Nurse Titration of Oxytocin for Post-Dates Labor Induction Across Body Mass Index Categories

BY

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DISSERTATION

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This dissertation is dedicated to a handful of friends and family.

To my husband, Tim, who has always stood by me, encouraged me, made me laugh, and brought me much happiness.

To my parents, who taught me the value of hard work.

To my sister, Andrea, who understands me better than anyone.

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LIST OF ABBREVIATIONS

APGAR	Appearance, Pulse, Grimace, Activity, and Respiration
BMI	Body Mass Index
CDC	Centers for Disease Control and Prevention
CINAHL	Cumulative Index of Nursing and Allied Health Literature
CNM	Certified Nurse Midwife
ECF	Extracellular Fluid
EFM	External Fetal Monitor
FHR	Fetal Heart Rate
ISMP	Institute for Safe Medication Practices
IUPC	Intrauterine Pressure Catheter
Kg	Kilograms
MeSH	Medical Subject Headings
mu/min	Milliunits per minute
MVU	Montevideo Units
NICU	Neonatal Intensive Care Unit
OB-GYN	Obstetrician Gynecologist
PPH	Postpartum Hemorrhage
RCT	Randomized Controlled Trial
SES	Socioeconomic Status
SVE	Sterile Vaginal Examination
Toco	Tocodynamometer
TOL	Trial of Labor
UC	Uterine Contraction
VBAC	Vaginal Birth After Cesarean

SUMMARY

This dissertation consists of an integrative literature and a retrospective cohort study. In the literature review, I aimed to describe nurses' oxytocin administration practices, related nursing interventions, and labor outcomes for overweight and obese women who received oxytocin infusion during the intrapartum period. In the original research study, I aimed to determine whether intrapartum nurses administer oxytocin infusion differently among normal weight, overweight, and obese women, and whether any differences in administration were related to differences in labor outcomes.

For the literature review, I used the scoping methodology for guidance in study selection, data abstraction, and data interpretation. Five studies met inclusion criteria. Two studies were retrospective and observational, and three studies were secondary analyses. Oxytocin administration variables reported included duration of oxytocin infusion, maximum rate of infusion, and total oxytocin infused in labor. The main labor outcomes reported were length of labor and method of delivery. Oxytocin-related nursing interventions (fetal heart rate and contraction monitoring) were reported in four out of five studies but were not measured in any. Authors of these five studies reported that more oxytocin is administered with increasing BMI, but length of labor becomes longer with increasing BMI and cesarean delivery rates increase with increasing BMI.

For the retrospective cohort study, electronic medical records were accessed for women who delivered between January 1, 2013 and June 30, 2013 and received oxytocin infusion for post-dates labor induction. After charts were screened for inclusion and exclusion criteria, 280 women's charts were included in the study. These women were grouped according to BMI at labor admission: normal weight (BMI < 25.0),

overweight (BMI 25.0 to 29.9), and obese (BMI ≥30.0). Oxytocin administration variables (e.g., total oxytocin infused, highest infusion rate, length of infusion), and labor outcomes (length of labor and method of delivery) were compared across BMI groups while controlling for maternal characteristics, labor interventions, and provider type. Obese women received more total oxytocin than overweight women, length of labor increased with increasing BMI group, and cesarean delivery rate increased with increasing BMI group.

I. OXYTOCIN ADMINISTRATION AND NURSING INTERVENTIONS FOR WOMEN OF VARYING BMI GROUPS: EXAMINING THE EVIDENCE

A. Introduction

Over the past decade there has been a dramatic rise in the use of oxytocin infusion during labor and obesity among pregnant women. Obese women receiving oxytocin during labor require high quality evidence-based nursing care to ensure efficacy and patient safety. Evidence for current intrapartum nursing practice for obese women focuses on health concerns specific to physiologic changes associated with pregnancy and obesity (Cesario, 2003; Mahlmeister, 2007; Morin & Reilly, 2007; Nodine & Hastings-Tolsma, 2012). These health concerns associated with obesity place women and their infants at high risk of adverse perinatal outcomes such as longer length of labor, cesarean delivery, post partum hemorrhage (PPH), macrosomia, shoulder dystocia, and neonatal hypoglycemia (Bhattacharya, Campbell, Liston, & Bhattacharya 2007; Garabedian, Williams, Pearce, Lain, & Hansen, 2011; Liu, Dai, Dai, & Li, 2012; Usha Kiran, Hemmadi, Bethel, & Evans 2005; & Yu et al., 2013). Obese women also have higher rates of failed vaginal birth after cesarean (VBAC), with obese women 47% more likely to have a failed VBAC than underweight women (Juhasz, Gyamfi, Gyamfi, Tocce, & Stone 2005). One group of authors found that the incidence of failed trial of labor (TOL) was 39.3% for morbidly obese women compared to 15.2% for normal weight women, and that morbidly obese women are at a 5 times greater risk for uterine rupture during vaginal TOL compared with normal weight women (Hibbard et al., 2006).

As the obesity epidemic has increased, rates of labor induction have also increased. Between 1990 and 2010, rates of labor induction nearly tripled rising from

9.5% to 23.4% (Martin et al., 2009; Martin et al., 2012). Rates of labor induction are higher in obese women with 28% of normal weight women experiencing labor induction and 34% of class III obese women experiencing labor induction (Wolfe, Rossi, & Warshak 2011).

Intravenous oxytocin, used to stimulate uterine contractions for labor induction and augmentation to achieve vaginal birth more quickly while reducing adverse outcomes (Budden, Chen, & Henry, 2014), is one of 12 high-alert medications according to the Institute for Safe Medication Practices (ISMP, 2014). A high-alert medication is one that can cause significant harm if used in error (ISMP, 2014). Despite the potential safety concerns with oxytocin, studies that inform current practice of intravenous oxytocin infusion titration were conducted predominately in the 1980s and early 1990s (Amico, Ulbrecht, & Robinson, 1987; Leake, Weitzman, & Fisher, 1980; Perry et al., 1996; & Seitchik, Amico, Robinson, & Castillo, 1984). During this time period obesity was not a major public health issue and, neither BMI nor maternal weight were reported. Additionally, these studies examining the effectiveness of oxytocin to facilitate labor included small samples of predominately nulliparous women requiring induction or augmentation of labor and did not report oxytocin-related nursing practices. The absence of a uniform oxytocin regimen for induction of labor at term is receiving increased attention. A recent Cochrane review of the literature comparing high and low dose regimens found there was not enough evidence to support a high dose rather than a low dose regimen. Authors recommended that research was needed to determine the most effective dosing regimen (Budden et al., 2014).

Intrapartum nurses need to be aware of the effects of comorbidities associated with obesity (hypertension, preeclampsia, and gestational diabetes) on the physiology of normal pregnancy. Additionally, special equipment including larger labor beds, longer fetal monitor straps, and internal monitors may be necessary for the intrapartum nurse to effectively do his or her job. Oxytocin administration is frequently accompanied by epidural anesthesia. The nurse assisting with anesthetic procedures may have barriers to properly caring for the obese laboring woman. For example, epidural placement may take a longer amount of time in an obese patient, and the intrapartum nurse may be unable to obtain a fetal heart rate (FHR) tracing during this time due to both the larger adipose layer between the uterus and external monitors and the maternal positioning during epidural placement. Ray, Hildreth, & Esen (2008) evaluated the difficulty of providing nursing care to normal weight versus obese women in the United Kingdom. While this study did not meet our inclusion criteria, it did provide some relevant information regarding intrapartum nursing care for obese women. Ray et al. (2008) reported that interventions including contraction monitoring and performing vaginal examinations were more difficult for obese than for normal weight women, and that obese women more often required internal monitoring. While it was not clear if intrapartum nurses were providing these interventions, in the United States, it is common practice for nurses to provide these interventions, therefore these results are important for consideration.

There is a dearth of research evidence supporting current practice for intrapartum nurses related to oxytocin administration among overweight and obese women (Budden et al., 2014). The labor nurse is the health care team member primarily

responsible for managing the oxytocin infusion. Nursing care of pregnant women receiving oxytocin infusion for labor induction or augmentation becomes more difficult as BMI increases due to the comorbidities associated with obesity, and the challenges of accurate continuous uterine and fetal monitoring (Ray et al., 2008). To ensure patient safety and efficacy, an understanding of nursing practices related to oxytocin administration is essential. As the obesity epidemic does not seem to have an end in sight, an examination of research is needed to develop evidence-based practice guidelines and hospital policy for intrapartum nurses administering intravenous oxytocin to overweight and obese women (Melnyk & Fineout-Overholt, 2014). The purpose of this review of the literature was to describe nurses' oxytocin administration practices, related nursing interventions during the intrapartum period, and labor outcomes for overweight and obese women.

B. Methods

1. Design

The scoping methodology, described by Arksey and O'Malley (2005) guided this literature review. This methodology, "a technique to map relevant literature in [a] the field of interest", is appropriate for studies that examine broad topics, determine the volume and characteristics of studies, summarize findings, and uncover gaps in the current literature (Arksey & O'Malley, 2005, p. 20). Compared to scoping studies, systematic reviews are based on well-defined, narrow questions and study designs appropriate for answering these questions (Arksey & O'Malley, 2005). Because scoping studies address broad topics and research questions, a range of designs may be included and the quality of studies is not assessed. The scoping methodology consists

of five stages: (a) identifying the research question, (b) locating relevant studies, (c) selecting the studies, (d) charting the data, and (e) grouping, summarizing, and reporting results (Arksey & O'Malley, 2005).

2. Research Question and Search Methods

The research question for this literature review was, "What is known about nurses' oxytocin administration practices and oxytocin-related nursing interventions during the intrapartum period for overweight and obese women, specifically, (a) the ability to attain an effective uterine contraction (UC) pattern to promote labor progress, (b) the oxytocin dosage administered, and (c) maternal and neonatal outcomes?" The intrapartum period begins at the onset of spontaneous labor or initiation of labor induction and ends at delivery of the newborn. Oxytocin administration refers to nurse practices related to titration of the oxytocin infusion, including frequency (timing) and amount of increase or decrease in the infusion rate, for augmentation or induction of labor. Oxytocin-related nursing interventions are any interventions that are done in conjunction with oxytocin infusion. Two key oxytocin-related nursing interventions are FHR and UC monitoring. Nurses need to obtain accurate tracings and interpret the FHR and UC tracings in order to make decisions about oxytocin titration.

Articles were sought that explicitly described nurses as the health care team members managing the oxytocin administration. Studies were selected for inclusion based on the following criteria: (a) described oxytocin administration practices by nurses or described oxytocin-related intrapartum nursing interventions (as defined in the above paragraphs), (b) included overweight or obese women who received oxytocin infusion, (c) published in English, (d) available in full-text, (e) primary or original research, and

(f) published between 1995 (year that the National Institutes of Health [National Heart, Lung, and Blood Institute, 1998] released updated guidelines on treatment of obesity and definitions of BMI categories) and January 2015.

Consistent with the scoping methodology, because there is little research about our topic, we did not exclude studies based on research design. Exclusion criteria were: studies examining the effectiveness of oxytocin where the administration of oxytocin was controlled by the researcher and studies where oxytocin was controlled by health care team members other than staff nurses (e.g., midwives).

A literature search was performed using PubMed, CINAHL Embase, and the Cochrane Library databases including keyword and MeSH term searches of terms including: perinatal nursing, obesity, labor and delivery, intrapartum nursing, management, oxytocin infusion, labor induction, nurse, and combinations of the above keywords and alternate spellings. Additionally, we examined the literature cited in retrieved articles to identify further relevant studies.

3. Search Outcome and Study Selection

Our initial search resulted in 360 studies (see Figure 1). The first author initially reviewed titles and abstracts to determine whether inclusion criteria were met. A total of 338 studies were considered potentially relevant after duplicates were removed. After reading the full-text, 331 studies were excluded for one or more of the following reasons: investigators did not discuss intrapartum interventions, did not mention the nurse or any interventions routinely performed by nurses, did not mention use of oxytocin for induction or augmentation of labor, did not mention overweight or obese women, and did not report original research. The remaining seven studies were

independently examined by the first (ABM) and second authors (SCV). Following discussion with all co-authors, we reached a consensus that two studies did not meet inclusion criteria. Because five studies did not explicitly mention nurses as the health care team members who administered the oxytocin infusion, we attempted to contact these authors, four of whom responded that labor nurses managed the oxytocin infusions (Chin, Henry, Holmgren, Varner, & Branch, 2012; Pevzner, Powers, Rayburn, Rumney, & Wing, 2009; Soni, Chivan, & Cohen, 2013; Zhang et al., 2011). We included the fifth study because it was conducted in the US where it is common practice for intrapartum nurses to manage the oxytocin infusion (Nuthalapaty, Rouse, & Owen, 2004).

4. Data Extraction and Synthesis

Based on the Matrix Method (Garrard, 2014) study components abstracted from studies included: author, year and country; study purpose and design; sample size and setting; main variables and data collection methods; main study findings; and limitations (see Table I). The authors independently critiqued all of the studies and reached consensus about main study characteristics to include for each of these components.

C. Results

Five studies were reviewed. Studies described nurses' oxytocin administration practices or oxytocin-related nursing interventions during the intrapartum period for overweight and obese women. Characteristics abstracted from the studies are reported in the next section.

1. Purpose and Design

The majority of studies had similar purpose statements. The purpose of four studies was to examine the relationship between maternal BMI and various maternal and/or neonatal labor outcomes of induced or augmented labor (Chin et al., 2012; Nuthalapaty et al., 2004; Pevzner et al., 2009; Soni et al., 2013). A fifth study compared the effects of high and low-dose oxytocin regimens for labor augmentation on perinatal outcomes (Zhang et al., 2011).

The designs of two studies were retrospective and observational (Chin et al., 2012; Soni et al., 2013). The other three studies were secondary analyses: one study used data from a randomized controlled trial (RCT) (Pevzner et al., 2009), and two studies used observational data (Nuthalapaty et al., 2004; Zhang et al., 2011).

2. Sample and Setting

All five studies were conducted at large health centers across the United States. It is not stated in the articles if obstetric care was provided by physicians (e.g., OB-GYNs, OB-GYN residents, or Family practice) or advanced practice nurses (Certified Nurse Midwives, CNM). However, at many U.S. health centers, both physicians and CNMs have privileges to deliver pregnant women in the hospital.

Women included in the five studies had a singleton pregnancy at 36 weeks gestation or greater, consisted of both nulliparous and multiparous participants, received oxytocin for induction and/or augmentation of labor, and varied by race/ethnicity, age, socioeconomic status (SES), and BMI. Exclusion criteria of the studies included contraindications to vaginal delivery and multiple gestations. Four of

the studies excluded women with medical conditions, such as preeclampsia, or pregnancies complicated by fetal anomalies.

3. Main Variables and Data Collection

Main outcome variables reported in the majority of studies included method of delivery (cesarean or vaginal), length of labor, and oxytocin administration variables. Additionally, type of FHR and/or UC monitoring was reported in four studies (Chin et al., 2012; Nuthalapaty et al., 2004; Pevzner et al., 2009; Zhang et al., 2011).

4. Operational Definitions of Variables

BMI of participants was reported in three studies (Chin et al., 2012; Pevzner et al., 2009; Soni et al., 2013), controlled for in one study (Zhang et al., 2011), and maternal weight in kilograms (kg) was reported in one study (Nuthalapaty et al., 2004). The Centers for Disease Control and Prevention (CDC) definitions for BMI groups (CDC, 2011) were used in all studies that reported BMI. Pre-pregnancy BMI was reported in one study (Chin et al., 2012), and delivery BMI was used in three studies (Pevzner et al., 2009; Soni et al., 2013; Zhang et al., 2011). Nuthalapaty et al. (2004) reported delivery weight.

Two studies consistently reported the length of stages one and two of labor (Chin et al., 2012; Zhang et al., 2011). Stage one was reported in minutes (Chin et al., 2012) or hours (Zhang et al., 2011) from time of admission to full dilation, and stage two was reported in minutes from time of full dilation to delivery (Chin et al., 2012; Zhang et al., 2011). Two studies (Nuthalapaty et al., 2004; Pevzner et al., 2009) reported similar operational definitions of total time in labor, defined as the number of hours from the time the study drug (a cervical ripening agent) was inserted until delivery (Pevzner et

al., 2009), or the time from oxytocin initiation to delivery (Nuthalapaty et al., 2004). Soni et al. (2013) defined length of labor as the time of oxytocin initiation until either vaginal delivery or decision for cesarean delivery.

Oxytocin dosing variables were maximum dose, total dose, and length of infusion. The maximum, or highest, dose of oxytocin (in mu/min) received during labor was reported in three studies (Chin et al., 2012; Nuthalapaty et al., 2004; Zhang et al., 2011). The total dose of oxytocin (in units) was reported in three studies (Pevzner et al., 2009; Soni et al., 2013; Zhang et al., 2011). Two variables (total dose of oxytocin, and duration of oxytocin infusion) had definitions that included a time component reflecting how length of labor was measured as described in the previous section.

In summary, operational definitions for length of labor, and dosing variables differed slightly across studies, and delivery method had similar operational definitions.

5. Main Study Findings

Labor outcomes and oxytocin variables by BMI group were analyzed in four studies. The most commonly analyzed outcomes were cesarean delivery rate (Chin et al., 2012; Nuthalapaty et al., 2004; Pevzner et al., 2009; Soni et al., 2013), length of labor (Chin et al., 2012; Nuthalapaty et al., 2004; Pevzner et al., 2009; Soni et al., 2013), duration of oxytocin infusion (Nuthalapaty et al., 2004; Pevzner et al., 2009; Soni et al., 2013), maximum dose of oxytocin (Chin et al., 2012; & Nuthalapaty et al., 2004), and total oxytocin infused (Pevzner et al., 2009; Soni et al., 2013). Cesarean delivery rate and length of labor increased with increasing maternal BMI in all studies. A longer duration of oxytocin infusion associated with increasing BMI (Nuthalapaty et al., 2004; Pevzner et al., 2009; Soni et al., 2013) was reported in three studies, and higher total

amounts of oxytocin infused during labor was related to increasing BMI in two studies (Pevzner et al., 2009; Soni et al., 2013). In contrast, outcomes were analyzed separately for women with vaginal and cesarean deliveries in one study, and it was found that the maximum dose of oxytocin and contraction strength did not differ across BMI groups (Chin et al., 2012). These investigators also found that increasing increments of the maximum oxytocin dose were related to lower odds of adequate contraction strength regardless of type of delivery. A fifth group of authors (Zhang et al., 2011) analyzed maternal and neonatal outcomes by three different oxytocin-dosing regimens: 1, 2 and 4 mu/min. While they did not examine BMI as a predictor, they reported no significant difference in BMI across dosing regimens. They found that length of labor decreased with increasing dosing regimens in a dose-response pattern.

Zhang et al. (2011) reported that higher oxytocin dosing regimens were associated with reduced risk of APGAR score below 7 at 5 minutes of life for nulliparous women, and reduced risk of meconium stained fluid, chorioamnionitis, and newborn fever in multiparous women. These were the only authors to report neonatal outcomes other than birth weight, which is not associated with oxytocin infusion.

a. Intrauterine pressure catheter use

This section describes outcomes in relation to the use of internal uterine contraction monitoring using an intrauterine pressure catheter (IUPC) - the gold standard for measuring contraction strength (Euliano, Nguyen, Marossero, & Edwards, 2007). While use of an IUPC for contraction monitoring was not a finding in these studies, it was an intervention used to track contraction patterns so that the intrapartum nurse could titrate the oxytocin infusion. The use of IUPCs was reported in four studies,

(Chin et al., 2012; Nuthalapaty et al., 2004; Pevzner et al., 2009; Zhang et al., 2011), but no authors reported on UC pattern including frequency or duration.

Zhang et al. (2011) included women with and without IUPCs and reported outcomes of different dosing regimens, while controlling for BMI, for nulliparous and multiparous women separately. The percentage of women who had IUPC monitoring decreased with increasing oxytocin-dosage group regardless of BMI for both nulliparous and multiparous women.

Chin et al. (2012) included women who had IUPC monitoring during the last two hours of the first stage of labor in their study and analyzed outcomes separately based on delivery type: vaginal and cesarean delivery. Length of labor did not differ significantly by BMI group for women who had cesarean delivery. For women who delivered vaginally, the first stage of labor increased significantly by BMI group. Maximum dose of oxytocin did not differ by BMI category for women who had vaginal or cesarean delivery. Additionally, contraction strength, measured by Montevideo units (MVU), did not vary by BMI category. Each 5-mu/min increase in maximum oxytocin dose was associated with decreased odds of MVU of greater than or equal to 200.

There were two studies in which all women had IUPCs throughout labor and similar outcomes were reported. Pevzner et al. (2009) and Nuthalapaty et al. (2004) found that length of labor increased with increasing BMI group or weight and cesarean delivery rates increased with increasing BMI group or weight. Median dose and duration of pre-delivery oxytocin were higher for obese and extremely obese women than for lean women.

In summary, findings are relatively consistent for similar oxytocin outcomes examined across studies. As maternal BMI increases, women tend to receive increasing amounts of oxytocin and still have poorer labor outcomes, such as cesarean delivery and longer length of labor, than normal weight women.

D. Limitations of Studies in the Review

There were several methodological limitations of the studies included in this review. The majority of studies used retrospective data, and although two studies used prospective data, both were secondary analyses: one used data from a RCT and the other was a nonrandomized comparison group design. There were multiple sites in many studies, and this would have contributed to uncontrolled variations in oxytocin administration and related nursing practices.

Contraction patterns, including frequency and duration of contractions, were not examined in any studies. Contraction pattern has been found to be a predictor of mode of delivery (Althaus et al., 2006; Zagami, Golmakani, Saadatjoo, Ghomian, & Baghbani, 2015). Use of tocolytics during labor was reported as a proxy for tachysystole in one study (Zhang et al., 2011). In practice, there may be periods of tachysystole that do not result in fetal compromise and therefore, tocolytics will not be used for all incidence of tachysystole.

There were major inconsistencies in the use and reporting of type of FHR and UC monitoring. IUPC monitoring was used for all women after rupture of membranes in two studies (Nuthalapaty et al., 2004; Pevzner et al., 2009). In a third study, all women had IUPC monitoring for at least the last two hours of the first stage of labor (Chin et al., 2012). Use of both internal and external contraction monitoring was reported in one

study (Zhang et al., 2011). There was no report of use of monitoring at all in the fifth study (Soni et al., 2013). When an IUPC is used, the intrapartum nurse will have a more exact UC tracing for interpretation than when an external contraction monitor is used. Therefore, the nurse will be able to more effectively titrate the oxytocin infusion with an IUPC than an external monitor as maternal BMI increases. Since different types of uterine monitoring were used across studies, it may be difficult to compare amounts of oxytocin received by women of different BMI groups because of the difficulty of monitoring women in higher BMI groups (Ray et al., 2008).

Measurement issues related to BMI and oxytocin administration were also identified. Measures of BMI varied based on source of data and study definition. Many of the studies used self-report weight and height to calculate BMI resulting in validity concerns. Pre-pregnancy BMI was used in some studies and BMI at delivery was used in others. Additionally, in one study, weight was used rather than BMI. Measures of oxytocin administration included total dosage, maximum dosage, and length of infusion. While oxytocin administration variables were operationally defined similarly among studies, not all variables were examined in all studies. In only one out of three studies in which length of infusion was evaluated, was it specified that the end of the infusion as the time of vaginal delivery or decision for cesarean delivery. The authors of the other two studies broadly defined the end of the infusion as time of delivery, and for women who had a cesarean delivery timing was not reported. One must assume that the oxytocin was discontinued when the decision to have a cesarean section was made. Measurement inconsistencies likely contributed to variations in findings across studies.

Statistical power was not reported in these studies. The sample sizes of three studies ranged from 1,273-15,054 and while those likely had statistical power, the sample sizes of the other two studies were smaller. In one study (Soni et al., 2013), there was a relatively small sample size of *N* = 118 and the study spanned a period of seven years.

Variations in oxytocin-related practices across clinic sites and years might have contributed to lack of statistically significant findings and inconsistent findings across studies. Over this period of years, oxytocin-related practices may have changed related to staffing turnover by nurses and physicians. The number of sites within studies ranged from one to 49. Because the majority of studies used data from multiple sites, oxytocin-related practices may have varied.

E. Discussion

Leading national organizations have called for improvements in the quality of intrapartum care to promote patient safety and reduce persistent inequalities in maternal and infant outcomes (Guterman, Davis, Stremikis, & Drake, 2010; Institute of Medicine, 2002; U.S. Department of Health and Human Services, n.d.). Over the last two decades, both obesity and rates of labor induction have increased, and more recently, oxytocin was listed as one of 12 high-alert medications (ISMP, 2014) resulting in greater awareness of the increased risk of childbirth complications among obese women. To provide the highest quality care, nurses need to base practice on the most currently available evidence (Melnyk & Fineout-Overholt, 2014). This review of the literature aimed to describe evidence about nurses' oxytocin administration practices and related nursing interventions during the intrapartum period for overweight and obese women.

Five studies met the inclusion criteria for this review. These few studies gave us an overall picture of the amount of oxytocin that is administered among women across different BMI groups and the association between the amount of oxytocin and childbirth outcomes, primarily length of labor and method of delivery. Authors of these studies did not directly measure nursing interventions, however the use of FHR and/or UC monitoring (common nursing interventions) was reported in four out of five studies. A glaring omission in the literature is the absence of studies examining a link between oxytocin administration practices and other related nursing interventions.

Investigators reported oxytocin-related practices including the use of UC and FHR monitoring, but did not measure these practices nor mention that these practices might be associated with oxytocin-administration. We still do not have information about how other nursing interventions interact with oxytocin titration by the intrapartum nurse.

1. Oxytocin Administration and Related Maternal and Neonatal Outcomes

We found that women of higher BMI groups are more likely to receive oxytocin at higher infusion rates, higher total doses, and longer lengths of infusions than normal weight women. Findings were consistent across studies despite variation in the definition of one oxytocin administration variable: length of infusion. To improve our understanding about oxytocin administration in practice and to generate research evidence for practice, a uniform definition of length of oxytocin infusion is needed. One study (Soni et al., 2013) defined length of infusion as the time period from the initiation of the oxytocin infusion until either vaginal delivery or decision for cesarean delivery. While the authors of the other two studies who measured length of infusion (Pevzner et al., 2009; Zhang et al., 2011) may have conceptualized this variable similarly, the

operational definition in the articles was time from initiation of oxytocin infusion until delivery, regardless of whether it was vaginal or cesarean. In practice, it is common for the oxytocin infusion to be discontinued when the decision is made for a cesarean delivery. However, based on the operational definition of oxytocin infusion for these two studies, it is difficult to know whether the authors measured the actual time of oxytocin infusion, or the time of oxytocin infusion plus the time that passed while waiting for the patient to be transferred to the operating room and until cesarean delivery. As a result, the amount of oxytocin administered to women who had cesarean deliveries may have been overestimated. Since obese women had cesarean deliveries at a higher rate than normal weight women, the overestimation of oxytocin administered would be greater for obese women. So, it is possible that study findings overestimate the strength of the positive association between BMI and amount of oxytocin. Our recommendation is to define length of oxytocin infusion from the time of initiation until the infusion is discontinued at either vaginal delivery or decision for cesarean delivery consistent with Soni and colleagues (2013).

To better understand the effectiveness of oxytocin in women of various BMI groups, measures of oxytocin administration should adjust for length of labor. Because we know that obese women have longer lengths of labor than normal weight women (Hilliard, Chauhan, Zhao, & Rankins, 2012; Kominiarek et al., 2011; Usha Kiran et al., 2005), it seems logical that obese women also receive higher total amounts of oxytocin and received oxytocin for a longer length of time than normal weight women. It would be prudent to calculate oxytocin administration variables that adjust for the length of labor

so we have more accurate measures of the amount of oxytocin relative to the length of labor.

The increase in length of labor and cesarean delivery in obese women compared to normal weight women may be related to oxytocin receptor desensitization due to higher amounts of and longer lengths of oxytocin infusion. When oxytocin is administered in high doses or for long periods of time, oxytocin receptors become desensitized, making the oxytocin infusion less effective (Phaneuf, Linares, TambyRaja, MacKenzie, & Bernal, 2000; Plested & Bernal, 2001). Chin et al. (2012) reported that with each 5-mu/min increase in maximum oxytocin dose, there was a decreased odds of generating UCs with MVU of 200 or greater. This finding may have been related to oxytocin receptor desensitization.

Since the intrapartum nurse is more likely to experience difficulty obtaining an accurate UC tracing for obese women than for normal weight women, he or she may also have a difficult time titrating up the oxytocin infusion to achieve active labor in a timely manner, thus exposing the obese woman to a lengthy oxytocin infusion before active labor is achieved. This could result in desensitization of oxytocin receptors even before the woman is able to begin active labor. Intravenous oxytocin is absorbed into the extracellular fluid (ECF) (JHP Pharmaceuticals, 2012) and obese women have a larger ECF space than normal weight women (Mager, 2009). So it is possible that a specific dose of oxytocin administered to normal weight women might become more dilute when administered to an obese women who has a larger ECF space. In practice, obese women may be receiving less oxytocin than they need to promote effective labor resulting in timely vaginal delivery.

Our findings showed that higher amounts of oxytocin were associated with more adverse maternal outcomes, primarily longer length of labor and cesarean delivery for obese women. These findings are consistent with numerous studies that focused on childbirth outcomes across BMI groups (Marchi, Berg, Dencker, Olander, & Begley 2015; Mission, Marshall, & Caughey, 2015). Among the few studies that included neonatal outcomes, results were inconsistent. One study included in our review found that higher oxytocin doses were related to reduced risk of APGAR score below 7 at 5 minutes of life for nulliparous women, and reduced risk of meconium stained fluid, chorioamnionitis, and newborn fever in multiparous women (Zhang et al., 2011), but these authors examined outcomes by oxytocin dosing group and not by maternal BMI. It is possible that these outcomes were related to a shorter time in labor for women who had the higher oxytocin-dosing regimens. Given the potential for serious adverse effects of oxytocin on the neonate, research is needed to understand the impact of oxytocin on the neonates of women of various BMI groups. One of the adverse neonatal effects that can be caused by oxytocin administration is incidents of tachysystole, defined as more than five UCs in a 10-minute period averaged over a 30-minute period (Macones, Hankins, Spong, Hauth, & Moore 2008). Tachysystole can result in poor neonatal outcomes such as non-reassuring FHR tracings in labor, acidemia, 5-minute APGAR score less than 7, respiratory problems at birth, and neonatal intensive care unit (NICU) admission (Heuser et al., 2013; & Simpson & James, 2008).

2. Oxytocin Administration and Nursing Interventions

Intrapartum nursing interventions commonly include FHR monitoring, UC monitoring, patient positioning and movement during labor, vaginal examinations, and

assisting with epidural positioning. The absence of evidence measuring these practices is striking.

Our findings show that there is only minimal evidence about two key nursing interventions related to oxytocin administration: FHR and UC monitoring. Strategies for monitoring FHR and UCs are critical for nurses' oxytocin titration. When monitoring externally, an ultrasound transducer or external fetal monitor (EFM) and a tocodynamometer (toco) (for UC monitoring) are placed on the abdomen. In women with larger adipose tissue layers, placement of the EFM and toco can be difficult as the intrapartum nurse has to palpate through the adipose layer to identify fetal lie and the uterine fundus in order to correctly place the monitors. In addition, with a larger physical distance between the external monitors and both the fetal heart and uterine muscle, currently available external monitors are less effective in detecting the FHR and UCs (Euliano et al., 2007).

Zhang et al. (2011) reported decreasing use of IUPC with increasing oxytocin-dosing regimens. It is possible that women who received higher oxytocin doses generated stronger UCs than women who received lower doses, and the intrapartum nurse was able to detect UCs with external monitors more easily for these women. Nuthalapaty et al. (2004) and Pevzner et al. (2009) also used samples of women who all had IUPCs for UC monitoring. Both authors reported that obese women received greater amounts of oxytocin than normal weight women. However, in practice, when not all women have internal UC monitoring, it may be more difficult for the intrapartum nurse to effectively titrate the oxytocin infusion when relying on external monitors, especially with increasing maternal BMI.

The use of internal monitors in obese women could actually result in lower total amounts of oxytocin being infused during labor than when external monitors are used since the intrapartum nurse will be able to obtain a more accurate UC tracing with which to make decisions about oxytocin titration. Achieving effective labor with the lowest amount of oxytocin necessary is important as oxytocin receptors can become desensitized when either high amounts are given, or with a long infusion. This can put a patient at risk for dysfunctional labor and PPH (Hawkins & Wing, 2012). Current practice may ascribe to the belief that "more oxytocin is better," when in reality it seems prudent to have effective monitoring techniques so that the least amount of this high-alert medication necessary can be given while still achieving an effective UC pattern.

While internal monitoring may be able to decrease the amount of oxytocin administered to obese women, it is also possible that obese women simply need more oxytocin to achieve effective labor than do normal weight women due to the larger ECF space for obese women into which intravenous oxytocin is infused.

Our findings suggest that IUPC monitoring can more effectively guide oxytocin titration compared to external monitoring. This is consistent with studies showing internal monitoring is a more exact method of UC monitoring than external monitoring (Euliano et al., 2007), especially as BMI increases (Ray et al., 2008). There are numerous considerations when developing best practices for the use of IUPCs. Internal monitors are used less commonly than the external monitors because placement of internal monitors requires the cervix to be dilated, the amniotic membrane to be ruptured, and there are some reports of increased risk of infection associated with internal monitors (Harper, Shanks, Tuuli, Roehl, & Cahill, 2013). For women of higher

BMI groups, who are already at risk of longer length of labor, the risks and benefits of using internal monitors must be carefully weighed. While there are reports of internal monitors being associated with infection, there is also a risk of intraamniotic infection the longer that the woman is in labor with the amniotic membrane is ruptured. It is possible that the use of internal monitors in women of higher BMI groups may result in the intrapartum nurse being able to more effectively titrate the oxytocin infusion, resulting in earlier active labor and a shorter length of total labor. Researchers who examine oxytocin administration should utilize IUPC monitoring, the gold standard for measuring UCs, to generate best evidence.

Other nursing interventions related to oxytocin administration can also become more difficult with obese women. Sterile vaginal exams (SVE) to assess for cervical dilation, effacement, and fetal station are reported to be more difficult as maternal BMI increases (Ray et al., 2008). Labor positioning and movement are also more difficult for obese women (Zwelling, 2010), as when oxytocin is administered, continuous FHR and UC monitoring are employed. As discussed above, external monitoring is more difficult with obese women and especially when laboring women are changing positions frequently and ambulating on portable monitoring. Due to the intrapartum nurse not being able to obtain a FHR and UC tracing when obese women are changing positions during labor, the woman is likely to be confined to bed so that the nurse can evaluate the FHR and UC pattern during oxytocin administration. Additionally, for women who choose to have epidural analgesia, positioning for the epidural placement is more difficult and the placement of the epidural may take longer due to the increased layers of tissue the anesthesiologist must negotiate during the procedure (Mace, Paech, &

McDonnell, 2011). During this time when the woman is positioned for epidural placement such that she is slumped over her gravid uterus, the intrapartum nurse is often unable to evaluate the FHR.

Since oxytocin titration must occur in conjunction with other nursing interventions, such as FHR and UC monitoring, we propose that future research should focus on evaluating these interventions together. For this review, we were unable to locate any studies that examined oxytocin administration and oxytocin-related nursing interventions together. In fact, none of the included articles evaluated any nursing interventions related to oxytocin infusion among women of BMI groups. As the majority of authors responded that intrapartum nurses did, in fact, administer the oxytocin infusions, and with the knowledge that this is common practice in the US, we determined that oxytocin administration variables such as length of infusion, highest rate of infusion, and total rate of infusion could be deemed nursing interventions since the nurse was the one managing the infusion.

F. Strengths and Limitations of this Review

This review has strengths and limitations inherent to the design and methodology that was used. A major strength of this study was the use of the scoping method to guide the review. This method was used because there is so little information available on our topic, yet allowed us to perform a methodologically rigorous and replicable literature review (Arksey & O'Malley, 2005). It would not have been possible to perform a systematic review in the conventional sense.

A major limitation of this review is the low number of studies included. However, comprehensive and systematic searches were performed in major databases with

keywords and MeSH terms, combinations of those terms, and additionally, hand searches of reference lists were completed. This enhanced rigor of our search strategies and increased the chances that relevant articles would be located. The first author screened articles for inclusion by reading the titles and abstracts. Articles that were clearly not applicable were excluded, and then the first author proceeded to read each article in entirety. For studies that the first author was unable to determine whether inclusion criteria were met, the second author read articles in entirety, a discussion ensued, and a decision about inclusion was reached by consensus.

Another limitation to our review is the inclusion of studies with different purposes making comparisons across studies challenging. However, the scoping method supports the inclusion of any study design that allows the investigator to answer the research question. Authors in four out of the five studies included divided their sample by BMI group, and one author divided the sample by oxytocin-dosing regimen. Since analytical groups varied, we were limited in the synthesis of select findings across these four studies.

Lastly, only studies published in English were included in this review. It is possible that studies published in other languages would have met inclusion criteria and provided information relevant to the research question. However, it was not feasible to include studies published in other languages, as the authors are not fluent in languages other than English.

G. Implications for Practice and Research

Little is known to guide nurses' oxytocin administration and oxytocin-related practices for overweight and obese women. To ensure patient safety, an understanding

of nursing practices related to oxytocin administration is essential. An examination of research is needed to develop evidence-based practice guidelines and hospital policy (Melnyk & Fineout-Overholt, 2014). Information gained from this review will help nurses and physicians better understand the association between oxytocin administration and maternal and neonatal outcomes, and a description of nursing interventions related to oxytocin administration.

With no foreseeable end in sight to the obesity epidemic, and with obese women more likely to require medical induction of labor, or receive oxytocin for augmentation due to slower progress of labor (Kobayashi & Lim, 2014; Kominiarek et al., 2011), intrapartum nurses can anticipate that they will be caring for increasing numbers of obese women receiving oxytocin infusions. Future research needs to consider oxytocin-related nursing interventions, such as FHR and UC monitoring, in conjunction with oxytocin administration and labor outcomes.

Obstetric providers, such as OB-GYNs and CNMs, and intrapartum nurses will need to have a clear line of communication while discussing plans of care, and carefully weigh the risks and benefits of utilizing internal monitors for obese women. While internal monitors may be associated with higher risks of intrauterine infection during labor, there is also a risk that if the intrapartum nurse is relying on less precise external monitors, he or she will be less able to effectively titrate the oxytocin infusion while ensuring safety of the mother and fetus. Additionally, future research of FHR and UC monitoring equipment should focus on methods of monitoring that are the least invasive, and least expensive possible, while still being accurate in obtaining a FHR and UC tracing for women of all BMI groups. Portable FHR and UC monitoring systems should

come equipped with the ability to connect to both IUPC and internal FHR monitors to ensure that overweight and obese women can still be mobile during labor and the intrapartum nurse can effectively monitor FHR and UCs while intravenous oxytocin is being administered.

Current recommendations include that obese women be considered high-risk during labor and have a one-to-one nurse assignment due to the increased workload in caring for these patients (Cesario, 2003). In reality however, obese patients are often assigned to nurses at the same one nurse to two patient ratio as normal weight women for the first stage of labor. Administrators and nurse managers who make decisions about nurse staffing may need to consider the implications of caring for obese women which result in a heavier workload for intrapartum nurses and how this can effect maternal and neonatal outcomes.

H. Conclusion

Our findings show that there is a gap in the literature regarding the care of overweight and obese women who receive intravenous oxytocin for labor induction or augmentation. In order for intrapartum nurses to practice with the best evidence, future research needs to consider oxytocin administration for overweight and obese women together with associated nursing interventions. Intrapartum nurses and obstetric providers also need to work together as members of the health care team in order to provide the best individualized care for overweight and obese women who are experiencing labor induction or augmentation with intravenous oxytocin.

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Table I: COLLECTIVE FINDINGS TABLE

Author(s), Year, & Country	Study Purpose and Design	Sample and Setting	Main Variables and Data Collection Methods	Main Study Findings	Limitations
Soni, Chivan, & Cohen, 2013. USA, NY Medical Center.	Purpose: To determine whether the effectiveness of OT augmentation differed in obese and lean women Design: Retrospective observational	Sample Size: *N* = 118 women in spontaneous labor who received OT augmentation (Group A: BMI<25, Group B: BMI 25-29.9, Group C: BMI 30-34.9, Group D BMI ≥ 35) Setting: One US medical center	Variables: Maternal demographics (age, parity, BMI at delivery, GA, dilation at arrest, BW) Outcomes: Progressing to full dilation, post-arrest slope ≥ pre-arrest slope, cesarean delivery, total OT administered, OT administered during first 3 hours, duration OT use, time to delivery or decision for cesarean Data collection methods: Investigator blinded to group assignment created a labor curve graph based on medical record documentation	Arrest of dilation: Group D was less dilated than other groups ($p < .001$) Progression: Fewer women in Group D reached full dilation after OT augmentation ($p < .001$) Post-arrest slope > or = to Pre-arrest slope: Occurred progressively less often with increasing BMI ($p = .001$) Cesarean delivery: Rate increased with increasing BMI ($p < .001$) Total OT infused: Group D received more OT than other groups ($p < .001$) OT infused during first 3 hours: Group D received more OT than other groups ($p = .003$) Duration OT use: Longer in Group D than other groups ($p < .001$) Time to delivery or decision for cesarean: Longer in Group D than other groups ($p < .001$)	No mention of type of fetal or uterine monitoring and no direct measure of uterine contractility. Small sample size over large number of years (practice may have changed during that time). Retrospective design. Exclusion of patients with medical conditions that may be related to arrest. No mention of power. Do not know if authors controlled for covariates in analysis.
Chin, Henry, Holmgren, Varner, & Branch, 2012. USA, University School of Medicine in UT.	Purpose: To evaluate whether obesity is related to contraction strength (measured in MVUs) and cesarean delivery during stage one	Sample size: *N* = 5410 women who had IUPC monitoring for at least the last 2 hours of stage one labor and who either delivered	Variables: Pre-pregnancy BMI category, maximum OT dose, GWG, maternal age, GA, infant BW, parity, IOL, admission dilation Outcomes: Method of delivery, length of labor,	Mode of delivery: Overweight and obese women had higher odds of cesarean in first stage labor than normal weight women (*OR* overweight = 1.3, *OR* obese = 2.4). Maximum dose of OT: Did not differ by BMI category Contraction strength: MVU values did not differ by BMI category. For women	Retrospective design may include unmeasured confounders. Unable to evaluate whether obese women are more likely to have dysfunctional

	of labor Design: Retrospective observational	vaginally or had cesarean delivery for labor dystocia (Normal weight: BMI ≤ 25, Overweight: BMI 26-30, Obese: BMI ≥ 30) Setting: One healthcare system	contraction strength Data Collection Methods: Medical record extraction	who had cesarean, odds of mean MVUs ≥ 200 were greater for obese women compared to normal weight women (*OR* = 1.76). Among women who had vaginal delivery, there was no relationship between BMI and mean MVUs ≥ 200. Each 5 mu/min increase in maximum OT dose was associated with decreased odds of mean MVUs ≥ 200. Length of labor: Did not differ by BMI group for women who had cesarean (p = .55). For women who had vaginal delivery, length of stage one labor increased with increasing BMI group (p = .003).	contractile patterns. Maternal height, weight, and GWG are self-reported. All women had IUPC. Do not know how long labor lasted before last 2 hours of first stage.
Zhang, Branch, Ramirez, Laughon, Reddy, Hoffman, Bailit, Kominiarek, Chen, & Hibbard (2011). USA.	Purpose: To examine the effectiveness and safety of high-dose and low-dose oxytocin administration regimens on labor outcomes. Design: Secondary analysis (data from Consortium on Safe Labor, a retrospective study)	Sample size: *N* = 15,054 women who received OT for labor augmentation under one of 3 dosing regimens: 1 mu/min, 2 mu/min, or 4 mu/min Setting: Six US hospitals	Variables: Dosing regimen, maternal characteristics (race, insurance type, maternal age, epidural use, IUPC use, FSE use, cervical examination at admission, contraction pattern at admission, cervical dilation at initiation of OT, highest dose of OT, median dose of OT) Outcomes: (Stratified by parity) length of first stage labor, length of time from initiation of OT to delivery, length of second stage labor,	Maternal characteristics: No significant difference in maternal BMI at admission, no clinically significant differences in GA or BW, no significant difference in dilation at initiation of OT, no significant difference in maximum dose among groups **Nulliparas:** Outcomes: Cesarean delivery lowest in 4 mu/min group, but after adjusting for confounders, risk of cesarean was same in all 3 groups, length of first stage labor decreased in dose-response pattern **Multiparas:** Outcomes: Compared with 1 mu/min regimen, 2 mu/min and 4 mu/min regimens related to reduced length of first stage labor	No information on contraction pattern. Tocolytic use reported as proxy for hyperstimulation. Retrospective observational study. Different study sites may have had different OT administration protocols.

			intrapartum tocolytic use, delivery method Data Collection Methods: Data collected from the Consortium on Safe Labor		
Pevzner, Powers, Rayburn, Rumney, & Wing (2009). USA.	Purpose: To evaluate the relationships among BMI and outcomes of IOL using prostaglandin Design: Secondary analysis of data from Misoprostol Vaginal Insert double-blind RCT	Sample Size: *N* = 1273 patients grouped by BMI category at admission (Lean: BMI < 30, Obese: BMI 30-39.9, Extremely obese: BMI ≥ 40) Setting: 49 US hospitals	Variables: Demographics and baseline characteristics (maternal age, race/ethnicity, parity, GA, height, reason for IOL, modified Bishop score, treatment group) Categorical Outcomes: Active labor achieved, delivery < 24 hours, cesarean delivery Continuous Outcomes: Modified Bishop score (baseline and 12-hour), OT infusion duration, total OT infused, length of labor Data Collection Methods: Secondary analysis of data from Misoprostol Vaginal Insert Trial	Demographics and baseline characteristics: Reasons for IOL differed across BMI groups ($p < .001$). Baseline modified Bishop score: similar among groups 12-hour modified Bishop score: Extremely obese group had lower Bishop score (5) than other groups (6), but not clinically significant ($p = .004$) Delivery within 24 hours: Less common with increasing BMI group ($p < .05$) Vaginal delivery within 24 hours: Less common with increasing BMI ($p < .05$) Median dose of pre-delivery OT: Higher for obese and extremely obese than for lean women ($p < .001$) Median duration of pre-delivery OT: Longer for obese and extremely obese than for lean women ($p = .008$) Cesarean delivery: Rates increased with increasing BMI group ($p < .05$)	Many study sites so variation in provider practice could influence results. Pre-pregnancy BMI and GWG not available. All women had IUPC.
Nuthalapaty, Rouse, & Owen (2004). USA.	Purpose: To evaluate the relationships among maternal weight, cesarean delivery, dilation rate, and length	Sample size: *N* = 509 women at or beyond 36 weeks gestation, vertex position, singleton pregnancy, indicated	Variables: Maternal demographics (age, weight, GA, race, parity, IOL indication, epidural) Labor outcomes: cesarean, cervical dilation rate, length of	Demographics: Mean weight of women who delivered by cesarean was higher than women who delivered vaginally ($p < .001$) Cesarean rate: For nulliparas, odds increased by 25% for each 10 kg increase in weight (Adjusted *OR* =	All women had IUPC. No evaluation of uterine contraction pattern (frequency or duration, only MVU). Relatively

	of labor Design: Secondary Analysis of prospective observational study data	induction, and cervix < 2 cm at enrollment, having a standardized protocol for labor management Setting: University health center	labor Maternal weight relationship with labor characteristics: risk of cesarean, dilation rate by 10 kg weight increments, labor duration by 10 kg weight increments Data Collection Methods: From dataset	1.17) Change in cervical dilation: Highest weight quartile participants had slower cervical dilation rate than lowest weight quartile (p = .01) Mean duration of OT infusion from initiation to delivery: Nulliparous women in highest weight quartile had length of infusion 5 hours greater than lowest quartile (p < .001); for multiparous women, duration was 3.6 hours greater for women in highest quartile than lowest (p = .01) Mean maximum rate of OT: Greater for nulliparous (p= .001) and multiparous (p= .02) women in highest than lowest quartile MVUs: Nulliparous women in highest weight quartile generated higher MVUs than women in lowest weight quartile (p = .08)	small sample size. May have been confounders not included in analysis.

Abbreviations: **BMI:** Body Mass Index, **GA:** Gestational Age, **BW:** Birth Weight, **OT:** Oxytocin, **FSE:** Fetal Scalp Electrode, **IUPC:** Intrauterine Pressure Catheter, **IOL:** Induction of Labor, **GWG:** Gestational Weight Gain, **MVU:** Monte Video Units, **mu/min:** milliunits per minute, **RCT:** Randomized Controlled Trial, **cm:** centimeters

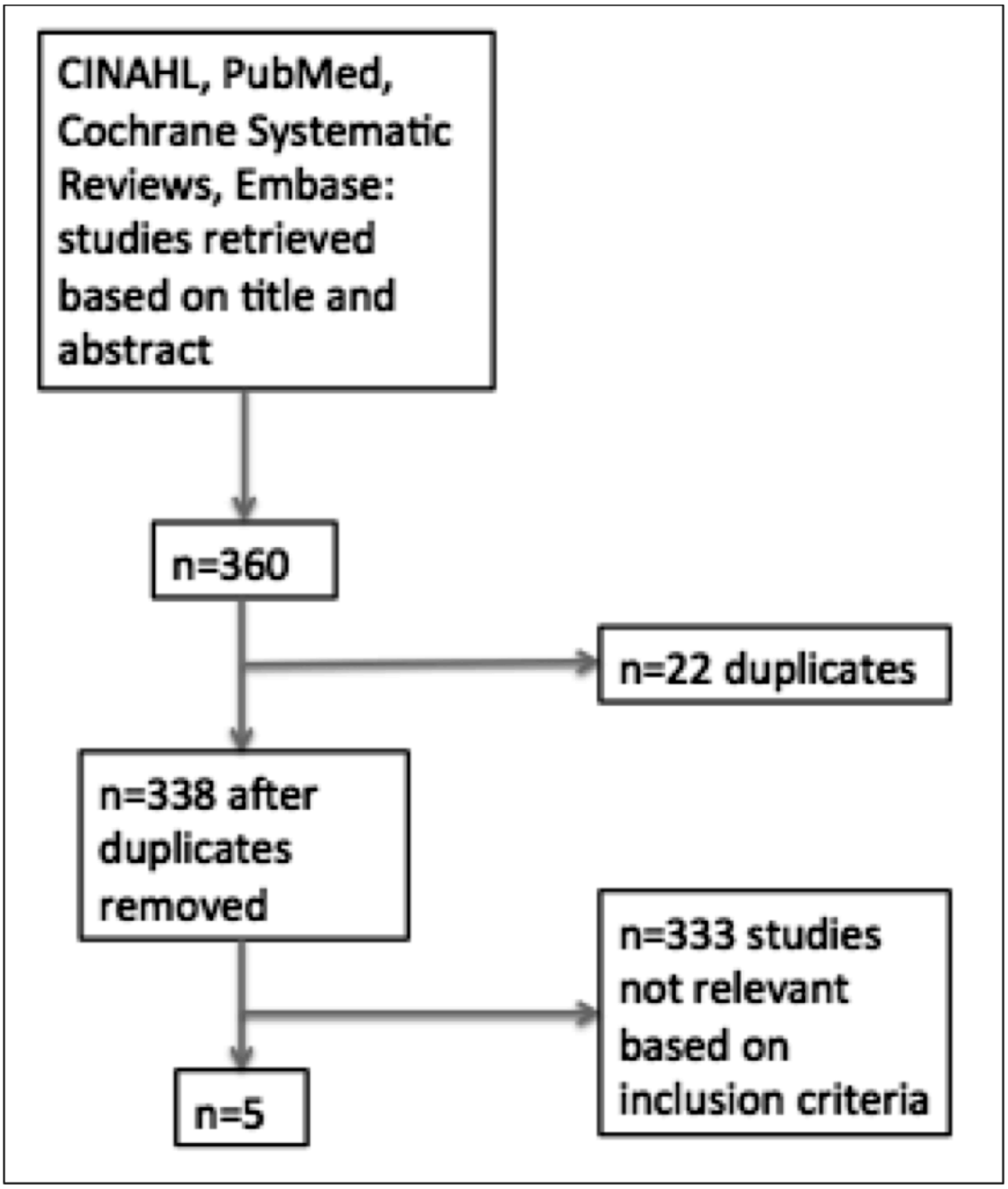

Figure 1: Summary of Study Selection

II. TITRATION OF INTRAVENOUS OXYTOCIN INFUSION FOR POST-DATES INDUCTION OF LABOR AMONG WOMEN OF VARIOUS BMI GROUPS

A. Background

Obesity is a rising epidemic in the United States affecting the nearly 4 million women who give birth each year (Martin, Hamilton, Osterman, Curtin, & Mathews, 2015). More than 1 in 5 U.S. women was obese when she became pregnant (Fisher, Kim, Sharma, Rochat, & Morrow, 2013) and 60% of obese women had excessive gestational weight gain (Bodnar, Siega-Riz, Simhan, Himes, & Abrams, 2010; Moore Simas et al., 2010). In Illinois, 41% of women were overweight or obese at the time they gave birth (Illinois PRAMS, 2013). Rates of obesity are highest among non-Hispanic black (55.8%) and Hispanic women (35.8%) compared to white women (27.8%) (Ogden, Carroll, Kit, & Flegal, 2014). Overweight and obese women are also at a higher risk for having induction of labor for reasons such as post-dates, hypertension, and diabetes than their normal weight counterparts (Denison, Price, Graham, Wild, & Liston, 2008; Kobayashi & Lim, 2014), and rates of labor induction for all women are also on the rise. Between 1990 and 2010, rates of labor induction nearly tripled, rising from 9.5% to 23.4% (Martin et al., 2009; Martin et al., 2012).

Overweight and obese women are more likely than their normal weight counterparts to experience poor labor outcomes such as longer length of labor (LOL), intrapartum infection, cesarean delivery, and postpartum hemorrhage (Bhattacharya, Campbell, Liston, & Bhattacharya, 2007; Hilliard, Chauhan, Zhao, & Rankins, 2011). While birth outcomes for infants born to overweight and obese women are reported less often than maternal outcomes, there is evidence that these infants are at higher risk for

macrosomia, hypoglycemia, and shoulder dystocia than neonates of normal weight women (Yu et al., 2013).

Intravenous oxytocin, the medication most commonly used for induction of labor is one of 12 high-alert medications according to the Institute for Safe Medication Practices (ISMP, 2014). A high-alert medication is one that can cause significant harm if used in error (ISMP, 2014). In practice, the intravenous oxytocin infusion is ordered by the obstetric provider (an Obstetrician-Gynecologist [OB-GYN], Certified Nurse Midwife [CNM], obstetric resident, or family practice physician), and administered by an intrapartum nurse. The intrapartum nurse must be able to effectively titrate the infusion based on the fetal heart rate (FHR) and uterine contraction (UC) tracings, which are often obtained using external monitors. These monitors can be less effective when used for women of higher BMI categories as there is a larger adipose tissue layer between the uterine muscle and the skin layer where monitors are applied (Euliano, Nguyen, Marossero, & Edwards, 2007; Ray, Hildreth, & Esen, 2008). Despite the risks and prevalent use of this high alert medication, there is a lack of studies that evaluate how oxytocin is titrated for labor induction among women of various body mass index (BMI) groups. Furthermore, there is little known about the association between oxytocin titration practices and maternal outcomes. Studies examining the effectiveness of oxytocin were controlled trials conducted up to three decades ago and did not include BMI (Amico, Ulbrecht, & Robinson, 1987; Leake, Weitzman, & Fisher, 1980; Perry et al., 1996; Seitchik, Amico, Robinson, & Castillo 1984). More recently, researchers have evaluated oxytocin requirements among BMI groups, and in these studies, oxytocin-dosing variables (total oxytocin, highest oxytocin, length of infusion) were analyzed, but

oxytocin-related interventions (FHR and UC monitoring) were reported but not analyzed (Chin, Henry, Holmgren, Varner, & Branch, 2012; Pevzner, Powers, Rayburn, Rumney, & Wing, 2009; Roloff, Peng, Sanchez-Ramos, & Valenzuela, 2015; Soni, Chivan, & Cohen, 2013). Together, the widespread use of oxytocin, a high-alert medication, and the barriers to effective oxytocin titration pose a serious risk to obese women and their infants. Studies are needed that comprehensively examine oxytocin titration practices, interventions related to oxytocin titration, and labor outcomes across BMI groups.

The first aim of this study was to determine whether titration of intravenous oxytocin infusion for post-dates labor induction differs among normal weight, overweight, and obese women, controlling for maternal characteristics, labor interventions, and type of provider. The second aim of this study was to determine whether labor outcomes (LOL, and method of delivery) for women who undergo post-dates labor induction differ by: a) titration of oxytocin infusion, controlling for the previously stated variables; and b) titration of oxytocin infusion by BMI group, controlling for the previously stated variables.

B. Methods

1. Sample

This retrospective cohort study included women who delivered following induction between January 1, 2013 and June 30, 2013 at a large, Midwestern, university-affiliated medical center. At this medical center, OB-GYNs and CNMs have privileges to practice, and obstetric residents manage the labor care of their clinic patients in conjunction with a unit attending OB-GYN. Intrapartum nurses are responsible for receiving the order for oxytocin infusion, beginning the infusion, and

titrating the infusion throughout labor. The oxytocin administration policy at this institution is as follows: oxytocin infusion is initiated by infusion pump at 1-2 mu/min and may be increased every 15-30 minutes at the discretion of the intrapartum nurse or obstetric provider. The rate must be decreased if either fetal intolerance or tachysystole (greater than five UCs in a 10 minute period, averaged over 30 minutes) are noted.

Inclusion criteria were: all women who were admitted for post-dates induction of labor (IOL) (defined as IOL at 41 weeks gestation or greater with no listed medical indication, or 40 weeks gestation or greater with provider notation of “post-dates” IOL); received intravenous oxytocin; a singleton pregnancy in the vertex position; and a documented weight and height at initiation of prenatal care and at admission to labor and delivery. Exclusion criteria were: scheduled or previous cesarean, or other indication for cesarean; maternal indication for induction (e.g., preeclampsia); fetal indication for induction (e.g., oligohydramnios); fetal demise; known lethal congenital fetal anomalies; and, women who are underweight at labor admission (BMI < 18.5). The institutional review boards of both Northwestern University and the University of Illinois at Chicago approved this study protocol.

Using electronic medical records (EMR) from the Cerner® Power Chart system, and admissions records, a dataset containing study variables for all women who were admitted at 40 weeks gestational age or greater, and who received intravenous oxytocin was obtained from the Enterprise Data Warehouse (EDW). The PI reviewed all Power Chart EMRs to verify that women were admitted for post-dates IOL, as defined previously. Any charts that indicated that the woman was admitted for spontaneous labor, spontaneous rupture of membranes (SROM), or IOL for any maternal or neonatal

condition were excluded. After the PI evaluated the EMRs for inclusion and exclusion criteria, 280 charts were included in the study.

2. Data Management

GE Centricity™ Perinatal is the EMR system that is used to store electronic FHR and UC tracings, oxytocin rate changes, and intrapartum nursing documentation. Two clinical nurses from the labor and delivery unit were hired as research assistants (RAs), and assisted the PI with manual chart reviews of both the Power Chart system to locate patient characteristic and labor outcome variables that were missing from the EDW dataset, and the Centricity™ Perinatal system to extract timing and amount of oxytocin rate changes and related nursing documentation of FHR and UC pattern. Both clinical nurses had master's degrees in nursing, and both were certified in their specialty with one holding certification in inpatient obstetrics and the other holding certification in intermediate electronic fetal monitoring. The PI reviewed 10% of the charts reviewed by the RAs to promote data quality.

3. Measures

Primary oxytocin administration variables were: total oxytocin dose (total amount in units infused from the time of initiation until the infusion was either discontinued, or delivery occurred), length of infusion (LOI, the time from initiation of the oxytocin infusion until it was either discontinued, or delivery occurred), highest oxytocin rate (the highest infusion rate in mu/min reached during the infusion), mean units infused by LOI (total oxytocin dose divided by LOI), time from initiation to the highest rate, mean time (in minutes) between rate changes from initiation to the highest rate, and mean time (in

minutes) between rate changes from initiation to the final oxytocin titration. Primary labor outcomes were LOL (in hours) and method of delivery (vaginal or cesarean).

Patient characteristics extracted from the EMRs included: age (in years), BMI at first prenatal visit and at labor admission, gestational weight gain (GWG), gravidity, parity, gestational age (GA) in weeks and days, race, ethnicity, cervical examination at admission (including dilation, effacement, and fetal station), and insurance type (as a proxy for socioeconomic status). Additional variables extracted from the EMR included: provider type (OB-GYN, CNM, or obstetric resident), use of cervical ripening (cervical ripening balloon, dinoprostone, or misoprostol), rupture of membrane (ROM) method (spontaneous or artificial), pain control method (epidural, narcotic medications, or none), FHR and UC monitoring methods (internal or external), time and amount of oxytocin rate changes, LOL (time from admission to labor and delivery until delivery), and method of delivery (vaginal or cesarean). While nurse characteristics such as years of experience, highest degree earned, and certifications are important variables to consider in relation to management of oxytocin infusion, for this study, it was not feasible to collect this data.

Oxytocin infusion variables were calculated using data extracted from the Centricity™ Perinatal system and Power Chart. Oxytocin infusion variables were analyzed by maternal BMI group (normal weight, overweight, and obese) at the time of labor admission, according to the Centers for Disease Control and Prevention guidelines (CDC, 2011). Additionally, maternal main outcome variables, LOL and method of delivery were analyzed by maternal BMI group.

4. Analysis

We used analysis of variance (ANOVA) and chi-squared procedures for descriptive analyses. The chi-square test was used to examine differences in maternal characteristics, provider type, and other interventions (e.g., use of epidural, cervical ripening) across BMI groups. As some cell sizes contained less than five cases, Fisher's exact test was done for all categorical variables. ANOVA was used to evaluate relationships between oxytocin infusion variables and BMI. Then, analysis of covariance (ANCOVA) was used to evaluate relationships between oxytocin infusion variables across the three BMI groups, controlling for potential confounders.

Multiple linear and logistic regression models were used to evaluate relationships between oxytocin dosing variables, and outcome variables (LOL and method of delivery) controlling for BMI and potential confounders. Multicollinearity checks were done and variables that were redundant were removed from the model. Both the multiple linear regression (for LOL) and the multiple logistic regression (for method of delivery) had three separate models. The first model included only the oxytocin infusion variables and the labor outcome. The second model included oxytocin infusion variables, BMI, and the labor outcome. And the third model included oxytocin infusion variables, BMI, all covariates, and the labor outcome. Women's characteristics that had statistically significant ($p \leq .05$) bivariate associations with BMI categories, other maternal characteristics, and those with clinical significance were considered potential confounding factors and were controlled for in the analysis. A power analysis for multiple regression was completed prior to data collection to determine differences in LOL and method of delivery across BMI groups. With a sample size of $N = 186$, we

calculated 80% power to detect a moderate effect size of (f^2) .15 (p = .01). G Power software version 3.1 was used for power analysis. SPSS version 22.0 software was used for statistical analysis.

C. Results

1. Demographics

Among the 570 deliveries of women who were admitted at 40 weeks gestational age or greater, and who received intravenous oxytocin, 280 met study inclusion criteria (see Figure 2). The characteristics of study participants and labor interventions are shown in Tables II and III. The BMI of participants ranged from 21.8 to 52.8, with 7.5% of women considered normal weight (BMI < 25.0), 47.9% of women considered overweight (BMI 25.0-29.9), and 44.6% of women considered obese at labor admission (BMI ≥ to 30.0).

Characteristics of the sample were examined and statistical differences across BMI groups were found. Maternal age ranged from 17 to 46 (mean 31.1, *SD* 5.0) with overweight women being older than normal weight or obese women. Admission cervical dilation ranged from 0 cm to 5 cm (mean 1.73, *SD* 1.12), with overweight and obese women being less dilated than normal weight women. Gestational weight gain ranged from 5.19 to 74.94 pounds (mean 33.82, *SD* 12.24), with overweight and obese women gaining more weight than normal weight women. More than half (54.6%) of women in the sample were non-Hispanic white, 8.2% were non-Hispanic black, 7.5% were non-Hispanic Asian, 13.2% were other non-Hispanic, 12.5% were Hispanic, and the race/ethnicity of 3.9% of women was unknown. More non-Hispanic black women and Hispanic were obese than non-Hispanic white or non-Hispanic Asian women. Most

women (81.1%) received prenatal care from an OB-GYN, 12.9% saw a CNM, and 6.1% were cared for by obstetric residents. More obese women were cared for by a CNM or obstetric resident than by an OB-GYN. The majority (82.1%) of women received care under private insurance and 17.9% had public insurance, with more obese women having public insurance. Almost half (41.4%) of women required cervical ripening prior to or in conjunction with oxytocin infusion. These differences across BMI categories were controlled for in the analysis. Significant relationships among variables were the same whether the chi-squared test or Fisher's exact test was used.

There were no significant differences across BMI groups for gestational age at delivery, parity, epidural use, FHR and UC monitoring methods, and comorbidities. Gestational age ranged from 41 weeks 0 days, to 42 weeks 2 days. The majority (80.7%) of women were nulliparous and 95.4% used an epidural. Most women did not have internal monitoring, with18.9% of women having an intrauterine pressure catheter (IUPC) to measure UCs, and 7.9% having an internal fetal monitor (IFE) to monitor FHR. Clinically important comorbidities included in the analysis were: group B beta strep (GBBS) infection (21.8%), thyroid disorders (9.6%), anxiety/depression disorders (8.6%), diabetes (2.5%) and hypertension (1.1%). While there were no differences across BMI categories, these characteristics were clinically significant and were controlled for in the analysis.

Differences among BMI groups were detected for the main outcomes LOL and method of delivery. Length of labor increased with increasing BMI group, with a grand mean of 18.27 hours (*SD* = 8.25). The percentage of women who had cesarean delivery

increased with increasing BMI group, with an overall cesarean delivery rate of 35.4% for this sample of women who experienced post-dates IOL (see Figure 3).

2. Oxytocin Administration Across BMI Groups

In study aim 1, we analyzed relationships between oxytocin variables and BMI categories. Results are presented in Table IV. In the initial oxytocin variable ANOVA, there were no overall mean differences across BMI groups for the main effects of total oxytocin dose, LOI, highest oxytocin rate, mean units infused by LOI, time from initiation to the highest rate, mean time (in minutes) between rate changes from initiation to the highest rate, and mean time (in minutes) between rate changes from initiation to the last rate change. However, post hoc testing using parameter estimates, revealed differences for 2 oxytocin variables between the overweight and obese groups: total oxytocin (B = -1.576, p = .031), and mean time between rate changes from initiation to the highest infusion rate (B = 14.8, p = .038). After controlling for race/ethnicity, provider type, maternal age, epidural use, insurance type, gestational age, ROM method, cervical ripening, GWG, parity, and comorbidities, there were no mean differences among groups for any oxytocin variables.

3. Relationships Among BMI, Oxytocin Administration, and Labor Outcomes

In study aim 2, we analyzed relationships between oxytocin variables and labor outcomes: LOL and method of delivery. Length of labor was analyzed separately for women who had vaginal deliveries and women who had cesarean deliveries, as the provider's decision to perform a cesarean modifies the length of labor. Length of labor

was approximately normally distributed and multicollinearity checks were completed prior to analysis.

a. Length of labor for women having vaginal delivery

For the initial multiple linear regression including oxytocin administration variables for women who had a vaginal delivery, the model was significant to explain LOL, and pseudo R^2 = .28 was calculated using the deviance and null deviance. Multiple linear regression analysis predicting longer LOL showed significant predictors were: increased LOI (B = .92, p < .001), and increased highest oxytocin rate (B = .30, p = .042). In the second multiple linear regression model for LOL, BMI was added to the model (p < .001, pseudo R^2 = .28). In this model, significant predictors of longer LOL were: increased LOI (B = 0.90, p < .001), and obese BMI category compared to normal weight (B = 2.30, p = .015). The final model included oxytocin administration variables and all covariates (p < .001, pseudo R^2 = .15). These results are presented in Table V. The following were significant predictors for longer LOL: increased LOI (B = .70, p < .001), increased highest oxytocin rate (B = .36, p = .002), lower mean units of oxytocin by LOI (B = -7.79, p = .021), fewer minutes between rate changes from initiation to the highest rate (B = -0.02, p = .002), obese BMI group compared to normal weight (B = 2.13, p = .005), nulliparity (B = 2.48, p < .001), other non-Hispanic race/ethnicity (B = 2.09, p = .002), public insurance (B = 2.17, p = .045), and use of cervical ripening (B = 4.84, p < .001).

b. Length of labor for women having cesarean delivery

In the initial multiple linear regression model including oxytocin administration variables for women who had a cesarean delivery, the model was significant to explain

LOL, and pseudo R^2 = .36. In this model, significant predictors for longer LOL were: increased LOI (B = 0.72, p < .001), more minutes to the highest infusion rate (B = 0.005, p = .021), and fewer mean minutes between rate changes from initiation until the last rate change (B = -0.04, p = .019). In the second model with BMI added, p < .001, and pseudo R^2 = .36. In this model, significant predictors for longer LOL were: increased LOI (B = 0.74, p < .001), more minutes until the highest rate (B = 0.005, p = .022), and fewer mean minutes between rate changes from initiation until the last rate change (B = -0.04, p = .019). In the final model (p < .001, pseudo R^2 = .11), significant predictors for longer LOL were: increased LOI (B = 1.10, p < .001), more mean units by LOI (B = 9.89, p = .023), fewer minutes to highest rate (B = -0.005, p = .007), fewer mean minutes from initiation to last rate change (B = -0.03, p = .002), older maternal age (B = 0.15, p = .044), unknown race/ethnicity (B = 3.56, p = .020), black non-Hispanic race/ethnicity (B = 3.96, p = .002), Asian non-Hispanic race/ethnicity (B = 2.61, p = .035), public insurance (B = 7.79, p < .001), and cervical ripening (B = 5.87, p < .001). Resident provider type (B = -8.18, p < .001), and artificial rupture of membranes (B = -3.01, p = .009) were significant predictors for shorter LOL prior to cesarean delivery. These results are presented in Table VI.

c. Method of delivery

The initial multiple logistic regression model for method of delivery (vaginal or cesarean) including only oxytocin administration was significant (p < .001), and had a Cox and Snell R^2 = .09. The only significant oxytocin administration variable that predicted cesarean delivery was lower mean units of oxytocin by LOI (OR = .01, p = .028). After BMI was added to the model (p < .001, Cox and Snell R^2 = .14), lower mean

units of oxytocin by LOI (*OR* = .004, *p* = .008) remained a significant predictor for cesarean delivery. Overweight (*OR* = 20.57, *p* = .019), and obese BMI groups (*OR* = 27.87, *p* = .010) compared to the normal weight group were significant predictors for cesarean delivery. In the final model including oxytocin administration variables and all covariates, the *p*-value was < .001, the Cox and Snell R^2 = .36. These results are presented in Table VII. The percent correct for the predicted outcome was 78.3%, which means this model can correctly detect predictors 78.3% of the time, and the area under the ROC curve was .87 indicating that this is a good prediction model. The Hosmer and Lemeshow goodness-of-fit Chi-square test *p*-value for the model was .956 so we can accept that the data fits the model. In this model, the absence of an anxiety/depression disorder (*OR* = .11, *p* = .012) was a significant predictor for cesarean delivery. Overweight BMI group (*OR* = 34.35, *p* = .021), obese BMI group (*OR* = 53.15, *p* = .010), nulliparity (*OR* = 9.68, *p* = .006), IUPC monitoring (*OR* = 7.44, *p* < .001), and use of cervical ripening (*OR* = 2.62, *p* = .010) were significant predictors for cesarean delivery.

D. Discussion

In this retrospective cohort study, we found that obese women received more total oxytocin in labor, but still experience poorer labor outcomes (longer LOL and higher cesarean delivery rate) than normal weight and overweight women. To our knowledge, this is the first time that oxytocin administration and labor outcomes have been analyzed by BMI group while taking into account that related interventions may interplay with effective oxytocin administration.

Our first aim was to examine whether nurse titration of intravenous oxytocin infusion for post-dates labor induction differed among normal weight, overweight, and

obese women, controlling for maternal characteristics and type of provider. While there were no significant differences for oxytocin administration variables across all three BMI groups in the ANOVA model, significant differences were found between the overweight and obese groups for two oxytocin variables: total oxytocin dose, and mean time between rate changes to highest oxytocin rate. The total oxytocin dose during labor was higher for the obese group compared to the overweight group. This is consistent with other authors who report total intrapartum oxytocin needs increasing with maternal BMI (Hill, Reed, & Cohen, 2014). The mean time between rate changes from initiation of the oxytocin infusion until the highest infusion rate was reached was significantly higher for the overweight group than for the obese group. Obese women likely need more oxytocin than normal weight women in order to achieve an effective UC pattern and vaginal delivery (Hill, Reed, & Cohen, 2014; Roloff et al., 2015).

Analysis using the adjusted model (ANCOVA) to examine oxytocin administration variables across all three BMI groups showed that there were no significant differences between the overweight and obese groups. Rather than BMI, other maternal characteristics and provider type were important for understanding oxytocin administration. One explanation for the absence of BMI as a predictor in our study might be related to the comparatively smaller number of women in the normal weight group. Another explanation is that the true relationship between BMI groups and oxytocin administration variables may not be linear and may be more complicated than ANOVA can detect. Pevzner et al., (2009) found that median oxytocin dose and duration of infusion were significantly higher for obese and extremely obese women than for lean women when controlling for confounders. In that study, the highest BMI group included

women with BMI $\geq$ 40. It is possible that there is a threshold point for BMI at which a significant relationship between BMI and oxytocin can be found. Future research should explore whether there is a BMI threshold, in addition to the current focus on existing BMI categories.

We found differences in significant predictors of LOL for women who have a vaginal compared to cesarean delivery. Oxytocin variables that predicted LOL were increased length of infusion, highest oxytocin rate, mean units of oxytocin by LOI, and mean minutes between rate changes. Increased LOI was associated with longer LOL for all women. Increased highest oxytocin rate was only associated with a longer LOL for women who had vaginal delivery. One explanation for this is that oxytocin continued to be increased for women who were making even slow progress in labor who then achieved vaginal delivery. Women who had cesarean delivery likely reached a high infusion rate (in the absence of signs of fetal distress), and when they did not progress after many hours at a high rate, the decision was made for cesarean delivery. Fewer mean units of oxytocin by LOI was associated with longer LOL for women who had vaginal delivery. In contrast, more mean units of oxytocin by LOI was associated with longer LOL for women who had a cesarean delivery. It is possible that women who had a cesarean delivery and received more mean units of oxytocin by LOI experienced oxytocin receptor desensitization (Phaneuf, Linares, TambyRaja, MacKenzie, & Bernal, 2000; Plested & Bernal, 2001), and therefore experienced longer LOL and subsequent cesarean delivery. Fewer mean minutes between rate changes from initiation to the highest rate was associated with longer LOL for women who had a vaginal delivery. However, while this was statistically significant, the coefficient represents approximately

one minute, which is not clinically significant. Regarding minutes from initiation to the highest rate and mean minutes between rate changes from initiation to the last rate change, fewer minutes were associated with longer LOL for women who had cesarean delivery. Similar to mean minutes between rate changes, these coefficients represent approximately one minute and are not clinically significant.

Maternal and type of provider characteristics that were significant predictors of LOL included BMI, parity, race/ethnicity, and provider type. Length of labor was longer for the obese group compared with normal weight and overweight groups only for women having a vaginal delivery. Obese women having longer LOL than normal weight women is consistent with the literature (Hilliard et al., 2012). It is possible that no difference in LOL was detected for women who had cesarean delivery because providers have a similar time threshold for deciding to perform a cesarean delivery regardless of BMI. Nulliparity was a significant predictor for longer LOL for women who had a vaginal delivery, but not cesarean delivery. In our study, only three multiparous women had a cesarean delivery. It is likely that providers wanted to give these women adequate time to progress before deciding on a cesarean delivery. We had so few multiparous women who had a cesarean delivery because we excluded women who had a prior cesarean delivery. Regarding race/ethnicity, other non-Hispanic race/ethnicity was a significant predictor for longer LOL. Similarly, women of unknown race/ethnicity, black non-Hispanic women, and Asian non-Hispanic women had longer LOL if they had a cesarean delivery. The reason for this is unclear. However, Getahun et al. (2009) reported that African American and Asian/Pacific Islander women had a higher primary cesarean rate than white women, and that Hispanic women had a lower

primary cesarean delivery rate than white women. While these investigators did not report comparisons of indication for cesarean across racial/ethnic groups, the African American and Asian/Pacific Islander women had higher rates of labor dystocia than white and Hispanic women. This finding of greater rates of labor dystocia in African American and Asian/Pacific Islander women is consistent with our finding that black non-Hispanic and Asian non-Hispanic had a longer LOL prior to cesarean delivery.

Provider type was not a significant predictor of LOL for women who had vaginal delivery, but women who had a resident provider were more likely to have a shorter LOL before a decision was made for cesarean delivery. It has been reported that a decision for cesarean is most often made due to nonreassuring fetal status or labor arrest (Barber et al., 2011). So it is likely that either the obstetric residents waited a shorter length of time to decide that labor arrest had occurred, or nonreassuring fetal heart tracings were more prevalent in their patients. Since obstetric residents are on the labor and delivery unit 24 hours a day and supervised by an attending OB-GYN, it seems unlikely that they would make a decision to perform a cesarean earlier than other providers based solely for prolonged labor. Therefore, it is likely that these women had a greater incidence of fetal intolerance to labor, which caused the obstetric resident providers to decide to perform a cesarean earlier in the labor process in order to maintain the health of the fetus. Public insurance was a predictor for longer LOL both for women who had vaginal delivery and those who had cesarean delivery.

Labor interventions that predicted LOL were AROM and cervical ripening. AROM was associated with shorter LOL for women who had cesarean delivery, but was not a significant predictor for women who had vaginal delivery. One possibility for this finding

is that if women became febrile, chorioamnionitis was suspected, and if they were not making progress towards delivery a decision was made for cesarean delivery. Use of cervical ripening was associated with longer LOL for both women who had vaginal delivery and those who had cesarean delivery. This is consistent with previous reports of longer length of labor when cervical ripening is used for IOL (Tam, Conte, Schuler, Malang, & Roque, 2013).

Our unadjusted analysis examining the association between oxytocin variables and method of delivery found that only lower mean units of oxytocin by LOI was a significant predictor for cesarean delivery. This is likely related to less than optimal management of the oxytocin infusion and resultant lack of effective UC pattern and labor. When oxytocin administration variables and BMI were considered, overweight and obese BMI (compared to normal weight BMI) was a significant predictor for cesarean delivery and mean units of oxytocin by LOI was no longer significant. That normal weight women have lower cesarean rate is consistent with the literature (Bhattacharya et al., 2007).

After all maternal characteristics and provider type were considered, overweight and obese groups were more likely to have a cesarean delivery compared to the normal weight group. The odds ratios for these two predictors are very large, but we believe they are overestimated because of the small size of the normal weight group compared to the other groups. Not having an anxiety/depression diagnosis was a predictor for cesarean delivery. While it is unknown whether the women with anxiety/depression diagnoses were undergoing treatment with medications or therapy, it is likely that women with a diagnosis were being treated. Perhaps they were then more able to

prepare for labor and delivery better than someone with an undiagnosed anxiety/depression disorder resulting in better outcomes. Use of an IUPC was also a significant predictor for cesarean delivery. It is common practice to place an IUPC when lack of labor progress is noted to determine whether UCs are adequate to promote cervical change. Use of cervical ripening is consistent with a less ripened cervix on admission, which is related to higher risk of cesarean delivery (Tam et al., 2013).

One important consideration when understanding our results about oxytocin administration is the type of monitoring used during labor. There was no significant difference among BMI groups for IUPC and IFE use in this sample. It has been shown that use of external monitors becomes more difficult as BMI increases (Euliano et al., 2007; Ray et al., 2008). Although there are reports of increased rates of intrapartum infection with use of internal monitors (Harper, Shanks, Tuuli, Roehl, & Cahill, 2013), rates of infection also increase with longer LOL (Cahill et al., 2012). Additionally, it is known that intravenous oxytocin is absorbed into the extracellular fluid (ECF) space (JHP Pharmaceuticals, 2012), and that obese women have a larger ECF space than normal weight women (Mager, 2009). Due to this physiological difference, a specific amount of oxytocin given to a normal weight women may be more dilute when given to an obese women, and the obese woman may actually need a larger dose of oxytocin to promote effective labor and vaginal delivery. Perhaps if internal monitoring were employed sooner for women of higher BMI groups when external monitoring is found to be inadequate, the oxytocin infusion could be titrated more effectively to promote an adequate UC pattern. This could possibly shorten the total LOL and increase the chance that obese women could deliver vaginally. Researchers evaluating oxytocin

dosing should consider closely related interventions such as FHR and UC monitoring when conducting studies.

E. Limitations

This study has some limitations. One limitation is the relatively small normal weight group compared to the overweight and obese groups. With a larger normal weight sample we might not have had odds ratios that overestimated the risk of cesarean delivery for overweight and obese women. Due to the retrospective design of this study, there are potential biases that we could not control. Because our dataset was extracted from the EMR, data were missing for race/ethnicity resulting in women being categorized as “other non-Hispanic” (13.2%) and “unknown race/ethnicity” (3.9%). We compared maternal characteristics across race/ethnicity groups to try and identify which other racial/ethnic groups might be different or be similar to these women. There was no pattern to further identify whom these women might represent.

F. Conclusion

Our study indicates that obese women receive more intrapartum oxytocin for post-dates IOL than normal weight women, but they may still be under dosed to promote timely vaginal delivery. Additionally, when external monitoring methods fail to produce an accurate FHR and UC pattern, internal monitors should be utilized so that oxytocin can be administered safely and effectively for IOL. Additional research should evaluate neonatal outcomes for obese women who receive intravenous oxytocin. Findings may be used to improve the safety and effectiveness of oxytocin administration to minimize risk of adverse outcomes for obese women and their infants. Future research is needed to focus on the women at greatest risk, specifically subcategories of

the obese group (class I, class II, and class III) as defined by the World Health Organization (World Health Organization, 2006).

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TABLE II: CHARACTERISTICS OF THE SAMPLE

Characteristic	Normal weight *n* = 21	Overweight *n* = 134	Obese *n* = 125	*P*-value
Age (years)	30.1 (±5.09)	31.99 (±4.51)	30.39 (±5.32)	.021
Gestational age at delivery (weeks)	41.18 (±.29)	41.23 (±.28)	41.27 (±.3)	.370
First prenatal care visit BMI	19.45 (±1.15)	22.03 (±1.79)	28.03 (±4.96)	< .001
Race/Ethnicity				.024
Hispanic	2 (9.5)	10 (7.5)	23 (18.4)	
White non-Hispanic	11 (52.3)	86 (64.2)	56 (44.8)	
Black non-Hispanic	2 (9.5)	5 (3.7)	16 (12.8)	
Asian non-Hispanic	3 (14.3)	11 (8.2)	7 (5.6)	
Other non-Hispanic	3 (14.3)	16 (11.9)	18 (14.4)	
Unknown	0 (0)	6 (4.5)	5 (4.0)	
Parity				.515
Nulliparous	15 (71.4)	110 (82.1)	101 (80.8)	
Multiparous	6 (28.6)	24 (17.9)	24 (19.2)	
Insurance type				.001
Private	18 (85.7)	121 (90.3)	91 (72.8)	
Public	3 (14.3)	13 (9.7)	34 (27.2)	
Gestation at first prenatal visit (weeks)	9.44 (±2.69)	10.52 (±4.53)	10.30 (±3.95)	.571
Gestational weight gain (pounds)	26.75 (±7.89)	31.90 (±8.54)	37.06 (±15.02)	< .001

(continued)

TABLE II: CHARACTERISTICS OF THE SAMPLE (continued)

Characteristic	Normal weight *n* = 21	Overweight *n* = 134	Obese *n* = 125	*P*-value
Delivery weight (kg)	66.26 (±5.24)	75.49 (±6.79)	91.75 (±13.19)	< .001
Admission dilation (cm)	2.17 (±1.09)	1.55 (±1.08)	1.86 (±1.14)	.016
Length of labor (hours)	14.64 (±8.07)	17.45 (±7.55)	19.76 (±8.73)	.008
Method of delivery				.003
Vaginal	20 (95.2)	89 (66.4)	72 (57.6)	
Cesarean	1 (4.8)	45 (33.6)	53 (42.4)	

Data are mean ± standard deviation or n (%) unless otherwise specified.

BMI, body mass index; kg, kilograms; cm, centimeters

TABLE III: PROVIDER TYPE AND INTERVENTIONS

Characteristic	Normal weight *n* = 21	Overweight *n* = 134	Obese *n* = 125	*P*-value
Provider type				.032
OB-GYN	16 (76.2)	119 (88.8)	92 (73.6)	
CNM	4 (19.0)	10 (7.5)	22 (17.6)	
Resident	1 (4.8)	5 (3.7)	11 (8.8)	
Epidural				.896
Yes	20 (95.2)	127 (94.8)	120 (96.0)	
No	1 (4.8)	7 (5.2)	5 (4.0)	
Cervical ripening				.034
Yes	4 (19.0)	64 (47.8)	49 (39.2)	
No	17 (81.0)	70 (52.2)	76 (60.8)	
ROM method				.729
AROM	19 (90.5)	122 (91.7)	111 (88.8)	
SROM	2 (9.5)	11 (8.3)	14 (11.2)	
IUPC				.855
Yes	3 (14.3)	23 (17.2)	27 (21.6)	
No	18 (85.7)	110 (82.1)	97 (77.6)	
Unknown	0 (0)	1 (0.7)	1 (0.8)	
IFE				.839
Yes	2 (9.5)	8 (6.0)	12 (9.6)	
No	19 (90.5)	125 (93.3)	112 (89.6)	
Unknown	0 (0)	1 (0.7)	1 (0.8)	

Data are n (%).

OB-GYN, Obstetrician Gynecologist; CNM, Certified Nurse Midwife; ROM, rupture of membranes; AROM, artificial rupture of membranes; SROM, spontaneous rupture of membranes; IUPC, intrauterine pressure catheter; IFE, internal fetal elect

TABLE IV: ANOVA OF OXYTOCIN-TITRATION VARIABLES BY BMI GROUPS*, UNADJUSTED AND ADJUSTED FOR COVARIATES

	Normal weight		Overweight		Obese			
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*(2, 278)	*P*
Unadjusted								
Total oxytocin (units)	6.37	7.06	5.92**	4.98	7.50**	6.46	2.38	.095
Length of infusion (hours)	13.08	7.72	13.75	6.49	15.32	7.01	2.12	.121
Highest oxytocin (mu/min)	12.00	6.54	11.31	5.28	12.21	6.31	0.77	.463
Mean oxytocin by LOI (units)	0.41	0.21	0.40	0.22	0.44	0.23	1.16	.316
Time to highest dose (min.)	445.81	356.22	509.9	371.07	557.14	423.36	0.94	.394
Mean time to high dose (min.)	77.89	38.78	98.19**	69.61	83.39**	43.10	2.68	.070
Mean time to last dose (min.)	92.37	74.38	94.58	47.85	102.35	77.46	0.55	.578
	M	*SD*	*M*	*SD*	*M*	*SD*	*F*(20, 260)	*P*
Adjusted								
Total oxytocin (units)	6.37	7.06	5.99	4.99	7.55	6.46	1.42	.243
Length of infusion (hours)	13.08	7.72	13.80	6.53	15.41	6.96	1.62	.200
Highest oxytocin (mu/min)	12.00	6.54	11.42	5.25	12.24	6.32	1.16	.315
Mean oxytocin by LOI (units)	0.41	0.21	0.40	0.22	0.44	0.23	0.36	.698
Time to highest dose (min.)	445.81	356.22	511.85	373.51	560.43	423.48	0.87	.422
Mean time to high dose (min.)	77.87	38.78	93.91	60.41	83.46	43.37	0.43	.653
Mean time to last dose (min.)	92.37	74.38	91.62	41.60	102.58	77.73	1.42	.244

M, mean; SD, standard deviation; F, f statistic; P, p value; mu/min, milliunits per minute; LOI; length of infusion

* BMI refers to BMI ($kg/m^{2)}$ at labor admission

** Significant differences between groups

TABLE V: MULTIPLE LINEAR REGRESSION PREDICTING LENGTH OF LABOR FOR VAGINAL DELIVERIES CONTROLLING FOR BMI, OTHER MATERNAL CHARACTERISTICS, AND TYPE OF PROVIDER

Variable	*B*	95% CI	*SE B*	*t*	*P*
Total oxytocin (units)	0.11	[-0.24, 0.47]	0.18	0.63	.531
LOI (hours)	0.70	[0.52, 0.89]	0.09	7.52	< .001
Highest oxytocin (mu/min)	0.36	[0.13, 0.59]	0.12	3.06	.002
Mean units by LOI	-7.79	[-14.38, -1.20]	3.36	-2.32	.021
Minutes to high rate	0.00003	[-0.003, 0.003]	0.002	0.02	.984
Mean to high rate (min)	-0.02	[-0.03, -0.007]	0.006	-3.10	.002
Mean to last change (min)	-0.002	[-0.008, 0.005]	0.003	-0.59	.624
Normal weight		Reference			
Overweight	1.25	[-0.21, 2.70]	0.74	1.68	.092
Obese	2.13	[0.63, 3.63]	0.76	2.79	.005
Age at delivery (years)	0.03	[-0.07, 0.14]	0.05	0.60	.547
Gestational age (delivery)	1.58	[-0.09, 3.26]	0.85	1.86	.064
Gestational weight gain	-0.03	[-0.07, 0.01]	0.02	-1.32	.186
Nulliparity	2.48	[1.18, 3.78]	0.66	3.74	< .001
Diabetes	0.56	[-2.17, 3.30]	1.39	0.40	.687
Hypertension	-1.86	[-6.03, 2.30]	2.13	-0.88	.381
GBS	-0.13	[-1.13, 0.86]	0.51	-0.26	.792
Anxiety/depression diagnosis	0.65	[-0.68, 1.98]	0.68	0.96	.339
Thyroid disorder	-0.87	[-2.43, 0.68]	0.79	-1.10	.271
Unknown race	-1.11	[-3.42, 1.20]	1.18	-0.94	.346
Hispanic	-1.09	[-2.90, 0.72]	0.92	-1.19	.236
Black non-Hispanic	0.58	[-1.56, 2.71]	1.09	0.53	.597
Asian non-Hispanic	1.29	[-0.51, 3.08]	0.92	1.41	.160
Other non-Hispanic	2.09	[0.75, 3.42]	0.68	3.06	.002
White non-Hispanic		Reference			

(continued)

TABLE V: MULTIPLE LINEAR REGRESSION PREDICTING LENGTH OF LABOR FOR VAGINAL DELIVERIES CONTROLLING FOR BMI, OTHER MATERNAL CHARACTERISTICS, AND TYPE OF PROVIDER (CONTINUED)

Variable	*B*	95% CI	*SE B*	*t*	*P*
Resident provider	-1.87	[-4.82, 1.08]	1.51	-2.75	.214
CNM provider	-0.42	[-1.90, 1.07]	0.76	0.11	.584
OB-GYN provider		Reference			
Public insurance	2.17	[0.05, 4.30]	1.08	2.00	.045
Private insurance		Reference			
Epidural	-1.02	[-2.99, 0.94]	1.00	-1.02	.308
AROM	0.08	[-1.55, 1.70]	0.83	0.10	.924
IUPC	-1.51	[-3.37, 0.36]	0.95	-1.58	.114
IFE	0.80	[-1.15, 2.75]	1.00	0.80	.423
Cervical ripening	4.84	[3.79, 5.88]	0.53	9.07	< .001
Model P-value < .001					
Model pseudo R^2 = .15					

B, beta; CI, confidence interval; SE B, standard error of B; t, t statistic; P, p-value; LOI, length of infusion; mu/min, milliunits per minute; GBS, group B streptococcus; CNM, certified nurse midwife; OB-GYN, obstetrician gynecologist; AROM, artificial rupture of membranes; IUPC, intrauterine pressure catheter; IFE, internal fetal electrode.

**Note*: CI = confidence interval for *B*.

TABLE VI: MULTIPLE LINEAR REGRESSION PREDICTING LENGTH OF LABOR FOR CESAREAN DELIVERIES CONTROLLING FOR BMI, OTHER MATERNAL CHARACTERISTICS, AND TYPE OF PROVIDER

Variable	*B*	95% CI	*SE B*	*t*	*P*
Total oxytocin (units)	-0.27	[-0.65, 0.11]	0.19	-1.38	.167
LOI (hours)	1.10	[0.86, 1.35]	0.12	8.92	< .001
Highest oxytocin (mu/min)	0.07	[-0.20, 0.34]	0.14	0.49	.626
Mean units by LOI	9.89	[1.34, 18.44]	4.36	2.27	.023
Minutes to high rate	-0.005	[-0.008, -0.001]	0.002	-2.78	.007
Mean to high rate (min)	0.006	[-0.01, 0.02]	0.009	0.66	.511
Mean to last change (min)	-0.03	[-0.06, -0.01]	0.01	-3.12	.002
Normal weight		Reference			
Overweight	1.40	[-6.14, 8.94]	3.85	0.36	.716
Obese	0.50	[-6.97, 7.97]	3.81	0.13	.896
Age at delivery (years)	0.15	[0.004, 0.30]	0.08	2.02	.044
Gestational age	2.03	[-0.32, 4.39]	1.20	1.69	.091
Gestational weight gain	0.004	[-0.05, 0.06]	0.03	0.15	.870
Nulliparity	0.13	[-4.29, 4.55]	2.26	0.06	.954
Diabetes	0.27	[-4.30, 4.84]	2.33	0.12	.907
Hypertension	-2.82	[-8.90, 3.26]	3.10	-0.91	.363
GBS	0.74	[-1.05, 2.52]	0.91	0.81	.420
Anxiety, depression, other psych	-0.72	[-4.25, 2.82]	1.80	-0.40	.691
Thyroid disorder	0.007	[-1.89, 1.91]	0.97	0.007	.994
Unknown race	3.56	[0.56, 6.56]	1.53	2.33	.020
Hispanic	2.30	[-0.36, 4.95]	1.35	1.70	.090
Black non-Hispanic	3.96	[1.50, 6.41]	1.25	3.16	.002
Asian non-Hispanic	2.61	[0.18, 5.04]	1.24	2.11	.035
Other non-Hispanic	0.93	[-1.07, 2.93]	1.02	0.91	.364
White non-Hispanic		Reference			

(continued)

TABLE VI: MULTIPLE LINEAR REGRESSION PREDICTING LENGTH OF LABOR FOR CESAREAN DELIVERIES CONTROLLING FOR BMI, OTHER MATERNAL CHARACTERISTICS, AND TYPE OF PROVIDER (continued)

Variable	*B*	95% CI	*SE B*	*t*	*P*
Resident provider	-8.18	[-12.23, -4.14]	2.06	-3.97	< .001
CNM provider	2.85	[-0.23, 5.94]	1.57	1.81	.070
OB-GYN provider		Reference			
Public insurance	7.79	[5.03, 10.55]	1.41	5.53	< .001
Private insurance		Reference			
Epidural	2.40	[-2.16, 6.96]	2.33	1.03	.302
AROM	-3.01	[-5.24, -0.77]	1.14	-2.63	.009
IUPC	-1.39	[-2.81, 0.03]	0.73	-1.92	.055
IFE	-0.38	[-2.30, 1.54]	0.98	-0.39	.698
Cervical ripening	5.87	[4.44, 7.29]	0.73	8.06	< .001
Model P-value < .001					
Model pseudo R^2 = .11					

B, beta; CI, confidence interval; SE B, standard error of B; t, t statistic; P, p-value; LOI, length of infusion; mu/min, milliunits per minute; GBS, group B streptococcus; CNM, certified nurse midwife; OB-GYN, obstetrician gynecologist; AROM, artificial rupture of membranes; IUPC, intrauterine pressure catheter; IFE, internal fetal electrode.

**Note*: CI = confidence interval for *B*.

TABLE VII: MULTIPLE LOGISTIC REGRESSION PREDICTING METHOD OF DELIVERY CONTROLLING FOR BMI, OTHER MATERNAL CHARACTERISTICS, AND TYPE OF PROVIDER*

Variable	*B*	SE	*OR*	95% CI	*Wald*	*P*
Total oxytocin (units)	0.20	0.12	1.22	[0.96, 1.54]	2.72	.099
LOI (hours)	-0.03	0.07	0.97	[0.85, 1.10]	0.23	.633
Highest oxytocin (mu/min)	0.06	0.08	1.06	[0.92, 1.23]	0.62	.430
Mean units by LOI	-4.39	2.42	0.01	[0.000, 1.40]	3.31	.069
Minutes to high rate	-0.001	0.001	0.999	[0.997, 1.001]	0.71	.399
Mean to high rate (min)	-0.002	0.004	0.998	[0.99, 1.01]	0.37	.541
Mean to last change (min)	0.000	0.003	1.00	[0.99, 1.01]	0.000	.991
Normal weight				Reference		
Overweight	3.54	1.54	34.35	[1.69, 699.97]	5.29	.021
Obese	3.97	1.54	53.15	[2.58, 1095.79]	6.62	.010
Age at delivery (years)	-0.001	0.04	0.999	[0.92, 1.08]	0.001	.972
Gestational age	0.27	0.64	1.31	[0.37, 4.62]	0.18	.676
Gestational weight gain	0.008	0.02	1.01	[0.98, 1.04]	0.29	.591
Nulliparity	2.27	0.82	9.68	[1.93, 48.65]	7.59	.006
Diabetes	-0.45	1.08	0.64	[0.08, 5.25]	0.17	.677
HTN	0.65	1.41	1.91	[0.12, 30.57]	0.21	.647
GBS	-0.85	0.44	0.43	[0.18, 1.02]	3.71	.054
Anxiety/depression disorder	-2.18	0.87	0.11	[0.02, 0.62]	6.34	.012
Thyroid disorder	0.44	0.58	1.55	[0.50, 4.78]	0.58	.447
Unknown race	-0.28	0.84	0.75	[0.15, 3.90]	0.11	.736
Hispanic	0.80	0.67	2.23	[0.60, 8.31]	1.43	.232
Black non-Hispanic	0.31	0.71	1.37	[0.34, 5.52]	0.19	.660
Asian non-Hispanic	0.40	0.65	1.49	[0.42, 5.27]	0.38	.540
Other non-Hispanic	0.27	0.53	1.31	[0.46, 3.69]	0.26	.612
White non-Hispanic				Reference		
Resident provider	-0.93	1.05	0.40	[0.05, 3.12]	0.78	.379
CNM provider	-1.13	0.72	0.32	[0.08, 1.32]	2.47	.116
OB-GYN provider				Reference		

(continued)

TABLE VII: MULTIPLE LOGISTIC REGRESSION PREDICTING METHOD OF DELIVERY CONTROLLING FOR BMI, OTHER MATERNAL CHARACTERISTICS, AND TYPE OF PROVIDER* (continued)

Variable	*B*	SE	*OR*	95% CI	*Wald*	*P*
Public insurance	0.59	0.84	1.81	[0.35, 9.28]	0.50	.479
Private insurance				Reference		
Epidural	-0.09	1.14	0.91	[0.10, 8.47]	0.01	.936
AROM	-0.45	0.55	0.64	[0.22, 1.87]	0.67	.412
IUPC	2.01	0.47	7.44	[2.99, 18.54]	18.59	< .001
IFE	0.88	0.60	2.41	[0.74, 7.85]	2.13	.144
Cervical ripening	0.96	0.37	2.62	[1.26, 5.44]	6.68	.010
Model p-value < .001						
Cox and Snell R^2 = .36						
Predicted percent correct = 78.3%						
ROC AUC = .87						
H-L goodness-of-fit chi-square p-value = .956						

B, beta; SE, standard error; OR, odds ratio; CI, confidence interval; P, p-value; LOI, length of infusion; mu/min, milliunits per minute; GBS, group B streptococcus; CNM, certified nurse midwife; OB-GYN, obstetrician gynecologist; AROM, artificial rupture of membranes; IUPC, intrauterine pressure catheter; IFE, internal fetal electrode; AUROC, area under receiver operating characteristic; H-L, Hosmer and Lemeshow.

CI = confidence interval for odds ratio (*OR*).

* Cesarean is reference group.

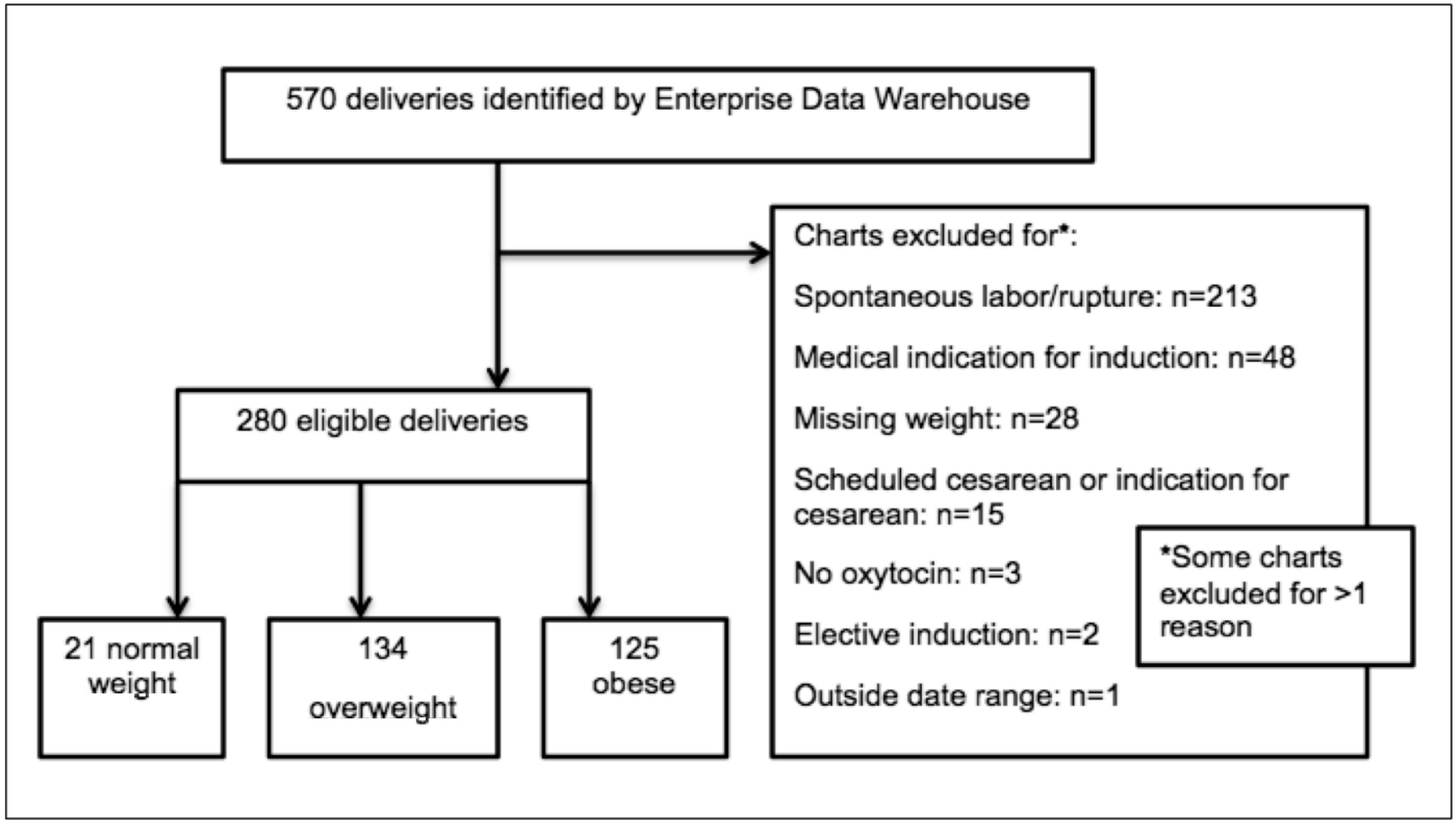

Figure 2: Participant Selection

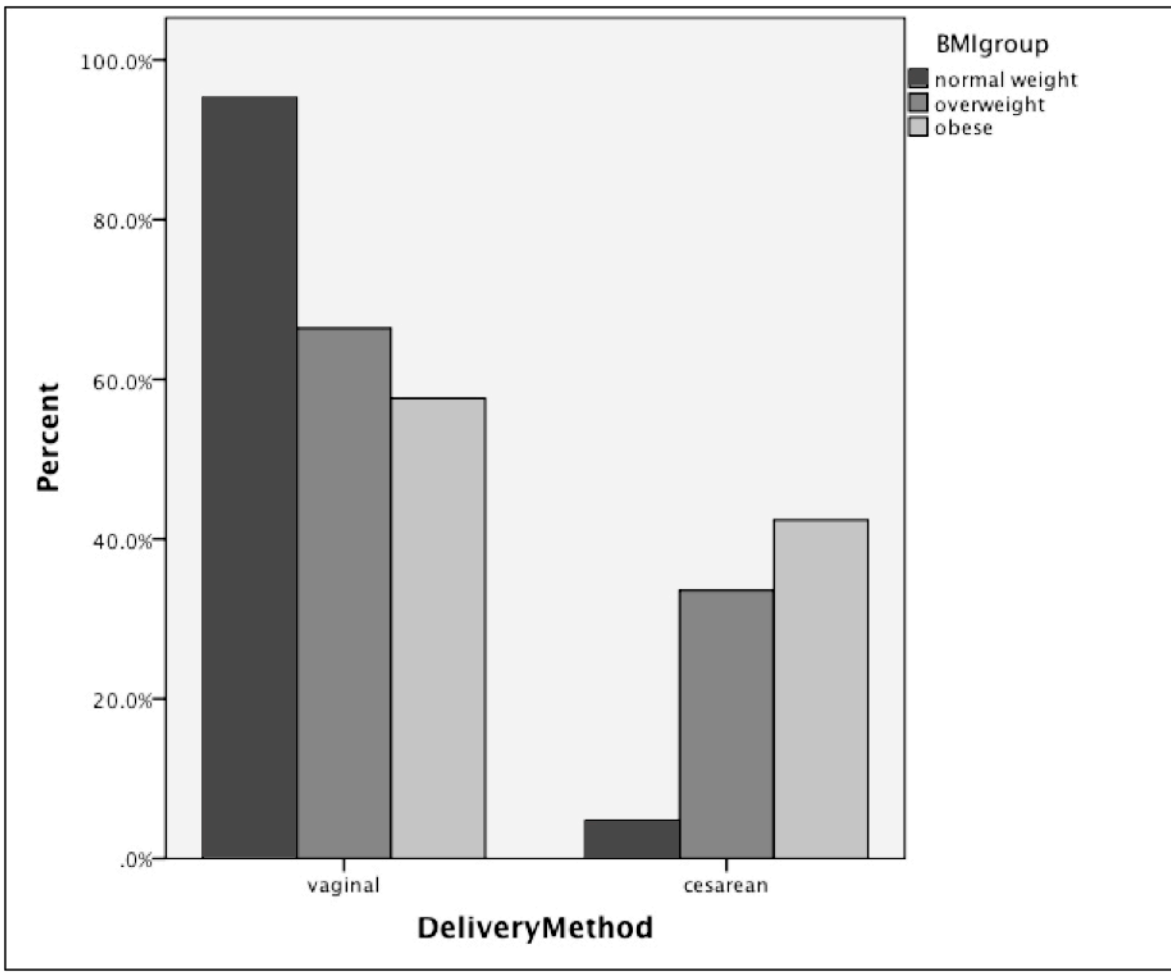

Figure 3: Delivery Method by BMI Group

APPENDIX

Institutional Review Board Office
Northwestern University
Biomedical IRB
750 North Lake Shore Drive
Suite 700
Chicago, Illinois 60611
312-503-9338

Social and Behavioral Sciences IRB
600 Foster Street
Chambers Hall, Second Floor
Evanston, Illinois 60208
847-467-1723

4/22/2014

Dr. Sheila Haas
Northwestern Memorial Hospital (NMH)
Feinberg 4-504
Chaicgo, IL 60611
shaas@nmh.org, shaas@luc.edu

IRB Project Number: STU00091822
Project Title: Nurse Titration of Oxytocin Infusion for Post-Dates Induction of Labor Among Normal Weight, Overweight, and Obese Women
Project Sites:

Northwestern Medical Faculty Foundation (NMFF)
Northwestern Memorial Hospital (NMH)

Submission Considered: New Submission **Submission Number:** STU00091822
Study Review Type: Expedited
Review Date 4/21/2014
Status: APPROVED **Approval Period:** (4/21/2014 - 4/20/2015)

Dear Dr. Haas,

The IRB considered and approved your submission referenced above through 4/20/2015. As Principal Investigator (P.I.), you have ultimate responsibility for the conduct of this study, the ethical performance of the project, and the protection of the rights and welfare of human subjects. You are required to comply with all NU policies and procedures, as well as with all applicable Federal, State and local laws regarding the protection of human subjects in research including, but not limited to the following:

- Not changing the approved protocol or consent form without prior IRB approval (except in an emergency, if necessary, to safeguard the well-being of human subjects).
- Obtaining proper informed consent from human subjects or their legally responsible representative, using only the currently approved, stamped consent form.
- Promptly reporting unanticipated problems involving risks to subjects or others, or promptly reportable non-compliance in accordance with IRB guidelines.
- Submit a continuing review application 45 days prior to the expiration of IRB approval. If IRB re-approval is not obtained by the end of the approval period indicated above, all research related activities must stop and no new subjects may be enrolled.

IRB approval includes the following:

Waiver of Consent: A Waiver of Consent was granted for this project in accordance with section 45CFR46.116d(1-4)

HIPAA: A HIPAA Waiver of Authorization was granted for this project in accordance with section 42CFR 164-512 (I) 2(ii) of the HIPAA Privacy Rule and with Northwestern University's HIPAA Research Policy.

Protocol Document:

Name
MaederChartReviewProtocol.doc

Institutional Review Board Office
Northwestern University

Biomedical IRB
750 North Lake Shore Drive
Suite 700
Chicago, Illinois 60611
312-503-9338

Social and Behavioral Sciences IRB
600 Foster Street
Chambers Hall, Second Floor
Evanston, Illinois 60208
847-467-1723

NORTHWESTERN
UNIVERSITY

APPROVAL OF CONTINUING REVIEW

April 9, 2015

Sheila Haas
Feinberg 4-504
Chaicgo, , IL 60611

Dear Dr. Sheila Haas:

On April 1, 2015, the IRB reviewed the following submission:

Determination Date:	4/1/2015
Type of Submission:	Continuing Review
Review Level:	Expedited
Expedited Category:	(5) Data, documents, records, or specimens
Title of Study:	Nurse Titration of Oxytocin Infusion for Post-Dates Induction of Labor Among Normal Weight, Overweight, and Obese Women
Principal Investigator:	Sheila Haas
IRB ID:	STU00091822-CR0001
Funding Source:	Northwestern Memorial Hospital (NMH)
Documents Reviewed:	• MaederChartReviewProtocolV2.doc

The IRB has approved the study to continue, with an approval period of: **4/1/2015 to 3/31/2016** inclusive. Thirty days before expiration, you are to submit a continuing review for this study. You will be sent reminder notifications as your last date of approval approaches; however, you are responsible for being aware of when your approval period expires.

In conducting this study, you are required to follow the requirements listed in the Northwestern University (NU) Investigator Manual (HRP-103), which can be found by navigating to the IRB Library within the eIRB+ system.

NU IRB approval does not constitute nor guarantee institutional approval and/or support. Investigators and study team members must comply with all applicable federal, state, and local laws, as well as NU Policies and Procedures, which may include obtaining approval for your research activities from other individuals or entities.

For IRB-related questions, please consult the NU IRB website at http://irb.northwestern.edu. For general research questions, please consult the NU Office for Research website at http://www.research.northwestern.edu.

Sincerely,

Heather Gipson
IRB Director

UNIVERSITY OF ILLINOIS
AT CHICAGO

Office for the Protection of Research Subjects (OPRS)
Office of the Vice Chancellor for Research (MC 672)
203 Administrative Office Building
1737 West Polk Street
Chicago, Illinois 60612-7227

Approval Notice

Initial Review (Response To Modifications)

July 24, 2014

Angela Maeder, BSN

Women, Child, & Family Health Science

2134 W. Chicago Ave., Unit 2N

Chicago, IL 60622

Phone: (312) 618-5450

RE: Protocol # 2014-0585

"Nurse Titration of Oxytocin Infusion for Post-Dates Induction of Labor Among Normal Weight, Overweight, and Obese Women"

Dear Ms. Maeder:

Your Initial Review (Response To Modifications) was reviewed and approved by the Expedited review process on July 23, 2014. You may now begin your research.

Please note the following information about your approved research protocol:

Protocol Approval Period: July 23, 2014 - July 23, 2015

Approved Subject Enrollment #: 0 at UIC ; 1000 at Northwestern

Additional Determinations for Research Involving Minors: The Board determined that this research satisfies 45CFR46.404, research not involving greater than minimal risk. Wards of the State may not be enrolled unless the IRB grants specific approval and assures inclusion of additional protections in the research required under 45CFR46.409. If you wish to enroll Wards of the State contact OPRS and refer to the tip sheet.

Performance Sites: UIC, Northwestern Memorial Hospital

Sponsor: Chapman Nursing Research Scholarship/Northwestern Memorial Hospital

Research Protocol(s):

a) Nurse Titration of Oxytocin Infusion for Post-Dates Induction of Labor Among Normal Weight, Overweight, and Obese Women, Version 2, July 9, 2014

Informed Consent(s):

a) Waiver of Informed Consent granted under [45 CFR 46.116(d)] for secondary use of Northwestern IRB approved data

HIPAA Authorization(s):

a) NOTE: Only de-identified data being transferred to UIC - No PHI. A waiver of authorization is not applicable to this research study.

Your research meets the criteria for expedited review as defined in 45 CFR 46.110(b)(1) under the following specific category:

(5) Research involving materials (data, documents, records, or specimens) that have been collected, or will be collected solely for nonresearch purposes (such as medical treatment or diagnosis).

Please note the Review History of this submission:

Receipt Date	Submission Type	Review Process	Review Date	Review Action
06/11/2014	Initial Review	Expedited	06/27/2014	Modifications Required
07/11/2014	Response To	Expedited	07/23/2014	Approved

	Modifications			

Please remember to:

→ Use your **research protocol number** (2014-0585) on any documents or correspondence with the IRB concerning your research protocol.

→ Review and comply with all requirements on the enclosure,

"UIC Investigator Responsibilities, Protection of Human Research Subjects"
(http://tigger.uic.edu/depts/ovcr/research/protocolreview/irb/policies/0924.pdf)

Please note that the UIC IRB has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

Please be aware that if the scope of work in the grant/project changes, the protocol must be amended and approved by the UIC IRB before the initiation of the change.

We wish you the best as you conduct your research. If you have any questions or need further help, please contact OPRS at (312) 996-1711 or me at (312) 355-1404. Please send any correspondence about this protocol to OPRS at 203 AOB, M/C 672.

Sincerely,

Sheilah R. Graham, MPH

IRB Coordinator, IRB # 3

Office for the Protection of Research Subjects

cc: Barbara McFarlin, Women, Child, & Family Health Science, M/C 802
Susan Vonderheid, Faculty Sponsor, Women, Child, & Family Health Science, M/C 802

UNIVERSITY OF ILLINOIS
AT CHICAGO

Office for the Protection of Research Subjects (OPRS)
Office of the Vice Chancellor for Research (MC 672)
203 Administrative Office Building
1737 West Polk Street
Chicago, Illinois 60612-7227

Approval Notice

Continuing Review

June 17, 2015

Angela Maeder, BSN

Women, Child, & Family Health Science

2134 W. Chicago Ave., Unit 2N

Chicago, IL 60622

Phone: (312) 618-5450

RE: Protocol # 2014-0585

"Nurse Titration of Oxytocin Infusion for Post-Dates Induction of Labor Among Normal Weight, Overweight, and Obese Women"

Dear Dr. Maeder:

Your Continuing Review was reviewed and approved by the Expedited review process on June 9, 2015. You may now continue your research.

Please note the following information about your approved research protocol:

Protocol Approval Period: June 9, 2015 - June 8, 2016

Approved Subject Enrollment #: 0

Additional Determinations for Research Involving Minors: The Board determined that this research satisfies 45CFR46.404 research not involving greater than minimal risk.

Performance Sites: UIC, Northwestern Memorial Hospital

Sponsor: Chapman Nursing Research Scholarship/Northwestern Memorial Hospital

Research Protocol:

b) Nurse Titration of Oxytocin Infusion for Post-Dates Induction of Labor Among Normal Weight, Overweight, and Obese Women, Version 3, September 9, 2014

Informed Consent:

b) Waiver of Informed Consent granted under [45 CFR 46.116(d)] for secondary use of Northwestern IRB approved data

HIPAA Authorization:

b) NOTE: Only de-identified data being transferred to UIC - No PHI. A waiver of authorization is not applicable to this research study.

Your research meets the criteria for expedited review as defined in 45 CFR 46.110(b)(1) under the following specific category:

(5) Research involving materials (data, documents, records, or specimens) that have been collected, or will be collected solely for nonresearch purposes (such as medical treatment or diagnosis).

Please note the Review History of this submission:

Receipt Date	Submission Type	Review Process	Review Date	Review Action
06/03/2015	Continuing Review	Expedited	06/09/2015	Approved

Please remember to:

→ Use your **research protocol number** (2014-0585) on any documents or correspondence with the IRB concerning your research protocol.

→ Review and comply with all requirements on the enclosure,

"UIC Investigator Responsibilities, Protection of Human Research Subjects"
(http://tigger.uic.edu/depts/ovcr/research/protocolreview/irb/policies/0924.pdf)

Please note that the UIC IRB has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

Please be aware that if the scope of work in the grant/project changes, the protocol must be amended and approved by the UIC IRB before the initiation of the change.

We wish you the best as you conduct your research. If you have any questions or need further help, please contact OPRS at (312) 996-1711 or me at (312) 413-0241. Please send any correspondence about this protocol to OPRS at 203 AOB, M/C 672.

Sincerely,

Ibraheem Oguntade

IRB Coordinator, IRB # 3

Office for the Protection of Research Subjects

Enclosure(s): None

cc: Barbara McFarlin, Women, Child, & Family Health Science, M/C 802
Susan Vonderheid, Faculty Sponsor, Women, Child, & Family Health Science, M/C 802

Angela B. Maeder, PhD, RNC-OB
Curriculum Vitae

Education:

University of Illinois at Chicago	PhD	2015
University of Nebraska Medical Center	BSN	2005

Professional Experience:

2005-present	Clinical Nurse – Labor and Delivery Northwestern Memorial Hospital, Chicago, IL
2012-2013	Graduate Research Assistant – Healthy Pregnancy Study (PI: Dr. Susan Vonderheid) University of Illinois at Chicago
2002-2005	Nursing Associate Madonna Rehabilitation Hospital, Lincoln, NE

Certifications and Licenses:

2008-present	Inpatient Obstetric Certification
2005-present	Illinois Registered Nurse License
2005-present	Neonatal Resuscitation Provider Certification
2002-present	CPR Certification

Honors and Awards:

2014	Chapman Nurse Scholar Award Northwestern Medicine

Presentations **(my name bolded)**:

Maeder, A. (2015). *Nurse Titration of Oxytocin Infusion for Post-Dates Induction of Labor Among Normal Weight, Overweight, and Obese Women.* Presented at Annual Chapman Nurse Scholar Presentations, Chicago, IL.

Maeder, A. (2014). *Nurse Titration of Oxytocin Infusion for Post-Dates Induction of Labor Among Normal Weight, Overweight, and Obese Women.* Presented at Annual Chapman Nurse Scholar Presentations, Chicago, IL.

Poster Presentation **(my name bolded)**:

Maeder, A. B., & Vonderheid, S. C. (2015). *Oxytocin Administration and Nursing Interventions for Women of Varying BMI Groups: A Review of the Literature.* Presented at Midwest Nursing Research Society 39th Annual Research Conference, Indianapolis, IN.

Mizell, A., Reed, S., Duncan, K., Baxa, D., & Dierks, K. (2005). *Family Involvement in Womens' Post-Surgical Nursing Care.* Presented at Bryan LGH Medical Center, Lincoln, NE.

Professional Membership:

2013-present	Midwest Nursing Research Society (MNRS)
2010-present	Association of Women's Health, Obstetric, and Neonatal Nurses (AWHONN)

Committee Memberships:

February 2014-present	Peer Review Committee Northwestern Medicine
February 2014-present	Labor and Delivery Interdisciplinary Professional Practice Committee Northwestern Medicine