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UNIVERSITY OF SAN DIEGO
Hahn School of Nursing and Health Science
DOCTOR OF PHILOSOPHY IN NURSING

SLEEP DISORDERED BREATHING IN PREGNANCY: PREVALENCE AND
OUTCOMES AT DELIVERY

By

Ryan L. Nations

A dissertation presented to the
FACULTY OF THE HAHN SCHOOL OF NURSING AND HEALTH SCIENCE
UNIVERSITY OF SAN DIEGO

In partial fulfillment of the
requirements for the degree
DOCTOR OF PHILOSOPHY IN NURSING
December 2015

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The study protocol was approved by the Naval Medical Center San Diego Institutional Review Board in compliance with all applicable Federal regulations governing the protection of human subjects.

ABSTRACT

Introduction

Sleep Disordered Breathing (SDB) during pregnancy is associated with maternal and neonatal morbidity, and in-hospital mortality. A recent prevalence study using the Nationwide Inpatient Sample reported an obstructive sleep apnea (OSA) prevalence of 7.3 per 10,000 in 2013, a rate of 24% per year over the last decade. The rise in prevalence mirrors the rise in obesity. Military Treatment Facilities (MTF) have seen an increase in obesity and related co-morbidities with an unknown prevalence of SDB. Most studies have been conducted in high-risk populations; the general prevalence of SDB and its association with adverse pregnancy outcomes in a military population needs exploration.

Methods

This prospective, observational study used the Facco Four Variable (FFV) model and STOP-Bang to screen parturients presenting for delivery at a MTF to determine the general prevalence of SDB. Logistic regression on parturient data who screened positive, FFV (score ≥ 75) and STOP-Bang (score ≥ 3) was used to examine if higher rates of adverse pregnancy outcomes (*gestational hypertension, preeclampsia/eclampsia, gestational diabetes, non-elective cesarean delivery, NICU admission, hospital stay >5 days, a composite variable of adverse pregnancy outcomes*) were associated with SDB. Demographic and prevalence data were compared between active duty and non-active duty participants.

Results

Of the study population (N=295), the FFV identified 12.3% (n=36) and STOP-Bang 7.1% (n=21) participants at high risk for SDB. Adverse pregnancy outcomes were experienced by 58% women with the FFV and 66% with STOP-Bang. Logistic regression indicated the FFV categorical score (≥ 75) was not predictive of adverse pregnancy outcomes. Utilizing FFV absolute score, an increased risk of APO was noted (adjusted OR=1.03, 95% CI 1.01-1.05, $p=.013$). Logistic regression indicated a STOP-Bang score ≥ 3 was predictive of an adverse pregnancy outcome (adjusted OR=3.26, 95% CI 1.23-8.62, $p=.018$).

Conclusion

Findings support the need for routine screening for identification of SDB during pregnancy and the opportunity for repeated testing to track progression, treatment, and resolution of SDB. Further research is needed to determine critical points in the development and management of SDB during pregnancy, if and when SDB resolves after delivery, and the long-term health effects for both mother and child.

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DEDICATION

I've been told that laboring and giving birth is a shifting tide of utter exhaustion and sheer joy. Many of the women that participated in this study did so within hours of giving birth. To pause on such a momentous day to listen to a student and fill out a questionnaire was a generous and selfless act. Thank you to all the moms who contributed to this endeavor of nursing science. I wish you all the best of health.

To MCN, EPN, MGN– On to our next adventure!

“I'd rather see a sermon than hear one any day; I'd rather one should walk with me than merely tell the way: The eye's a better pupil than the ear, fine counsel is confusing, but example's always clear.” Edgar Guest

To Dr. Mr. Kitty – Without whom none of this would be possible.

To my Lab Assistant, Andy, always ready to research his options.

To Deborah “Ace” Acomb Nations – We did it!

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CHAPTER I

INTRODUCTION

Sleep Disordered Breathing (SDB) is a not-so-silent syndrome that is largely undiagnosed, yet has significant implications for health. SDB is often associated with loud snoring, older men, and obesity but there is another population who may be at significant risk: pregnant women. Pregnancy has been associated with alterations in sleep that may come from a number of causes, including SDB (August et al., 2013). There is mounting evidence SDB plays a significant role in the morbidity and mortality of perinatal outcomes directly involving the nurse anesthetist. For nurse anesthetists, factors associated with SDB, for instance, obesity, preeclampsia, diabetes, difficult intubation, cesarean delivery, and sensitivity to anesthetic agents, sedatives, and hypnotics can complicate anesthetic care (Chung, Yuan, & Chung, 2008). Screening for SDB may alert the anesthetist to underlying factors that can contribute to an adverse outcome and provide essential information to change the anesthetic plan. A confluence of variables directly related to the anesthetic plan such as medications and side effects, sleep deprivation and fatigue, and lack of monitoring protocols may be placing our patients at risk for such catastrophic outcomes as respiratory depression and death. Obesity and hypertensive disorders intertwined with SDB may be contributing to cesarean deliveries, pre-term deliveries, and low birth weights. Unrecognized and undiagnosed SDB during the antenatal time frame may lead to adverse pregnancy outcomes. Without screening for SDB in pregnancy we may be overlooking a significant contributor to morbidity and mortality in pregnancy.

Background

Obesity is perhaps the strongest correlate with SDB across all populations. Alarming, a recent study predicts a 33% increase in the prevalence of obesity over the next two decades (Finkelstein et al., 2012). Excess body weight and fat accumulation can work in several ways to develop SDB. Fat accumulation can alter upper airway structure, increase total body oxygen demand, and decrease functional residual capacity—all of which can promote or exacerbate SDB (Young, Peppard, & Gottlieb, 2002). Obesity during pregnancy has been associated with increased risk for gestational diabetes, preeclampsia, cesarean delivery, macrosomia, low Apgar scores, and still birth (Ovesen, Rasmussen, & Kesmodel, 2011). Excess weight gain before or during pregnancy over and above Institute of Medicine recommendations is also an independent predictor of preeclampsia (O'Brien et al., 2012). The prevalence of SDB among pregnant women has risen dramatically, 24% per year over the past decade, and coincides with the rise in obesity rates (J. M. Louis, Mogos, Salemi, Redline, & Salihu, 2014). Similar to obesity, SDB is associated with maternal morbidities such as chronic hypertension and diabetes mellitus in addition to asthma and depression (Louis, Auckley, Sokol, & Mercer, 2010). Obesity and SDB have similar risks for the neonate such as NICU admission (J. Louis, Auckley, Miladinovic, et al., 2012), pre-term birth, and cesarean delivery (Bourjeily, Ankner, & Mohsenin, 2011). The commonality of such adverse pregnancy outcomes as gestational diabetes, preeclampsia, cesarean delivery, pre-term delivery, and NICU admission is concerning based on what we already know about the prevalence of obesity and what we are learning about the rising prevalence of SDB.

Unlike the obstetrician who may have the benefit of establishing a relationship and monitoring co-morbidities over several months of the pregnancy, the anesthetist may only meet the patient shortly before delivery. Sleep disordered breathing is associated with co-morbidities such as obesity, preeclampsia, diabetes, difficult intubation, cesarean delivery, and sensitivity to anesthetic agents, sedatives and hypnotics – all of which can complicate anesthetic care. The sensitivity to anesthetic agents, sedatives, and hypnotics is of particular interest. With a limited window of opportunity to address co-morbidities, the nurse anesthetist may be left with few options other than to alter the anesthetic technique by reducing the amount of narcotic medications the patient receives—a critical component of pain management.

A large percentage of obstetric anesthesia practice is centered on providing neuraxial anesthesia in the form of spinal and epidural solutions of local anesthetic and narcotic medications. Preservative-free morphine has been approved for neuraxial administration for post-operative analgesia since 1984 and has been used extensively (Sultan et al., 2011). However, there is the potential adverse effect of respiratory depression that is significantly concerning. The pharmacokinetics of opioids can be complex, especially when comparing interactions or differences between compartments such as spinal or epidural and plasma. Epidural pharmacokinetics are especially challenging as they may vary by level of insertion (Sultan et al., 2011). Level of insertion may vary depending upon patient positioning and anesthesia provider technique. The incidence and degree of respiratory depression from neuraxial administration of preservative-free morphine is difficult to ascertain in the perinatal period due to intermittent monitoring of vital signs—a practice that is often unreliable in predicting

respiratory depression (Carvalho, 2008). Screening for SDB may provide additional information to the nurse anesthetist that can be used to alter the anesthetic plan. Narcotic dosing with spinal anesthetics may be decreased or eliminated based on concerns for SDB and a need for additional monitoring. Alternative pain management plans such as non-narcotic pain medications and transverse abdominal plane regional anesthesia blocks may be used. A study evaluating sleep in the five nights prior to delivery and early labor found women with less total sleep time (TST) the night before birth had higher total pain scores during labor (Beebe & Lee, 2007). Sleep deprivation may impact the ability to tolerate labor pain and could change the timing and duration of epidural pain management. Early initiation of an epidural or replacement of a poorly performing one based on a risk assessment of SDB may be appropriate. If general anesthesia is required, a provider may make extra preparations to prepare for a difficult airway or to decide when to extubate. Additional resources and supportive therapies such as continuous positive airway pressure (CPAP) and continuous end-tidal carbon dioxide (ETCO₂) monitoring may be required. Depending upon the hospital or birthing facility size, resources for both mother and child may not be sufficient. Transfer of care may be required to a facility with a NICU and continuous monitoring capability. Not knowing about a condition like SDB and how it interacts with so many crucial aspects of anesthesia may be the most dangerous situation of all.

Purpose and Specific Aims

The purpose of this study was to examine the prevalence of Sleep Disordered Breathing (SDB) and its association with adverse pregnancy outcomes in pregnant

women at delivery using the Facco Four Variable model and the STOP-Bang model at a large Military Treatment Facility (MTF). This was achieved through the following aims.

Aim 1: To examine the prevalence of SDB using a cut-score of ≥ 75 on the Facco Four Variable model and a score ≥ 3 on the STOP-Bang model in a general obstetric population admitted in the immediate postpartum period at a large academic Military Treatment Facility.

Aim 2: To examine if parturients suspected of having SDB as assessed by the Facco Four Variable Model (FFV; score ≥ 75) or the STOP-Bang (SB; score ≥ 3) have higher rates of the following adverse maternal child outcomes: *gestational hypertension, low birth weight <2500 gms, NICU admission, Preterm delivery <37 weeks gestation, preeclampsia/eclampsia, gestational diabetes, cesarean delivery, hospital stay >5 days, a composite score of adverse pregnancy outcomes, and a composite score of cardiopulmonary complications that includes pulmonary embolism, in-hospital mortality, pulmonary edema, congestive heart failure, and cardiomyopathy.*

Aim 3-Exploratory: Compare the prevalence rates of suspected SDB at delivery between active duty and non-active duty parturients.

Theoretical Perspective

Pregnancy is a time of almost unprecedented change in a woman's life. When viewed through the lens of nursing science (person, environment, health, and illness) all aspects undergo significant alterations in a relatively short amount of time. The physical and physiologic changes produce a wide range of symptoms that occur throughout the pregnancy and can vary from day to day. Symptoms can range from the obvious, such as an increase in physical size to an insidious rise in blood pressure. Multiple symptoms may be present at any time and arise from multiple conditions. As a woman experiences symptoms she must perceive, evaluate, and manage the symptom appropriately.

Symptom Management Theory (SMT) was used to guide the study (Humphries et al., 2008). There are three essential concepts that comprise SMT: symptom experience, symptom management strategies, and symptom status outcomes. Symptom experience is the simultaneous perception, evaluation, and response to a change in how one usually feels. Symptom management is the effort to avert, delay, or minimize the symptom experience. Symptom status outcomes are measures of how effective the symptom management was at decreasing the perceived symptom (Humphries et al., 2008).

As mentioned previously, there are a number of symptoms of pregnancy. Specific to SDB, snoring and daytime sleepiness are symptoms that may develop at any time and worsen throughout the pregnancy. These symptoms may present a challenge to manage. Snoring may not be noted if a woman lacks a sleep partner or may be perceived as a sign of deep sleep— a confusing result when experiencing excessive daytime sleepiness. Arousal and sleep fragmentation may result from SDB but be associated with other physical discomforts and an inability to enter a restful state. Cultural expectations of

fatigue during pregnancy may mask an underlying physiologic cause. The use of SMT guides the patient and provider to explore the symptoms of snoring and excessive daytime sleepiness, screen and test for SDB, explore options to manage the symptoms (minimize weight gain, airway support therapies), and assess management progress with testing (at home sleep study). Through identification and management of the symptoms of SDB definitive action can be taken to minimize or alleviate the impact of SDB on the pregnancy and ultimately improve the outcome.

Figure 1. Model of Symptom Management Theory

Implications for Nursing Research

Disturbance of sleep during pregnancy is not a new phenomenon but the relationship between poor sleep and adverse pregnancy outcomes is gaining attention. Traditional assumptions and tolerance of poor sleep during pregnancy needs to be examined through nursing science. While the time span of pregnancy may be short relative to a person's life span, the stresses and changes that occur may have a greater impact on future health than is currently understood. Kestenbaum et al. (2003) examined cardiovascular and thromboembolic events after a hypertensive pregnancy. All singleton births in Washington State from 1987 to 1989 were examined for diagnosis of gestational hypertension, preeclampsia, chronic hypertension, and then linked to later hospital admissions. The results showed an increased risk for cardiovascular events such as acute myocardial infarction, stroke, deep vein thrombosis, coronary artery revascularization, and pulmonary embolism. The associations are as follows: gestational hypertension 2.8 (95% CI, 1.6-4.8), mild preeclampsia 2.2 (95% CI, 1.3-3.6), and severe preeclampsia 3.3 (95% CI, 1.7-6.5). Women with hypertensive disorders during pregnancy are at 2-3 times greater risk for the development of significant cardiovascular events later in life.

During a pregnancy, a woman will have multiple exposures to nurses and numerous opportunities to be engaged on issues of her health-both short and long term. The knowledge and information from these interactions can shape the future health of a family. Nursing research is well prepared to provide the science to support these families for a lifetime of good health.

CHAPTER II

LITERATURE REVIEW

Pregnancy has been associated with alterations in sleep that may come from a number of causes, including Sleep Disordered Breathing (SDB). There is mounting evidence SDB plays a significant role in the morbidity and mortality of perinatal outcomes. Sleep disordered breathing is a broad term covering a spectrum of disorders that effect breathing while sleeping and have a range of physiologic consequences. Obstructive sleep apnea (OSA) is a specific form of sleep disordered breathing with periods of apnea, oxygen desaturation, excessive daytime sleepiness, and snoring that result from airway obstruction (J. Louis, Auckley, Miladinovic, et al., 2012; Quan et al., 1997). The airway obstruction is from a combination of anatomic and neuromuscular factors that in turn are influenced by age, gender, and body habitus (Young, Peppard, & Gottlieb, 2002). During pregnancy, a woman may be more likely to develop SDB and experience perinatal complications.

History

A review of the literature reveals sleep apnea syndromes have been an area of inquiry since the 1970's (Guilleminault, Tilkian, & Dement, 1976). Research into the causes of cardiovascular disease developed links to SDB. Large population studies for SDB began and have been instrumental in forming the body of knowledge about SDB and pregnancy. Two studies of historical interest are the the Sleep Heart Health Study (Quan et al., 1997) and Wisconsin Sleep Cohort Study (Young et al., 2008).

The Sleep Heart Health Study (SHHS) is an example of early (and ongoing) research into links between cardiovascular disease and sleep. The study began in 1994 as

a prospective, longitudinal, cohort design investigating cardiovascular disease and the independent contribution of sleep apnea. Subjects were recruited from established cardiovascular and pulmonary epidemiologic cohort studies already underway throughout the country. All subjects were a minimum age of 40 years and predominately male; pregnancy was not a focus. A cross sectional analysis was published to discuss interval findings (Gottlieb, 2008). The relationship between sleep apnea and cardiovascular disease showed hypertension strongly associated with even mild OSA and significant changes to ventricular morphology resulting in a lower left ventricular ejection fraction. The report also describes how the methodology of SDB research has changed as a result of the study. The definition of an apnea-hypopnea event, a fundamental variable in SDB research, was different based on the amount of oxygen desaturation or presence of arousal. Oxygen desaturation could range from 2-5% and the resulting AHI would vary from 2.0 events per hour with a 5% desaturation to 17.4 events per hour with a 2% desaturation. This resulted in an increase in SDB prevalence of patients with an AHI >15 from 10% to over 50%. The results of this study prompted the standardization of the methodology for diagnosing SDB by the American Academy of Sleep Medicine Manual for the Scoring of Sleep and Associated Events.

The Wisconsin Sleep Cohort Study began in 1988 as a prospective population based study on the natural history of SDB (Young et al., 2008). Participants were recruited from a sampling of payroll records from state agencies of Wisconsin, were not patients, and did not have a diagnosis of SDB. Men and women age 30-60 (n=2940) completed a survey and were invited to participate in an overnight polysomnography (PSG) protocol (n= 1522) and were followed for several years (mean = 13.8 years, range

1.5-18.7). An eighteen-year follow-up finds that all-cause mortality risk increased significantly with SDB severity (Young et al., 2008). The adjusted hazard ratio (95% CI) for SDB vs no SDB was 3.0 (1.4, 6.3). Individuals with severe SDB had a hazard ratio (95% CI) of 5.9 (2.6, 13.3). Having SDB, especially unrecognized or untreated, significantly increases mortality. This study has slightly more male participants (55%), the first exclusion criteria is pregnancy, and the enrollment of subjects 30-60 years of age covers only a fraction of a woman's reproductive period. The study is important in establishing that SDB has a significant impact on cardiovascular events and life expectancy. It also emphasizes the need to clinically recognize and treat SDB regardless of age, sex, or BMI. By not screening, diagnosing, and treating this problem we are putting patients at risk. The second point to be made about this study is younger women, especially pregnant women were not included as part of the study population and there is a growing body of knowledge that indicates they are at risk for SDB, higher mortality during pregnancy, and later in life.

Both of these studies focused on the influence of SDB on cardiovascular events such as hypertension and myocardial infarction with the result being a strong association. In addition, these studies demonstrate the direction SDB research has been moving: older adults and mostly men. Both studies are the bedrock of research into SDB and have been instrumental in guiding subsequent research. Unfortunately, the majority of research has been focused on studying the older, predominately male. Women of reproductive age are underdiagnosed and understudied in regards to SDB (J. Louis, Auckley, Miladinovic, et al., 2012).

Theoretical Perspective

Pregnancy is a time of almost unprecedented change in a woman's life. When viewed through the lens of nursing science (person, environment, health, and illness) all aspects undergo significant alterations in a relatively short amount of time. The physical and physiologic changes produce a wide range of symptoms that occur throughout the pregnancy and can vary from day to day. Symptoms can range from the obvious, such as an increase in physical size to an insidious rise in blood pressure. Multiple symptoms may be present at any time and arise from multiple conditions. As a woman experiences symptoms she must perceive, evaluate, and manage the symptom appropriately.

Symptom Management Theory (SMT) was used to guide the study (Humphries et al., 2008). There are three essential concepts that comprise SMT: symptom experience, symptom management strategies, and symptom status outcomes. Symptom experience is the simultaneous perception, evaluation, and response to a change in how one usually feels. Symptom management is the effort to avert, delay, or minimize the symptom experience. Symptom status outcomes are measures of how effective the symptom management was at decreasing the perceived symptom (Humphries et al., 2008).

The symptom management model is based on six assumptions. (Dodd et al., 2001) First, the perception of the individual experiencing the symptom is the gold standard for the study of symptoms. The symptom does not have to be experienced by an individual to apply the model. The individual may be at risk for the development of the symptom and require a plan to manage the symptom at some point in the future. Non-verbal patients may experience symptoms with a caregiver interpreting the symptom for the purpose of intervening. The management strategy may be targeted at multiple levels

from the individual to groups or a work environment. Symptom management is a dynamic process that is modified based on individual outcomes and the influences of healthcare providers, the environment, and health/illness domains. Three of these assumptions are especially important for this study. The risk for developing a symptom (snoring, sleepiness) based on a context variable (pregnancy) directly applies. A woman at the beginning of pregnancy may not have any symptoms of changing health or illness but as the pregnancy progresses symptoms are bound to appear. Symptom management is a dynamic process with constant perception, evaluation and response and is ideally suited to the steady onset of change during pregnancy. As the fetus grows and develops, physiology, psychology and social changes all take place. The management strategy may include the participant's spouse or bed partner, changes to the work environment, and support of family members.

As mentioned previously, there are a number of symptoms of pregnancy. Specific to SDB, snoring and daytime sleepiness are symptoms that may develop at any time and worsen throughout the pregnancy. These symptoms may present a challenge to manage. Snoring may not be noted if a woman lacks a sleep partner or may be perceived as a sign of deep sleep— a confusing result when experiencing excessive daytime sleepiness. Arousal and sleep fragmentation may result from SDB but be associated with other physical discomforts and an inability to enter a restful state. Cultural expectations of fatigue during pregnancy may mask an underlying physiologic cause. The use of SMT guides the patient and provider to explore the symptoms of snoring and excessive daytime sleepiness, screen and test for SDB, explore options to manage the symptoms (minimize weight gain, airway support therapies), and assess management progress with

testing (at home sleep study). Through identification and management of the symptoms of SDB definitive action can be taken to minimize or alleviate the impact of SDB on the pregnancy and ultimately improve the outcome.

Figure 1. Model of Symptom Management Theory

Prevalence

The prevalence of OSA in the pregnant population is not known and determining that number is complicated due to a lack of a validated screening instrument. Using data from the Wisconsin Sleep Cohort Study, Young et al. (1993) were able to demonstrate

2% of women and 4% of men in the middle-aged workforce meet minimum diagnostic criteria for sleep apnea syndrome. The prevalence of SDB was significantly higher in men, in all age groups, and at three AHI cut points of ≥ 5 , ≥ 10 , and ≥ 15 with men 2.0-3.7 times more likely than women to have SDB. The study population was a random sample of Wisconsin state employees who were selected to be more likely to have SDB based on a six question survey. The age for inclusion was a minimum of 30 years and the first exclusion criteria was pregnancy. This is an ongoing community-based study and a recent follow-up analysis found that the prevalence of SDB continues to rise at substantial rates across all subgroups over the past two decades. (Peppard et al., 2013)

Using the Wisconsin Sleep Cohort Study (WSCS) data, Peppard et al (2013) developed SDB prevalence models based on age group, sex, and weight status categories for two time periods: the early 1990's and late 2000's. The prevalence model was then applied to data over the same time periods from the National Health and Nutrition Examination Survey (NHANES) and compared with the original data from the WSCS. The study found that men aged 30-49 had a prevalence estimate of moderate to severe SDB ($\text{AHI} \geq 15$) of 10% while women in the same cohort had a prevalence of just 3%. As both groups increased in age the prevalence increased. For men aged 50-70 the prevalence estimate of moderate to severe SDB ($\text{AHI} \geq 15$) was 17% and for women it was 9%. Based on this information, women have roughly half the risk of developing OSA as men. However, the study may have missed the greatest period of exposure for the development of SDB/OSA and the associated morbidities-pregnancy.

The majority of studies of SDB in pregnancy have focused on the sub-set of the obstetric population at greatest risk: patients with obesity, diabetes, and hypertensive

disorders. Louis et al. (2012) investigated perinatal outcomes in obese pregnant women with and without OSA and reported a prevalence of 15.4% (95% CI, 10.4-21.6%). A strength of this study was that the diagnosis of SDB was confirmed by polysomnography. Sahin et al. (2008) also investigated pregnancy outcomes related to OSA. From a small sample of 35 pregnant women, an OSA prevalence of 11.4%, confirmed by polysomnography, was reported. A key factor for both studies is the use of polysomnography to confirm the diagnosis of SDB, the gold standard. Polysomnography is expensive, cumbersome, and time consuming making it difficult to apply to larger studies and further supports the need for less expensive, reliable, and efficient screening measures.

The prevalence of SDB changes throughout pregnancy. Facco et al (2014) examined a cohort of 128 pregnant women at high-risk for SDB. (Facco, Ouyang, Zee, & Grobman, 2014) Pregnant women with any of the following were recruited: BMI > 30, chronic hypertension, pregestational diabetes, history of preeclampsia, and/or a twin gestation. At-home overnight sleep studies were conducted between 6-20 weeks gestation and again between 28-37 weeks gestation. Sleep disordered breathing was defined as an AHI ≥ 5 and categories of mild (AHI 5-14.9), moderate (AHI 15-29.9), and severe (AHI ≥ 30) were used. Participants that had an initial AHI < 5 at baseline but then had an AHI ≥ 5 in the third trimester were reported as new onset SDB. The baseline prevalence of mild, moderate, and severe SDB was 21%, 6%, and 3%. The third trimester prevalence for mild, moderate, and severe was 35%, 7%, and 5%. A new diagnosis of SDB was made in 20% of the participants and 27% of participants had increased severity of SDB.

Sleep disordered breathing is as dynamic as pregnancy and may develop or increase in severity throughout pregnancy.

In a recent study, Louis et al. (2014) used ICD-9 codes and the Nationwide Inpatient Sample (NIS) database to identify Obstructive Sleep Apnea (OSA) in pregnant women and evaluate patient outcomes. The study estimated 55 million pregnancy-related inpatient discharges were evaluated in the United States over an 11-year period (1998-2009) from the NIS database were evaluated. During the first year of the study, 1998, the prevalence of OSA in the study population was 0.7% per 10,000 population; during the last year of the study, 2009, the prevalence rate had increased tenfold to 7.3 per 10,000 population with an annual average increase of 24.4% (95% CI, 22.1-26.8%) (J. M. Louis et al., 2014). The annual average increase correlates strongly with a reported average increase in clinically diagnosed obesity rate of 20%. The study results may be affected by the general increase in knowledge of SDB and OSA as more research has been conducted over the 11-year period. A limitation was that the authors could not confirm if women were treated with continuous positive airway pressure therapy. However, the rise in OSA prevalence is impressive, especially with the corresponding rate of obesity, and predicts a major threat to health that is not being assessed on a regular basis.

Outcomes

While the prevalence of SDB varies between studies and populations and is hindered by a lack of validated screen for use during pregnancy, there are consistent and concerning trends in the outcomes. SDB is associated with chronic hypertension, asthma, diabetes mellitus, and depression (J. M. Louis, Auckley, Sokol, & Mercer, 2010). During pregnancy, OSA may be associated with preeclampsia, cesarean delivery, preterm birth,

and increased morbidity. In a retrospective cohort study of obese and non-obese pregnant women with OSA confirmed by polysomnography, Lewis et al. (2012) identified several concerns. Women with OSA were more likely to have a primary cesarean delivery for arrest of labor when compared with obese controls and normal-weight controls (19% vs. 10% and 3.5%, respectively; $p < .001$). Preeclampsia was also more prevalent in the OSA group than in the normal weight controls (19.3% vs. 7%, $p = .02$). Preterm birth (<37 weeks) was greater in the OSA group than normal weight controls (29.8% vs. 12.3%, $p = .007$). A composite morbidity factor was also evaluated as an outcome measure. The composite factor was defined as a patient having one or more of the following: blood transfusion, conversion from regional to general anesthesia, unexpected surgical procedure (excluding cesarean section), postpartum endometritis, maternal sepsis, pneumonia, wound complications, prolonged post-delivery hospital stay (≥ 3 days for vaginal delivery, ≥ 5 days for cesarean delivery), intensive care unit admission, and/or hospital readmission. Subjects with OSA had greater morbidity (OR 4.6, 95% CI 1.5-13.7) than those without. This study is unique in that all cases of OSA were confirmed by polysomnography and matched controls of both obese and normal weight participants were used. This study underscores the relationships between obesity, OSA, and comorbid conditions.

Another study focusing specifically on snoring during pregnancy and delivery outcomes reported women with SDB were at greater risk for emergency cesarean delivery and small-for-gestational age. Obrien et al. (2013) studied 1,673 pregnant women ≥ 18 years of age and ≥ 28 weeks pregnant to determine the effect of maternal snoring on delivery outcomes. The study found an independent association between

chronic, pre-pregnancy snoring and <10th birth centile (OR 1.65, 95%CI 1.02-2.66, $p=0.041$). Chronic and pregnancy onset snoring are independently associated with elective cesarean delivery (OR 2.25, 95% CI 1.22-4.18, $p=0.006$ and OR 1.70, 95% CI 1.13-2.57, $p=0.012$). In a separate analysis that controlled confounding variables such as presence of preeclampsia and gestational diabetes, maternal education, induction of labor, and birth centile pregnancy onset snoring was independently associated with emergency cesarean delivery (OR 1.68, 95% CI 1.22-2.30, $p=0.001$).

With more operative deliveries and more emergent operative deliveries a rise in morbidity can be expected but the underlying cause needs to be evaluated, especially if it is preventable. Emergent operative deliveries and intensive care for infants of low birth weight or small-for-gestational-age is extremely expensive. A wide range of complications from surgery may occur and can range from the mundane to life threatening. If a facility is unprepared or lacks adequate resources to manage a maternal or neonatal complication related to SDB the result may be catastrophic.

During labor and delivery, OSA also has been linked with outcomes that have specific anesthesia implications. A study evaluating sleep in the five nights prior to delivery and early labor found women with less total sleep time (TST) the night before birth had higher total pain scores during labor (Beebe & Lee, 2007). Sleep deprivation may impact the ability to tolerate labor pain and could change the timing and duration of epidural pain management

Another unique study of OSA and pregnancy outcome is from Lee and Gay (2004). A prospective observational study of 131 women during the ninth month of pregnancy used actigraphy and questionnaires to determine the effect of sleep and fatigue

on labor duration and delivery type. Participants wore a wrist actigraph to determine total sleep time (TST) and wake after sleep onset (WASO)—an estimate of sleep disruption. Women with sleep disruption ($\text{WASO} \geq 15\%$) were 5.2 times more likely to have cesarean delivery. Women with a total sleep average of less than 6 hours of sleep per night were 4.5 times more likely to have a cesarean delivery than women who averaged 7 hours of sleep. Labor duration was also studied but relied on self-report of labor duration rather than confirmation by vaginal exam. This study proposes a prescription for an amount of sleep (at least 8 hours) during pregnancy and draws on the analogy of other habits during pregnancy. In addition to “eating for two” pregnant women should also consider “sleeping for two” and should be getting a minimum of 8 hours of sleep each night.

One of the most dramatic outcomes in the association between OSA and maternal mortality comes from Louis et al. (2014). In a study using an estimated 55 million records from the National Inpatient Sample over an 11-year period, women with OSA had a approximately five-fold higher odds of dying prior to discharge than women without OSA even after adjusting for comorbidities such as cardiovascular, renal, and metabolic conditions (J. M. Louis et al., 2014). A risk this great demands action.

Obesity

Obesity is perhaps the strongest correlate with OSA across all populations. Excess body weight and fat accumulation can work in several ways to develop OSA. Fat accumulation can alter upper airway structure, increase total body oxygen demand, and decrease functional residual capacity—all of which can promote or exacerbate OSA

(Young et al., 2002). Excess weight gain before or during pregnancy in excess of Institute of Medicine recommendations is also an independent predictor of preeclampsia.

Obesity is a significant confounding variable in the study of OSA. Excess weight gain is thought to play a role in the development and progression of OSA. The overall trend in the United States is an increase in the number of individuals who can be classified as overweight or obese. A recent study found the incidence of obesity (BMI > 30) among adult women over 20 years of age in the U.S. is 35.8% (95% CI, 34.0-37.7%) (Flegal, Carroll, Kit, & Ogden, 2012). When overweight (BMI > 25%) is included the number jumps to 63.7% (95% CI, 60.9%-66.4%) (Flegal et al., 2012). Being overweight during pregnancy increases the risk for several co-morbidities that have specific cardiovascular implications for the nurse anesthetist. A large study in Denmark found that as BMI increased above 25% the risk of co-morbid conditions and complications increased. Notably, of all births in Denmark from January 1, 2004 through June 30, 2010, Ovesen et al. (2011) found as BMI increased from overweight, obese, and severely obese the odds ratios for diabetes, preeclampsia, and cesarean delivery also increased significantly. Specifically for preeclampsia, the odds ratios were 1.9, 3, and 4.4 for the three BMI groups. Because of the relationship between obesity and OSA, studies have focused on the obese pregnant population. Louis et al. (2012) investigated outcomes of 175 obese gravid women and found OSA prevalence of 15.4% that was confirmed through PSG. The authors noted the group diagnosed with OSA had a higher mean BMI (46.8 ± 12.2 compared with 38.1 ± 7.5 ; $p = .002$), was more likely to be diagnosed with asthma (48.1% compared to 22.9%, $p = .007$), and chronic hypertension (55.6% compared to 32.4%; $p = .02$) than the control group.

Hypertension

The link between SDB and hypertensive disorders during pregnancy is becoming more evident. O'Brien et al. (2012) conducted a prospective cohort study for pregnancy-onset habitual snoring, gestational hypertension, and preeclampsia. Women were recruited during their third trimester of pregnancy and compared to a non-pregnant control group. This study chose to examine the presence of habitual snoring instead of using a multi-item sleep disordered breathing questionnaire. The authors argue no study has failed to associate snoring with objective measures of SDB obtained from polysomnography and validation of SDB screening tools have not been performed on pregnant subjects. The study reports pregnant women were more than twice as likely to snore than the non-pregnant control group (34.1% vs. 14.9%, $p < .0001$). Through a logistic regression that controlled for covariates, pregnancy-onset snoring was independently associated with gestational hypertension (OR, 2.36; 95% CI, 1.48-3.77; $p < .001$) and preeclampsia (OR, 1.59; 95% CI, 1.06-2.37; $p = .024$). This study is important as the first to prospectively, in a large population, report significant risk to maternal cardiovascular health from pregnancy-onset snoring.

These studies have focused on a sub-set of the obstetric population deemed to be at high-risk for SDB and have not included the general obstetric population. While obesity, diabetes, and hypertension have strong correlations with SDB, they have not been shown as causative and it is possible to have SDB without any of these co-morbidities. The prevalence of SDB in the general obstetric population is unknown.

Screening

The Berlin questionnaire is widely used to screen for SDB/OSA and was originally validated in the primary care setting, but has since been used in the surgical population with moderately high sensitivity (68.9), specificity (56.4), positive predictive value (77.9) and negative predictive value (44.9) (Chung & Elsaid, 2009). The Berlin questionnaire consists of 11 items comprising three categories: snoring, daytime sleepiness, and hypertension. The scoring of the instrument is cumbersome. Items have multiple responses and are assigned a point value which is added with other items in the category to create a category score that will either be “positive” or “negative.” If two of the three categories are positive, the participant is at high risk for OSA. Reports of sensitivity for the Berlin Questionnaire range from 54% to 86% with specificity from 43% to 87% in a primary care setting. In the surgical population, the Berlin Questionnaire has been compared alongside the STOP Questionnaire and the American Society of Anesthesiologists (ASA) checklist. The sensitivity and specificity of the Berlin questionnaire varies depending upon the level of the apnea-hypopnea index (AHI) used and the population under study. In addition, the Berlin questionnaire has been used in pregnant populations (Sahin et al., 2008).

STOP-Bang (SB) is a model derived from the Berlin questionnaire and used extensively in anesthesia. Initially, SB was created as a condensed, four item version of the Berlin questionnaire for the surgical population that was easier to administer and score (Chung et al., 2008a). SB was later created to gain greater sensitivity and specificity. STOP-Bang consists of eight items: S-snoring, T-tired or fatigued, O-observed apnea, P-pressure (high blood pressure), B-body mass index (BMI),

A-age, N-neck circumference, and G-gender. STOP-Bang has a sensitivity of 83.6%, 92.9%, and 100% for the AHI cutoff scores of 5, 15, and 30 respectively. The test re-test reliability was found to be 96.4% with a kappa coefficient of 0.923 (CI, 0.82-1.00). For validity, the STOP questionnaire was compared against a one-night-in-laboratory PSG study with a calculated apnea-hypopnea index (AHI) scored by a sleep physician using American Academy of Sleep Medicine practice guidelines. The guidelines classify severity as: mild (AHI 5-14), moderate (AHI 15-29), severe (AHI >30). Both STOP and STOP-Bang models were assessed for sensitivity at the guideline levels. STOP has sensitivities of 65.6% for AHI > 5, 74.3% for AHI > 15, and 79.5% for AHI > 30. The alternative scoring model STOP-Bang had significantly increased sensitivities of 83.6 % AHI $\geq$ 5, 92.9 % for AHI $\geq$ 15, and 100 % for AHI $\geq$ 30. Each item is a forced choice yes/no question with basic measurements and simple calculations and can easily be scored. Answering “yes” to three or more items indicates a high risk for OSA, answering “yes” to less than three items is a low risk for OSA. The instrument can be completed in a relatively short period of time and provides a simple endpoint of risk assessment for OSA. Tantrakul et al (2015) recently validated the STOP-Bang in an obstetric population. (Tantrakul et al., 2015) Pregnant women from a high-risk pregnancy clinic were recruited to undergo sleep evaluations utilizing the Berlin and STOP-Bang questionnaires and at-home overnight sleep studies. Of the 72 women recruited, 23 were in the first trimester, 24 in the second trimester, and 25 were in the third trimester. The prevalence of OSA by trimester was 30.4% in the first, 33.33% in the second, and 32.0% in the third trimester and was confirmed by sleep study. The sensitivity across the trimesters was 57.1% in the first, 62.5% in the second, and 62.5% for the third. The specificity was 87.5% for the

first, 93.8% for the second, and 88.2% for the third trimester. These values indicate a limited utility for STOP-Bang in the first trimester but acceptable results for use in the second and third trimester.

A Four-Variable Model (FFV) has been proposed specifically for use in the pregnant population. Facco et al. (2012) set out to develop a screening algorithm using the most sensitive indicators from the Berlin and ESS questionnaires by conducting a multivariable logistic regression. While both Berlin and ESS performed poorly, four variables overall were found to be independent significant factors in the identification of OSA in high-risk pregnant women: self-reported snoring, chronic hypertension, pre-pregnancy BMI, and age. To score this assessment, the age is added to the BMI and if snoring ≥ 3 times per week is noted, 15 points are added. If chronic hypertension is noted, another 15 points is added. A combined score for all four variables ≥ 75 indicates SDB with a sensitivity of 86% (95% CI, 66%, 95%) and a specificity of 74% (95% CI, 62%, 83%) while being validated in the pregnant population (Facco, Ouyang, Zee, & Grobman, 2012). This study points out while pregnant, daytime sleepiness is not specific to OSA but is quite common throughout pregnancy. Neither ESS or Berlin includes age in the assessment and the Berlin uses BMI ≥ 30 as a categorical variable where there may be a more direct and linear relationship between OSA and BMI.

Anesthesia, OSA, and Pregnancy

Unlike the obstetrician who may have the benefit of establishing a relationship and monitoring co-morbidities over the duration of the pregnancy, the anesthetist may only meet the patient a few hours before delivery. Obstructive sleep apnea is associated with obesity, preeclampsia, diabetes, difficult intubation, cesarean delivery, and

sensitivity to anesthetic agents, sedatives and hypnotics—all of which can complicate anesthetic care. In the immediate setting of providing anesthesia for a cesarean section, perhaps the only modifiable risk factor is the anesthetic and the use of neuraxial narcotics.

Preservative-free morphine has been approved for neuraxial administration for post-operative analgesia since 1984 and has been used extensively (Sultan, Gutierrez, & Carvalho, 2011). There is the potential adverse effect of respiratory depression that is significantly concerning. The pharmacokinetics of opioids can be complex, especially when comparing interactions or differences between compartments such as spinal or epidural and plasma. Epidural pharmacokinetics are especially challenging as they may vary by level of insertion (Sultan et al., 2011). The incidence of respiratory depression from neuraxial administration of preservative-free morphine is difficult to ascertain. Kato et al. (2008) conducted a retrospective review of 1,915 cesarean section cases that used a standard dose of 0.15 mg intrathecal morphine. Of the study population, only five women (0.26%) developed bradypnea (respiratory rate ≤ 10 breaths/min) and only one required naloxone (0.052%). The study has key limitations that prevent application to broader populations. The authors did not report a mean BMI for the study population and only patient number five of the bradypnea group was reported to have an elevated BMI of 34.7 kg/m². The study took place in Japan which may have a different rate of obesity than the United States. A confounding variable, additional pain medication use during the study period, was not reported and there was no investigation of sleep apnea or other co-morbidities. A more relevant study to the US population that does account for obesity was recently conducted. Crowgey et al. (2013) used a retrospective study of 5,036 postcesarean patients with a mean BMI = 34 kg/m² who all received neuraxial morphine.

The rate of obesity is impressive with 63% having a BMI ≥ 30 kg/m². The anesthetic dose and route were monitored with 3,554 patients receiving spinal morphine doses ranging from 0.05 to 0.25 mg (90.4 % received 0.15 mg) and 1,080 patients receiving epidural doses ranging from 1 to 5 mg (92.9% received 3 mg). The records were reviewed to determine if naloxone was given to reverse respiratory depression or if the Rapid Response Team (RRT) was activated to respond to the respiratory depression. Despite the large sample size and prevalence of obesity, not a single patient was identified as requiring naloxone treatment or rapid response team involvement for respiratory depression. A significant limitation is the study does not account for minor incidents of hypoventilation or desaturation primarily because respiratory monitoring was intermittent. In addition, there was no investigation into co-morbid factors such as sleep apnea. Both of these studies show a lack of respiratory depression in what should be an at-risk population—especially with a high rate of obesity.

Screening for OSA may provide additional information to the nurse anesthetist that might be used to alter the anesthetic plan. A provider may make extra preparations to prepare for a difficult airway knowing there is a high likelihood for OSA. Epidural pain management may be initiated earlier or a tenuous epidural replaced based on the knowledge of an increased cesarean delivery rate with OSA. Narcotic dosing with spinal anesthetics may be decreased or eliminated based on concerns for increased OSA after surgery and a need for additional monitoring. Alternative pain management plans such as non-narcotic pain medications and regional anesthesia such as transverse abdominal plane blocks may be used. If general anesthesia is required, knowledge of OSA can affect decisions about when to extubate. Resources for both mother and child may not be

sufficient and a transfer of care may be required to a facility with a neonatal intensive care unit (NICU) and continuous monitoring capability. Not knowing about a condition like OSA that interacts with so many crucial aspects of anesthesia may be the most dangerous situation of all.

Future Research

Many screening tools currently in use have been designed for sleep clinics or primary care settings and may measure single attributes of SDB, such as sleepiness, but not be of predictive value for SDB. Research shows pregnant women are at significant risk of poor outcomes with tremendous cost to the patients and the healthcare system. Sleep clinics and labs are already struggling to accommodate the increased awareness of OSA in the general population and struggling to meet the need for screening. Pregnant patients may choose not participate in overnight, in-lab PSG studies. Pregnancy, especially late into the third trimester, is notorious for poor sleep even in the routine conditions of home. Reporting to a hospital for an overnight study may be inconvenient in accommodations have to be made for the care of children at home. While the risk of respiratory depression after neuraxial narcotics may be low, the consequence may be fatal. A nurse anesthetist in the busy perioperative setting can not change many of the risk factors and co-morbid conditions but must adapt an anesthetic plan that best fits the patient's condition. Not knowing about the presence and severity of a condition like SDB is a significant risk. Awareness of the prevalence of SDB at the time of delivery can help in the allocation of resources and staffing. A screen that is simple, reliable, and valid for the pregnant population could greatly improve the outcomes of a growing number of obese pregnancies and enhance our understanding of SDB.

CHAPTER III

METHODOLOGY

The purpose of this study was to examine the prevalence of Sleep Disordered Breathing (SDB) and its association with perinatal complications in pregnant women at delivery using the Facco Four Variable model and the STOP-Bang score at a large Military Treatment Facility (MTF). In this chapter information on how the study was conducted is provided and includes the study aims, the research design, the sample and sampling, data collection procedures, and analysis plan. A discussion of protection of human subjects is also provided.

Specific Aims:

Aim I. To examine the prevalence of SDB using a cut-score of ≥ 75 on the Facco Four Variable model and a score ≥ 3 on the STOP-Bang model in a general obstetric population admitted in the immediate postpartum period at a large academic Military Treatment Facility.

Aim 2: To examine if parturients suspected of having SDB as assessed by the Facco Four Variable Model (FFV; score ≥ 75) or the STOP-Bang (SB; score ≥ 3) have higher rates of the following adverse maternal child outcomes: *gestational hypertension, low birth weight <2500 gms, NICU admission, Preterm delivery <37 weeks gestation, preeclampsia/eclampsia, gestational diabetes, cesarean delivery, hospital stay >5 days, a composite score of adverse pregnancy outcomes, and a composite score of cardiopulmonary complications that includes pulmonary embolism, in-*

hospital mortality, pulmonary edema, congestive heart failure, and cardiomyopathy.

Aim 3. Compare the prevalence rates of suspected SDB at delivery between active duty and non-active duty parturients.

Design

This study used a prospective, cross-sectional, observational design utilizing the Facco Four Variable (FFV) model and STOP-Bang model to examine the prevalence of SDB in the third trimester, pregnant population at a large military treatment facility.

Sample and Sampling

The setting for this research was the post-partum wards of a tertiary care military medical center and teaching hospital in the southwestern United States. The primary source for data collection was from the main postpartum wards. The MTF averages more than 300 deliveries a month including high-risk and complicated OB patients. There is a dedicated in-house obstetric anesthesia team supporting 10 labor, delivery, recovery, postpartum (LDRP) suites 24 hours a day. Participants enrolled were geographically limited to Southern California and the greater San Diego area.

Sample Size Estimation

The primary aim of this study was to examine the prevalence of SDB using a cut-score of ≥ 75 on the Facco Four Variable model and a score ≥ 3 on the STOP-Bang model in a general obstetrical population in the immediate postpartum period at a large academic Military Treatment Facility. Previous research suggest between 16.4 - 26.7% of parturients considered to be at high-risk for SDB at term have symptoms and/or confirmed SDB (Facco et al., 2012 and Pien et al., 2014). We estimated 20% of our

patients may have symptoms of SDB at term. To estimate the sample size for a descriptive study of a dichotomous variable, a sample size estimating table from Hulley et al. (2007) was used. The expected proportion of our sample to screen positive for SDB was 20%. With an estimated proportion of 0.20 positive for SDB, a 95% confidence interval with a total width of 0.10 (0.05 below and 0.05 above), using table 6E our estimated sample size was 246 participants. To account for attrition a total sample of 300 participants were recruited. The population at the site of the study was unique in that active duty military and dependents all have access to the same high-quality health care. None of the participants were uninsured or lacking resources for health care. Additionally, the active duty subjects are required to maintain strict standards for body composition and exercise performance. In theory, the active duty participants were in good health. These two components made it difficult to estimate a prevalence of SDB and adverse pregnancy outcomes for the study.

For the second aim, to examine if parturients suspected of having SDB as assessed by the Facco Four Variable Model (score ≥ 75) and STOP-Bang (score ≥ 3) have higher rates of the adverse pregnancy outcomes (*gestational hypertension, preeclampsia/eclampsia, gestational diabetes, non-elective cesarean delivery, NICU admission, low birth weight <2500 gms, preterm delivery <37 weeks, a composite score of adverse pregnancy outcomes, and a composite score of cardiopulmonary complications (pulmonary embolism, in-hospital mortality, hospital stay >5 days, pulmonary edema, congestive heart failure, cardiomyopathy)*). An analysis was conducted after enrolling the first 300 participants. As previously stated, disparity between initial prevalence estimates of outcome data resulted in a reassessment of sample size and study

feasibility. Based on concerns for time, resources, and feasibility recruitment was halted after an analysis of the initial 300 participants was concluded.

Data Collection Procedures

Patients in the third trimester of pregnancy were asked if they would like to participate in the study “Sleep Disordered Breathing in Pregnancy.” The PI approached the patient about her potential enrollment in the study if she was in the third trimester of pregnancy and met the inclusion criteria with no conditions from the exclusion criteria. Inclusion criterion: any woman eligible for care at MTF presenting for delivery in the third trimester. Exclusion criteria were limited to any patient not wishing to participate in the study, not eligible for care at MTF, not admitted for delivery, and any patient admitted for fetal demise. The patient could refuse to participate at any time and withdraw from the study without any retribution. Written informed consent was obtained, baseline demographic data collected, and the Facco Four Variable and STOP-Bang models were completed. This concluded Phase I of data collection. The participant was told she could refuse to participate at any time and withdraw from the study at any time without any retribution. The second phase of data collection commenced after the participant completed the baseline study data. The electronic medical record was reviewed after birth and data regarding the study outcome variables collected and entered into the study database. This concluded the second phase of data collection.

Instrumentation

Facco Four Variable (FFV) Model. The gold standard for evaluating and diagnosing OSA is an in-laboratory, overnight polysomnogram. Unfortunately, this test is cumbersome, expensive, and time consuming. Alternative methods for screening and

evaluating for obstructive sleep apnea have been developed, but very few have been studied in the pregnant population. The Berlin questionnaire (Netzer et al., 1999) and the Epworth Sleepiness Scale (ESS) (Johns, 1991) are instruments used to screen for sleep disordered breathing and have both been tested in pregnant populations. The Berlin questionnaire and the ESS were used to develop a four variable, pregnancy specific, SDB screening model used in this study.

The Berlin questionnaire (Netzer et al., 1999) is perhaps the most widely used screener for OSA and was originally validated in the primary care setting, but has since been used in the surgical population with moderately high sensitivity (68.9), specificity (56.4), positive predictive value (77.9), and negative predictive value (44.9).¹⁹ The Berlin questionnaire consists of 11 items comprising three categories: snoring, daytime sleepiness, and hypertension. The scoring of the instrument is cumbersome. Items have multiple responses and are assigned a point value which is added with other items in the category to create a category score that will either be “positive” or “negative.” If two of the three categories are positive, the participant is at high risk for OSA. Reports of sensitivity for the Berlin questionnaire range from 54% to 86% with specificity from 43% to 87% in a primary care setting. The sensitivity and specificity of the Berlin questionnaire varies depending upon the level of the apnea-hypopnea index (AHI) used and the population under study. The Berlin questionnaire has been used in pregnant populations. (Sahin et al., 2008)

From the Berlin questionnaire and the ESS, Facco and colleagues (2012) developed a four variable model to screen for SDB during pregnancy. The Berlin and ESS questionnaires were administered to 114 parturients at high-risk for SDB. The study

participants also underwent an at-home overnight sleep study. An item analysis was conducted to determine which items from each questionnaire were of greatest value in accurately identifying a woman as having SDB. Demographic, clinical, and subjective symptoms associated with SDB through univariable analysis were included as covariates in a multivariable logistic regression model with the items from the Berlin and ESS questionnaires. The result of the analysis is the four variable model: pre-pregnancy BMI, age, chronic hypertension, and frequent snoring were independent significant risk factors for SDB. The model consists of a score for these four variables to calculate a total score. The subject receives 15 points for frequent snoring (≥ 3 times per week) and another 15 points if they report chronic hypertension. This sum is added to the summation of their age (years) and BMI. If the total score is ≥ 75 , the model predicts, in a high-risk group, the diagnosis of OSA with a sensitivity of 85.7% (66.4%, 95.3%) and specificity of 73.6% (61.7%, 83.0%) (Facco et al., 2012).

STOP-Bang (SB) Model

STOP-Bang is a model also derived from the Berlin questionnaire. STOP-Bang consists of eight items: S-snoring, T-tired or fatigued, O-observed apnea, P-pressure (high blood pressure), B-body mass index >35 (BMI), A-age, N-neck circumference >40 cm, G-gender (Chung et al., 2008b). SB has a sensitivity of 83.6%, 92.9% and 100% for the AHI cutoff scores of 5, 15, and 30 respectively. The test re-test reliability was found to be 96.4% with a kappa coefficient of 0.923 (CI, 0.82-1.00). For validity, the STOP questionnaire was compared against a one-night-in-laboratory PSG study with a calculated apnea-hypopnea index (AHI) scored by a sleep physician using American Academy of Sleep Medicine practice guidelines. The guidelines classify AHI severity as:

mild AHI 5-15, 15-30 moderate, greater than 30, severe. STOP-Bang model was assessed at the guideline levels with sensitivities of 83.6 % AHI > 5, 92.9 % for AHI > 15, and 100 % for AHI > 30. Each item is a forced choice yes/no question with basic measurements, simple calculations, and easy scoring. Answering “yes” to three or more items indicates a high risk for OSA, answering “yes” to less than three items is a low risk for OSA. The instrument can be completed in a relatively short period of time and provides a simple endpoint of risk assessment for OSA. STOP-Bang was developed for use in sleep clinics, but has been evaluated during pregnancy. A recent study compared SB with the Berlin questionnaire in each trimester of pregnancy in women recruited from a high-risk antenatal clinic in Thailand (Tantrakul et al., 2015). A total of 72 women (23 first trimester, 24 second trimester, 25 third trimester) were recruited, completed both the Berlin and SB questionnaires, and then given an at-home, wrist worn, overnight sleep study. The authors used a unique cutoff point of BMI >27.5 for SB that was determined to be culturally specific for their sample. The study found the ability of SB to recognize OSA was poor in the first trimester (sensitivity = 57.1%, specificity = 87.5%, PPV = 66.7%, NPV = 82.7%, AUC 0.71, p = 0.23, CI 95% = 0.47-0.92), improved in the second trimester (sensitivity = 62.5%, specificity = 93.8%, PPV = 83.3%, NPV = 83.3%, AUC 0.78, p = 0.23, CI 95% = 0.47-0.92), then decreased in the third trimester (sensitivity = 62.5%, specificity = 88.2%, PPV = 71.4%, NPV = 83.3%, AUC 0.75, p = 0.04, CI 95% = 0.53-0.97).

Outcome Data

Maternal Outcome data for this study was based on a review of the literature and comes from studies that have focused on women at high risk for developing SDB

(obesity, diabetes, hypertensive disorders). **Obesity** figures prominently in SDB and multiple measures of body weight and body mass index was assessed. Due to the association of SDB with hypertensive disorders in the general population, diagnosis of **hypertensive disorders of pregnancy** (gestational hypertension, preeclampsia, chronic hypertension) were recorded from the electronic medical record along with any **incidence of pulmonary edema, congestive heart failure, or cardiomyopathy as a composite variable of cardiopulmonary complications**. Cesarean delivery has been associated with obesity in the literature therefore SDB therefore **delivery method** (vaginal vs. cesarean) was collected.

Infant Outcome data included low birth weight (<2500 gms), NICU admission, and gestational age.

Statistical Analysis Plan

Aim 1: To examine the prevalence of SDB at time of delivery using the Facco Four Variable Model and the STOP-Bang model in a general, third trimester, obstetric population who deliver at a large Military Treatment Facility (MTF).

Aim 1 Analysis Plan: To examine the prevalence of SDB, a sample of 300 patients was collected. Descriptive statistics were used to calculate the frequency and prevalence of SDB as indicated by a score ≥ 75 on the Facco Four Variable model and a STOP-Bang score ≥ 3 . Percentages and frequencies were used to describe the results.

Aim 2: To examine if parturients suspected of having SDB as assessed by the Facco Four Variable Model (FFV; score ≥ 75) or the STOP-Bang (SB; score ≥ 3) have higher rates of the following adverse maternal child outcomes: *gestational hypertension, low birth weight <2500 gms, NICU*

admission, Preterm delivery <37 weeks gestation, preeclampsia/eclampsia, gestational diabetes, cesarean delivery, hospital stay >5 days, a composite score of adverse pregnancy outcomes, and a composite score of cardiopulmonary complications that includes pulmonary embolism, in-hospital mortality, pulmonary edema, congestive heart failure, and cardiomyopathy.

Aim 2 Analysis Plan: The outcome variables (gestational hypertension, low birth weight, preeclampsia, gestational diabetes, cesarean delivery, hospital stay > 5 days, and a composite variable of adverse pregnancy outcomes) and the diagnosis of SDB based on a score ≥ 75 on the Facco Four Variable Model and a score of ≥ 3 for the STOP-Bang model were dichotomized. Continuous variables such as age, weight (prepregnancy and at delivery), BMI (prepregnancy and at delivery), neck circumference, gestational age, and length of stay were assessed by *t*-test. Fisher's Exact test was used for dichotomous variables such as prepregnancy BMI >30, primigravid status, pregestational diabetes, previous cesarean delivery, prior preeclampsia, NICU admission, preterm delivery <37 weeks, low birth weight <2500 gms, and chronic hypertension. Next, logistic regression was used to examine the risk of adverse pregnancy outcomes (*gestational hypertension, preeclampsia/eclampsia, gestational diabetes, cesarean delivery, NICU admission, low birth weight <2500 gms, preterm delivery <37 weeks, a composite of adverse pregnancy outcomes, and a composite score of cardiopulmonary complications (pulmonary embolism, in-hospital mortality, hospital stay >5 days, pulmonary edema, congestive heart failure, cardiomyopathy)*) in patients with and without SDB. Within our model we adjusted for several maternal characteristics and other covariates (active duty status,

ethnicity, obesity, advanced maternal age, parity, twin gestation). Adjusted and unadjusted odds ratios (OR) with the 95% confidence interval were calculated. A *p*-value < 0.05 was considered significant.

Aim 3-Exploratory: Compare the prevalence rates of suspected SDB at delivery between active duty and non-active duty parturients.

Aim 3 Analysis Plan: Descriptive statistics were used to calculate the frequency and prevalence of SDB as indicated by a score ≥ 75 on the Facco Four Variable model and a score of ≥ 3 for the STOP-Bang model in each group. Bivariate descriptive statistics were computed to compare active-duty vs. dependent patients with the presence or absence of SDB as determined by each instrument. Percentages and odds ratios with 95% confidence intervals (95% CI) were used to describe the results.

Compliance Plan

The principal investigator was present in the post-partum wards for the recruitment of all participants.

Statement of Assumptions and Protection of Human Subjects

Previous studies have been conducted using similar methods without report of harm to the subject. Completion of a questionnaire involves minimal risk to a subject who is no greater than risk experienced in everyday life.

Fatigue may pose a minimal risk to the subjects while completing the demographic data and questionnaire. Subjects were seated while the PI gathered the data and the entire process took less than 30 minutes to complete. If fatigue occurred, subjects could terminate the session and dis-enroll from the study.

The Principal Investigator is a Naval Officer and Certified Registered Nurse Anesthetist (CRNA) and subjects may be enlisted military members, officers of lower or higher rank, or have preferences about the use of anesthesia for delivery. The risk of coercion or intimidation was addressed by the PI not wearing a military uniform. The subjects were vocally instructed their participation was completely voluntary and they could dis-enroll at any time without any bearing on the healthcare they receive or their military service.

Confidentiality was maintained through the use of a unique subject identifier linked to all gathered data and only the investigators have access to this link. All electronic data is stored on a password-protected computer and the computer stored in a locked case. All of these measures ensure compliance with HIPAA standards.

Safety Precautions and Emergency Protocols

The study involved minimal risk to the subjects and did not interfere with care being rendered for the pregnancy. The interviews were conducted on the hospital grounds and standard Navy medical procedure and hospital policy was deemed sufficient for immediate management of medical events or injuries.

Description of the system for Maintenance of Records

The sources of data for this study are the demographic information file and case report form containing the Facco Four Variable model and STOP-Bang model. All of the instruments were coded with the subject identification number. A master coding list was kept in a locked file in an assigned office at MFT, accessible only to the investigators. No protected health information was on any of the data collection forms or computer files. The principal investigator kept the research protocols and consent forms in a locked

file in an assigned office at NMCSD in compliance with SECNAVINST 3900.39C and BUMEDINST 3900.6B.

CHAPTER IV

RESULTS

The purpose of this study was to examine the prevalence of Sleep Disordered Breathing (SDB) and its association with perinatal complications in pregnant women at delivery using the Facco Four Variable model and the STOP-Bang score at a large Military Treatment Facility (MTF). In this chapter, study results will be presented including sample characteristics and results for each research aim.

Data were collected from March 24, 2015 through June 17, 2015 on 37 data collection days. A total of 320 eligible women were screened on the postpartum wards at a tertiary care Military Treatment Facility (MTF) with 302 women (94%) agreeing to participate and enroll in the study. A database was created using SPSS Statistical Software version 23. After reviewing questionnaires and cleaning the data (excluded twin deliveries), data provided by 295 participants were used for the analyses.

Participant Profile

Study participants were women eligible for care in the Department of Defense, Military Health System and were categorized as either an active duty service member or other. Active duty participants comprised 38.5% (n=116) of the total sample. The active duty group was 86.5 % Navy, 9% Marine Corps, 1.8% Air Force, and 1.8% Army. Enlisted ranks from E2-E8 were represented with the largest portion being E4 with 25.7%, E5 24.8%, and E3 23.9%. Officer participants were considerably smaller in number with only 11 participants (3.8%) whose rank ranged from O1-O4. The sample

was diverse with 51.7% White, 16.2% Latina, 14.2% Black, and 17.9% Other included Asian, Pacific Islander, Native Hawaiian, and Native American/Alaskan Native.

Participants mean age was 27.5 ± 5.27 years with a range of 17-43 years. For 37% of the sample, this was their first delivery (primiparous) and mean gestation was 274 days ± 10.03 (39 weeks, 1 day), range 230 days (32 weeks, 6 days) to 292 days (41 weeks, 5 days). The mean pre-pregnancy weight was 150.68 lbs (68.34 kg) ± 34.10 , range 77 lbs. (34.9 kg) to 284 lbs. (128.82 kg); a mean weight gain of 33.54 lbs ± 6.62 (15.21 kg) range a loss of 13 pounds (5.89 kg) to a maximum gain of 76 lbs. (34.47 kg). At delivery, the mean weight was 184.42 lbs (83.65 kg) with a range of 105-299 lbs (47.62-135.62 kg). For delivery BMI, the mean was 31.26 ± 5.27 with a range of 20.98-46.82. Neck circumference measured at delivery had a mean of 13.98 in ± 2.69 (35.51 cm), range 10.63 in.-17.72 in (27-45 cm). The mean birth weight was 7 lbs 6 oz ± 534.07 (3351.52 gm), range 12.69 oz-10 lbs, 5.64 oz (360 gm-4899 gm). The mean length of stay was 3.57 days ± 1.02 with a range of 2-10 days. See Table 1.

Table 1

Demographic and Clinical Characteristics of Study Population (N = 295)

Characteristic	<i>n</i>	%	<i>M</i>	<i>SD</i>	Range
Age (years)	--	--	27.47	5.30	17 - 43
Race					
White	156	51.7	--	--	--
Hispanic	49	16.2	--	--	--
Black	43	14.2	--	--	--
All Others	54	17.8	--	--	--
Military Status					
Active Duty	116	38.3	--	--	--
Dependent	184	61.1	--	--	--
Body Mass Index (kg/m ²)					
Pre-pregnancy	--	--	25.54	5.22	16 - 45
Delivery	--	--	31.26	5.27	21 - 47
Weight Gain During Pregnancy (kg)	--	--	15.19	6.62	-6 - 35
Gestational Age (days)	--	--	275.19	9.63	230 - 292
Neck Circumference (cm)	--	--	35.51	2.69	27 - 45
Child's Birth Weight (g)	--	--	3355.00	534.07	360 - 4899
Length of Stay at Hospital (days)	--	--	3.56	1.02	2 - 10

Note. *M* = Mean; *SD* = Standard Deviation. Some percentages do not add up to 100 because of missing data.

Comorbidities found in the sample are presented in table 2. Induction of labor was noted in 38.6% (n=115) of deliveries, 22.8% (n=69) had a cesarean delivery, and 6.3% (n=19) delivered prior to term. A pre-pregnancy BMI >30 was noted in 18.7% (n=56). Gestational hypertension was found in 9.9% (n=30), preeclampsia in 9.3% (n=28), and gestational diabetes in 6% (n=18). Of the infants, 7.3% (n=22) were determined to have low birth weight <2500 grams and 10.9% (n=33) required admission to the NICU.

Table 2

Overall Prevalence of Select Comorbidity (N = 295)

Comorbidity	Sleep Disordered Breathing			
	Present		Absent	
	<i>N</i>	%	<i>n</i>	%
Gestational Hypertension	30	9.9	265	90.1
Gestational Diabetes	18	6	289	94.0
Preeclampsia	28	9.3	267	90.7
Preterm Delivery (< 37 weeks)	19	6.3	276	93.7
Low Birth Weight (< 2500 g)	22	7.3	273	92.7
Induction	115	38.6	180	61.4
Cesarean Delivery	69	22.8	226	77.2
NICU Admission	33	10.9	262	89.1
Pre-pregnancy BMI (≥ 30 kg/m ²)	56	18.7	239	81.3

Note. BMI = Body Mass Index; NICU = Neonatal Intensive Care Unit. Some percentages do not add up to 100 because of missing data.

Specific Aim #1

To examine the prevalence of SDB at time of delivery using the Facco Four Variable Model of SDB in pregnancy and the STOP-Bang score ≥ 3 in a general, third trimester, obstetric population who deliver at a large Military Treatment Facility (MTF).

The prevalence of OSA in the sample was 12.3% (n=36) utilizing the Facco Four Variable (FFV) model and 7.1% (n=21) utilizing the STOP-Bang model.

Specific Aim #2

To examine if parturients suspected of having SDB as assessed by the Facco Four Variable Model (FFV; score ≥ 75) or the STOP-Bang score ≥ 3 have higher rates of the following perinatal maternal-infant outcomes: gestational hypertension, low birth weight, preeclampsia/eclampsia, gestational diabetes, cesarean delivery, hospital stay >5 days, a composite score of adverse pregnancy outcomes, and a composite score of cardiovascular complications that includes pulmonary embolism, in-hospital mortality, pulmonary edema, congestive heart failure, and cardiomyopathy.

Parametric and nonparametric tests were used to examine differences in being high-risk for SDB (FFV ≥ 75 or STOP-Bang ≥ 3) and demographic and clinical variables. Chi-square and Fischers Exact tests were used to examine the association between being high-risk for SDB and adverse pregnancy outcomes. Multivariable logistic regression was used to examine if the FFV model (≥ 75) was predictive of a composite adverse pregnancy outcomes variable while controlling for covariates. All potential covariate variables (primagravida, prior cesarean delivery, prior preeclampsia, advanced maternal age, chronic HTN, pregestational DM, obesity, and weight gain during pregnancy) were

entered into the model, those variables with a $p > .10$ were eliminated from the final model, $p < .05$ was significant.

Facco Four Variable Model (FFV) demographics. Using the FFV, 12.3% of participants ($n=36$) screened positive with a score ≥ 75 . Statistically significant differences were found in women who screened positive for SDB versus those who did not (Table 3). Women who screened positive on the FFV with a score ≥ 75 were found to be older (32.9 ± 5 years vs. 26.7 ± 4.7 , $p < .0001$), to have a pre pregnancy BMI >30 (61.1% vs. 12.8%, $p < .0001$), a higher delivery BMI (36.6 ± 5.1 vs 30.5 ± 4.8 , $p < .0001$), a larger neck circumference ($37.7 \text{ cm} \pm 2.3$ vs. 35.2 ± 2.6 $p < .0001$), more chronic hypertension (19.4% vs. 1.6% $p < .0001$), and had a higher incidence of a previous cesarean delivery (30.6% vs. 19.1% $p < .0001$).

Table 3

Demographic and Clinical Characteristics by Facco Four Variable Model Categorical (N = 295)

Variable	Facco (+) n=36		Facco (-) n=259		<i>t</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
Age (years)	32.97	5.02	26.74	4.87	-7.16**
Pre-Pregnancy BMI (kg/m ²)	31.96	6.38	24.64	4.34	-8.87**
Delivery BMI (kg/m ²)	36.58	5.14	30.50	4.84	-7.00**
Gestational Age (days)	273.78	9.74	275.39	9.65	0.94
Neck Circumference (cm)	37.71	2.38	35.18	2.58	-5.91**
	<i>n</i>	%	<i>n</i>	%	χ^2
Race					
White	19	50.0	135	51.5	0.31
Hispanic	42	16.0	7	18.4	
Black	6	15.8	37	14.1	
All Others	6	15.8	48	18.3	
Primigravida	7	19.4	101	39.3	5.35*
Pre-pregnancy BMI ≥ 30	22	61.1	33	12.8	28.25**
Chronic Hypertension	7	19.4	4	1.6	27.84**
Prior Preeclampsia	4	11.1	10	3.9	3.56
Pregestational Diabetes	0	0.0	3	0.2	0.43
Prior Cesarean Delivery	32	30.6	11	12.5	8.12**
Stop-Bang (+)	23	63.9	49	19.1	34.23**

Note. BMI = Body Mass Index; *M* = Mean; *SD* = Standard Deviation. This table only presents *n* and % values for the presence (coded “Yes” = 1) of Primigravida, Pre-Pregnancy BMI ≥ 30 (kg/m²), Chronic Hypertension, Prior Preeclampsia, Pregestational Diabetes, Prior Cesarean Delivery, and Stop-Bang Score ≥ 3 (high-risk for Obstructive Sleep Apnea).

* $p \leq .05$, ** $p \leq .001$.

Facco Four Variable Model (FFV) Chi-Square tests. Subjects who were considered high-risk for SDB based on the FFV ($\text{FFV} \geq 75$) were found to have statistically significantly higher rates of adverse pregnancy outcomes (composite score = 58.3% vs. 39.7%, $p = .027$). Women who screened positive for SBD using the FFV model had a statistically significant higher unadjusted rates of cesarean delivery (36.1% vs. 20.6%, $p = .035$; (Figure 2). (Table 4). Higher rates of gestational hypertension (16.7% vs. 9.3%, $p = .14$), gestational diabetes (8.3% vs. 5.1%, $p = .31$), and NICU admission (11.1% vs. 9.7%, $p = .49$) were found in subjects with $\text{FFV} \geq 75$, but differences were not statistically significant. No patients experienced any cardiopulmonary complications.

Figure 2. Adverse Pregnancy Outcomes by Facco Four Variable Model Categorical ($N = 295$). Facco (+) categorical score = Age (years) + Pre-pregnancy BMI (kg/m^2) + Snoring ≥ 3 days/week (15 points) + Pre-pregnancy Hypertension (15 points). Facco (+) ≥ 75 = positive screening for Sleep Disordered Breathing.

* $p \leq .05$, ** $p \leq .001$.

Table 4

Adverse Pregnancy Outcomes by Facco Four Variable Model Categorical (N = 295)

Variable	Facco (+) n=36 ^a		Facco (-) n=254		χ^2
	<i>n</i>	%	<i>n</i>	%	
APO Composite Score ^b	21	58.3	103	40.1	4.31*
Gestational Hypertension	6	16.7	24	9.3	1.85
Gestational Diabetes	3	8.3	13	5.1	0.66
Preeclampsia	3	8.3	24	9.3	0.04
Preterm Delivery (< 37 weeks)	2	5.6	13	5.1	0.02
Cesarean Delivery	13	36.1	53	20.6	4.34*
Low Birth Weight (< 2500 g)	1	2.8	13	5.1	0.37
NICU Admission	4	11.1	25	9.7	0.07
Length of Stay at Hospital (> 5 days)	1	2.8	12	4.7	0.53

Note. APO = Adverse Pregnancy Outcomes; NICU = Neonatal Intensive Care Unit. This table only presents *n* and % values for the presence (coded “Yes” = 1) of APO Composite Score, Gestational Hypertension, Gestational Diabetes, Preeclampsia, Preterm Delivery (< 37 weeks), Cesarean Delivery, Low Birth Weight (< 2500 g), NICU Admission, and Length of Stay at Hospital (> 5 days). Analysis excluded cases of twin delivery.

^a Facco (+) = Age (years) + Pre-pregnancy BMI (kg/m²) + Snoring ≥ 3 days/week (15 points) + Pre-pregnancy Hypertension (15 points). Facco (+) ≥ 75 = positive screening for Sleep Disordered Breathing.

^b APO Composite Score = “Yes,” if all APOs above are present.

* $p \leq .05$, ** $p \leq .001$.

Logistic regression of Facco Four Variable categorical score (FFV +). A test of full model against a constant only model was statistically significant using the FFV as a categorical variable, indicating predictors, as a set, reliably distinguished between those who had an adverse pregnancy outcome ($X^2 = 33.286$, $p < .0001$, $df = 5$). Hosmer-Lemeshow test indicated the model was a good fit to the data, $X^2 = 7.342$ $df(4)$, $p = .119$. Nagelkerke's R^2 of .133 indicated a small relationship between prediction and grouping. The model correctly classified 64.6% of cases. The Wald criterion demonstrated primigravida, prior cesarean delivery (CSD), and prior preeclampsia made a significant contribution to the probability of a patient having a adverse pregnancy outcome ($p < .05$). The FFV (+) was not significantly associated with adverse pregnancy outcomes ($B = .405$, $Wald = .924$, $p = .336$, $OR = 1.499$, $95\% CI = .657-3.423$). (Table 5).

Table 5

Logistic Regression Analysis for Variables Predicting Adverse Pregnancy Outcomes Utilizing the Facco Four Variable Model Categorical Score. (N = 295)

Predictor	Adverse Pregnancy Outcomes			
	B	SE B	OR	95% CI
Facco (+) ^a	0.595	.388	1.813	[0.85, 3.98]
Primigravida	0.672*	.273	1.958	[1.15, 3.35]
Prior Cesarean Delivery	1.253**	.381	3.499	[1.66, 7.38]
Prior Preeclampsia	2.182**	.794	8.864	[1.87, 42.00]
Constant	-0.934**	.197	0.393	--
χ^2		28.89**		
df		4		
% APO		64.60		

Note. Facco (+) = Facco Four Variable Model Categorical Score (≥ 75); APO = Adverse Pregnancy Outcomes; OR = odds ratio; CI = confidence interval. The APO Composite Score variable includes the following risk factors; Gestational Hypertension, Preeclampsia, Gestational Diabetes, Cesarean Delivery, Low Birth Weight, NICU Admission, Preterm Delivery, and Hospital Stay (> 5 days). Analysis excluded cases of twin delivery.

^a Facco (+) = Age (years) + Pre-pregnancy BMI (kg/m²) + Snoring ≥ 3 days/week (15 points) + Pre-pregnancy Hypertension (15 points). Facco (+) ≥ 75 = positive screening for Sleep Disordered Breathing.

* $p \leq .05$, ** $p \leq .001$.

Logistic regression Faccio Four Variable–Absolute Score. A test of full model against a constant only model was statistically significant using the FFV as a continuous variable using the total score, indicating that predictors, as a set, reliably distinguished between those who had a adverse pregnancy outcome ($X^2 = 32.678$, $p < .0001$, $df = 4$). Hosmer-Lemeshow test indicated the model was a good fit to the data, $X^2 = 7.971$ $df(8)$, $p = .436$. Nagelkerke's R^2 of .143 indicated a small relationship between prediction and grouping. The model correctly classified 66.3% of cases. The Wald criterion demonstrated FFV-AS, primagravida, prior cesarean delivery (CSD), and prior preeclampsia made a significant contribution to the probability of a patient having a adverse pregnancy outcome ($p < .05$). The FFV-AS was significantly associated with adverse pregnancy outcomes ($B = .028$, $Wald = 6.193$, $p = .013$, $OR = 1.028$, $95\% CI = 1.006-1.051$). As the FFV-AS score increased, the odds of an adverse pregnancy outcome increase by 1.028. (Table 6)

Table 6

Logistic Regression Analysis for Variables Predicting Adverse Pregnancy Outcomes Utilizing the Facco Four Variable Model Continuous Score. (N = 295)

Predictor	Adverse Pregnancy Outcomes			
	B	SE B	OR	95% CI
Facco Score ^a	0.028*	.011	1.028	[1.01, 1.05]
Primigravida	0.684*	.277	1.982	[1.15, 3.41]
Prior Cesarean Delivery	1.094**	.389	2.986	[1.39, 6.40]
Prior Preeclampsia	-2.212**	.795	9.137	[1.93,
Constant	-2.499**	.693	0.082	--
χ^2		32.68**		
df		4		
% APO		66.30		

Note. Facco Score = Facco Four Variable Model Continuous Score; APO = Adverse Pregnancy Outcomes; OR = odds ratio; CI = confidence interval. The APO Composite Score variable includes the following risk factors; Gestational Hypertension, Preeclampsia, Gestational Diabetes, Cesarean Delivery, Low Birth Weight, NICU Admission, Preterm Delivery, and Hospital Stay (> 5 days). Analysis excluded cases of twin delivery.

^a Facco Score = Age (years) + Pre-pregnancy BMI (kg/m²) + Snoring $\geq$ 3 days/week (15 points) + Pre-pregnancy Hypertension (15 points).

* $p \leq .05$, ** $p \leq .001$.

STOP-BANG demographics. Compared to the 36 women who screened positive on the FFV, only 21 women screened positive on the STOP-Bang. Women who screened positive for SDB with a STOP-BANG ≥ 3 score had some significant differences from those that who did not. (Table 7), specifically weight and body mass index (BMI). Pre-pregnancy weight (190.3 ± 39.3 vs. 147.6 ± 32.0 t (292) = 5.795, $p = <.001$), pre-

pregnancy BMI (31.7 ± 6.3 vs. 25.1 ± 4.8 , $p = <.0001$), delivery weight (224.7 ± 24.7 vs. 181.0 ± 33.9 , $p = <.0001$), and delivery BMI (37.6 ± 3.6 vs. 30.80 ± 5.1 , $p = <.0001$), and pre-pregnancy BMI $>30\%$ (61.9 vs. 15.4 , $p = <.0001$). More women with chronic hypertension (14.3% vs. 2.9% , $p = .036$) screened positive, as well as those with a larger neck circumference (39.5 cm vs. 35.2 cm, $t(292) = 7.667$, $p <.0001$). Prepregnancy BMI >35 , chronic hypertension, and age are all factors in the STOP-Bang model and greater percentages among women that screened positive with the instrument can be expected. A longer hospital stay was also noted among women who screened positive for SDB (4.0 ± 1.2 days vs. 3.5 ± 1.0 days, $t(288)=2.091$, $p = .037$).

Table 7

Demographic and Clinical Characteristics by Stop-Bang Categorical (N = 295)

Variable	Stop-Bang (+)		Stop-Bang (-)		<i>t</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
Age (years)	29.48	6.02	27.32	5.22	-1.80
Pre-pregnancy BMI (kg/m ²)	31.71	6.31	25.07	4.82	-5.95**
Delivery BMI (kg/m ²)	37.55	3.58	30.77	5.06	-6.02**
Gestational Age (days)	273.62	11.36	275.31	9.50	0.78
Neck Circumference (cm)	39.48	2.49	35.21	2.46	-7.67**
	<i>n</i>	%	<i>n</i>	%	χ^2
Race					
White	8	38.1	148	52.7	
Hispanic	4	19.0	45	16.0	4.33
Black	6	28.6	37	13.3	
All Others	3	14.3	51	18.1	
Primigravida	7	33.3	14	36.2	0.13
Pre-pregnancy BMI ≥ 30	13	61.9	42	15.4	27.6**
Chronic Hypertension	3	14.3	8	2.9	6.98**
Prior Preeclampsia	1	4.8	13	4.8	0.00
Pregestational Diabetes	0	0.0	3	1.1	0.23
Prior Cesarean Delivery	4	19.0	39	14.3	0.35

Note. BMI = Body Mass Index; *M* = Mean; *SD* = Standard Deviation. This table only presents *n* and % values for the presence (coded “Yes” = 1) of Primigravida, Pre-Pregnancy BMI ≥ 30 (kg/m²), Chronic Hypertension, Prior Preeclampsia, Pregestational Diabetes, Prior Cesarean Delivery, and Stop-Bang Score (+) ≥ 3 (high-risk for Obstructive Sleep Apnea).

*p $\leq .05$, **p $\leq .001$.

STOP-BANG Chi-Square tests. Subjects who were considered high-risk for SDB based on the STOP-Bang score ≥ 3 were found to have statistically significant higher rates of several adverse pregnancy outcomes (table 8): composite score (66.7% vs. 40.9%, $p = .019$), gestational hypertension (33.3% vs. 8.4%, $p = .002$), and cesarean delivery (42.9% vs. 21.2, $p = .027$). Higher rates of preeclampsia (19.0% vs. 8.4%, $p = .112$) and low birth weight <2500 grams (9.5% vs. 4.8%, $p = .293$), and NICU admission (19.0% vs. 9.5%, $p = .152$), were found, but did not reach statistical significance. Similar rates of gestational diabetes (5.5% vs. 5.4%, $p = .590$), pre-term delivery less than 37 weeks (4.8% vs. 5.1%, $p = .710$), and length of stay greater than 5 days (0% vs. 2.3%) were found in subjects with a STOP-Bang score ≥ 3 . No participants experienced any cardiopulmonary complications.

Table 8

Adverse Pregnancy Outcomes by Stop-Bang Categorical (N = 295)

Variable	Stop-Bang (+) ^a		Stop-Bang (-)		χ^2
	<i>n</i>	%	<i>n</i>	%	
APO Composite Score ^b	14	66.7	112	40.9	5.30*
Gestational Hypertension	7	33.3	23	8.4	13.28**
Gestational Diabetes	1	4.8	15	5.5	0.02
Preeclampsia	4	19.0	23	8.4	2.66
Preterm Delivery (< 37 weeks)	1	4.8	14	5.1	0.01
Cesarean Delivery	9	42.9	58	21.2	5.23*
Low Birth Weight (< 2500 g)	2	9.5	13	4.8	0.90
NICU Admission	4	9.5	26	19.0	1.95
Length of Stay at Hospital (> 5 days)	3	14.3	10	3.6	5.55

Note. APO = Adverse Pregnancy Outcomes; NICU = Neonatal Intensive Care Unit. This table only presents *n* and % values for the presence (coded “Yes” = 1) of APO Composite Score, Gestational Hypertension, Gestational Diabetes, Preeclampsia, Preterm Delivery (< 37 weeks), Cesarean Delivery, Low Birth Weight (< 2500 g), NICU Admission, and Length of Stay at Hospital (> 5 days). Analysis excluded cases of twin delivery.

^a Stop-Bang (+) continuous score was calculated. A Stop-Bang (+) ≥ 3 indicated high-risk for Obstructive Sleep Apnea; a Stop-Bang (-) < 3 indicated low-risk for Obstructive Sleep Apnea.

^b APO Composite Score = “Yes,” if all APOs above are present.

* $p \leq .05$, ** $p \leq .001$.

Logistic regression of STOP-BANG ≥ 3 = High Risk. A test of full model against a constant only model was statistically significant, indicating that predictors, as a set, reliably distinguished between those who had a adverse pregnancy outcome ($X^2 = 31.806$, $p < .0001$, $df = 4$). (Table 9) Hosmer-Lemeshow test indicated the model was a good fit to the data, $X^2 = .088$ $df(2)$, $p = .957$. Nagelkerke's R^2 of .138 indicated a small relationship between prediction and grouping. The model correctly classified 65.5% of cases. The Wald criterion demonstrated SB High Risk, primigravida, prior cesarean delivery (CSD), and prior preeclampsia made a significant contribution to the probability of a patient having an adverse pregnancy outcome ($p < .05$). The SB High Risk was significantly associated with adverse pregnancy outcomes ($B = 1.167$, $Wald = 5.503$, $p = .019$, $OR = 3.211$, $95\% CI = 1.211-8.510$). As the SB High Risk score increased, the odds of an adverse pregnancy outcome increase by 3.21. (Figure 3).

Table 9

Logistic Regression Analysis for Variables Predicting Adverse Pregnancy Outcomes Utilizing the Stop-Bang Categorical Score. (N = 295)

Predictor	Adverse Pregnancy Outcomes			
	B	SE B	OR	95% CI
Stop-Bang (+) ^a	1.167	.497	3.211	[1.21, 8.51]
Primigravida	0.657	.273	1.928	[1.13, 3.29]
Prior Cesarean Delivery	1.314	.380	3.721	[1.77, 7.84]
Prior Preeclampsia	2.311	.796	10.081	[2.12, 47.98]
Constant	-0.932	.194	0.394	--
χ^2		31.81**		
<i>df</i>		4		
% APO		65.50		

Note. APO = Adverse Pregnancy Outcomes; OR = odds ratio; CI = confidence interval. The APO Composite Score variable includes the following risk factors; Gestational Hypertension, Preeclampsia, Gestational Diabetes, Cesarean Delivery, Low Birth Weight, NICU Admission, Preterm Delivery, and Hospital Stay (> 5 days). Analysis excluded cases of twin delivery.

^a Stop-Bang (+) continuous score was calculated. A Stop-Bang (+) ≥ 3 indicated high-risk for Obstructive Sleep Apnea; a Stop-Bang score (-) < 3 indicated low-risk for Obstructive Sleep Apnea.

* $p \leq .05$, ** $p \leq .001$.

Figure 3. Adverse Pregnancy Outcomes by Stop-Bang (+) ($N = 295$). Stop-Bang (+) ≥ 3 indicated high-risk for Obstructive Sleep Apnea; a Stop-Bang (-) < 3 indicated low-risk for Obstructive Sleep Apnea.

* $p \leq .05$, ** $p \leq .001$.

Exploratory Aim. Compare demographic, outcomes data, and the prevalence rates of suspected SDB at delivery between active duty (AD) and non-active duty or dependent (DEP) parturients.

Exploratory aim demographics. Of 294 participants, 38.6% (n=114) were active duty and 60.7% (n=179) were dependents (Table 10). An independent samples t-test was conducted on demographic and outcomes data and statistically significant differences were found between active duty and dependents in age and weight gained during pregnancy. Active duty participants were younger (M=25.55, SD=4.68) compared to dependents (M=28.71, SD=5.33), ($t(291) = 5.179, p=.0001$). Weight gain during pregnancy was greater among active duty (M=38.50 lbs, SD=15.19) compared to dependents (M=30.40 lbs, SD=13.54) ($t(285) = 4.701, p=.0001$). Active duty women were more likely to be primigravid (47.4% versus 30.7%) Pearson $\chi^2 = 8.859, df(2), p=.012$.

A significant association was noted between a positive FFV score and active duty status, with active duty subjects having significantly lower rates of SDB as defined by the FFV model (≥ 75 ; active duty: 16.7% (n=6) vs dependents: 83.3% (n=30) Pearson Chi-Square = 8.663, $df(2), p=.013$). When utilizing the STOP-Bang instrument 7.1% (n=21) of participants screened positive for SDB. Of the 21 positive screenings, 42.9% (n=9) were active duty compared to 57.1% (n=12) dependents.

For adverse pregnancy outcomes, 42.5% (n=125) of participants experienced an adverse pregnancy outcome. There was no association between active duty or dependent status and the rate of adverse pregnancy outcomes. Of the active duty participants, 39.5% (n=45) had an adverse pregnancy outcome while 44.7 % (n=80) of dependents experienced one (Pearson Chi-Square = 1.518 $df(2), p=.468$).

Table 10

Demographic and Clinical Characteristics of Study Population by Military Status (N = 295)

Variable	Active Duty		Dependents		<i>t</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
Age (years)	25.55	4.68	28.71	5.33	-5.18**
Pre-Pregnancy BMI (kg/m ²)	25.12	3.76	25.82	5.98	-1.11
Delivery BMI (kg/m ²)	31.62	4.51	31.07	5.71	0.87
Gestational Age (days)	276.08	9.70	274.57	9.60	1.31
Neck Circumference (cm)	35.55	2.54	35.50	2.80	0.16
	<i>n</i>	%	<i>n</i>	%	χ^2
Race					
White	55	47.4	100	54.3	
Hispanic	18	15.5	30	16.3	13.40*
Black	25	21.6	18	9.8	
All Others	116	100.0	184	100.0	
Primigravida	54	47.4	55	30.7	8.86*
Pre-pregnancy BMI ≥ 30	16	13.9	40	21.9	3.16
Chronic Hypertension	2	1.8	9	5.1	2.14
Prior Preeclampsia	4	3.5	10	5.6	0.75
Pregestational Diabetes	2	1.8	1	0.6	1.00
Prior Cesarean Delivery	9	7.9	33	18.6	6.68*
Stop-Bang (+)	26	22.8	47	26.3	0.78

Note. BMI = Body Mass Index; *M* = Mean; *SD* = Standard Deviation. This table only presents *n* and % values for the presence (coded "Yes" = 1) of Primigravida, Pre-Pregnancy BMI ≥ 30 (kg/m²), Chronic Hypertension, Prior Preeclampsia, Pregestational Diabetes, Prior Cesarean Delivery, and Stop-Bang Score ≥ 3 (+) (high-risk for Obstructive Sleep Apnea).

* $p \leq .05$, ** $p \leq .001$.

CHAPTER V

DISCUSSION

In this study two different instruments were used to assess the prevalence of sleep disordered breathing (SDB) in a general pregnant population presenting for delivery at a tertiary care military treatment facility (MTF). The overall prevalence of sleep disordered breathing in the general population at time of delivery using the Facco Four Variable (FFV) model was 12.3% and 7.1% using STOP-Bang (SB). The FFV is relatively new and purpose-built for the obstetric population while SB was designed for the pre-operative surgical population and is used extensively throughout the military health system in primary care and anesthesia preoperative clinics. Screening positive for SDB showed strong associations with gestational hypertension and cesarean delivery—both of which are morbidities with adverse effects on pregnancy outcomes. Pregnancy is a biologically active portion of a woman's life that can have a profound influence on future health. The inflammation caused by SDB seem to have adverse physiological effects on a woman's health and how her infant is delivered. This adds to the significance of our results and demonstrates a need to improve awareness, interventions for, and further research of SDB in the pregnant population. As we discovered, a significant percentage of women are at risk for SDB yet few are aware of this risk. All of the participants who screened positive were essentially undiagnosed cases of SDB as none had undergone screening or objective testing for SDB prior to participating in this study. This “unknown” risk is significant and, at first, surprising. However, SDB is underdiagnosed and underreported in women—especially during pregnancy (J. Louis, Auckley, & Bolden, 2012). Another concern is the persistence of the SDB diagnosis after delivery. Does the

rapid reduction in weight and BMI resolve SDB? What is the relationship of SDB, sleep fragmentation, and fatigue in the postpartum period? There are many questions that still need to be investigated about SDB and pregnancy.

The FFV was created, based on the Berlin questionnaire, to screen pregnant women at high risk for SDB (Facco et al., 2012). Pregnant women at increased risk for SDB may have chronic hypertension, pre-gestational diabetes, obesity, or prior a history of preeclampsia. The prevalence of SDB in populations with these risk factors can range from 15.4% (Pien et al., 2014) to over 45% (Facco et al., 2014). In this study, the FFV was applied to a general pregnant population and participants were not pre-selected based on attributes for increased risk of SDB. This is a unique aspect of this study and a new application for the FFV. Early studies, such as the Wisconsin Sleep Cohort Study (WSCS, Young, 1993), focused on the general adult population. The WSCS found an initial prevalence of SDB for adult women was 9%, much higher than the estimated 2% at the study's inception, but still significantly less than the 24% prevalence for men (Young, 1993). The 12.3% prevalence found in our study suggests there may be an increased amount of SDB during pregnancy, which may be related to the weight gain and physiological changes of pregnancy which affect airway architecture. Because formal sleep studies were not performed, we cannot confirm patients enrolled had SDB, and it is unknown what percentage of them would have SDB symptoms resolve after pregnancy. It should be noted the first exclusion criteria for the Wisconsin Sleep Cohort Study was pregnancy and for enrollment the participants were between 30-60 years of age. The WSCS study was initiated over 20 years ago and the prevalence of obesity and SDB have since risen dramatically since then (J. M. Louis et al., 2014).

Increased body weight and body mass index (BMI) figured prominently in the study reported here. Both instruments include measures of BMI as factors to identify SDB risk and they highlight the relationship between body weight and SDB in pregnancy. For women who screened positive with the FFV, more presented with a pre-pregnancy BMI >30 , a larger neck circumference, and had a higher BMI at delivery than those who screened negative. Using SB, women who screened positive had a higher pre-pregnancy weight, pre-pregnancy BMI, neck circumference, higher delivery weight and delivery BMI, and a greater percentage with a pre-pregnancy BMI >30 . Complications of maternal obesity in pregnancy include gestational diabetes, preeclampsia, cesarean delivery, low apgar scores, and macrosomia (Ovesen et al., 2011). Patients screening positive on the FFV and SB had significantly higher rates of cesarean delivery, a finding consistent with obesity in pregnancy.

For this study, a pre-pregnancy BMI >30 was noted in 18.7% of participants compared to a national prevalence of obesity (BMI ≥ 30) reported as 35.8% among adult women (Flegal et al., 2012). Our sample contains 38.5% (n=116) active duty women who are required to maintain physical fitness and BMI standards as part of their military service. In addition, all participants have access to high quality healthcare through the Department of Defense, Military Health System and the study inclusion criteria required eligibility for care and enrollment in this system. Clinical settings with higher rates of obesity and possibly with less access to healthcare may have a greater prevalence of obesity and ultimately, SDB. Based on the results of this study, excess weight gain and elevated BMI are significant factors in the development of SDB.

Limitations

Results from this study must be viewed in light of the following limitations. This study lacks objective verification for the diagnosis of sleep disordered breathing. Both the FFV and SB are screening tools used to help make decisions about whether further diagnostic intervention is needed; neither is able to provide more than a suspected range for an apnea-hypopnea index value. While the FFV has been validated with PSG in a population at high-risk for SDB it has not been validated in the general obstetric population. Similarly, while SB has been extensively validated in the surgical population using PSG, there are limited studies that have been conducted in the obstetric population. Recently, a study compared SB with the Berlin questionnaire in each trimester of pregnancy in women recruited from a high-risk antenatal clinic in Thailand (Tantrakul et al., 2015). A total of 72 women (23 first trimester, 24 second trimester, 25 third trimester) were recruited, completed both the Berlin and SB questionnaires, and then given an at-home, wrist worn, overnight sleep study. The authors used a unique cutoff point of BMI >27.5 for SB that was determined to be culturally specific for their sample. The study found the sensitivity to identify patients with OSA was poor in the first trimester (sensitivity = 57.1%, specificity = 87.5%, PPV = 66.7%, NPV = 82.7%, AUC 0.71, $p = 0.23$, CI 95% = 0.47-0.92), improved in the second trimester (sensitivity = 62.5%, specificity = 93.8%, PPV = 83.3%, NPV = 83.3%, AUC 0.78, $p = 0.23$, CI 95% = 0.47-0.92), and decreased in the third trimester (sensitivity = 62.5%, specificity = 88.2%, PPV = 71.4%, NPV = 83.3%, AUC 0.75, $p = 0.04$, CI 95% = 0.53-0.97). The high specificity in all three trimesters suggests patients who screened positive most likely had OSA, but the moderate sensitivity suggests we cannot be certain if a patient screened

negative that they do not have OSA. The positive predictive value was the highest in the second trimester, with 83.3% screening SB positive having confirmed OSA based on an apnea hypopnea index (AHI) ≥ 5 events per hour. This suggests the second trimester may be the best time to screen women for OSA; however, earlier screening during the first trimester may allow for earlier intervention. The decrease in the positive predictive value in the third trimester is somewhat counterintuitive given that weight gain during pregnancy, in the majority of cases, will increase until delivery. It would be expected that symptoms of SDB would peak during the third trimester with maximum weight, BMI, and symptoms occurring at delivery and most easily recognized. Comparatively, a recent study by Facco et al. (2014), found the prevalence of SDB increased during pregnancy among a cohort of women at high-risk for SDB. A prospective observational study involving 128 women screened as high-risk for developing SDB underwent an at-home sleep study at 6-20 weeks gestation and repeated in the third trimester. Worsening or increasing severity of SDB during pregnancy was noted in 27% of the population and the incidence of new-onset SDB was 20%. One explanation for this difference may be that in the Tantrakul et al. (2015) study, a single cohort of women was not followed throughout pregnancy. The dynamic process and continuous changes throughout pregnancy may require continuous monitoring and screening for optimal risk assessment regardless of the instrument used. The SB instrument, well known for ease of use and reliability in the surgical population, will require further validation and refinement for use during pregnancy.

Self-reporting of symptoms and co-morbidities is another limitation of this study. Participants were asked to self-report the loudness of their snoring and the presence of

apneic episodes that occur while the participant is asleep. The case report form included questions to elicit a bed partner or roommate's assessment of snoring and apneic episodes. Overall, 90.3% of respondents reported having a bed partner, 3% reported a partner/roommate in another room, and 6.7% reported no bed partner or roommate at all. Participants were not monitored during completion of the case report form and bed partner or roommate participation was not verified. There is some evidence of disagreement in which the self-report was negative for symptoms while the bed partner's report was positive for symptoms and vice-versa. Without direct engagement of the bed partner or roommate it is difficult to ascertain their involvement in the completion of the case report form and accuracy of responses. An objective and quantifiable measure of SDB, such as an at-home sleep study, would have greatly strengthened the results.

There are several types of hypertension during pregnancy: chronic hypertension, preeclampsia-eclampsia, chronic hypertension with superimposed preeclampsia, gestational hypertension, and postpartum hypertension (American College of Obstetricians and Gynecologists. Task Force on Hypertension in Pregnancy & American College of Obstetricians and Gynecologists, 2013). For this study, only chronic hypertension prior to pregnancy was used in scoring of the instruments. Both the FFV and SB instruments are derived from the Berlin questionnaire to screen for SDB/OSA but in different populations. FFV focused on women at high risk for SDB during pregnancy and SB for OSA in the surgical population (Chung et al., 2008b; Facco et al., 2012). The Berlin Questionnaire uses chronic hypertension as a factor in screening for OSA and was designed for primary care settings (Netzer, Stoohs, Netzer, Clark, & Strohl, 1999). This methodology has been carried over in the wording of both instruments in this study as

“chronic hypertension” and “high blood pressure” were used in the case report form without discussion of “preeclampsia-eclampsia” or “gestational hypertension”. The diagnosis of chronic hypertension came from the physician’s history and physical as reported in the medical record. Including gestational hypertension and preeclampsia in this study most likely would have resulted in a greater percentage of women screened as “positive” for SDB, but not necessarily improved the sensitivity and specificity of the instruments. Chronic hypertension has a different physiologic mechanism than gestational hypertension and preeclampsia despite the common outcome of elevated systemic blood pressure. This may have been the reason for the decreased sensitivity of SB noted by Tantrakul et al (2015). Of the 72 women enrolled, 13 (18.1%) had hypertension. However, chronic hypertension was diagnosed in just 2 participants while 11 were diagnosed with preeclampsia. There may still be a relationship between SDB and the hypertensive disorders of pregnancy. Future studies should include methodology to parse out such differences.

Despite these limitations, findings from this study advances our understanding of strategies for screening for SDB during pregnancy. Overall, the study found a prevalence of SDB by the Facco Four Variable Model of 12.3% and 7.1% by the STOP-Bang model in the general pregnant population presenting for delivery at a large military treatment facility. Strong associations with cesarean delivery and gestational hypertension were noted. Obesity continues to play a role in SDB as those who screened positive with either model were more likely to have elevations of weight and or BMI both in the beginning of pregnancy and at delivery. The study population was unique with 38.5% active duty military members who are required to meet specific health requirements for weight and

BMI. The prevalence of obesity was almost half of a national estimate and all of the participants had access to high quality healthcare throughout pregnancy.

Conclusion

Routine screening for SDB during pregnancy utilizing the FFV model should be conducted. Increased awareness of SDB and the effects of sleep on overall health is noted in scientific and popular literature. In the past, a lack of screening tools specific to the population under study and the use of clinic-based polysomnography (PSG) were obstacles that had to be overcome in order to diagnose and treat SDB. New technology has brought the ability to conduct at-home sleep studies that rival clinic based PSG- possibly the most important recent advance in sleep medicine. The at-home monitors are less expensive, applied by the patient, and physically less of a burden to sleep with (Facco et al., 2012). These new devices may facilitate research by providing more objective, quantifiable information about SDB. An at-home testing device could facilitate the development of more accurate screening instruments, a lower threshold for testing, earlier detection and the opportunity for repeated testing to track progression, treatment, and resolution of SDB. Further research is needed to determine critical points in the development and management of SDB during pregnancy, if or when SDB resolves after delivery, and the long-term health effects that may occur for both mother and child.

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APPENDIX A

Institutional Review Board Project Action Summary

Action Date: March 20, 2015   *Note: Approval expires one year after this date.*

Type: ☐ New Full Review ☒ New Expedited Review ☐ Continuation Review ☐ Exempt Review
☐ Modification

Action: ☒ Approved ☐ Approved Pending Modification ☐ Not Approved

Project Number: 2015-03-196

Researcher(s): Ryan Nations Doc SON
Dr. Cynthia Connelly Fac SON
Research Assistants TBD

Project Title: Prevalence of Sleep Disordered Breathing & its Association with Maternal-Infant
Complications in Parturients Delivering at a Large Military Treatment Facility

*Note: We send IRB correspondence regarding student research to the faculty advisor,
who bears the ultimate responsibility for the conduct of the research. We request
that the faculty advisor share this correspondence with the student researcher.*

Modifications Required or Reasons for Non-Approval

None

The next deadline for submitting project proposals to the Provost's Office for full review is N/A. You may submit a project proposal for expedited review at any time.

Dr. Thomas R. Herrinton
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REQUEST FOR CLEARANCE FOR AUTHORIZED WORK		
A. AUTHOR		
1. Name (Last, First, MI) NATIONS, RYAN L	2. Grade / Rank O-5/CDR	3. Title
4. Command / Workplace NMCSO/DUINS/USD	5. E-Mail Address ryannations13@gmail.com	6. Telephone Number (Include Area Code) 858705-4472
B. AUTHORED WORK		
1. Authored Work Title Sleep Disordered breathing and pregnancy: prevalence and outcomes at delivery		
2. Relevance of authored work to operational medicine / Navy Medicine Active duty pregnant women participated in a study to screen for Sleep Disordered Breathing (SDB) to determine prevalence of SDB and relationship to Adverse Pregnancy Outcomes (APO's).		
3. Summary of media sensitive subject matter Active duty pregnant women and adverse pregnancy outcomes		
4. Format		
a. Select type of Authored Work Journal Article		
b. Publication Date (DD MMM YYYY) 31 Dec 2015		
c. Audience Nurse anesthetists, health care providers for women and pregnancy		
d. Article Name Sleep Disordered Breathing and Pregnancy: prevalence and outcomes at delivery		
e. Publication Name ProQuest		
f. List Publications Where Article Was Previously Published None		
5. Synopsis (In layman's terms)		
a. Background Increased obesity rates have been seen in pregnancy. Sleep disordered breathing is strongly associated with obesity. Pregnancy is similar to obesity in that there is a rapid increase in weight and body mass index. More women are experiencing obesity prior to becoming pregnant and maintaining above average weight gains and BMI throughout pregnancy. What is the prevalence of SDB in pregnancy? Does having SDB in pregnancy lead to adverse pregnancy outcomes?		
b. Results In this study, 12.3% of women screened positive for SDB using the Facco Four Variable Model of SDB. Screening positive for SDB was associated with an increased risk of hypertension and cesarean delivery.		
c. Conclusions Sleep disordered breathing during pregnancy was found in 12.3% of the study population using the Facco four variable model. Sleep disordered breathing was associated with hypertension and cesarean delivery. None of the women that screened positive for SDB had been previously screened or diagnosed with SDB.		
d. Sensitive Areas / Media Interest Pregnant women, active duty		
C. LOCAL / REGIONAL PUBLIC AFFAIRS OFFICER		
I have reviewed this authored work and request a BUMED/PA review and approval		
1. Name LT Jill S Cunningham	2. Grade / Rank LT/O3	3. Telephone Number (Include Area Code) 301-319-8055
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D. BUMED PUBLIC AFFAIRS		
1. Approval		
☒ a. BUMED Public Affairs has approved for submission / presentation	Date	12/31/15
☐ b. BUMED Public Affairs has forwarded for higher review	Date	
☐ c. BUMED Public Affairs has received from higher review	Date	
☒ d. BUMED Public Affairs has notified sender	Date	12/31/15
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