use theatrical type make up also known as moulage to make a case, injury, or illness seem more real. Scenario settings such as hospital rooms, surgical suites, or home bedrooms are replicated in laboratories and represent the patient environment as closely as possible. Health professions students interact with each other and with simulated patients such as an HFS or SP in this controlled, but realistic environment. Students can practice various skills.
such as assessments, communication, or interventions. This learning environment fosters skill practice and judgement development opportunities which cannot be “scheduled” for student learning in the patient care environment. For example, faculty cannot schedule true patient emergencies in the clinical environment for students, however, simulation allows each student to practice for emergency events in a controlled environment.

In 2000, the Committee on Quality of Health Care in America issued the report *To Err is Human* on the high rates of errors which occur in health care (Kohn, Corrigan, & Donaldson, 2000). Simulation training methods were one measure suggested to improve health care safety. The Institute of Medicine (IOM, 2010) recommends simulation as a teaching and learning method for both intraprofessional and interprofessional health care education.

Although simulation methods used for health care education are increasing in frequency, simulation practice itself can also be stressful. Nursing students report increased feelings of stress with simulation practice even on routine tasks such as catheterization, dressing changes and medication administration (Jarzemsky & McGrath, 2008) and some reports of increased anxiety relate to lower performance scores (Gantt, 2013). Of schools of nursing that report using simulation methods, the second most common compulsory scenarios are patient emergency or “code blue” simulations (Kardong-Edgren, Willhaus, Bennett, & Hayden, 2012). In a systematic review of research about simulation in health professions education, Cook et al. (2011) report the most commonly studied simulation scenarios were surgical procedures and resuscitation/trauma training.

It is also clear that simulation scenarios can alter physiological measures in caregivers such as heartrate and neuroendocrine levels like cortisol or alpha amylase (Harvey, Nathens, Gandiera, & LeBlanc, 2010; McKay, Buen, Gohan, & Maye, 2010). Because stress is a
multidimensional construct it is important to assess multiple physiological markers when attempting to document effects (Engert, et al., 2011). Early nursing and later medical studies attempted to measure the physiological nature of student reactions to emergency scenarios, but researchers encountered technical difficulties collecting data such as heartrate or blood pressure using tools available at the time. (Manderino, Yonkman, Gonong, & Royal, 1986; Gizardas, Delis, Bose, Hall, Rzechula, & Kulstad, 2009). Improved and alternate methods of measurement are now available.

**Statement of the purpose, definition of terms and research questions**

This investigation explored the relationships between psychological stress, physiological stress, and performance measures in health professions students who participate in acutely stressful health care simulation scenarios. For the purposes of this investigation an *acutely stressful health care simulation scenario* was defined as a replicated patient care teaching/learning activity in which it appears that the patient is severely ill or injured and may be at risk for death if the student participant did not take action.

*Psychological stress* was defined as the relationship between the person and the environment appraised by the person as tasking or exceeding his or her resources and endangering his or her well-being (Lazarus & Folkman, 1984) This definition was operationalized in a cognitive appraisal of threat or challenge using the 10-item Stressor Appraisal Scale (SAS) (Schneider, 2008).

*Physiological measures* were defined in this investigation as mean heart rate, mean maximal heart rate, alpha amylase, and cortisol. Heart rate was measured and operationalized using a Sigma Onyx fit™ device to detect the average heart rate and average maximal heart rate before,
during, and after simulation activities. Alpha amylase (sAA) and cortisol (sC) were defined as neuroendocrine markers which change in response to stressful situations and were operationalized and measured from saliva specimens collected from each subject before, during, and after the acutely stressful health care simulation scenarios.

Performance was defined as a score from a checklist instrument (See Appendix A) adapted from the First Five Minutes®, a standardized simulation learning curriculum. Scenarios from this curriculum were adapted for the intervention as the simulated learning opportunity.

The following research questions were proposed:

1. Is there a significant relationship between physiological measures of stress, psychological measures of stress, and performance in health professions students before, during, and after an acutely stressful health care simulation in those who have had simulated learning opportunities versus those who have not?

2. Do physiological measures of stress significantly differ before, during, and after an acutely stressful health care simulation in those health professions students who have had simulation learning opportunities versus those who have not?

3. Do measures of psychological stress significantly differ between health professions students before, during, and after an acutely stressful health care simulation in those who have had simulation learning opportunities versus those who have not?
Conclusion

Both psychological and physiological acute stress has been found to have a negative impact on cognitive performance and reaction time in tasks unrelated to health care, however, behavioral interventions and training have been found to provide a beneficial effect on performance (Scholz, et al., 2009; Gildea, Schneider, & Shebilske, 2007). Simulation as a teaching tool is a type of behavioral intervention. Although students may describe participating in a scenario as stressful, studies are emerging that indicate that simulation practice (Cass, Crofts, & Draycott, 2011) improves learning and results in better patient outcomes. Studies (Gantt, 2012; Szpak & Kamig, 2013) that measure student anxiety as a state or trait before and after simulations, have not attempted to evaluate whether anxiety is directed at the simulation experience and/or whether it is helpful to learning. Understanding the impact that acute stress poses on students in simulation further informs its use in health care education.
CHAPTER 2
LITERATURE REVIEW

Introduction

Study and data collection of neuroendocrine biomarkers and perceptual stresses posed by simulated learning environments requires a thorough understanding of the current research literature. This chapter begins with an introduction to the theoretical framework about the theories of stress, coping, and emotion. Psychological measures such as the Stressor Appraisal Scale (SAS) are evaluated and compared with other tools for stress measurement in the literature. Studies which use simulation as a proxy for the complex clinical environment in the study of stress and performance are also reviewed. A section has been dedicated to the literature about neuroendocrine markers cortisol (sC) and alpha amylase (sAA) as well as the physiological indicator heart rate. Reviews of studies which use combinations of these variables during simulation for health professions students complete this chapter.

Theoretical Framework

A simple Google search February 14, 2013, using the term “stress” returned 546 billion results in less than 0.22 seconds which is more than 27 times the number of results on the same topic returned in 2007 (Cohen-Charash, 2007). Stress has become a household word and messages about how it can be dealt with, avoided, and managed have become popular in the media (Lazarus, 2007). The study of stress maintains a high profile in research and theory because it plays an important role in social, physiological, and psychological health. Lazarus and Folkman (1984) defined psychological stress as “a particular relationship between the person and the environment that is appraised by the person as taxing or exceeding his or her resources and endangering his or her well-being”.

A person evaluates a stressful event in a twofold process called cognitive appraisal. Although each of the two steps happens almost simultaneously, they are called “primary” and “secondary”
appraisal. In the primary appraisal, the person asks him or herself “Am I in trouble or being benefited now or in the future by this event.” In the secondary appraisal, he or she asks “What, if anything, can I do about it?” This cognitive appraisal process allows the individual to categorize the event as either a “threat” or a “challenge” (Lazarus & Folkman, 1984, p. 31). The process of coping is defined as “constantly changing cognitive and behavioral efforts to manage specific external and internal demands that are appraised as taxing or exceeding the resources of the person” (Lazarus & Folkman, p. 141).

Lazarus and Folkman postulated that the cognitive appraisal process alerts the individual to environmental demands which in turn initiates physiological responses. It is unclear however, whether body processes or performance differ when the event is considered either a threat or a challenge. This study explored that phenomenon and attempted to detect whether differences in cognitive appraisal correlated with differences in physiological processes and/or performance.

Four types of stressors are described by Elliott and Eisdorfer (1982). They are acute stressors, time limited stressors, longer stressor sequences which occur over time, chronic intermittent stressors which occur briefly several times, and chronic stressors which do not relent. In this investigation the acute, time limited stressor category was represented by an acutely stressful health care simulation scenario. This category of stressor is likened to going parachute jumping, awaiting surgery, or encountering a rattlesnake.

**Psychological measures of stress**

Emotion is often a consideration when attempting to evaluate reactions to an event. Emotions are also often linked to the process of coping (Lazarus & Folkman, 1984). The cognitive appraisal process allows the person to detect and evaluate conditions which require action. This determines emotional state and promotes response efforts to the event (Lazarus, 1991). Some simulation researchers have attempted to measure the effect of stress from simulation activity by evaluating the emotion of “anxiety” using the Spielberger State-Trait Anxiety Inventory (STAI) (McKay, Buen, Bohan, & Maye, 2010; Szpak &
The STAI is a valid and reliable tool for measuring state the intensity of anxiety as an emotional state and the individual differences in anxiety as a personal trait (Spielberger, 2009). The use of only one emotional construct such as anxiety to attempt to evaluate a stressful encounter is limiting. Lazarus (1991) has identified at least 14 other emotions which might be expressed in an encounter including fright, relief, happiness, and others.

For example: During a pilot study in preparation for this dissertation work (Willhaus & Kardong-Edgren, 2011), students participants verbally expressed and exhibited a variety of emotions which impacted their actions during an unexpected and acutely stressful health care simulation scenario. One student expressed “relief” that the simulated patient was lying on the floor bleeding, because he said he had dreaded the patient teaching he had anticipated practicing in the scenario. Another student expressed and exhibited “fear” and fled the simulation entirely when presented with the bleeding patient. A third student expressed and exhibited “happiness” that her skills in the simulation would not be limited entirely to teaching.

Three cognitive appraisal instruments to evaluate stressful encounters have been reported in the literature. The first instrument is a two-question tool utilized in three other studies (Tomaka, Bascovich, Kelsey, & Leitten, 1993; Tomaka & Blascovich, 1994; Tomaka, Blascovich, Kibler, & Ernst, 1997). This instrument used a literal interpretation of the Lazarus and Folkman (1984) questions from the definition of primary and secondary appraisal using a Likert-type scale. “How threatening do you expect the simulation task to be? How are you able to cope with the simulated event?”. The overall appraisal index was computed as a ratio of the primary and secondary appraisal demands and reflects whether the subject perceives the task to be a threat or challenge. Because the tool is only two questions it is not possible to perform any psychometric analysis of the measure.

A second scale was used to evaluate long term stress and coping (Folkman, Lazarus, Dunkel-Schetter, Delongis, & Gruen, 1986). The tool contained 84 items in total and although the results
indicated that coping was related to cognitive appraisal, this tool was deemed too long and not appropriate for an acutely stressful encounter.

A third instrument, the 10-item Stressor Appraisal Scale (Schneider, 2008), measures primary and secondary appraisal subscales. The scores of each of these subscales are added and means calculated. Primary (alpha = .81) and secondary appraisal (alpha = .79) scale means are then used to indicate a ratio score with an overall reliability score of .79. Scores less than one are considered challenge and scores greater than one are considered threat. An earlier version of the SAS and the two question tool were compared in another investigation employing a computer game simulation (Gildea, Schneider, & Shebilske, 2007). Although pretest differences in the two instruments were not detected, post test results differed significantly and the SAS was more consistent and reliable than the two question tool. Since the proposed investigation will evaluate performance, the 10-item SAS (Schneider, 2008) will be used to collect cognitive appraisals from subjects to determine whether they perceive the acutely stressful simulation to be either threatening or challenging.

**Physiological stress**

Selye (Naylan, 1998) described the General Adaptation Response (GAS), as the three stage process which begins with general alarm after an organism is suddenly confronted with a critical situation. The brain as the key organ of response determines whether an event is stressful and responds by releasing chemical mediators throughout the autonomic nervous system that increase heart rate and blood pressure. Attention is enhanced and the brain focuses on the event. Cardiac output and respirations increase while blood flow is redirected to provide circulation and fuel to the brain, heart, and muscles (Tsigos & Chrousos, 2002). The hypothalamic-pituitary-adrenal (HPA) axis is stimulated and after a series of complex bioneurological steps the production of the hormone cortisol is increased.

It is important to remember that the brain not only controls physiological response, but also the psychological response to the environment. It is the brain’s response to what is considered threatening or
challenging that initiates this complex physiological cascade (McEwen, 1998). The human ability to
determine what is threatening or challenging has contributed to the theories of natural selection aka
“survival of the fittest” and the “fight or flight” response (Motzer & Hertig, 2004). Some research
supports gender differences in the physiological responses to stressors in certain neuroendocrine measures
such as cortisol (van Stegeren, Wolf, & Kindt, 2008; Buchanan & Tranel, 2008).

The physiology of stress is complex and involves a system of nonlinear networks in which each
biological mediator has the ability to regulate the activity of other biological mediators (McEwen, 2007).
This nonlinearity means that as one mediator is increased or decreased other mediators compensate on
differing timelines in an eventual attempt to bring the body back to a balance. This nonlinearity must be kept in mind when performing any study using biological markers and must also be considered when interpreting results (McEwen). The use of multiple measures of stress and the accompanying timeframes for their activation are important (Balodis, Wynne-Edwards, & Olmstead, 2010).

**Physiological Measures of Stress**

In this investigation three measures of physiological stress were identified for measure. They are mean heart rate, cortisol, and alpha-amylase. Technology now allows the collection of these measures more efficiently, less-expensively, and less-invasively than in earlier years. Although each measure will be discussed here, studies which incorporate these variables will be reviewed later in this chapter.

*Heart rate.* Heart rate in normal adults is governed by electrical impulses from the sinoatrial node (SA) also known as the pacemaker of the heart. The SA node is controlled by the autonomic nervous system and influenced by both the sympathetic and parasympathetic pathways. Although in the proposed study an attempt will be made to capture heart rate responses related to an acutely stressful activity, it is important to consider other influences on heart rate and make an attempt to control for them.
A review of variables influencing heart rate by Valentini and Parati (2009) classified determinants of heart rate in two categories, non-modifiable and physiologic. Age, sex, and race are considered influences which cannot be changed. Physiologic determinants include circadian cycle, posture, blood pressure, physical activity, obesity, mental stress, smoking, and alcohol consumption. Although heart rate is easy to quantify it is not considered a very specific measure of neural cardiovascular changes. However, in a pilot investigation (Willhaus & Kardong-Edgren, 2011) there were significant differences in mean heart rate before, during, and after the stressful patient care simulations.

Using the Sigma Onyx Fit™ sports monitoring device, heart rate can be collected from a subject in a minimally invasive manner. Heart rate monitors of this type do not need calibration and meet standards for medical equipment (Bassett Jr, Rolands, & Trost, 2012). The subject wears a band around the upper chest with two conductive pads next to the skin. A wrist device receives a digital signal from the band conductors and transmits the heart rate to the wrist device. Mean heart rate can be collected for each session measured and the device will store up to seven measurement sessions. Each band has its own frequency and does not interfere with others using similar heart rate collection devices in the same area. This is the device used in the study to collect mean and mean maximal heart rate.

*Alpha Amylase.* The ability to measure biological analytes in saliva has made data collection of stress neuroendocrine markers easier for both subjects and investigators. Alpha amylase (sAA) is a digestive enzyme produced in saliva that begins the breakdown of carbohydrates in the oral cavity during food intake (Bosch, Veerman, de Gues, & Proctor, 2011). It has also been found to be an indirect but reliable measure of acute stress in numerous investigations that will be detailed in another section of this literature review.

sAA levels in saliva have been successfully used as indicators of both psychological and physiological stress conditions and can serve as an indirect indicator of autonomic activation (Nater & Rohleder, 2009). sAA is produced in the salivary glands by the acinar cells which are innervated by both
sympathetic and parasympathetic branches. Although early studies attempting to link sAA to stress were mixed or indeterminate, more recent studies show sAA reactivity using relatively small sample size (McKay, Buen, Bohan, & Maye, 2010; Engert, et al., 2011). Many of the early inconsistencies could be explained by data collection such as timing or other issues now known to influence sAA levels. sAA levels peak 5-10 minutes after an event and return quickly to baseline (Nater, et al., 2005) and they are altered by the timing of food intake. (Toda & Morimoto, 2007).

**Cortisol.** Another physiological measure of stress isolated from saliva samples is cortisol. Cortisol is produced by the hypothalamic-pituitary-adrenal (HPA) axis, and like alpha-amylase, researchers must be aware of sources of variance which may impact its measure (Hellhammer, Wuest, & Kudielka, 2009). The hypothalamus regulates secretion of adrenocorticotrophic hormone (ACTH) from the anterior pituitary gland in the brain. ACTH then stimulates production of hormones such as cortisol in the adrenal cortex. Cortisol is produced in a circadian fashion and is usually at its highest level in the body in the morning after waking (Tsigos & Chrousos, 2002). Levels are altered by gender, food consumption, work schedules, and different types of stress. Individual levels can vary greatly from day to day. Not all individuals exhibit a cortisol elevation in response to a stressor and therefore a larger sample size may be required to find significant differences in treatment or control groups.

**Simulation in health professions education**

Opportunities to practice psychomotor tasks have long been a part of practice in health profession education. Students routinely go to laboratories to see tasks demonstrated and then practice them. As early as 1911, nursing students at the Hartford Training School for Nurses were using a trademarked life-sized doll made by Martha Chase. In 1913 various ages of dolls in infant and child sizes were marketed.
by the Chase Company and in 1914 a Chase manikin with internal reservoirs permitting invasive treatments was shown at a St. Louis nurses convention (Herrman, 2008).

In the 100 years since the Chase dolls made their debut, manikins and simulators of various types have advanced in sophistication due to advances in teaching and technology. Students now practice on high fidelity simulators with computerized components that give the impression that the manikin is breathing. Students can also engage in complex interactions with trained actors known as SP’s or they can interact over time and distance with other students through screen-based simulations using virtual reality. Because the low incidence of health care emergencies experienced by health professions students and the variations which may occur (Manderino, Yonkman, Gonong, & Royal, 1986), researchers have relied on laboratory simulations to study the phenomenon of stressful health care encounters in this population.

**Simulation and stress measures in health professions education**

A small but growing number of general reports about simulation and stress exist in the literature. Many are limited to controlled studies where the stressful simulation event involves math computations or public speaking (Engert, et al., 2011; Noto, Sato, Kudo, Kurata, & Hirota, 2005). A few reports discuss simulated firefighting or police work (Groer, et al., 2010; Regehr, LeBlanc, & Barath, 2008; Perroni, et al., 2009). Leblanc (2009) reviewed the literature for reports on health professions education and stress and found that majority of team training in healthcare is conducted using simulation, however no interprofessional studies measuring stress and team training were noted. The majority of reports about simulation and stress in health professions students come from the fields of nursing and medicine. Fewer reports exist from other health disciplines.

*Nursing.* An early attempt to measure the stress associated with acute nursing care utilized a emergency cardiac care scenario to measure changes in anxiety, pulse rate, and blood pressure in senior baccalaureate nursing students (Manderino, Yonkman, Gonong, & Royal, 1986). The STAI was administered before and after students were exposed to a simulation
scenario where a 35-year-old woman complaints of chest pain and then goes into cardiac arrest. Student subjects were evaluated on task performance in cardiac emergencies which included cardiopulmonary resuscitation (CPR) and medication recall, preparation, and administration. The investigation compared two groups. One group received environmental stressors such as odors, sounds and equipment problems during the scenario while the second group was exposed to interpersonal stressors such as arguing physicians, ambiguous orders and the presence of an anxious spouse.

There were significant pre- to post-test increases in pulse rate ($t = 7.62, p < .01$), systolic blood pressure ($t = 1.96, p < .03$), and STAI scores ($t = 6.15, p < .01$) in both groups. There were no differences between the groups for environmental or interpersonal stressors. Some difficulties were reported in the data collection process. The researchers did not report access to non-invasive or continuous data collection techniques for the heart rate and blood pressure monitoring. The measures of pulse and blood pressure simply taken manually before and after the scenario. Performance measures reported that only one of the subjects ($N = 27$) met the criteria for satisfactory CPR although all were certified by the American Heart Association during the preceding year. Additionally none of the subjects met the performance standards for the medications tasks. It was not clear from the report whether any of the students had prior simulation experiences or whether this may have contributed to their poor performance.

The current investigation taking these factors into account utilized a non-invasive technology to record heart rate during the simulation, debriefing, and rest periods and that allowed for mean and mean maximal heart rate to be recorded. Additionally subjects repeated the simulation scenarios to explore whether experience was a confounding factor.

Another more recent report by McKay, Buen, Bohan, and Maye (2010) described stress, anxiety, and performance in nurse anesthesia students during simulation. Measures of sAA, presence of sweat on the brow, heart rate, and STAI scores were compared with performance during a simulated standard
anesthesia induction. No significant relationships were found to measures of stress in high, medium or low performance. Pre- and post-test differences were reported for sAA ($t = 87.6, p = .02$), heart rate ($t = 10.5, p < .01$), and STAI scores ($t = 10, p < .01$). Presence or absence of perspiration was not reported with the findings. Non-invasive techniques were not employed in the collection of heart rate. Rates were collected before and after the simulation experience using a pulse oximetry device on the finger which would have impeded performance during the scenario. This report did not indicate whether the student subjects had experience in simulation.

Only one report in the nursing literature used heart rate, sAA, and cortisol as measures of stress (Haas, et al., 2010). Student nurse anesthetists participated in a simulation where they inducted and maintained general anesthesia for 25 minutes. All students were familiar with the simulation environment. Although the sample size was small ($n = 10$) significant differences in sAA and heart rate were noted during the simulation period. There were no significant differences in cortisol values. The researchers used a visual analog scale (VAS) for measures of psychological stress. This scale from 0-100 allows the subject to indicate a level of stress. There was no correlation in the level of stress verbalized with the physiological stress measures. The researchers postulated that some subjects may not be willing to admit or feel stress despite physiologic stress indicators. This was the only investigation located in the nursing literature where cortisol was measured in response to acute stress.

The remaining nursing literature reports explore only the psychological stress that students report in response to simulations. Three studies employed the STAI to measure anxiety during simulations. In an attempt to determine the impact of prior simulation experience on anxiety before the first clinical experience, Bremner, Aduddell and Amason (2008) used an experience with a high fidelity simulator to orient beginning undergraduate baccalaureate nursing students with assessment skills. A control group received a traditional skills lab practice session where vital signs, basic physical assessment, and safety
skills were taught by demonstration video and return demonstration. Only descriptive statistics were reported so it is not clear whether differences in anxiety were significant between the two groups.

A recent investigation in the literature exploring the relationships between student preparation for simulation and STAI scores (Gantt, 2013) attempted to address the need for student preparation prior to simulation experiences, however, small sample size and changes in teaching strategies confounded the results. Megel et al. (2012) employed simulation interventions with undergraduate baccalaureate nursing students to determine whether anxiety on the first day of pediatric clinical experiences would be changed. Student participants assigned to one of two groups were oriented to a high fidelity infant manikin and were allowed to practice assessment skills. Participants in the control group received instruction and faculty attention equal to the time that participants in the simulation treatment group spent in a simulation scenario. The STAI was administered after the orientation, before and after the simulation or attention experiences, and before and after completing an assessment of a hospitalized child in the clinical setting. A repeated measures ANOVA was used to compare scores from both groups and revealed that students in the experimental simulation group had lower anxiety scores both before and after the clinical activity with a real child ($F(1,50) = 14.29; p < .01$).

A survey of nursing students ($n = 101$) in the San Francisco area (Ganley & Linnard-Palmer, 2012) reveals that students do not feel safe when they are unsure what to expect in a simulation. They also feel unsafe when they do not have the required skills or knowledge to respond appropriately. Cordeau (2010) explored the experience of novice nursing students in simulation using phenomenology and found that there are various levels of anxiety which occur at different times throughout a clinical simulation.

These studies demonstrate that there are clearly stressors related to simulation. Psychological stress may be more complex than the measurement of anxiety alone can explain. The limited numbers of reports in the nursing literature about stress and simulation experiences emphasize that well-planned
research and data collection methods are important to measurement outcomes. Screening and preparation of student subjects is also an important factor for consideration.

**Medicine.** Seven journal articles and one poster abstract were located in the medical literature which measured biomarkers in connection with stressful simulation activities. This section summarizes the applicable literature for medicine.

Increased sAA and cortisol levels were reported in German intensive medicine physicians during a simulation study attempting to show a difference in team training (Crew Resource Management or CRM) and traditional medical simulator training (Mueller, et al., 2009). Physicians were randomized into two groups. There is no report of how many years of experience for each physician or other demographic characteristics of the sample group. The CRM group participated in a one day training designed to improve team skills while the traditional group participated in classic training with a medical simulator. Although both groups showed significant increases in cortisol and sAA during the test scenarios and significant increases in sAA after the scenarios, there was no significant difference between groups in performance or team training skills post-intervention. The authors indicate a need to include a measure of psychological stress as well as physiological markers in future investigations of this nature. They also acknowledge that timing of saliva samples may have confounded some of the results since samples for both sAA and cortisol were collected at the same times despite the differing timelines of peaks and resolutions for these biomarkers.

Keitel, et al (2011) also report attempts to assess physiological and psychological stress during simulations in medical students. The researchers used a randomized counterbalanced order with a repeated measures design to expose 34 medical students in their last trimester of study to an emergency medical simulation scenaio and a public speaking scenario. A rest condition was used as a control. Salivary cortisol, medical performance, and psychological stress were compared. Psychological stress was measured using a visual analog scales measuring the individual items of exerted, stressed, helpless,
relaxed, threatened, tense, out of control, angry and insecure. Both the public speaking and the emergency medical scenarios demonstrated increases in physiological and psychological stress measures. There was no relationship between cortisol response and performance measures in the medical stimulation task. This report gave many details regarding the data collection making it a good candidate for future replication.

A similar although less detailed report about psychological and physiological stress among anesthesiology residents (Tuval, et al., 2010) in Israel concluded that there was no correlation between cortisol, psychological stress, and performance success on a simulation-based board examination. Sample timing for the cortisol is a criticism of this report as the researchers compared cortisol levels taken a month apart at a training event and at the board examination. Cortisol levels vary greatly in some individuals from day to day. No information was given about when the samples were collected during the day. Not surprisingly, cortisol levels and psychological measures of stress were significantly higher during the high stakes examination event than at the training workshop.

Harvey, Nathens, Bandiera and LeBlanc (2010) reported that cortisol levels and cognitive assessment scores were positively correlated among emergency and surgical residents who appraised a simulated trauma scenario as “threatening”. In a “threat” the demands of the event outweigh resources. There was no correlation with cortisol for those who felt “challenged,” meaning resources were sufficient to meet demands. This report is the only one found in the literature where a cognitive assessment tool was used to evaluate psychological stress in conjunction with a healthcare simulation scenario.

Four investigations using medical students or medical residents as participants employed heart rate as a biomarker in the study of stress and healthcare simulations. Despite reports of difficulty measuring continuous heart rate with pulse-oximetry finger probes, Gizardas et al (2009) found small, but significant increases in heart rate regardless of the role the participant was assigned (team leader, procedure chief, or team member) during a stressful emergency simulation. Reiber et al (2009) found that heart rate variability decreased (a physiological indicator of stress) when medical students participated in
a medical history taking scenario with a standardized patient. When adding emotional stressors to an
emergency simulation scenario average and maximum heart rate in medical students were significantly
higher than in peers who had no emotional stressors during a simulation (DeMaria, et al., 2010). In a test
of Advanced Cardiac Life Support (ACLS) performance six months later the participants exposed to
emotional stressors also scored significantly higher in the performance skill section (Mega code) of the
ACLS exam. A report of heart rate and stress among emergency medicine residents also described
significant mean heart rate increases of 42 beats per minute over baseline during a stressful immersive
emergency simulation scenario (Kharasch, Aitchison, Pettineo, Pettineo, & Wang, 2011). All participants
indicated even though the scenarios was stressful they desired to participate in similar future scenarios.
This demonstrates the importance in understanding the nature of stress and whether an event it is
perceived as a threat or challenge. An measurement of heart rate alone is not enough information
determine whether simulation is useful to the participant.

One final medical education simulation study (LeBlanc, Woodrow, Sidhu, & Dubrowski, 2008)
examined the effects of subjectively reported stress on first year surgery residents during the performance
of simulated surgical tasks. Resident participants reported higher stress levels when performance of
surgical tasks were completed during a high-stakes examination. Improvement in technical performance
also improved in the high-stress situation suggesting that the residents were better at following an
itemized sequence of movements when stressed. Stress was measured with a single item Likert type
question asking about how stressful the participant perceived the task to be.

**Allied health.** The literature revealed only three journal articles about simulation and stress
measurement. Two reports were from pharmacy work and a third was from paramedicine.

Schell and Grasha (2000) examined the relationship of stress, anxiety and performance during a
simulated pharmacy tasks. Anxiety appeared to be a predictor of task error. Work pace did not predict
accuracy directly. A criticism of this report is that the student participants were not pharmacy students,
but undergraduate psychology students without any pharmacy training. A later study by Reilley, Grasha, Matthews, and Schafer (2003) used similar a undergraduate participant sample and found that stress scores changed over the time as the participants began to become more automatic in their task performance. Neither study used physiological markers as indicators of stress and and both measured longer simulation periods lasting several hours. Acute stress was also not a target of measurement.

An investigation about the nature of acute stress and its effects on emotional response and performance revealed that paramedics in highly stressful patient care emergency simulation scenarios made significantly more medication errors than in low stress patient care simulation scenarios (LeBlanc, MacDonald, McArthur, King, & Lepine, 2005) No physiological measures were recorded and the stress was measured as self-reported anxiety using the STAI.

Although it is clear that allied health professionals participate in potentially stressful healthcare situations how stress may impact their work has not received much study. Allied health professions students from physical therapy, occupational therapy, speech disorders, and pharmacy participated in the current investigation.

**Interprofessional simulations.** One investigation in the literature examined physiological stress and compared differences in stress simulation activities and traditional tutorial-based interactive training (Bong, Lightdale, Fredette, & Weinstock, 2010). Heart rate and salivary cortisol was compared in physicians, nurses, and technicians across four time points for the simulation training and in physicians only at two time points in the traditional training. Among the physician groups, heart rate and cortisol levels increased in the simulation group before and after the event, while in the tutorial group both heart rate and cortisol levels decreased. In the simulation groups physicians, nurses, and technicians all demonstrated increases in heart rate before and after the simulations, but there were no significant differences among the provider groups. Additionally all three provider groups showed increases in salivary cortisol before and after the simulations. Nurse and physician groups did not differ significantly,
but technicians showed slightly lower increases than the other two groups ( \( p = .05 \)). Despite experience all physicians showed increased physiological and biochemical measures of stress during the simulation activities.

**Conclusion**

A review of the literature reveals that although stress is an important consideration in the delivery of health care by providers, it has been studied only minimally and without consistency. Results between and within disciplines are confounding and conflicting as some studies indicate stress improves learning and performance while others show it to be harmful and cause greater chance for performance errors. Instruments used to measure psychological stress vary or measure only anxiety. It is clear that simulation imposes physiological and psychological stress, but what is unclear is whether simulation interventions can change measures of stress and performance. This investigation examined whether a simulation intervention can change measures of stress and performance among health professions students of different disciplines.
CHAPTER 3

STUDY DESIGN

Introduction

This quasi-experimental study incorporated a modified switching replications design to compare the relationships between psychological, physiological and performance measures in health professions students who participated in acutely stressful health care simulation scenarios. This design is considered to be one of the most ethical of the quasi-experimental methods because all subjects receive the treatment (Trochim & Donnelly, 2008). (See Appendix B) Approval for this investigation was sought and received from the Washington State University Institutional Review Board (IRB) (# 12753-001 and -002).

Sample and recruiting, power analysis

In preparation for this investigation a pilot study was conducted to estimate the sample size required for significant results in alpha amylase, cortisol and heart rate (Willhaus & Kardong-Edgren, 2011). During the pilot study, mean heart rate differences in participants were significant from baseline in both moderately and highly stressful healthcare simulation scenarios. The program G*Power 3.1.3 was used to compute estimated sample sizes for sAA, mean heart rate, sC, and SAS scores. A sample size of 24 participants indicated it would yield significant differences for cortisol measures. G*Power calculations indicated that fewer than 24 participants would be needed for significant differences in the remaining dependent variable categories. Cost of supplies for processing the sAA and sC samples was also taken into consideration. An a priori sample size goal of 24 participants was selected. Post-hoc assessments of power will be discussed for each research question in the analysis section.
The investigator recruited 71 total potential student participants from six different health science disciplines for this investigation. Key faculty and administrators from the nursing, pharmacy, speech and hearing science, medicine, occupational therapy, and physical therapy programs on the Washington State University Riverpoint Campus allowed the investigator to speak briefly at one or more class sessions for the purpose of recruitment. Administrators from the health science disciplines also circulated information about the study to students via email. Potential participants were also recruited by poster advertisements placed on Riverpoint Campus bulletin boards. The Riverpoint Interprofessional Education and Research director (RIPER) also assisted the investigator in recruitment by sending email notices about the study to administrators, faculty, and RIPER members. After one classroom visit with poor recruitment results, an incentive of a $50 grocery store gift card was proposed to and approved by the Institutional Review Board (IRB). After this incentive was implemented volunteerism increased during future classroom recruitment visits.

Of the 71 potential participants, 30 were identified who met the study criteria and who could attend data collection on the required times and dates. All participants were novice health professions students with limited patient contact. All had been trained in Cardiopulmonary Resuscitation (CPR), but none had ever performed CPR. Student participants who had more advanced emergency skills such as emergency medical technician training or military medical training were excluded from the study. Of the 30 student participants scheduled for the investigation, 27 completed the data collection. Three individuals either forgot or cancelled participation just prior to the data collection. The increased number of participants over the a priori sample goal of 24 allowed for the addition of one control and one intervention group. All student subjects were advised of the purpose of the study and its requirements and consents were obtained prior to participation.

Because data collection took approximately four hours with each group, days for data collection were pre-assigned as either treatment or control days. Due to the diurnal nature of the
cortisol levels in the body, data collection occurred only during afternoon hours when sC levels are generally lower. Participants were assigned to one of 10 teams representing either a control ($n = 5$) or a simulation intervention group ($n = 5$). Assignment was not random because each team was intentionally composed of members who did not know each other and were from different health disciplines. Assignment was also made based on the date and time the participant was available. Descriptive analysis of the sample’s characteristics will be discussed in Chapter 4.

**Independent variable**

A simulation teaching activity from the First Five Minutes™ curriculum was adapted to serve as the treatment for this investigation. The First Five Minutes™ is a commercially available curriculum designed to teach hospital-based personnel how to manage a patient crisis and respond appropriately while waiting for a more advanced care team to arrive. The course was written and developed by Dongilli (2008) at the Wiser Simulation Center in Pittsburgh, PA. It is used in the Wiser Training network which is comprised of 22 hospitals in the Pittsburgh area and is also commercially available to hospitals around the world through SimMedical. The objectives of the First Five Minutes™ program are to help staff improve identification of critical events, establish standardized behaviors for response to critical events, and promote improved patient outcomes.

**Dependent variables**

Heart rate was one of three physiological measures of stress in this investigation. Mean heart rate and mean maximal heart rate were measured with the Sigma Onyx Fit™ device for each of the established time periods during the procedure. After signing the consent form, each subject was instructed in how to apply the conductive band portion of the device. A small
amount of water was applied to the band per the device instructions to enhance the signal conduction. Privacy was provided while the subjects fitted and adjusted the band. Each subject secured the accompanying receiving device to wrist. This device displayed and recorded the heart rate at intervals just prior to each simulation, immediately after each simulation, and immediately after each debriefing.

Saliva samples for sAA measurement were collected using small rolls of absorbent material called Salimetrics Oral Swabs™ (SOS) prior to each simulation, at the end of the 5 minute simulation, and at the end of the debriefing due to the timing of sAA’s natural peak and rapid return to baseline. The participant placed the swab under the tongue for 60 seconds. The participant then secured the swab in the SOS tube and was directed by the research assistant to apply a coded identification label indicating time period of the sample and participant number. Saliva samples were kept cool using ice packs until the data collection was complete for that day and then frozen to –20 C until ready to be thawed for processing. When processing, the samples were thawed to room temperature and then centrifuged for 15 minutes. All sAA samples were assayed by the investigator using a commercially available kinetic reaction assay (Salimetrics, State College, PA).

Cortisol was the second neuroendocrine marker assayed from the saliva samples. Saliva samples for sC were collected upon arrival, before each simulation, 20 minutes after each simulation, and 20 minutes after each debriefing due to the delay in cortisol elevation after a stressful event. Samples were collected between noon and 4 p.m. on each day of data collection at the specified intervals due to the diurnal nature of cortisol which declines in the afternoon. All samples were assayed by the investigator for salivary cortisol in duplicate using a highly sensitive enzyme immunoassay kit obtained from Salimetrics, State College, PA.
Psychological stress was measured as a cognitive appraisal using the 10-item Stressor Appraisal Scale (SAS) (Schneider, 2008). Participants completed the SAS prior to the simulations, immediately after the simulations and immediately after the debriefings. The instrument was comprised of two subscales for primary (α = .78) and secondary appraisal (α = .89) and had an overall reliability score of α = .79 (Gildea, Schneider, & Shebilske, 2007). The scores were computed into a ratio of primary/secondary scores where scores less than one indicated challenged and scores over one indicated threatened. “Challenge” meant the subject believed he or she has the resources to meet the demands of the task. “Threatened” meant the subject believed the demands of the task exceeded his or her resources. The SAS was developed by Schneider (2008) as an alternative to the two question scales utilized by prior stress researchers for threat appraisals (Tomaka, Bascovich, Kelsey, & Leitten, 1993; Tomaka, Blascovich, Kibler, & Ernst, 1997).

Subjects were also evaluated on performance during the acutely stressful patient care scenarios. Teams were scored using an instrument from two combined task checklists from the First Five Minutes™ curriculum (See Appendix A). All simulations were recorded using the Laerdal AVS recording system available in the simulation lab in the WSU College of Nursing where the data collection took place. Two independent evaluators who were not acquainted with any of the students viewed and scored the digitized recordings of the simulation sessions using the 20-point checklist instrument. All performance items were worth one point each. The digitized recording files were identified with coded numbers so that the evaluators would not be cued as to whether a performance was the first simulation or the second simulation or which teams were assigned to either control or simulation intervention. Both evaluators were trained on the scoring procedure by viewing recorded scenarios staged for this training purpose while
observing a corresponding pre-scored performance checklist. The three recordings demonstrated a low scoring, a moderate scoring, and a high scoring team performance.

**Simulation Scenario**

The stressful simulation activity utilized a standardized patient. When the team of participants entered in the patient room, a man was lying on the floor with what appeared to be a pool of blood around his head (See Appendix C). He had a 2 inch simulated wound on his head and the wound gave the appearance to be actively bleeding. He was breathing and moaned periodically, but he was not alert. There was a bed in the room with a bedside commode next to the head of the bed. The setting suggested he had fallen while trying to transfer to the commode. There was a phone in the room. Student participants were told they could use the phone to summon assistance. The team of students was informed prior to the simulation that they would encounter a patient fall emergency and should be prepared to take action to assist the patient as a team. All teams were oriented to the room, emergency equipment, and use of the phone prior to the simulation when the patient was not in the room. At the start of each simulation participants entered the room as a team and events were allowed to unfold naturally for up to five minutes. The standardized patient was instructed not to respond verbally to any student action. The investigator monitored and recorded the simulation sessions from an observation room. If any unsafe action posed a risk to the standardized patient, the investigator could have stopped the scenario.

**Procedure**

On the day of data collection each group of participants experienced the data collection process as a team. After signing of consents (See Appendix D), a saliva sample was collected
from all subjects. This first sample was used only to detect any baseline concerns related to disease or possible conditions and was not used in the final analysis. Each subject completed a demographic form (See Appendix E). The Sigma Onyx Pro™ heart rate monitor was applied and synced to the matching wrist device. The team of participants were introduced to each other, oriented to the simulation lab and introduced to the standardized patient. The participants were asked not to text, email, or talk on cell phones with anyone not involved in the data collection process throughout the course of the data collection. Subjects were allowed read, study, watch television, or chat with other team members about subjects other than the data collection as long as the activity had limited potential for physiological or psychological stress. Because eating, smoking, and chewing gum can alter salivary testing these activities were also not allowed. Participants were allowed to drink water if it was not within 5 minutes of collection of a saliva sample.

This initial orientation, completion of paperwork, and application of heart monitors allowed for an initial adjustment period of 30-45 minutes after subject arrivals. Keitel, et al. (2011) recommend an initial adjustment period to distinguish between stress of travel and arrival and stress of the data collection. Just prior to the simulation, the team of participants was briefed on the simulation activity from scripted material (See Appendix C) to ensure that each team received the same information and instructions. Mean heart rate and mean maximal heart rate were recorded and a saliva sample was taken from each person on the team just after the briefing. Each team member also completed the SAS instrument (See Appendix F). The team entered the simulation and events were allowed to unfold naturally and lasted no longer than five minutes.

Immediately after the simulation, the team was taken to a debriefing room, mean heart rate was recorded and each team member completed another SAS (See Appendix G). At five
minutes (sAA) and 20 minutes (sC) post scenario, saliva samples were collected. A short debriefing (See Appendix H) was conducted with the team members and a digital audio recording was made for future analysis. Participants completed another SAS (See Appendix G) upon completion of the debriefing. Mean heart rate for the debriefing was again recorded. Saliva samples were collected at five (sAA) and 20 minutes (sC) post debriefing. Participants in the control groups were then given a 45 minute rest period to allow individual stress biomarkers to return to baseline.

Participants in simulation intervention groups received the simulation teaching/learning activity the First Five Minutes™ after the saliva sample collection for the first debriefing. After the teaching/learning intervention participants in the simulation intervention groups were given a 45 minute rest period.

All teams repeated the stressful simulation activity and data collection after the rest period. After the second debriefing and saliva collections, the heart rate device was discontinued. Participants in the both groups were discharged with instruction not to discuss the data collection activities with others until the entire data collection period for the study was completed. Participants in the control group were offered the simulation/teaching learning activity after the data collection was completed. Control group participants were given the option to repeat the simulation and debriefing a third time after the teaching activity although data collection for this activity was not part of the investigation.

**Analysis Plan**

All data sets were first examined for errors and/or missing variables. Data sets for scale variables contained between 0 - 14% missing data points. Missing data points were replaced with
the mean for that data set. Outliers were examined for scale variables using a multivariate regression technique where the Mahalanobis distance is evaluated and scores which exceed the critical $\chi^2$ value are identified. Data sets were then examined for normality using histograms and scatter plots.

After examining the processed sAA and sC sample values, samples with questionable scores were re-assayed for confirmation. The repeat tests were run on samples which had been refrozen and centrifuged again on a different date. The sAA guideline for human range is between 3.1 and 423.1 U/ml (Salimetrics, 2012). Any samples with data point scores which were above or below these linearity limits were retested. If results returned were still too low or too high, the absolute low of 3.1 U/ml and the absolute high of 423 U/ml were substituted. One subject had persistently low sAA readings in all time intervals resulting in the substitution of the absolute low values. Two others had two persistently high readings at one time interval resulting in the need for absolute high value substitution. There were no sC values which exceeded or fell below the normal human expectations of 0 - 1.551 ug/dL.

A multiple regression was used to examine the relationships between physiological measures of stress, psychological measures of stress, group membership, and performance in health professions students before, during, and after an acutely stressful health care simulation in teams who have had simulated learning opportunities versus those who have not. The variables cognitive appraisal, mean heart rate, mean maximal heart rate, sAA, and sC were all examined using a 2 (Between: Control vs. Simulation Intervention) x 6 (Within: Presimulation 1 vs. Simulation 1 vs. Debrief 1 vs. Presimulation 2 vs. Simulation 2 vs. Debrief 2) mixed ANOVA. Performance scores were compared using a mixed 2 (Between: Control vs. Simulation Intervention) x 2 (Within: Simulation 1 vs. Simulation 2) ANOVA. A priori significance was set
at p ≤ 0.05. Demographic statistics of the control and simulation intervention groups were also analyzed using t tests and χ2 tests to determine if differences existed in group assignments for health discipline, gender, age, simulation experience, and prior healthcare experience. Power was not sufficient to control for differences.
CHAPTER 4

RESULTS

Introduction

The purpose of this investigation was to explore the relationships between psychological stress, physiological stress, and performance measures in health professions students who participated in acutely stressful health care simulation scenarios. This chapter begins by addressing the description of the sample participants. A report on the analysis of statistical findings from the three research questions follows.

Sample

The 27 student participants, six males and 21 females, represented all six health disciplines in the investigation (See Figure 1). The average participant age was 25 (\(M = 25.77, SD = 5.68\)), however age ranged from 19 to 44 years. Twenty of 27 participants indicated that they had had some prior healthcare experience in non-emergency care. Pharmacy technician or pharmacy assistant was the most commonly reported experience (\(n = 7\)). Approximately half of the student participants reported some limited prior experiences with simulation education and training (\(n = 13\)).

![Participation by Health Profession](image)

Figure 1. Number of student participants from each health science discipline.
Group assignment

Participants were assigned to one of 10 teams representing either a control (n = 5) or a simulation intervention group (n = 5). An independent samples *t*-test was calculated comparing numbers of simulation experiences that the participants reported in each group. The control (M = 1.42, SD = 1.40) did not differ from the simulation intervention group (M = 0.93, SD = 1.93) by simulation experience (t(25) = .78, p = .44). The groups did however, significantly differ (t(17.2) = 2.16, p = .04 equal variances not assumed) in age of participants (control M = 27.96, SD = 6.92; simulation intervention M = 23.54, SD = 27.6). No statistical relationships were detected between the groups based on gender (χ²(1) = 1.06, p = .303), combination of health disciplines (χ²(5) = 3.65, p = .60), or amount of prior clinical (χ²(1) = 1.45, p = 2.28).

Due to unforeseen participant dropout at the time of data collection, three control groups had three members and two had only two members. Likewise the simulation intervention groups had four teams with three members and one with two members.

Research Question 1

*Is there a significant relationship between physiological measures of stress, psychological measures of stress, and performance in health professions students before, during, and after an acutely stressful healthcare simulation in those who have had a simulation learning intervention versus those who have not?*

This question was answered using a multiple regression model. First, the variable *performance* was analyzed for interrater reliability and group differences. Second, group performance was compared using a mixed ANOVA. Finally a standard multiple regression model was conducted to determine what, if any, predictive relationships exist among
performance, physiological stress, and psychological stress measures for participants who received a simulation learning intervention and those who did not.

Interrater reliability of performance scores between the two evaluators was computed using a kappa statistic for each of the 20 items and is displayed on Table 1. A kappa statistic of .41 to .60 (Viera & Garrett, 2005) or greater is accepted as an indication of moderate agreement between raters on any given item. Additionally, a Pearson correlation coefficient across raters was computed for overall scores and indicated that although total scores for the first simulations were not significantly correlated ($r = .30, p = .41$) the total scores for the second simulations were significantly correlated ($r = .81, p = .01$).

An average of the scores from each rater was used as the final indicator of performance for each team. A 2 (between: Control vs. Simulation) x 2 (within: Simulation 1 and Simulation 2) mixed ANOVA was used to analyze differences. A statistically significant between group effect (observed power = .64, effect size = .46, $F = 6.99 (1.8), p = .03$) was detected in performance scores. Within group scores were also significant (observed power = 1, effect size = .98, $F = 312.74 (1.8), p < .001$). The simulation and group interaction was also statistically significant (observed power = 1, effect size = .85, $F (1,8) = 47.63, p < .01$). An independent samples $t$-test was computed for both the control and the intervention groups’ scores. As expected the mean scores for control and intervention groups were not significantly different for the first simulation (Control $M = 8.1, SD = .55$; Intervention $M = 8.4, SD = 1.56$), however mean scores for the second simulation (Control $M = 10.6, SD = .96$; Intervention $M = 14.1, SD = 1.43$) were significantly different, $t = 4.54, p < .01$. Figure 2 graphically displays the differences.
Table 1
Agreement Between Raters for Performance Measures

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>% agreement</th>
<th>kappa statistic</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establish responsiveness</td>
<td>100</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Check airway</td>
<td>75</td>
<td>-.09</td>
<td>.61</td>
</tr>
<tr>
<td>Check breathing</td>
<td>100</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Manual pulse check</td>
<td>55</td>
<td>.17</td>
<td>.18</td>
</tr>
<tr>
<td>Call for help</td>
<td>100</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Stabilize head and neck</td>
<td>90</td>
<td>.70</td>
<td>&lt;.01**</td>
</tr>
<tr>
<td>Apply direct pressure</td>
<td>80</td>
<td>.58</td>
<td>&lt;.01**</td>
</tr>
<tr>
<td>Retrieve crash cart and open</td>
<td>95</td>
<td>.88</td>
<td>&lt;.01**</td>
</tr>
<tr>
<td>Move bedside commode away from patient</td>
<td>100</td>
<td>1</td>
<td>&lt;.01**</td>
</tr>
<tr>
<td>Apply pads for defibrillator</td>
<td>100</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Remove other furniture (bedside table or bed)</td>
<td>90</td>
<td>.79</td>
<td>&lt;.01**</td>
</tr>
<tr>
<td>Use universal precautions</td>
<td>95</td>
<td>.83</td>
<td>&lt;.01**</td>
</tr>
<tr>
<td>Apply Oxygen</td>
<td>100</td>
<td>1</td>
<td>&lt;.01**</td>
</tr>
<tr>
<td>Check for IV access</td>
<td>80</td>
<td>.58</td>
<td>&lt;.01**</td>
</tr>
<tr>
<td>Record events on clipboard</td>
<td>100</td>
<td>1</td>
<td>&lt;.01**</td>
</tr>
<tr>
<td>Utilize SBAR</td>
<td>85</td>
<td>.32</td>
<td>.14</td>
</tr>
<tr>
<td>Obtain pulse oximetry</td>
<td>95</td>
<td>.88</td>
<td>&lt;.01**</td>
</tr>
<tr>
<td>Take blood pressure</td>
<td>85</td>
<td>.68</td>
<td>&lt;.01**</td>
</tr>
<tr>
<td>Evaluate neuro function (pupillary response / directed movement)</td>
<td>100</td>
<td>1</td>
<td>&lt;.01**</td>
</tr>
<tr>
<td>Attempt to evaluate pain</td>
<td>95</td>
<td>.81</td>
<td>&lt;.01**</td>
</tr>
</tbody>
</table>

--No Kappa statistic computed as one or both evaluators were constants

**Statistically significant at p < .01
Because measures of performance in the second simulation were significantly higher than
those for the first simulation, a multiple regression was conducted for each simulation to
determine what relationship (if any) physiological stress, psychological stress, and/or control or
intervention group membership contributed to the performance. Measures for sAA, sC, SAS,
mean heart rate, and mean maximal heart rate were transformed, recoded, and aggregated into a
single team scores for each measure. The new variables were examined for normality and
linearity. The enter method was used to compute the analysis. Regression results indicate that
none of the variables predicted performance during the first simulation, $R^2 = \cdot57, R^2_{adj} = \cdot29, F$
$(6, 3)= \cdot66, p = \cdot70$ (post hoc power = \cdot14, effect size = \cdot75) A summary of the coefficients for
the model variables is presented in Table 2.
### Table 2

Performance Score Coefficients for Model Variables from First Simulation

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>β</th>
<th>t</th>
<th>p</th>
<th>Bivariate r</th>
<th>Partial r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate 1</td>
<td>-.02</td>
<td>-.17</td>
<td>-.085</td>
<td>.94</td>
<td>.28</td>
<td>-.49</td>
</tr>
<tr>
<td>Max heart rate 1</td>
<td>.15</td>
<td>.94</td>
<td>.408</td>
<td>.71</td>
<td>.24</td>
<td>.23</td>
</tr>
<tr>
<td>sC 1</td>
<td>2.26</td>
<td>.10</td>
<td>.117</td>
<td>.91</td>
<td>-.07</td>
<td>.07</td>
</tr>
<tr>
<td>sAA 1</td>
<td>.02</td>
<td>.43</td>
<td>.848</td>
<td>.46</td>
<td>.39</td>
<td>.44</td>
</tr>
<tr>
<td>SAS 1</td>
<td>-3.64</td>
<td>-.80</td>
<td>-1.107</td>
<td>.35</td>
<td>-.21</td>
<td>-.54</td>
</tr>
<tr>
<td>Control/intervention</td>
<td>.97</td>
<td>.46</td>
<td>9.53</td>
<td>.41</td>
<td>.14</td>
<td>.48</td>
</tr>
</tbody>
</table>

Independent variables heat rate 2, max heart rate 2, sC2, sAA 2, SAS 2, and control/intervention group were then used to evaluate performance predictors in the second simulation. The regression was computed using the enter method which revealed a violation of multicollinearity for the variable mean heart rate 2. The regression model was computed again without the variable heart rate 2. The combination of variables did not predict performance, $R^2 = .80$ $R^2_{adj} = .559$, $F (5, 4) = 2.05, p = .14$ (post hoc power = .22, effect size .89). A summary of the coefficients for the model variables is presented in Table 3. Control/intervention group membership is the only independent variable which significantly contributes to the model as a predictor of performance.

### Table 3

Performance Score Coefficients for Model Variables from Second Simulation

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>β</th>
<th>t</th>
<th>p</th>
<th>Bivariate r</th>
<th>Partial r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max heart rate 2</td>
<td>.03</td>
<td>.08</td>
<td>.32</td>
<td>.77</td>
<td>.09</td>
<td>.16</td>
</tr>
<tr>
<td>sC 2</td>
<td>-3.638</td>
<td>.09</td>
<td>-.32</td>
<td>.76</td>
<td>.22</td>
<td>-.16</td>
</tr>
<tr>
<td>sAA 2</td>
<td>&lt;.01</td>
<td>.01</td>
<td>-.05</td>
<td>.96</td>
<td>.09</td>
<td>-.02</td>
</tr>
<tr>
<td>SAS 2</td>
<td>-2.15</td>
<td>-.33</td>
<td>-1.25</td>
<td>.28</td>
<td>-.24</td>
<td>-.53</td>
</tr>
<tr>
<td>Control/intervention</td>
<td>3.58</td>
<td>.87</td>
<td>3.72</td>
<td>*.02</td>
<td>.85</td>
<td>.88</td>
</tr>
</tbody>
</table>

*Indicates significance at $p < .05$. 
**Research Question 2**

*Do physiological measures of stress significantly differ before, during, and after an acutely stressful healthcare simulation in those health professions students who have had a simulation learning intervention versus those who have not?*

Mixed 2 (between: Control vs. Simulation Intervention) x 6 (within: Presimulation 1 vs. Simulation 1 vs. Debrief 1 vs. Presimulation 2 vs. Simulation 2 vs. Debrief 2) ANOVAs were used to examine the within, between, and interaction effects for each biomeasure.

**Heart rate**

No statistically significant between group effect was observed in mean heart rate over the six time periods $F = .26; (1, 25), p = .61$. (observed power .078, effect size = .01). However, within groups values were significant and detected an overall heart rate response $F = 47.167, (3, 11, 77.70) p < .01$ (observed power = 1, effect size = .65). The interaction between the control and simulation intervention groups was not significant $F = 1.10, (3, 11, 77.70), p = .36$ (observed power = .38, effect size = .04). Test for sphericity is not met therefore Greenhouse-Geisser computations are reported. A graphic distribution of the values for both control and simulation intervention appear in Figure 3.
Figure 3. Graphic representation of mean heart rate over the six time periods. Although the groups did not differ significantly, heart rate was responsive in both groups to the stressful simulation.

There was no statistically significant effect detected between the control and simulation interventions groups for mean maximal heart rate $F = .39 (1,25), p = .54$ (observed power .09, effect size = .02). There was, however, a significant within groups effect detected in overall mean maximum heart rate $F = 44.98, (3.22, 80.46) p < .01$ (observed power = 1, effect size = .63). No significant interaction was detected $F = 1.37, (3.22, 80.46) p = .26$. (observed power = .37, effect size = .05) Greenhouse-Geisser calculations are reported as sphericity was not assumed. Figure 4 shows a graphic distribution of the values for maximum mean heart rate.
Figure 4. The mean maximum heart rates for the control and simulation groups are not significantly different. However, a non-specific response to the simulation by both groups is detected.

sAA

No significant effect was detected between the control and simulation intervention group for sAA $F = .11 (1, 25), p = .75$ (observed power .06, effect size < .01). However, there was a significant effect within sAA values over time $F = 2.73 (3.37, 84.20), p = .04$ (observed power = .68, effect size = .98). No significant interaction was detected $F = 1.13 (3.37, 84.20), p = .35$ (observed power = .31, effect size .04). Greenhouse-Geisser calculations are reported as sphericity is not assumed (see Figure 5).
Figure 5. The control and the simulation interventions group do not exhibit significant differences or relationships, however sAA is reactive during the debriefing interval as graphically depicted above.

$sC$

A 2 (between: Control vs. Simulation Intervention) x 6 (within: Presimulation 1 vs. Simulation 1 vs. Debrief 1 vs. Presimulation 2 vs. Simulation 2 vs. Debrief 2) mixed ANOVA for $sC$ values was conducted and was not significant for between group differences $F = .01$ (1, 25), $p = .91$ (observed power .05, effect size < .01). There was a significant effect within $sC$ readings over time $F = 4.70$ (2.14, 53.47), $p = .01$ (observed power .78, effect size = .15), but there was no significant interaction detected $F = 1.03$ (2.14, 53.47), $p = .37$ (observed power .23, effect size = .04). Greenhouse-Geisser calculations are reported as sphericity is not assumed. Figure 6 displays the result graphically.
Figure 6. sC graphic results of group comparisons. Cortisol is diurnal in nature and naturally falls in the afternoon hours.

**Research Question 3**

*Do measures of psychological stress significantly differ among health professions students before, during and after an acutely stressful health care simulation in those who have had a simulated learning intervention and those who have not?*

The measure used for psychological stress in this investigation is the Stress Appraisal Scale (SAS) (Schneider, 2008). The internal consistency or Cronbach’s α for each scale was greater than .70 in this investigation (primary appraisal α = .78 and secondary appraisal α = .89), which is considered acceptable in measuring the reliability of the instrument (DeVellis, 2003).

The ratio scores were analyzed using a 2 (between: Control vs. Simulation Intervention) and (within: Presimulation 1 vs. Simulation 1 vs. Debrief 1 vs. Presimulation 2 vs. Simulation 2 vs. Debrief 2) mixed ANOVA. No significant effect was detected between the control and the simulation intervention group $F = 1.26 (1,25)$, $p = .27$ (observed power $=.19$, effect size $=.04$),
however there was a significant within scores effect $F = 20.07 \ (2.48, 61.87), p < .01$ (observed power = 1, effect size = .45). There was no significant interaction effect detected $F = .79 \ (2.48, 61.87), p < .48$ (observed power = .15, effect size = .03. Greenhouse-Geisser calculation was reported as sphericity was not assumed (See Figure 7).

![Stress Appraisal Scores](image)

*Figure 7.* Although there were no differences detected between the two groups, scores in both groups fell after the first stimulation indicating participants felt less threatened and more challenged.

**Conclusion**

In summary the results described in this chapter statistically addressed the purpose of the investigation which was to explore the relationships between psychological stress, physiological stress, and performance measures in health professions students who participated in acutely stressful health care simulation scenarios. Three research questions were answered using data collected from 27 interprofessional students from six different health professions programs. Group assignment to either a control or the simulation intervention group was found to be the
only indicator in performance score improvement. Individual measures examined included
evaluation of psychological stress using a survey instrument and physiological stress using data
from heart rate and saliva specimens. Although none of the individual stress indicators were
significant for between group interactions, all were found to be reactive within the groups over
time. The next chapter will provide discussion and implications related to these findings as well
as plans for future inquiry.
CHAPTER 5

DISCUSSION

Introduction

This chapter provides a summary of the study and includes a discussion of the results reported in Chapter 4. Additionally study limitations and implications of the findings as well as recommendations for future research are presented.

Summary of the study

Learning to be a healthcare professional requires practice. Practicing on real people with real healthcare problems can be stressful for the learner and imposes an element of risk for the patient. Practice can also be accomplished in the simulated learning environment using role play, standardized patients, task trainers, and computerized or static manikins. Practice, even in the simulated environment, imposes stress on the learner. This study explored both physiological and psychological aspects of learner stress in novice health professions students and attempted to determine whether individual stress measures and team performance can be changed by using simulation teaching techniques.

Using methods fully described in Chapter 3, this study answered three research questions using data from 27 novice health professions students representing six health disciplines. Participants were assigned to one of 10 teams and all teams initially participated in a simulation where a hospitalized patient had experienced a fall. Teams rendered aide to the standardized patient in the simulation until more definitive care arrived. After the simulation, each team debriefed together with the facilitator. Five teams served as a control group in the investigation and after a one hour rest period repeated the same simulation. The remaining five teams received a simulation teaching intervention (First Five Minutes™) after the first debriefing and then after a rest period of one hour repeated the simulation. Psychological measures from the Stress Appraisal Scale (SAS) (Schneider, 2008) and physiological measures of heart
rate, (sAA), and (sC) collected at specified intervals during the two simulations were examined to see if differences existed in measured stress between the control and simulation intervention groups. Additionally two independent evaluators analyzed digitized recordings of each team’s simulations and scored performance achieved using a checklist.

The investigator analyzed the data from the 27 participants and two evaluators. A multiple regression analysis was conducted to determine whether aggregate stress measures and membership in either the control or simulation intervention group predicted team performance. Additionally team performance, psychological, and physiological measures were analyzed using mixed ANOVA to determine if differences existed between the control and the simulation interventions groups. The following section will discuss these findings.

**Discussion of results**

**Sample.** Analysis of descriptive statistics form the sample revealed that the simulation and control group differed by mean age of approximately four and one half years. Although this was statistically significant it was not clinically significant as the mean age of both groups remained in the mid-20’s. Amount of prior healthcare experience and simulation experience were not significantly different between the control and intervention groups. Limitations of the sample will be discussed in in the next section.

**Simulation learning’s influence on performance.** The statistical analysis of team performance suggests that simulation coupled with facilitated debriefing can improve performance in a lab environment. Although the simulation intervention teams improved scores significantly over the control teams, all teams, despite group designation, improved performance in the second simulation. Raw score examination reveals that every team improved performance from the first to the second simulation. During the debriefings team members verbally evaluated their own performance and postulated ways they could better assess and care for the simulated patient. With facilitation, team members recalled learning
from their health professions lectures and readings and then collaborated on what actions they could take when repeating the simulation. Participants sometimes changed action roles in the repeated scenario because during debriefing they learned that one teammate had a skill that others did not.

The simulated learning intervention, The First Five Minutes™, focused a timely simulated learning opportunity which significantly increased team performance scores for the simulation intervention group teams. This is one example of how simulated learning activities can assist health professions students with preparation for work in the clinical setting. The intervention training came after the first simulation and debriefing where students had already reviewed and presumably exhausted their own knowledge and resources about what actions to take. Rationale for new actions from the teaching intervention allowed these teams to exceed the achievements of peer teams in the control group.

In this study aggregate measures of psychological and physiological stress and membership in either the control or intervention group did not statistically predict performance scores. Membership in the control or intervention group was the only variable which was a significant predictor of team performance in the second simulation. Teams in the intervention group significantly outperformed teams in the control group during the second simulation.

**Physiological stress and simulation.** One of the three bioindicators for stress, heart rate, was reactive to the simulations in this investigation. sAA was reactive to the debriefings. Although heart rate and sAA did not differ significantly between control and intervention groups, the results demonstrate that the simulation activities did induce an acute but non-specific physiological stress response in the participants. sC was not reactive in this investigation to simulation or debriefing and demonstrated what might be considered a natural diurnal decline in levels throughout the four hour afternoon data collection periods. sC will be further discussed in the limitations section.

Heart rate rose significantly above the baseline readings during both simulations; however, means for both heart rate and maximal heart rate declined approximately 10 beats per minute (bpm) and 33 bpm respectively between simulation 1 and simulation 2. This demonstrates a potential reduction in
physiological stress when the simulation was no longer novel. There were no mean differences however between individuals on teams who had a simulation intervention and teams which did not. This supports the General Adaptation Response (GAS) theory, known colloquially as *fight or flight syndrome*, that the stress response at least for heart rate is non-specific and rises whether one is prepared to handle a situation or avoid it. Maximum mean heart rate responded similarly to the stressful simulations in both groups which again supports the possibility that heart rate is a non-specific indicator of stress.

*sAA* responses demonstrated maximal reactivity during the debriefing sessions after each simulation. The response is non-specific and *sAA* rose whether the participant was prepared or not to respond to the emergency. In the case of *sAA* the response to stress appeared to peak during the debriefings and not during the simulation as postulated. Future investigation of whether event recall increases stress may be advised as no other reports in the literature evaluated physiology related to debriefings.

**Psychological stress and simulation.** Measures of psychological stress declined overall between the first and second simulation sessions. There were no significant interactions detected between the control and the simulation intervention groups. Because there was also small a decrease in physiological stress in one of the three bio indicators during the second simulation, there is some support for the premise in the Transactional Model of Stress and Coping (Lazarus & Folkman, 1984) that psychological stress reduction can potentially reduce physiological stress.

It is important to note that reduction in psychological stress in this investigation was not a statistical factor in predicting performance. A future analysis of the recorded debriefing sessions may contribute answers about why participants reported less stress in the second simulation. Mean ratio scores indicated an initial increase in *threat* during the first simulation session in groups. Scores fell below the threshold of the ratio into a *challenge* classification for during the second
simulation. It is unclear whether it was familiarity with the simulation or the debriefing activity which altered the scores.

**Limitations related to the sample and methods**

As discussed in Chapter 3, the sample was a convenience sample of 27 individuals from six different health professions at one health science campus who volunteered for the study. The complex data collection requirements, diversity in class schedules, and limited availability of the simulation laboratory space meant that volunteer participants had to devote a four hour block of time on a weekend afternoon in order to participate in the study. A $50 incentive to participate complicates the understanding of the reason for volunteerism in this case, but past studies have shown that volunteers may differ in responses than the overall population (Oswald, Wand, Zhu, & Selvy, In press). This may limit the application of findings and results to the general health science student population. A larger sample size with specific team assignments by health profession may yield more information about what combinations of students should be placed together in a simulation. Future studies may be designed to include multiple sites to ensure that results are not unique only to one campus.

The saliva samples were not processed in a certified commercial laboratory due to funding limitations. Samples instead were processed by the researcher in the university lab. Although adequate training in the lab processing techniques had been achieved, it is possible that results from a commercial lab might have been more exact than those obtained by the researcher due to her limited experience and less than expert bench science skills. It is also possible that the simulation used was not stressful enough or of long enough duration to induce sC reactivity in participants.

Another limitation of the study concerns the use of a simulation as a representation for a real patient occurrence. It is unclear whether the stress experienced by the students was mitigated because they knew and understood that the simulated patient was not truly injured. This was mentioned in more than one debriefing by the participants. It appeared the stress experienced was based more on an intrinsic self-
evaluation of skills than on concern for the patient’s injury. Although it is difficult to measure intrinsic versus extrinsic stress in the clinical environment, this may be a direction for future research.

A limitation of the study is that performance scores between the two raters were not significantly correlated for the first simulation (Hoyt, 2010). Due to limitations in the angle of the cameras, unless a participant verbalized an action such as a manual pulse check or airway check, it was difficult to determine if the actions had been taken. During the second simulation, participants verbally communicated more with other team members about assessment findings. Performance scores between raters for the second simulation were significantly correlated. Revisions to the performance checklist may be an answer to this limitation in future studies. Items where there was low agreement between raters could be eliminated, however, consideration for changes in camera placement (if practical) is another possible suggestion for future studies where close observation is required during scoring.

A major limitation of the study was that all primary analyses were underpowered for the multiple regression and mixed ANOVA analyses. Power and sample size were estimated using analysis from the pilot study of a single group repeated measures ANOVA and not the mixed ANOVA or multiple regression analyses used in the final investigation. Power was sufficient to show within group interactions for all variables which is what the information from the a priori analysis was designed to predict.

Additionally, future study in this area should consider multi-level and hierarchical analysis to examine relationships between performance (a group measure) and stress (individual measures). Although a multilevel regression analysis was attempted it indicated that the team level variable explained all of the variance in performance. This is because every person on the same team got the same performance score. A different mix of the group and individual level variables are needed to utilize this analysis method.
Implications of findings

This investigation provides evidence that simulation practice, debriefing, and teaching can be used to improve team achievements in laboratory settings. Psychological and physiological stress, although important to the individual, may have little relevance to team response in a patient emergency. Incidental to the data collection and statistical analysis, a finding emerged which explains much about novice health science students as a group. All verbally expressed a desire to learn more about each other’s professions and many asked if there was a class where they could learn these kinds of team response skills together. The ability and desire to learn as health professions teams offers promise for future improvements in patient care.

Physiological stress indicators. During the course of the planning and implementation of this investigation, the elimination of sC as a physiological indicator was considered. However, because the bioindicator sAA may be a less well-known marker in stress research for the health sciences, sC was retained in the data collection plan. Because of the delayed nature of sC reactivity, participants had to wait 20 minutes after the simulation for the debriefing and 20 minutes after the debriefing for the final specimen collection. This lengthened the time burden on the participant and in the end sC did not result in applicable findings. Future research in this area should consider eliminating sC as a bioindicator.

Heart rate data can be collected using a number of different non-invasive monitors. The Sigma Onyx Fit™ heart rate monitor required several steps to set and record heart rate. Future research should consider a device which is easier to operate and requires fewer steps to record these data. This could reduce the incidence of data lost due to researcher error.

Psychological stress measures. The SAS (Schneider, 2008) proved to be an efficient and reliable instrument to have participants evaluate their psychological stress. It provides a more general stress assessment than instruments which evaluate only one emotion such as anxiety and is a more
psychometrically sound instrument than a one or two question instrument or visual analog scale as reported in other investigations of stress and simulation from the literature review.

**Recommendations for future research**

The first study, which will be undertaken following this dissertation, is a qualitative analysis of the debriefing recordings from the 10 teams for both simulations. The discussion by participants in the debriefings revealed important information which could not be easily quantified and reported in this investigation. For example, self-doubt, uncertainty, and lack of knowledge about the skills of others were commonly expressed by individual participants after the first simulation. Mitigating information and planning for future actions were discussed by the group during the debriefing and all groups improved performance in the second simulation. Distilling these themes from the debriefing recordings would allow for future training to address fears and uncertainties and improve the focus of team actions for learning.

Future studies on stress and performance should include studies of a similar design using working health professions teams. Emergency room teams or emergency response teams in hospitals may demonstrate different findings in the patient care setting than novice health professions teams in the academic simulation setting. If performance of working professional teams could be improved using simulation intervention training, the implications for patient care are very positive. Additionally future studies of, about, and with health science students can help us learn which simulation models work best to improve learning and performance of future health care professionals. This approach at two levels—study of professionals and study of interprofessional students—will improve understanding of how individual stress factors may impact team achievement and help hasten the progress to better and more cohesive teamwork in healthcare.

**Conclusion**

This investigation explored individual stress and team performance and attempted to change these measures using simulation and simulation training in novice health science students. Stress is a complex
condition requiring both physiological and psychological measures and is presumed to have some impact on performance. In this investigation no relationship between team performance and individual stress was found during participation in simulated patient care emergency scenarios. The methods and measures used in this investigation provide valuable guidance for future research. The analysis of recorded debriefings will provide additional insight into improvements in education, training, and team performance.
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doi:10.1111/j.1365-2923.2009.03374.x


doi:10.1016/j.ecns.2011.07.003


APPENDIX A

Performance Evaluation Tool

Scenario #:____________

Please note actions taken by the team in this scenario recording. (Actions do not have to be taken is a specific order.)

☐ Establish unresponsiveness
☐ Check airway
☐ Check Breathing
☐ Circulation (Manual pulse check)
☐ Call for help
☐ Stabilize head/neck
☐ Apply direct pressure
☐ Retrieve crash cart and open
☐ Move bedside commode away from patient
☐ Apply pads for defibrillator
☐ Remove other furniture (bedside table and/or bed)
☐ Use universal precautions
☐ Apply O2
☐ Check for IV access
☐ Record events on clipboard
☐ Utilize SBAR to communicate with provider (call back or call from provider)

Other Assessments
☐ Pulse Ox
☐ Blood pressure
☐ Neuro (pupils) or Directed movement (squeeze my hands, can you move your leg?, etc.)
☐ Pain (attempt to communicate about pain)

Total score: _____/20 possible

(Adapted from Scenario 7 and Scenario 10, Sim Medical, First Five Minutes 2008, University of Pittsburgh Medical Center)

Additional Notes:
### APPENDIX B

**Data Collection Procedure**

Data Collection Part 1
(both groups the same)

<table>
<thead>
<tr>
<th>Time</th>
<th>Timeline</th>
<th>Activity</th>
<th>Physiologic Test</th>
<th>Psychologic Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>Pre study (a)</td>
<td>Arrive, Sign informed consent</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>T+15</td>
<td>Pre-study (b)</td>
<td>Apply heart monitor</td>
<td>sAA, Cort saliva samples</td>
<td>none</td>
</tr>
<tr>
<td>T+25</td>
<td>Pre study ©</td>
<td>Orient to simulation lab/introduce patient</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>T+35</td>
<td>Pre-sim1</td>
<td>Reset heart monitor; introduce sim scenario</td>
<td>sAA, Cort saliva samples</td>
<td>SAS</td>
</tr>
<tr>
<td>T+45</td>
<td>Sim 1</td>
<td>5 minutes scenario</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>T+50</td>
<td>Post sim1</td>
<td>Stop scenario; reset heart monitor</td>
<td>Record heart rate; sAA (5 min); Cort (15 min)</td>
<td>SAS</td>
</tr>
<tr>
<td>T+65</td>
<td>Post sim1 debrief</td>
<td>Reset heart monitor; begin debriefing</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>T+70</td>
<td>Post debrief 1</td>
<td>Reset heart monitor</td>
<td>Record heart rate; sAA (5 min); Cort (15 min)</td>
<td>SAS</td>
</tr>
</tbody>
</table>
Control Procedure (part 2)

<table>
<thead>
<tr>
<th>Time</th>
<th>Timeline</th>
<th>Activity</th>
<th>Physiologic Test</th>
<th>Psychologic Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>T+75</td>
<td>Rest period 1</td>
<td>45 minutes of quiet time</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T+110</td>
<td>Pre-Sim 2</td>
<td>Reset heart monitor; introduce sim scenario</td>
<td>Record heart rate; sAA, Cort saliva samples</td>
<td>SAS</td>
</tr>
<tr>
<td>T+120</td>
<td>Sim 2</td>
<td>5 minutes scenario</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T+125</td>
<td>Post Sim 2</td>
<td>Stop scenario; reset heart monitor</td>
<td>Record heart rate; sAA (5 min); Cort (15 min)</td>
<td>SAS</td>
</tr>
<tr>
<td>T+140</td>
<td>Post sim2 debrief</td>
<td>Reset heart monitor; begin debriefing</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T+155</td>
<td>Post debrief 2</td>
<td>End debriefing; Reset heart monitor</td>
<td>Record heart rate; sAA (5 min); Cort (15 min)</td>
<td>SAS</td>
</tr>
<tr>
<td>T+160</td>
<td>End data collection</td>
<td>Remove heart monitor</td>
<td></td>
<td>none</td>
</tr>
<tr>
<td>T+170</td>
<td>Simulation teaching</td>
<td>Offer First Five Minutes teaching session</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>T+200</td>
<td>Discharge</td>
<td>Discharge counseling</td>
<td>none</td>
<td></td>
</tr>
</tbody>
</table>
Simulation Group (part 2)

<table>
<thead>
<tr>
<th>Time</th>
<th>Timeline</th>
<th>Activity</th>
<th>Physiologic Test</th>
<th>Psychologic Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>T+75</td>
<td>Simulation teaching</td>
<td>First Five Minutes teaching session</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>T+105</td>
<td>Rest period</td>
<td>45 minutes of quiet time</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>T+150</td>
<td>Pre-Sim 2</td>
<td>Reset heart monitor; introduce sim scenario</td>
<td>Record heart rate; sAA, Cort saliva samples</td>
<td>SAS</td>
</tr>
<tr>
<td>T+160</td>
<td>Sim 2</td>
<td>5 minutes scenario</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Record heart rate; sAA (5 min); Cort ( 15 min)</td>
<td>SAS</td>
</tr>
<tr>
<td>T+180</td>
<td>Post Sim 2</td>
<td>Stop scenario; reset heart monitor</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Reset heart monitor; begin debriefing</td>
<td>none</td>
</tr>
<tr>
<td>T+200</td>
<td>Post debrief 2</td>
<td>End debriefing; Reset</td>
<td>Record heart rate; sAA (5 min)</td>
<td>SAS</td>
</tr>
<tr>
<td>Time (T+205)</td>
<td>Event</td>
<td>Activity</td>
<td>Notes</td>
<td>Notes</td>
</tr>
<tr>
<td>-------------</td>
<td>---------------------</td>
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<td>---------</td>
<td>-------</td>
</tr>
<tr>
<td></td>
<td>End data collection</td>
<td>Remove heart monitor</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>T+210</td>
<td>Discharge</td>
<td>Discharge counseling</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Location: Patient Room 217

Patient: James Smith

Patient Information:

Mr. Smith is a 35 year old patient of Dr. Novak admitted for observation earlier today after a car accident caused by an episode of severe ataxia. Although you have not been providing care to Mr. Smith, you were passing by his room and overheard a shout followed by a loud crash.

Please respond to the crash in Mr. Smith’s room as a team and take actions you feel are appropriate to responding to his needs and condition.
APPENDIX D

Consent Form

WASHINGTON STATE UNIVERSITY
College of Nursing

Research Study Consent Form

Study Title: MEASURES OF PHYSIOLOGICAL AND PSYCHOLOGICAL STRESS IN NOVICE HEALTH PROFESSIONS STUDENTS DURING A SIMULATED PATIENT EMERGENCY

Researchers:
Suzan Kardong-Edgren, PhD RN, ANEF
Associate Professor
College of Nursing, WSU Spokane
208-426-2210
Janet Willhaus, MSN, RN
PhD in Nursing Student
College of Nursing, WSU Spokane
509-324-7360 (office) 620-791-7164 (cell)

You are being asked to take part in a research study carried out by Suzan Kardong-Edgren and Janet Willhaus. This form explains the research study and your part in it if you decide to join the study. Please read the form carefully, taking as much time as you need. Ask the researcher to explain anything you don’t understand. You can decide not to join the study. If you join the study, you can change your mind later or quit at any time. There will be no penalty or loss of services or benefits if you decide to not take part in the study or quit later. This study has been approved for human subject participation by the Washington State University Institutional Review Board.

What is this study about?
This research study is being done to measure how stress effects health professions students psychologically and physiologically in the simulated patient care environment and whether simulation teaching can change these effects. The study will also evaluate whether simulation teaching sessions can improve the performance of health care in simulation. You are being asked to take part because you are a novice health professions student in pharmacy, nursing, medicine, occupational therapy, physical therapy or speech therapy and could encounter a patient emergency while working in a hospital setting.
Taking part in the study will take about 4 to 5 hours.

Page 2 of 5
You cannot take part in this study if you are not a student of pharmacy, nursing, medicine, occupational therapy, physical therapy or speech therapy, if you do not have a CPR license or if you have performed CPR on another person.

**What will I be asked to do if I am in this study?**

- If you take part in the study, you will be asked to
- Upon completion of this consent form, you will be asked to fill out a one page demographic questionnaire that includes questions about when you have last eaten or what medications you are taking. You will also be oriented to the simulation suite and introduced to the actor who will be playing the role of the patient in the simulations. This will take about 5 minutes.
- You will also be fitted with a sports monitor device that measures your heart rate at specified intervals. This device has a band which is applied around the chest and another that is placed on your wrist. The device looks like a watch.
- At specified intervals you will be asked to produce a saliva specimen. You will be given a small swab about 1 inch in length and asked to place it under your tongue for 2 minutes. When the swab is saturated, the research assistant will have you place the swab in a special tube marked with your subject number and a letter indicating the time when the swab was collected.
- You will participate as a member of a team in two simulated patient care scenario where an actor playing the role of a patient requires your assistance.
- You will participate as a member of a team in an educational simulation learning activity.
- Each simulation will last 5 minutes.
- Before and after each simulation and after a debriefing period you will be asked to fill out 2 short questionnaires which are designed to measure your psychological stress response to the simulation.
- After each simulation you will be debriefed as a team by one of the researchers.
- After each debriefing you will be provided a quiet room for relaxing for 60 minutes. You will not be allowed to eat, but you may drink water during this time. During this time will not be allowed to communicate with anyone outside the study and you will not be allowed to use the internet.
- You may refuse to answer any question on the questionnaire or during the debriefing periods.
- Your saliva will be analyzed for cortisol and alpha amylases levels after the data collection period. If your levels should be found abnormal in any way, you will be notified so you may seek the counsel of a physician.
- Each simulation and debriefing will be recorded for later evaluation by an independent evaluator.

**Are there any benefits to me if I am in this study?**

Some health science students feel that participating in health care simulations is a benefit because it gives them additional practice with patient care. The information learned from this study will be used to better understand how psychological and...
physical stress is related. This may help other health science students and practitioners in the future. There is no direct benefit to you from being in this study; however you will receive a $50 grocery card at the end of data collection which some students may consider a benefit.

**Are there any risks to me if I am in this study?**

Some students experience physical or psychological stress when participating in patient care or in events simulating patient care. This is the phenomenon we are measuring with this investigation. You will participate in a debriefing after each simulation scenario to discuss any stress you may have felt. Additionally, you will be asked to provide saliva samples at different intervals throughout the data collection procedure. The sample will be collected using a small cotton swab that is placed under the tongue. This may be mildly uncomfortable for some people.

You will not be allowed to speak or communicate with anyone, except the personnel conducting the study. This means you will not be allowed to call text or email others during the 3-4 hours that you are participating in the data collection. You will not be allowed to speak with other participants during the study.

You will not be allowed to eat during the 3-4 hours of the data collection and you will only be allowed to drink water during the rest intervals. You may not smoke or use other tobacco products or chew gum during the study. These activities have an impact on saliva samples so they will be prohibited during the 3-4 hour data collection time.

Although no injuries are anticipated, if you experience an injury of any kind as a result of participating in this study you may contact Dr. Suzan Kardong-Edgren 208-426-2210 or Janet Willhaus 509-290-5146.

**Will my information be kept private?**

The data for this study will be kept confidential to the extent allowed by federal and state law. No published results will identify you, and your name will not be associated with the findings. Under certain circumstances, information that identifies you may be released for internal and external reviews of this project.

- Your data will be coded and the key to participant codes will be kept separate from the data collected under lock and key. All information collected will be kept under lock and key in the College of Nursing.
- The investigators will not discuss your information with other participants in the study.
- The following persons will have access to the information collected in the investigation:

Page 4 of 5
Dr. Kardong-Edgren, Janet Willhaus, Research Assistants trained by Janet Willhaus to help collect the data, and if necessary the IRB

As mentioned earlier, the simulation and debriefing sessions will be recorded. A digital recording will be made of the simulation scenario which includes both audio and video images. During the debriefing a digital recording will be made of the audio proceedings. The results of this study may be published or presented at professional meetings, but the identities of all research participants will remain anonymous.

The data for this study will be kept for 5 years.

Are there any costs or payments for being in this study?

There will be no costs to you for taking part in this study. You will be offered a $50 grocery card after the data collection is complete as an incentive for taking part in this study.

Who can I talk to if I have questions?

If you have questions about this study or the information in this form, please contact the researchers Suzan Kardong-Edgren (skedgren@wsu.edu or 208-426-2210) or Janet Willhaus (jwillhaus@wsu.edu or 509-324-7360), PO Box 1495, Spokane, WA 99201-1495. If you have questions about your rights as a research participant, or would like to report a concern or complaint about this study, please contact the Washington State University Institutional Review Board at (509) 335-3668, or e-mail irb@wsu.edu, or regular mail at: Albrook 205, PO Box 643005, Pullman, WA 99164-3005.

What are my rights as a research study volunteer?

Your participation in this research study is completely voluntary. You may choose not to be a part of this study. There will be no penalty to you if you choose not to take part. You may choose not to answer specific questions or to stop participating at any time.

What does my signature on this consent form mean?

Your signature on this form means that:
• You understand the information given to you in this form
• You have been able to ask the researcher questions and state any concerns
• The researcher has responded to your questions and concerns
• You believe you understand the research study and the potential benefits and risks that are involved.
• You consent to the audio and video digital recordings of the simulations and debriefings.
Statement of Consent
I give my voluntary consent to take part in this study. I will be given a copy of this consent document for my records.

__________________________________  _________________________
Signature of Participant Date

__________________________________  _________________________
Printed Name of Participant

Statement of Person Obtaining Informed Consent
I have carefully explained to the person taking part in the study what he or she can expect. I certify that when this person signs this form, to the best of my knowledge, he or she understands the purpose, procedures, potential benefits, and potential risks of participation. I also certify that he or she:
• Speaks the language used to explain this research
• Reads well enough to understand this form or, if not, this person is able to hear and understand when the form is read to him or her
• Does not have any problems that could make it hard to understand what it means to take part in this research.

__________________________________  _________________________
Signature of Person Obtaining Consent Date

__________________________________  _________________________
Printed Name of Person Obtaining Consent Role in the Research Study
APPENDIX E

Demographic Information

Name__________________________________
Address_________________________________________________________
Phone (cell)__________________ (other)___________________________
Program of study______________________________________________
Year and semester in program____________________________________
Prior healthcare experience (please describe)_______________________
I am □male □female
Current Age _________
Please list any medications you are currently using (please include inhalers if applicable)
______________________________________________________________
______________________________________________________________
When did you last eat?________________________
When did you last exercise?____________________
When did you last smoke?____________________
When did you last consume:
Products containing alcohol______________
Products with Caffeine______________
Products with nicotine______________
Do you have any experience with simulation? □yes □no
If yes, please indicate approximately how many times you have experienced simulation______________
APPENDIX F

Stress Appraisal Scale (SAS) Pretest

1. How threatening do you expect the task to be?
   (Low) 1 2 3 4 5 6 7 (high)

2. How demanding do you think the task will be?
   (Low) 1 2 3 4 5 6 7 (high)

3. How stressful do you expect the task to be?
   (Low) 1 2 3 4 5 6 7 (high)

4. To what extent do you think you will need to exert yourself to deal with this task?
   (Low) 1 2 3 4 5 6 7 (high)

5. How much effort (mental or physical) do you think the situation will require you to expend?
   (Low) 1 2 3 4 5 6 7 (high)

6. How important is it for you to do well on this task?
   (Low) 1 2 3 4 5 6 7 (high)

7. How uncertain are you about what will happen during this task?
   (Low) 1 2 3 4 5 6 7 (high)

8. How well do you think you can manage the demands imposed on you by this task?
   (Low) 1 2 3 4 5 6 7 (high)

9. How able are you to cope with this task?
   (Low) 1 2 3 4 5 6 7 (high)

10. How well do you think you will perform on this task?
    (Low) 1 2 3 4 5 6 7 (high)
APPENDIX G

Stress Appraisal Scale (SAS) Post test

1. How threatening was the task?
   
   (Low) 1  2  3  4  5  6  7  (high)

2. How demanding did you think the task was?
   
   (Low) 1  2  3  4  5  6  7  (high)

3. How stressful did you expect the task to be?
   
   (Low) 1  2  3  4  5  6  7  (high)

4. To what extend do you think you needed to exert yourself to deal with this task?
   
   (Low) 1  2  3  4  5  6  7  (high)

5. How much effort (mental or physical) did you think the situation will required you to expend?
   
   (Low) 1  2  3  4  5  6  7  (high)

6. How important was it for you to do well on this task?
   
   (Low) 1  2  3  4  5  6  7  (high)

7. How uncertain were you about what would happen during this task?
   
   (Low) 1  2  3  4  5  6  7  (high)

8. How well do you think you managed the demands imposed on you by this task?
   
   (Low) 1  2  3  4  5  6  7  (high)

9. How able were you to cope with this task?
   
   (Low) 1  2  3  4  5  6  7  (high)

10. How well do you think you performed on this task?
    
    (Low) 1  2  3  4  5  6  7  (high)
APPENDIX H

Debriefing Questions

The following questions were utilized to guide the debriefing of each subject following each scenario.

- How do you think the scenario went?
- What did you notice about the patient?
- What do you think went well?
- What would you change or improve upon for next time?