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Risk-Appropriate Maternal Care: Identifying Risk Factors that Effect Maternal Outcome

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RISK-APPROPRIATE MATERNAL CARE: IDENTIFYING RISK FACTORS THAT EFFECT MATERNAL OUTCOME

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Abstract

Although maternal deaths are the most tragic of obstetric events it continues to be a rare event. Maternal morbidity, on the other hand, is increasing and poses a greater impact on the economic, psychological, and physical health of the woman and her family, yet it has not been the focus of measurement or research since there is no systematic collection of data available. As complications increase, the likelihood of adverse maternal outcomes such as longer postpartum stays due to the need for more extensive care will also increase. Nurses are being challenged to use their knowledge and skills to identify potential factors that may cause injury or harm to the patient. The earlier these factors are recognized the better the nurse can initiate the decision making process to mitigate the risk.

In order to adequately address the topic of risk-appropriate maternal care, three aims were developed and met through literature review, concept analysis, and data collection. This entire body of work aimed to describe the evolution of regionalization and its effect on maternal risk-appropriate care, clarify the meaning of risk and explore implications for practice, and identify the relationship between selected risk factors and an extended length of stay. The work is presented as three manuscripts.

The first manuscript *"Perinatal Regionalization: Changing Trends in Maternity Care"* describes the evolution of regionalization, discusses the trends and practice changes that influenced the present day perinatal arena, and provides recommendations for an improved system of care. The second manuscript *"Understanding the Concept of Maternal Risk during Pregnancy"* provides an analysis of the concept of risk, clarifies the meaning of risk, and explores implications for practice as well as future research of

this concept. The third manuscript *"Mothers at Risk: Factors Effecting Maternal Length of Stay"* describes the maternal risk factors identifiable during pregnancy, delivery, or postpartum that have the greatest odds of increasing postpartum length of stay in order to support the development of maternal risk-appropriate care. As previous studies indicate, many of the high-risk factors prompting adverse maternal outcomes are identifiable prior to delivery. An understanding of these risks can help identify measures to be taken to minimize their effect. The study findings provide needed evidence to develop policies on early identification and appropriate care to decrease risk.

Dedication

This entire body of work is dedicated to my family without whose constant support and belief in me this project would go unfinished. To my husband Kevin, you have been such a strength and calming force behind this work. Thank you for always telling me I should, I could, and that I would. You came alongside me, willing to read and edit everything I wrote even when you had no interest in the topic. Your sense of humor helped bring me in off the ledge so many times and yes, had I known it before I would have still married you. To my children Nick and Leah, thank you for your prayers over the past four years (He listened) and for being so proud of me. I can only hope I've inspired you both to aim high and take a few chances. It's a great feeling when you've accomplished what you've set out to do no matter the path that gets you there.

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CHAPTER I

Background

The number of high-risk pregnancies due to maternal or neonatal complications has significantly increased over the past decade (Kuklina et al., 2009). The US Department of Health and Human Services reported that 31.1% of pregnant females suffered complications during hospitalized labor and delivery in 2007 (USDHHS, 2010). As a result, Healthy People 2020 objectives include the reduction of maternal illness and complications due to pregnancy (complications during hospitalized labor and delivery) by 10%.

Antenatal risk assessment and timely maternal transfer are key strategies to the successful provision of risk-appropriate care and prevention of maternal mortality and/or morbidity. This is particularly true in rural areas where low population densities render local development of regional facilities impractical (Gibson, Bailey, & Ferguson, 2001). The American Academy of Pediatrics (AAP) and American College of Obstetrics and Gynecology (ACOG) emphasize that the majority of maternal-fetal and neonatal problems can be identified before complications occur (AAP/ACOG, 2012). Perinatal complications can often be prevented when healthcare providers are appropriately educated to meet the unique needs of the patients they serve and when patients have rapid access to the appropriate healthcare. The importance of communication, education, and effective anticipatory planning for the safe delivery of patient care is supported nationally by The Joint Commission (TJC), Institute for Medical Quality, and the Centers for

Medicare and Medicaid Conditions of Participation, as well as Title 22 and CCS. In their published Sentinel Event Alert, Issue 44, TJC states the goal of all labor and delivery units is a safe birth for both mother and fetus and suggests high-risk patients be referred to appropriate health care providers and have access to specialized services. Furthermore, TJC strongly suggests that clinicians be educated regarding the additional risks pregnancy imposes on underlying medical conditions.

The concept of risk-appropriate care emerged in the United States in the 1960's and 1970's. It gained interest within obstetric and pediatric communities as technological advancements provided new opportunities for treatment and survival. Key elements included the provision of quality care to all pregnant women and newborns, maximum utilization of highly trained perinatal personnel and intensive care facilities, and assurance of reasonable cost effectiveness. Simply put, it was suggested that pregnant women be cared for in the facility appropriate to their level of risk. As a result, regional perinatal centers were established, and they developed formal relationships with smaller community hospitals. Arrangements were made to transfer high-risk women antenatally or newborn infants postnatally if they required a higher level of care. Reports in the literature have consistently supported the benefits of such arrangements including improved outcomes for mother and fetus, as well as better survival rates for high-risk infants (Bode, O'Shea, Metzguer, & Stiles, 2001; Chen et al., 2001; Samuelson, Buehler, Norris, & Sadek, 2002; Towers, Bonebrake, Padilla, & Rumney, 2000; Warner, Musial, Chenier, & Donovan, 2004).

Unfortunately, the existence of multiple level-of-care standards and regulations, market competition and forces including the advent of managed care, as well as the

proliferation of technology in diagnostic testing and therapeutic modalities have blurred the definition of risk-appropriate perinatal care and prevented the comprehensive adoption and maintenance of perinatal regionalization (Sinkin, Fisher, Dozier, & Dye, 2005; Wall, Handler, & Park, 2004). Furthermore, many hospital systems have developed perinatal regionalization programs within their own organizations that cross traditional geographic lines and pre-existing regional relationships. Although referral and transfer agreements may exist, these changes have limited the opportunities for collaborative evidence-based practice, outreach education, research, and quality improvement, as well as increased the unnecessary duplication of services and cost.

Although California embraced the concept of regionalization, gaps in care still exist. Formal definitions of level of care for providers, hospitals, and services exist for neonates within the California Children's Services (CCS) program. However, no similar maternal/fetal care definitions exist. Title 22 of the California State Code of Regulations and *Guidelines for Perinatal Care* [standards of AAP and ACOG] both refer to maternal levels of care, but without the specificity needed to define appropriate setting, provider, and competency required for individual patients or complications. Other standard setting organizations including the AAP are supportive of risk-appropriate care for pregnant women. Their attention however, is focused on the care of the infant once delivered. Research is limited on maternal levels of care and, compared to neonatal levels of care, are ill-defined and poorly implemented.

While the majority of perinatal complications can be cared for adequately at any facility providing obstetric care, there are many for which a higher level of care is required, and subsequent transport of the mother is necessary. Nurses are being

challenged to use their knowledge and skills to identify potential factors that may cause injury or harm to the patient. The earlier these factors are recognized the sooner the nurse can initiate the decision making process to mitigate the risk. Information is needed about potentially modifiable versus non-modifiable risk factors. Modifiable risk factors could be reduced through primary and secondary prevention strategies. Women with non-modifiable risk factors would potentially benefit from increased vigilance and care to minimize adverse outcomes and decrease cost. Costs associated with adverse maternal outcomes can be astronomical related to the number of inpatient days accrued and professional ancillary fees (Diehl-Svrjcek & Richardson, 2005). For many organizations, maternity/newborn expenses are the single most expensive category of health plan costs, and most of the expense is associated with the small number of high-risk births (Fetterolf, Stanziano, & Istwan, 2008). These high-risk pregnancies/births tend to have additional care needs including repeat ER visits or admissions, disease management strategies, additional testing/medications, and maternal-fetal specialist care (Bruce et al., 2008; Fleschler, Knight & Ray, 2001; Gazmararian et al., 2002). The effects on society and the family are also substantial in regards to loss of productivity, on-going disabilities, emotional pain, and quality of life (Fetterolf et al., 2008).

Study Purpose and Aims

Although several studies have been conducted on the effect of maternal factors related to newborn outcomes (Dooley, Freels, & Turnock, 1997; Graham, Zhang, & Schwalberg, 2007; Shapiro-Mendoza et al., 2008) few have focused on the effect these risk factors have on the mother's health outcome. Therefore, the purpose of this descriptive correlational study was to identify the maternal risk factors that have

predictive value in determining adverse maternal outcomes in order to support the development of maternal risk-appropriate care. Adverse maternal outcomes was defined as an extended length of stay (>48 hours for vaginal and > 72 hours for cesarean delivery) as women requiring extended hospitalization and related care require a medical reason to do so. The study used linked vital statistics and admission/discharge data to answer the question: what identifiable maternal risk-factors (demographic or obstetric) are present prior to or during labor/delivery that can predict adverse maternal outcomes? The specific aims of this study were to:

- identify patterns of high-risk factors present in cases with an extended length of stay.
- describe the relationship between selected sociodemographic variables, presence of obstetric/medical comorbidities and complications and an extended length of stay.

Significance of the Study

Data sources regarding maternal outcomes is limited or non-existent. Neonatal outcomes have been used as a proxy for maternal-fetal care evaluation (Bode et al., 2001), but still do not address the unique needs of the pregnant woman herself. The results from this study contribute information regarding what pregnancy related complications increase the risk for poor maternal outcomes. Information gained informs practice standards and improves the recognition of these elements of risk and subsequent requirements for care to mitigate the potential for adverse outcomes.

Conceptual Framework

Figure 1 illustrates the conceptual framework used in this study. The framework,

derived from the empirical literature, identifies the variables that have been shown to increase maternal risk during pregnancy, labor, or delivery and their effect on maternal delivery outcomes. Demographic factors can directly affect these outcomes, as well as exacerbate the effects of other risks.

Independent Variables: Maternal risk factors

Various risk factors contribute to the occurrence of complications during pregnancy, labor, or delivery. These factors can be incorporated into two basic groups: those that cannot be changed (e.g., age, race, parity, and previous pregnancy/medical history) and those that can be potentially modified (e.g., stress, obesity, present medical conditions, peripartum care). These risk factors include demographic, behavioral and psychosocial, prenatal care, obstetrical and medical, and peripartum care. Studies have shown that risks of adverse pregnancy outcome appear to increase with advancing maternal age (Cleary-Goldman et al., 2005) and parity (DeLange et al., 2008; Jung, Bae, Park, & Yoon, 2010), as well as low socioeconomic status (Usta, Hobeika, Abu Musa, Gabriel, & Nassar, 2005). African American women are at 3 to 4 times greater risk of death from pregnancy complications than white women (Tucker, Berg, Callaghan, & Hsia, 2007). Psychiatric disorders, substance use, and smoking further add to the risk for poor outcomes (DeLange et al., 2008; Oates, 2003) as does prepregnancy maternal obesity (Robinson, O'Connell, Joseph, & McLeod, 2005) and lack of antenatal care. Poor peripartum care (i.e. failure to diagnose/recognize, failure to act, and poor communication) has also contributed to maternal mortality and morbidity rates (Lawton et al., 2010). Multiple risk factors in a single pregnancy increase the risk of adverse delivery outcomes.

Maternal Factors Outcome Variable

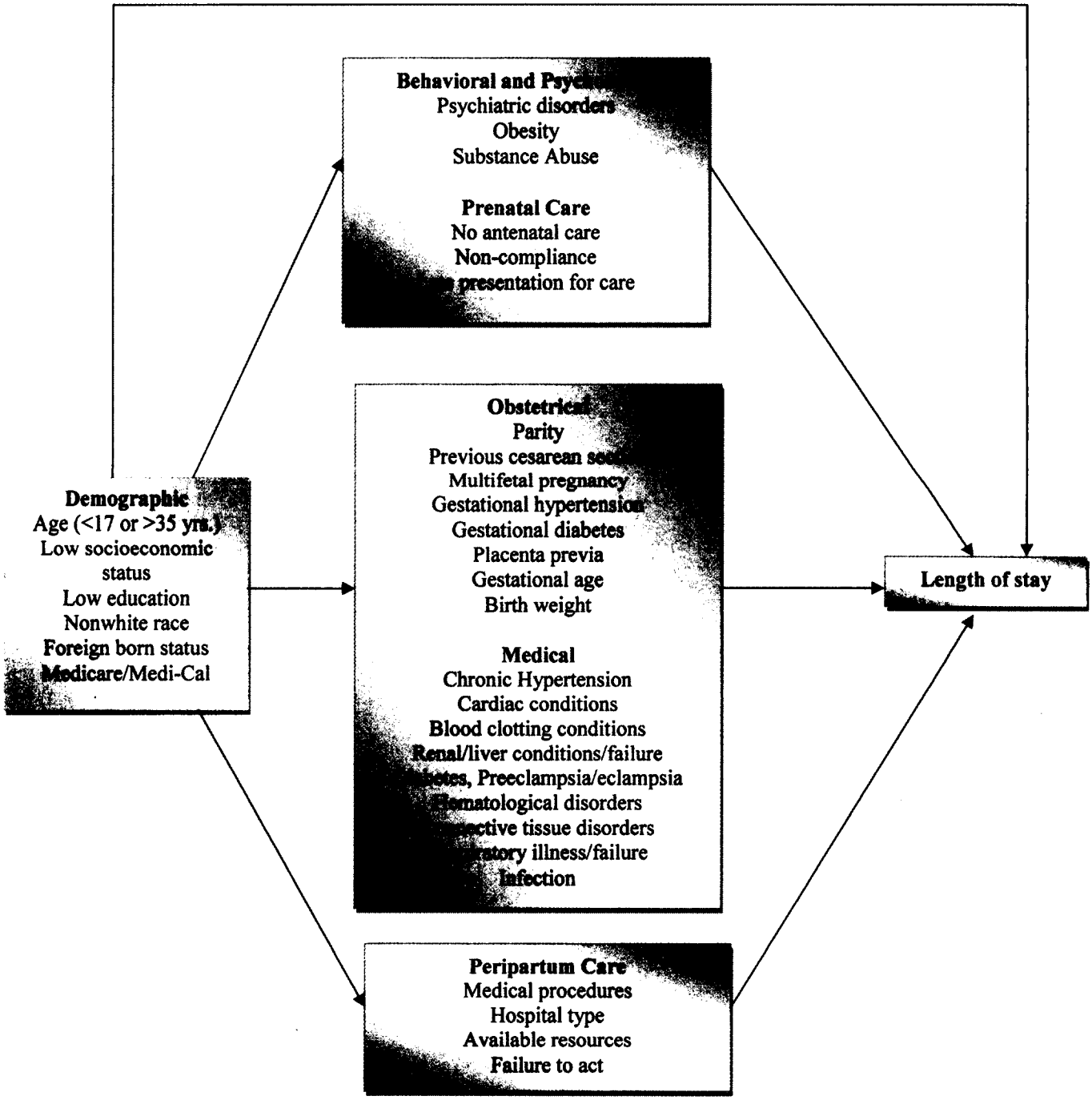

Figure 1. Conceptual model: Identifying risk factors that affect maternal outcome

Outcome Variable

The presence of maternal risk factors has been shown to increase the potential for maternal mortality and morbidity. Although maternal mortality has increased over the last decade (California Maternal Quality Care Collaborative, 2009), the total numbers remain relatively small making analysis difficult. Morbidity is equally as concerning for the mother, as well as the health care system. Research has shown that high-risk mothers may require more extensive care including blood replacement and mechanical ventilation, as well as transfer to the intensive care unit due to complications arising from obstetric hemorrhage, hypertensive disorders of pregnancy, acute renal failure, multifetal pregnancy, and diabetes (Baskett & O'Connell, 2005; Madan et al., 2009; Vasquez et al., 2007; Zeeman, Wendel, & Cunningham, 2003; Zwart, Dupuis, Richters, Ory, & van Roosmalen, 2010). Data sources for admission to intensive care units with adequate numbers for analysis are cumbersome and difficult to obtain. It can be assumed that women with complications/comorbidities requiring more extensive care would need to remain hospitalized for longer than the normal mandated time. Considering that over 4 million women give birth in the U.S. per year, childbirth is the most common reason for hospitalization. Factors influencing the length of stay in postpartum women have received little attention in the literature. Therefore, the outcome variable for this study is the presence of an extended postpartum length of stay ($\geq$48 hours for vaginal and $\geq$72 hours for cesarean delivery). Determining the factors influencing the hospitalization period may help decrease the length of hospital stay, reduce costs, and improve efficiency of obstetrical units.

Implications for Research: The research surrounding maternal risk factors has focused predominately on neonatal outcomes including preterm birth, low birth weight, and admission to the NICU (Roy et al., 2006; Samuelson et al., 2002) or risk prediction of cesarean section (Elliot, Russell, & Dickason, 1997; Gregory, Korst, & Platt, 2001). This study addressed this lack of a maternal focus when determining needs of care. Several risk scoring measures have been utilized to predict the risk for preterm birth, but none are useful in determining maternal outcomes. Evaluating a system of risk scoring for pregnant women at increased risk for complications during labor/delivery would provide valuable information in improving care to this population, as well as inform future planning decisions. Although this study included women with various types of health care coverage, additional studies are needed to determine the effects of maternal risk factors on the mother herself in specific populations including those with managed care and private coverage. These studies will further support the development of criteria for maternal levels of care, provide the foundation to identify those women who may be at increased risk, and inform a more global health policy. Additional cost analysis studies with private/public funding sources, as well as with various health care systems may further increase knowledge on the contribution of risk-assessment and maternal levels of care to patient care outcomes.

Implications for Practice: The presence of risk is a common phenomenon in the health care arena. In order to improve the outcomes of pregnancy, nurses must be involved in the decision-making process around risk and develop evidence-based guidelines for levels of care specific to obstetric patients. A thorough understanding of risk allows for the development of an individualized plan of care for each pregnant

woman and empowers the nurse to advocate for appropriate care. The JCAHO mandates that nurses participate, contribute, and measure issues related to quality care in their patients (Fleschler et al., 2001). Many times, nurses are the first line of defense in assessing for risk and preventing adverse outcomes. Accurate and complete documentation regarding obstetric and medical co-morbidities, as well as assessment findings must be communicated to the health care provider promptly and assertively. Identification tools, educational programs, and screening strategies can assist nurses in identifying risk factors and preventing potential medical complications of high-risk pregnant women. The earlier and more complete the assessment of risk the better appropriate care services can be matched with the patient along the continuum of care. Hospitals need to develop guidelines for systematic identification of women at risk for adverse outcomes and ensure the availability of appropriate resources required to provide care. Policies that support recommended criteria for transport and enhanced communication between referring and receiving institutions must be instituted. Collaboration and communication between nurses in the obstetric department and the intensive care unit ensure prompt response to emergencies. Perinatal nurses are in a position to influence a pregnant woman's actions in recognizing her risk status through increased education. The perinatal nurse can teach the woman to become involved in her pregnancy, to improve her awareness of early signs of complications, and to access appropriate services thus improving overall outcome. In addition, with an increasing number of women deemed "at risk", it is important for nurses to understand and respond to the pregnant woman's comprehension of risk, as well as assess maternal psychosocial/familial needs to minimize concerns surrounding the plan of care. This

study identifies patterns of risk factors present in cases with adverse outcome and provides information for appropriate assessment and care. Once identified, at-risk pregnant women, providers, and delivery sites can be matched according to level of need, resources available, and capacity to provide risk-appropriate care.

Implications for Health Policy: The overall goal of obstetric care is to achieve optimal pregnancy outcomes through early risk identification, care in a setting appropriate for the level of risk and transport if necessary to reduce the adverse consequences of risk (Pasquier et al., 2005). The components of risk appropriate care must be supported by state agencies, professional organizations, organizers of hospital and health systems, and payers for the system to accomplish its goal of optimizing the outcome of pregnancy. A common classification system for levels of maternal care across the State of California is required to identify standards for the provision of care, to facilitate transfer of patients from one center to another, and streamline planning and allocation of resources. Health care professionals should work together to define maternal levels of care to ensure the needs of high risk women are matched to optimal health care to minimize maternal-fetal risk. The State legislature and regulatory bodies must recognize and commit to the need for standards and definitions, determine what these standards will be, and incorporate them into perinatal care standards of practice tied to reimbursement and hospital licensing and certification. Without the political will for change, the needs of high-risk pregnant women will continue to be minimized, opportunities for improving quality care will be missed, and maternal morbidity/mortality rates will continue to increase. This study provides much needed evidence to support

standardized risk assessment and appropriate care that minimizes the need for extended lengths of stay.

Implications for Education: The majority of pregnant women encountered in any given labor/delivery unit are healthy and normal. Since the number of adverse outcomes overall are small, adequate exposure to gain the expertise and competency required for early identification of at-risk mothers is limited for many nurses. Perinatal nurses must be aware of the risk factors that increase adverse outcomes in order to identify triggers and intervene quickly. When a complication occurs, timely identification, appropriate interventions, and a team effort are required to minimize patient harm (Simpson, 2005). Education programs should be tailored to address the specific needs of this low-volume, high-risk population. This study identified pregnant women at higher risk for poor outcome that can be used to inform such educational programs.

CHAPTER II

Review of the Literature

The process of pregnancy and birth, albeit a major life event, is a natural, developmental, physiological stage. Although the woman's body goes through extraordinary physical changes to adapt to the needs of the growing fetus, the majority of women do so without medical concern. For a small percentage of women, the changes that occur trigger a cascade of events that can lead to tragic results including maternal mortality and morbidity. Complications during pregnancy can pose a serious risk to both maternal and fetal health (Elixhauser & Wier, 2011). As such, much of the research in obstetrics has focused on finding answers to the questions of who is at risk and how do health care professionals recognize and minimize the effects of these risks.

In this chapter the accumulated knowledge related to high-risk maternal factors, maternal health outcomes, and risk-appropriate maternal care will be presented. An overview of pregnancy changes that increase the potential for previously unknown risk factors to surface will also be discussed. Factors known to influence maternal health outcomes will be described with regards to the conceptual framework directing this study. In addition, an overview of the state of the science regarding risk-appropriate maternal care is provided.

Although the literature on maternal risk factors affecting maternal morbidity and mortality is extensive, research evidence on the effects of risk-appropriate maternal care and maternal levels of care is limited. The majority of studies on maternal risk factors

and outcomes were either prospective population-based cohort studies or retrospective descriptive analysis studies. Of the virtual plethora of studies on perinatal regionalization/risk-appropriate care and outcomes, only one focused solely on maternal factors. All of the studies reviewed were published in medical, nursing, or social science journals within the last 10 years.

Pregnancy

Pregnancy is a time of major physical, emotional, and relational change for the pregnant woman. From the moment of conception, the female body begins to transform in response to the needs of the developing embryo and fetus. Considering the complexity of the human being who arrives at the end of a few months, these changes are nothing short of amazing. A pregnant woman's body changes in size and shape, organ systems modify their functions to protect the dyad, as well as maintain an environment to nourish the fetus, hormonal fluctuations and responses effect emotional states, and relational adjustments between mother and her significant others must be made (Davidson, London, & Ladewig, 2012). Complications in any of the three spheres - biological, psychosocial, and spiritual - will influence the progression of a normal pregnancy and a healthy maternal-fetal dyad.

The antepartal period is divided into three equal trimesters of 3-months. In the first trimester, organogenesis and rapid development of the fetus occur. Environmental teratogens can affect normal development causing miscarriage, congenital anomalies, or birth defects (Handisurya et al., 2011; Mook-Kanamori et al., 2010). Genetics and familial tendencies toward disease may pose additional concerns (Berk, 2010). The mother may not notice the pregnancy as few outward physical changes occur during this

period. Feelings of ambivalence and anxiety regarding the pregnancy are common.

The second trimester begins the physical transformation of the mother. The growing uterus has the greatest effect on the mother as it begins to push other organs including stomach, intestines, lungs, and heart upward and laterally. Discomforts, including shortness of breath, dizziness, palpitations, indigestion, and back pain are common and may worsen as the pregnancy progresses. Without appropriate care, chronic medical conditions including diabetes, hypertension, cardiac disease, blood clotting disorders, and hematological or connective tissue disorders may worsen adding a layer of risk as the gestation continues (Clowse, Magder, Witter, & Petri, 2005; Dunne, Brydon, Smith & Gee, 2003; Graham et al., 2007). The third trimester poses the greatest challenge to the pregnant woman. Rapid growth of the fetus increases discomforts, as well as workload for the heart and lungs. Alterations in cardiac output, respiratory function, and systemic vascular resistance require adaptation of the pregnant body to accommodate these changes. For most women, these changes occur without threat while others may experience cardiac dysfunction, gestational diabetes, hypertension in pregnancy, and/or bleeding disorders (Cunningham et al., 2010; Kuklina, Ayala, & Callaghan, 2009; Mihu, Costin, Mihu, Seicean, & Ciortea, 2007; Ramaraj & Sorrell, 2009). Previously undiagnosed medical conditions may surface at this time as the body is challenged to adapt to the workload required to maintain the pregnancy.

As women complete the process of pregnancy and enter the intrapartal period of labor and birth, concerns regarding the progression of the pregnancy and any identified risk factors should be communicated to the health care providers and staff so risk-appropriate care, including mode of delivery and appropriate monitoring, may be

provided for optimal outcomes. The labor process, with its physiological demands as well as the delivery, can pose additional concerns for any woman - especially those already at risk. Once the birth of the newborn has occurred, the body must return to its non-pregnant state. Organ systems revert back to normal function including decreased cardiac output and oxygen consumption. Certain demographic variables including age, parity, socioeconomic status, and race/ethnicity can increase the woman's risk of complications throughout her pregnancy and must be considered at each trimester interval, as well as during the labor and birth (Harper, Dugan, Espeland, Martinez-Borges, & McQuellon, 2007; Jordan & Murphy, 2009). Not all risk factors pose an immediate threat to the woman or her fetus. It is possible that some risks may remain unchanged during pregnancy, while others, combined with newly developed risk factors can cause maternal mortality or morbidity (Davidson et al., 2012).

Risk-Appropriate Care

The overall goal of risk-appropriate maternal care is to achieve optimal pregnancy and birth outcomes through early risk identification, care in a setting appropriate for level of risk and transport when necessary. Evidence supporting the need for risk-appropriate neonatal care has been well documented. Due to the lack of available information regarding maternal transport and care, as well as the inadequacies in data collection methods for maternal outcomes, neonatal outcomes have been used as a proxy for assessment of appropriate maternal care. At-risk infants born outside a level III hospital have a significantly increased likelihood of neonatal death (Cifuentes et al., 2002), chronic lung disease (Chung, Fang, Chung, Hwang, & Chen, 2009) and intraventricular hemorrhage (Palmer et al., 2005), as opposed to those born at a level III hospital. In a

meta-analysis conducted by Laswell, Barfield, Rochat & Blackmon (2010) to evaluate published data on associations between hospital level at birth and neonatal mortality of very low birth weight (VLBW) and very preterm (VPT) infants, an increased odds of death for these populations born outside a level III hospital was observed. Forty-one publications met a priori inclusion criteria in years 1976 to 2010 concluding that access to risk-appropriate perinatal care improves infant mortality outcomes in VLBW and VPT deliveries. Analysis was limited in this review as definitions of hospital levels and capabilities differed among studies and institutions, potentially causing variation in reported results. Furthermore, control of confounding variables, as in severity of illness upon transfer, was limited.

Similar findings were observed by Warner and colleagues (2004) conducting a population-based cohort study on all live births of 500 to 1499 grams at the 19 hospitals in the greater Cincinnati region. The purpose of this study was to test the hypothesis that mortality and morbidity of VLBW infants was reduced when delivered at subspecialty hospitals. They determined the odds of death or major morbidity for VLBW infants who are born at nonsubspecialty perinatal centers is twice that of infants who are born at subspecialty centers despite controlling for demographic and practice characteristics. In contrast to these findings, Gessner & Muth (2001), in a study of low-birth weight infant deaths in Alaska, concluded although lower mortality rates were noted at the tertiary center than at other facilities, only 4% of deaths among low birth weight infants were associated with care decisions and none of these deaths involved intentional inappropriate retention of infants or mothers. Alaska has only one tertiary center, making the assessment of practice policies difficult as market competition is limited. Further

regionalization of care is unlikely to change these mortality rates. In both of these studies, application of results to other regions is difficult as unique characteristics of the perinatal care system in other areas may be different.

Other studies performed in Europe found comparable results. Merlo et al. (2005), conducted a population-based study in Sweden using the Swedish Birth Register to obtain information on 691,742 deliveries during a 6-year period from 1990-1995. The aim of the study was to use multilevel logistic regression analysis to investigate interhospital differences in neonatal mortality and to understand the effect the availability of neonatal resources has on mortality. Results revealed the existence of a high degree of regionalization in Sweden. The majority (82%) of deliveries occurred in large regional or county hospitals with well-established neonatal services. Further findings showed in low-risk deliveries, mortality decreased with improved access to neonatal resources. Mortality was lowest in larger regional hospitals with full access to neonatal care. In a study conducted by Hohlagschwandtner et al. (2001) at the University Hospital of Vienna, Austria, a noteworthy trend toward a decrease in severe neonatal morbidity when the infant was transferred antenatally rather than after delivery was shown. Antenatal transfer guaranteed a significantly better neonatal outcome concerning severe neonatal morbidity than postnatal transport and compared favorably with inborn admissions. The purpose of this study was to assess differences in morbidity and mortality between neonates transferred in-utero, after delivery, and inborn neonates. All three groups were comparable regarding maternal age and parity, but the mean gestational age was higher in the inborn neonates. In both of these studies, the presence of universal health care coverage may influence decisions surrounding the transfer and subsequent care of the

newborn. The presence of different maternal risk factors that may affect outcome could potentially cause selection bias.

Adequacy of prenatal care and distance from a regional center increased the risk of out-born deliveries. Samuelson and colleagues (2002) conducted a study using linked birth and death certificates of Georgia births. The purpose of this study was to determine whether improvements in the regionalized system of perinatal care could reduce neonatal mortality. To do so, they examined the proportion of births at each level of care, identified characteristics of women who did not deliver at a recommended level of care, and assessed the number of potentially averted deaths if delivered at the appropriate site. Most of the VLBW infants (77%) were delivered at a subspecialty hospital. The maternal characteristic most strongly associated with out-born infants was distance from the appropriate hospital. Women were also less likely to deliver at the appropriate hospital if they received less than adequate prenatal care. The study also found 16-23% of neonatal VLBW deaths could have been avoided if 90% of out-born infants delivered at the recommended level of hospital. These authors recommended further research on factors associated with lack of access to subspecialty care among women including risk assessment, delays in assessment, adequacy of maternal transport resources, and physician's willingness to transfer mothers. Attar, Hanrahan, Lang, Gates, and Bratton (2006) found similar results when they conducted a retrospective cohort study of VLBW infants residing in the service area of a community level II facility but admitted to a regional intensive care unit. The purpose of their study was to evaluate barriers to utilizing available risk-appropriate services for women not living near the appropriate center. Ninety-eight VLBW infants were admitted to the regional center of which there

was an equal distribution between out-born and inborn newborns. No differences were noted in type of insurance coverage, race, gestational age, severity of illness, or maternal demographic factors between the two groups. Inadequate prenatal care and increasing distance from the regional center were closely associated with an increasing frequency of out-born infants. Improved education regarding the importance of prenatal care and improved access to care may diminish these effects. Unfortunately, this study evaluated only one county limiting the sample size and its ability to detect smaller differences.

The studies on in-born vs. out-born infants all addressed outcomes of a single high-risk infant population and did not evaluate maternal outcomes or other improvements in the provision of care that perinatal regionalization was designed to support. One of the aims of the present study is to identify risk factors that can affect not only the newborn birth outcome, but also the health outcome of the mother, thus highlighting a portion of perinatal care regionalization usually ignored. The studies reviewed also used homogenous populations cared for in relatively controlled environments such as universal health care or a hospital-system. Policies regarding practice can be implemented with more ease when the competition for market share is eliminated. The present study has the potential to provide information on outcomes as they relate to the varying practice policies and health care systems within California.

Although improved outcomes are associated with appropriate levels of care, definitions and criteria for neonatal levels of care, and mechanisms for measuring and improving neonatal risk-appropriate care vary widely across states. Blackmon, Barfield, and Stark (2009), searched internet sites for all 50 states and Washington, DC to describe how states designate hospital neonatal services levels. Of the 50 states, only 33 states

used some sort of designation to describe the levels of neonatal services available. In a similar study, Nowakowski et al. (2010) examined and compared state models of perinatal regionalization and risk-appropriate care. The study identified mechanisms of measurement for risk-appropriate care in seven states and found variation in level definition, clinical capacity, and population served. Some states define additional sub-levels of care based on patient volume and only a few include transport requirements in the definition. An assessment of California's maternal-fetal and neonatal systems of care (Regional Perinatal Programs of California (RPPC), 2004) showed wide variability in policies, training/education, consultation, and joint review of outcome data. It would stand to reason, if levels of care and practice standards are inconsistently and inadequately defined and followed with a population so well studied and financed, then even more difficulties arise when attempting similar designations for maternal care. Evidence regarding maternal health outcomes and risk factors that impact those outcomes must be sought in order to support the need for improved care practices and policies.

Hospital volume also plays a role in the rate of maternal and neonatal mortality and morbidity. It can be assumed the more experience health care providers have with a particular population, the better skilled and knowledgeable they are regarding the best possible care options. Phibbs et al. (2007) conducted a study on linked birth certificates, hospital discharge abstracts, and fetal and infant death certificates to assess neonatal mortality rates among 48,237 very low birth weight infants in California. Using logistic regression models they found the number of NICUs increased over the study period and the percentage of VLBW deliveries at level III facilities decreased. Further findings concluded after adjusting for risk factors, hospitals with lower-level and lower-volume

NICUs were associated with an increased risk of death. Chung, Phibbs et al. (2010), in a more recent study to determine the effect of hospital level of care and volume on VLBW infant mortality, also concluded lower-level, lower volume units were associated with higher odds of mortality. Similar methods were employed including linked admission/discharge data and infant birth/death certificates. The study determined a decline in higher level facilities and increase in lower level facilities had occurred with the volume of high-risk infants decreasing across the board. Women delivering in high-volume units were more likely to be of advanced maternal age, have higher educational levels, or have initiated prenatal care early. African-American women were also more likely to deliver at high-volume facilities. High-risk maternal antenatal factors including diabetes, hypertension, and renal disease were more commonly seen in women delivering in higher-volume units. Hispanic women and women with government insurance were more likely to deliver in lower-level facilities. In the multivariate analysis, factors such as no prenatal care, incompetent cervix, placental abruption, preterm labor, polyhydramnios, breech presentation, birthweight, and male sex were associated with an increased odds of neonatal death. Hospital volume was a stronger predictor of death than hospital level of care.

Both of these studies show the importance that experience and volume have on neonatal outcomes. Unfortunately, although Chung, Phibbs et al. (2010) included maternal risk-factors as a variable of study, neither study included their effect on maternal health outcomes. As noted, the majority of studies on maternal risk factors do so in the context of their effect on the newborn when in fact, a sick mother may also require specialty care. More recent studies have focused on hospital volume and

maternal complications. Using administrative data, Kyser et al. (2012) identified women admitted for childbirth in 2006 and compared their composite complication rates across delivery volume deciles. After evaluating over 1.6 million births in 1045 hospitals, the authors found women who delivered at very low-volume hospitals have higher complications rates, as do women who delver at exceedingly high-volume hospitals. Most women who delivered in extremely low-volume hospitals had a higher volume hospital located within 25 miles. Similarly, Janakiraman et al. (2011) in a nationwide retrospective cohort study of women giving birth in 2007 examined the relationship between both hospital and provider case volume and obstetric complication rates. In contrast, they found no consistent relationship between hospital volume and rates of maternal complications. The study determined though women cared for by providers in the lowest quartile of provider volume (fewer than seven deliveries per year) had 50% higher odds of complications compared to women cared for by obstetricians in the highest quartile. Hospitals in the highest quartile of obstetric volume were more likely to care for women with medical and obstetric risk factors. Both of these studies indicate maternal mortality and morbidity rates may decrease in hospitals staffed and stocked with experienced personnel and adequate resources.

Barriers to timely transfer to a higher level of care have also been documented. Wall and colleagues (2004) using data from live birth certificates from the American Hospital Association's Annual Survey of Hospitals and Illinois hospital discharge records examined the effect of hospital factors including reimbursement sources and teaching status on the rate of nontransfer of very low birth weight babies. Of the 2,904 very low birth weight infants born from 1989-1996, 1172 (40.4%) were not transferred. After

adjusting for individual risk factors, several hospital factors were associated with nontransfer including birth in a level II+ hospital, high Medicaid revenues, high HMO revenues, and status as a teaching hospital. With the proliferation in the availability of neonatologists able to care for smaller infants at Level II facilities and the increase in economic demand many level II facilities believe they are adequately staffed to care for lower birth weight babies.

Sinkin et al., (2005) supported these findings noting despite a well-regionalized organization for perinatal care in New York, where pre-existing written protocols for transfer between institutions are established independent of insurance status, managed care influences decisions on the nature and location of care delivery. In contrast, Dobrez, Gerber, and Budetti (2006), conducted a study on a total of 8,479,144 deliveries reported at 615 facilities in Washington, California, North Carolina, and Illinois across a 10-year period. The purpose of the study was to describe trends in regionalization of perinatal care and to identify factors that predict the extent of regionalization. The study found significant variation in the extent of regionalization across states. An increasing number of deliveries at level II and level III facilities were found in the later years of analysis. Although HMOs have increased substantially in all four states, it was not found to affect the extent of regionalization and/or delivery at a lower level facility.

These findings hold true for maternal care as well. As stated previously, pregnancy is a normal developmental, physiological state. The majority of women have no identifiable risk factors prior to delivery and the number of women dying in childbirth remains relatively small. These facts have the potential to decrease vigilance for and assessment of the possibility of poor maternal health outcomes. In a managed care arena,

obstetricians receive reimbursement for prenatal care only after the delivery is completed. Providers feel they have the knowledge and skills to deliver any newborn, but concur that the newborn may need more extensive specialty care after delivery. Other adult/critical care specialists within the facility can be called upon to care for the mother should complications arise. This fragmentation in care increases the potential for adverse outcomes for both mother and baby.

Maternal variables including medical conditions have been used to assess neonatal outcomes as well. Maternal sociodemographic and medical conditions including age, race, acculturation level, gravida, psychiatric disorders, and hypertension can increase risk of poor neonatal outcome. DeLange et al. (2008) conducted a study to analyze risk factors for perinatal death, specifically those that could be prevented and determine differences in the frequency of suboptimal care factors between different levels of maternity care using data obtained from birth and death certificates the authors reviewed 608 pregnancies that resulted in neonatal deaths in South Australia. Forty-four percent of cases were found to have one or more avoidable maternal risk factors including smoking, illicit drug use, minimal antenatal care, late entry into care, and domestic violence. Five percent had a risk factor related to access to care and 11.2% were associated with deficiencies in professional care. In the multivariate analysis, significant risk factors for perinatal death included indigenous status, assisted reproductive therapy, preterm labor, antepartum hemorrhage as a result of abruption, intrauterine growth restriction, cervical incompetence, threatened miscarriage, pre-existing hypertension, psychiatric disorders, and minimal antenatal care. Of the cases associated with a peripartum care deficiency, failure to act on or recognize complications

or high-risk pregnancy was the most common. The authors suggested education of maternity care providers on early recognition and management of high-risk pregnancies may improve outcomes.

Shapiro-Mendoza et al. (2008), using a population-based approach, carried out a study on 26,170 late preterm infants in Massachusetts in order to determine outcomes of these infants with or without selected maternal medical conditions including hypertension during pregnancy, diabetes, antepartum hemorrhage, acute or chronic lung disease, maternal infection, cardiac disease, renal disease, and genital herpes. The study found late preterm infants born to mothers with any of the maternal conditions were at higher risk for newborn morbidity. Infants who were exposed to antepartum hemorrhage and hypertension were especially affected and infants exposed to a greater number of maternal complications further increased that risk.

Maternal Outcomes

In contrast to the plethora of studies on neonatal care and birth outcomes, similar studies to support maternal levels of care to improve maternal outcomes are scarce within the last 10 years. Perinatal regionalization and levels of care studies focus predominantly on neonatal birth outcomes including birth weight and complications due to gestational age. Several states including Washington, Tennessee, New York, and Arizona have developed guidelines for levels of care specific to obstetrical patients based on services and capabilities. Maternal levels of care in these states are defined as basic, intermediate, and intensive based on pregnancy diagnosis and management needs, ability to provide respiratory support and stabilization, and arrangements for follow-up. These guidelines were developed to help hospitals assess the type of patient best suited to their facility's

capabilities and scope of care. There is evidence, albeit minimal, that great gains can be made in maternal health by ensuring women with pregnancy complications can quickly reach a facility where they can receive high-quality care. Wright et al. (2010) conducted a study with women who underwent peripartum hysterectomy at the time of cesarean section in a quality and resource utilization database. The database collects inpatient data from more than 500 acute-care hospitals in the US. The purpose of the study was to examine factors that influence the morbidity and mortality of peripartum hysterectomy and analyze the effect of hospital volume on mortality. A total of 2,209 women were included in the study results. Maternal mortality was 1.2%. The results further showed maternal mortality in women who experience a peripartum hysterectomy at high-volume hospitals was 71% lower compared with those treated at low-volume hospitals. These women also had a lower incidence of perioperative surgical complications and intensive care unit admissions. High volume hospitals tend to have more resources; including the immediate availability of an interdisciplinary team of providers, adequate nursing support, laboratory and blood bank support, critical care units, and the ability to provide invasive cardiac monitoring. These factors allow for the immediate identification of complications and rapid response to minimize mortality and morbidity outcomes. Fournier, Dumont, Tourigny, Dunkley, and Drame (2009) conducted a study in Mali to evaluate the effect of a national referral system to reduce maternal mortality rates by improving access to emergency obstetric care. In an uncontrolled pre-post intervention study, obstetric emergencies, interventions, and deaths were recorded for the year prior to the intervention, the year of the intervention, and 1-2 years after the intervention. In women treated for an emergency during pregnancy and delivery, the risk of death after

the intervention was half the risk recorded before the intervention. The number of women receiving emergency obstetric care doubled in the first year from implementation of the improved services. The availability of obstetric interventions, reduced transport time, and reduced financial barriers can decrease overall maternal mortality rates. Approximately half of the reduction in death was attributable to decreased hemorrhage related deaths. In another study looking at maternal factors and levels of care, Mostello, Droll, Bierig, Cruz-Flores, and Leet (2003) purposed to determine whether the level of hospital care affects cesarean delivery rates for women with preeclampsia. In this population-based cohort study using Missouri birth certificate data, logistic regression was used to analyze data from 13,646 nulliparous women with preeclampsia. After adjusting for gestational age and birth weight, the data showed women with preeclampsia were more likely to be delivered by cesarean section if admitted to a primary or secondary hospital than to a tertiary hospital. The level of expertise, comfort level, and staffing at tertiary hospitals may allow greater attempts and success with vaginal delivery.

In summary, numerous studies have been conducted during the last decade to evaluate variables that effect newborn birth outcomes including place of delivery and transport, access to appropriate care, barriers to care, hospital volume and capacity for care, reimbursement, and maternal risk factors. Several studies found a significant improvement in short- and long-term outcomes for the neonate when risk-appropriate care at a facility that possesses the specialty care required is provided (Chung et al., 2009; Cifuentes et al., 2002; Hohlagschwandtner et al., 2001; Laswell et al., 2010; Merlo et al., 2005; Palmer et al., 2009; Warner et al., 2004). Infants who were transferred to a higher-

level facility, born at a low-volume hospital, had managed care coverage, had a mother who lived outside of the catchment area or had a previously diagnosed medical complication were more likely to suffer mortality or morbidity. Retrospective, population-based designs make up the majority of studies on neonatal outcomes. These studies used birth registry data for a region, state, health care system, or combined regional/state data sets with sample sizes ranging from 4,770 (Samuelson et al., 2002) to 7,238,400 (Dobrez et al., 2006). Other than the few studies examining the effect of maternal risk factors on neonatal birth outcomes (DeLange et al., 2008; Dobrez et al., 2006; Samuelson et al., 2002; Shapiro-Mendoza et al., 2008) neonatal studies were conducted using birth weight and/or gestational age as the area of interest, therefore no demographic data was collected or analyzed.

Unlike the neonatal realm, few studies have been conducted on regionalization and maternal health outcomes over the past ten years. Those studies completed indicated similar results in improved maternal outcomes can be obtained when at-risk mothers are delivered in high-volume tertiary facilities where emergency services and resources are available. These large population-based cohort studies examined one maternal outcome - either hemorrhage or preeclampsia (Fournier et al., 2009; Mostello et al., 2003; Wright et al., 2010). Women in these studies were predominately white, aged 18-35, and married. Analysis of these variables on the outcome was not completed. The information was used simply to characterize the population studied and to ensure homogeneity of study groups. Results support the need for further examination on adverse maternal outcomes and the identification of risk factors present that increase the potential for such outcomes. The paucity of studies on maternal care services as compared to neonatal care serves to

further support the need for evidence that maternal levels of care/maternal risk-appropriate care is important.

Maternal Mortality and Morbidity

Maternal and neonatal mortality rates are the most widely used indicators of the health of a nation. The death of a woman during pregnancy or in the postpartum period is a relatively rare occurrence, but the number of high-risk pregnancies due to maternal or neonatal complications has significantly increased over the past decade (Kuklina et al., 2009) leading to an increased number of adverse maternal health outcomes post-delivery. Among the 4.2 million deliveries in the U.S. in 2008, 94.1 percent listed some type of pregnancy complication (Elixhauser & Wier, 2011). Maternal mortality rates have tripled from 1996 to 2006 and are 4.5 times higher than the Healthy People 2010 benchmark (CMQCC, 2009). Maternal mortality and morbidity continue to be major issues in the United States and California.

Berg, Chang, Callaghan, and Whitehead (2003) conducted a study to describe risk factors and trends in pregnancy-related mortality. Using linked birth and death certificates, data on 3,201 pregnancy-related deaths was analyzed. Findings indicated the mortality ratio for pregnant women increased from 10.3 to 12.9 in a 7-year period. An increased risk for death was found in women who were of African American ethnicity, older, and had no prenatal care. The leading causes of death were embolism, hemorrhage, and other pre-existing medical conditions such as cardiac disease and diabetes. Another study by Berg, Harper, Atkinson et al. (2005) was conducted in North Carolina to identify all pregnancy-related deaths and determine possible reduction strategies. The Pregnancy-Related Mortality Review Committee reviewed 108 records of

women who died during or within one year of pregnancy as a result of a complication of pregnancy or treatment. They found 40% of pregnancy-related deaths were potentially preventable depending on the cause of death. Deaths due to hemorrhage and complications of chronic diseases were determined to be preventable with earlier identification and rapid, aggressive treatment. The most common cause of death was cardiomyopathy (21%) followed by hemorrhage (14%), hypertension in pregnancy (10%), cerebrovascular accidents (9%), and chronic medical conditions (9%). The authors noted that changes in several areas including preconception care, patient actions, system factors, and quality of care contribute to the preventability of death. In a similar review of California's pregnancy-related mortality (2011), the leading causes of death for the 98 cases in 2002 and 2003 were cardiomyopathy (15%), preeclampsia/eclampsia (15%), amniotic fluid embolism (14%), obstetric hemorrhage (10%), and sepsis/infection (8%). These findings differ slightly from those reported nationally and in other regions such as New York where embolism, hemorrhage, and hypertension were the leading causes of death. More than a third of the deaths were determined to have had a good-to-strong chance of being prevented. Eighty-seven percent of deaths reviewed had at least one factor related to the patient, the health care professional, or the health care facility contributed in some way to the fatal outcome. In both of these statewide reviews, the authors encouraged further research and examination of risk factors that increase a woman's potential for pregnancy-related mortality, as well as morbidities.

In a descriptive study, Geller, Cox, and Kilpatrick (2006) explored the issue of preventability of maternal mortality and morbidity by identifying and categorizing preventable events occurring in women with severe health problems. Of the 237 women

with medical/obstetric complications, 79 (33%) had at least one event that was determined to be preventable. The most common types of preventable events were related to inadequate diagnosis/recognition of high-risk status by the provider (54.4%), inappropriate treatment primarily due to delay in treatment (38.0%), and inadequate documentation (30.7%). These events may be linked, as one misstep in the diagnosis or documentation can cause inappropriate or delayed treatment. These findings further support the need for further research and the dissemination of findings in order to educate health care providers at all levels in the appropriate assessment and treatment of at-risk pregnant women. In a similar report, Clark et al. (2008) conducted a study to determine the etiology and preventability of maternal death and the role cesarean delivery may play in mortality risk. The authors examined medical records of all maternal deaths from 2000 to 2006 in facilities associated with the largest health care delivery system in the US. There were 95 maternal deaths in a population of 1,461,270 mothers. The median age of women who died was 29 years, parity was 1, 45% were White, 27% were African American, 20% were Hispanic, and 8% were Asian. Fifteen percent of women in this study had known preexisting medical conditions that caused or contributed to their death including cardiac conditions, chronic hypertension, HIV/AIDS, ethanol abuse, epilepsy, diabetes, and malignancy. Eighteen percent of deaths were determined to be preventable with appropriate medical care including postpartum hemorrhage, preeclampsia, medication error, and infection. Eleven percent of deaths were determined to be patient driven including suicide, motor vehicle accident, drug abuse, and lack of compliance issues. Four deaths were determined to be directly due to hemorrhage caused by cesarean delivery. These findings indicate the majority of deaths may occur in women who are

low-risk during pregnancy. Improved identification and rapid treatment may diminish this risk, but unfortunately, a broad array of practice standards in the US, as well as variance in health care systems pose a stiff barrier to changes in practice standards.

Pregnancy-related death continues to be a relatively rare occurrence. Due to the lack of data sources available that truly examine the conditions surrounding the event that contributes to mortality, individual states must investigate each death in detail to determine cause and preventability. This can be a time consuming and demanding process. Furthermore, the number of maternal deaths is substantially underestimated (Horon, 2005) adding to the difficulty in obtaining accurate information. Maternal mortality is just the tip of the iceberg. Under the surface lies a host of maternal morbidities that effect maternal health and newborn outcomes. Maternal morbidity is more frequent and often-times preventable, yet little attention has been given to identifying factors leading to complications. Characterizing such factors is valuable for monitoring the quality of care and for assessing the incidence of life-threatening complications. Furthermore, reviewing pregnancy complications and determining the potential factors associated with them has the possibility of improving maternal health outcomes by providing information to influence providers' decision-making process, as well as overall health policy (Callaghan, MacKay, & Berg, 2008).

Berg, MacKay, Qin, and Callaghan (2009) using a large dataset from the National Hospital Discharge Survey assessed changes in maternal morbidity rates. The authors compared two time periods (1993-1997 and 2001-2005) and determined the overall rate of obstetric complications remained unchanged at 28.6%, but the prevalence of pre-existing medical conditions at delivery increased from 4.1% to 4.9%. The percentage of

delivery hospitalizations with postpartum hemorrhage, severe preeclampsia, transient hypertension of pregnancy, postpartum fever of unknown origin, gestational diabetes, preexisting diabetes mellitus, and asthma each increased significantly. The authors speculated possible factors effecting this change in rate may include changes in the underlying risk profiles of women (i.e. age, parity, obesity, previous c/s) and changes in clinical practice (i.e. inductions). Further information on these risk factors may be meaningful to clinicians, public health, and policy makers as they attempt to improve the morbidity rates in pregnancy. In an unpublished report by Lu, Fleege, Fridman, Gregory, and Korst (2011) similar results were found. The authors used linked birth cohort data for a three-year period (1999, 2002, & 2005) of 1,551,017 deliveries in 310 hospitals in California to examine trends in maternal morbidity. Using hierarchical logistic regression models, the study found a significant increase over the three-year period in the presence of several pre-existing medical conditions (pre-gestational hypertension, pre-gestational diabetes, asthma, and thyroid disorders), obstetrical complications (gestational hypertension, gestational diabetes, and chorioamnionitis), as well as primary and repeat cesarean section rates with or without labor. This study further noted substantial disparities in maternal morbidity across racial-ethnic groups. Non-Hispanic black mothers were more likely to have hypertension (1 in 10), Asian Pacific Islander mothers were more likely to have diabetes (1 in 10), and hypertension and diabetes increased by nearly 50% among Native American mothers. In light of these increasing numbers of women with complications before or during pregnancy, further research on risk factors that add to adverse maternal outcomes could provide evidence to substantiate the need for closer surveillance for the diverse population in California today.

In an English multicenter, case-control, population-based study of 48,865 deliveries, Waterstone, Bewley, and Wolfe (2001) estimated the incidence and predictors of severe obstetric morbidity including severe hemorrhage, severe pre-eclampsia, severe sepsis, and uterine rupture. Using logistic regression models they found the incidence of severe obstetric morbidity to be 12/1000 deliveries. The main predictors of severe maternal morbidity were age over 34, non-white race, low socio-economic status, general medical conditions including diabetes and hypertension, and obstetric factors (previous hemorrhage, multiple pregnancy, antenatal admission, emergency cesarean section). Although these conditions may not be amenable to change, they are useful in the identification of women who require added vigilance during the labor and delivery process, as well as during the postpartum period.

Baskett and O'Connell (2005) conducted a similar study in Nova Scotia. The purpose of this population-based study was to identify the incidence of markers of maternal morbidity and determine its relationship to age, parity, and method of delivery. Five markers of morbidity were used including blood transfusion of greater than 5 units, emergency hysterectomy, complete uterine rupture, eclampsia, and the need for intensive care. Of the 159,896 women delivered, 313 had a total of 385 markers of severe morbidity. There was a statistically significant association between multiparity and emergency cesarean section and uterine rupture; between age greater than 35 and emergency hysterectomy, uterine rupture, and ICU admission; and between cesarean delivery and blood transfusion, emergency hysterectomy, uterine rupture, eclampsia, and ICU admission. Hemorrhage accounted for 64.7% of the causes leading to severe morbidity, and hypertensive disorders contributed 16.8%. A more recent study by

Goffman, Madden, Harrison, Merkatz, and Chazotte (2007) identified risk factors for life-threatening maternal outcomes. Using hospital chart review from one large regional center in New York, the authors identified 69 cases of morbidity. Significant risk factors included age >35 years, African-American race and Hispanic ethnicity, chronic medical conditions, obesity, prior cesarean section, and number of pregnancies.

Similar studies in the US have been performed to determine the incidence, consequence, and preventability of life-threatening events during pregnancy, labor, and delivery. Danel, Berg, Johnson, and Atrash (2003) sought to determine the prevalence of maternal morbidity during labor and delivery. The authors analyzed a total of 154,001 records from the National Hospital Discharge Survey data from 1993 to 1997. Maternal morbidity was defined as conditions affecting the health of the mother. Conditions affecting the fetus, but not the mother directly were excluded, as was mental illness. Forty-three percent of women experienced some type of morbidity during their delivery and 31% had at least one obstetric complication or at least one pre-existing medical condition. These results show the magnitude of the problem of complicating events and support the need to identify factors that can predict adverse outcomes.

Kuklina et al. (2009), examined trends in rates of severe obstetric complications and the potential contribution of cesarean section rates and maternal age to these trends. In addition, data on selected pregnancy conditions and hospital characteristics including region, location, teaching status, and number of beds was collected as potential predictors of outcome. Using data from the Nationwide Inpatient Sample that includes approximately 90% of all hospital discharge information in the US, the authors examined two study periods, 1998-1999 and 2004-2005. The prevalence of deliveries complicated

by at least one severe obstetric complication increased from 0.64% to 0.81%. Complications that increased significantly included renal failure, pulmonary embolism, adult respiratory distress syndrome, shock, blood transfusion, and mechanical ventilation. More women were older and/or on Medicaid/Medicare in the 2004-2005 study period than in 1998-1999. An increase in the number of women with multiple pregnancy, hypertension, diabetes, and cesarean delivery was also noted. Adjustment for maternal age had no effect on the increased risk, but adjustment for cesarean section explained a majority of the increase in risk of renal failure, adult respiratory syndrome, and mechanical ventilation. The authors suggested future studies on major risk factors, such as multiparity, obesity, and chronic disease may shed further light on these trends.

More recently, Callaghan, Creanga, and Kuklina (2012) using the Nationwide Inpatient Sample updated previous estimates of severe maternal morbidity during both delivery and postpartum hospitalizations, as well as provided estimates of trends in these events in the U.S. between 1998 and 2009. The Nationwide Inpatient Sample is the largest all-payer hospital inpatient care database in the U.S. encompassing approximately 20% of all community hospitals. Trends were reported using two-year increments of data. The authors determined that compared with 1998-1999, severe complications during delivery hospitalization increased by 75% and by 114% during postpartum hospitalization in the period 2008-2009. Blood transfusion was the leading reason for being classified as having severe morbidity across all time periods for both delivery and postpartum hospitalizations. There were increases in many complications including acute renal failure, shock, thrombotic pulmonary embolisms, respiratory distress syndrome, acute myocardial infarction, aneurysms, and operations of the heart and pericardium.

The authors noted during the same study period, increases in the U.S. cesarean delivery rate and in the proportion of pregnant women with chronic conditions, postpartum hemorrhage, obesity, multiple births, and advanced maternal age have also been documented. Further review of cases is needed to identify modifiable risks and develop best practices to deal with risks that might not be modifiable.

Lyndon et al. (2012) conducted a similar study to determine the incidence and risk factors for maternal morbidity during childbirth hospitalization using ICD9-CM and vital records codes from linked hospital discharge and vital records data for over 1.5 million singleton births in California during 2005-2007. The overall rate of maternal morbidity was 241/1000 births. The morbidity rate declined 11% over the study period. The most common morbidities were episiotomy, pelvic trauma, maternal infection, postpartum hemorrhage, and 3rd or 4th degree lacerations. While postpartum hemorrhage overall was lower in 2007 than in 2005, blood transfusion increased by 21% and severe postpartum hemorrhage increased by 10%. Although pelvic floor and non-pelvic floor morbidity decreased over the study period, severe morbidity (defined as length of stay >90th percentile and the presence of severe complication) was 9% higher in 2007 than in 2005. As has been found in previous studies, Lyndon et al. further substantiate the risks of age, non-White race, inadequate prenatal care, and comorbidities including hypertension, preeclampsia, and diabetes as being associated with higher morbidity. Furthermore, the authors noted a greater risk for severe morbidity in smaller volume hospitals. This may be due to having fewer resources to address serious complications when they occur without time to transfer to a higher level of care. Establishing and simulating the

implementation of emergency protocols could help facilities with more limited resources respond to complications quickly and more effectively.

In summary, maternal death and morbidity due to complications in pregnancy, labor, delivery, or the postpartum period has been shown to be a serious and prevalent problem in the US. Studies have shown an increasing trend over the past several years in the presence of complications that affect morbidity rates. These complications are often times preventable with the availability of appropriate resources. Although maternal deaths are the most tragic of obstetric events it continues to be a rare event. Maternal morbidity poses a greater impact on the economic, psychological, and physical health of the woman and her family, yet it has not been the focus of measurement or research as there is no systematic collection of data available (Bruce et al., 2012). Population-based data sources are fraught with limitations in accuracy and estimation.

Postpartum Length of Stay

Approximately 4.1 million women give birth annually in the United States making childbirth the primary reason for hospitalization, as well as a main contributor to overall health care costs (Podulka, Stranges, & Steiner, 2011). As complications related to pregnancy, labor and delivery increase, the likelihood of longer postpartum stays due to more extensive care needed will also increase. Although several studies have been published regarding early discharge and maternal outcomes, few studies have been conducted during the last decade on the contributing factors associated with an extended length of stay. Determining the factors influencing the hospitalization period can add a different perspective on understanding the effects of perinatal risk factors on maternal outcomes.

Elattar, Selamat, Robson, and Loughney (2008) conducted a prospective observational study in the UK to identify factors with the greatest influence on maternal length of stay. Risk factors were grouped as obstetric, medical, social, and neonatal. After review of 500 sets of maternal and neonatal case notes, the results revealed the mean length of stay increased in an approximately linear fashion with the number of risk factors identified. When the study group (risk factors present) was compared to the control group (no identifiable risk factors) a significant increase in length of stay was noted especially in women whose babies required specialized neonatal care, women with social problems, women with obstetric complications and women with medical conditions. Although specialized neonatal care had the greatest statistical influence on length of stay, numerically women with primarily obstetric complications were the most likely to have an extended length of stay. Further findings showed while major maternal illness such as infection, preeclampsia, hemorrhage, and perineal trauma strongly influences the length of stay for individual patients, relatively minor conditions such as anemia are more common and therefore have a greater influence on bed occupancy. Roberts et al. (2009) conducted a similar study in New South Wales, Australia to determine trends in severe adverse maternal outcomes during the birth admission. The impact of adverse outcomes on duration of hospital admission was also examined. Of the 500,603 women with linked birth and hospital records 12.5/1000 suffered an adverse outcome. The rate of adverse maternal outcomes increased from 11.5 in 1999 to 13.8 in 2004, and annual increase of 3.8%. This increase occurred almost entirely among women with postpartum hemorrhage (67%). Overall, the decline in the number of births and in the duration of hospital admissions resulted in a decline of maternal hospital days for

births. Among women with severe adverse outcomes there was a 12% decrease in hospital days over the study period, whereas women with no severe adverse outcome occupied 23% fewer hospital days. The authors indicated the impact of adverse maternal outcomes is somewhat inflexible and costs could be better reduced by implementing quality preventative measures prior to delivery. In a similar, but more recent, Australian study looking at pre-pregnancy obesity and excess pregnancy weight gain, Mamun et al. (2011) purposed to determine the association of these specific high-risk factors with adverse outcomes and length of hospital stay. In this population-based cohort study multivariable regression and multivariable multinomial regression models were used to analyze data of 6632 women who gave birth between 1981 and 1983. Study findings indicate mothers with excess pre-pregnancy BMI and mothers who gained excess weight during pregnancy were at greater odds of pregnancy complications, cesarean delivery, and had excess length of stay. For normal vaginal delivery the mean length of hospital stay was 4.00 (SD 1.33) days, for cesarean delivery 6.21(SD 1.58) days and for other types of delivery it was 4.80 (SD 1.55) days. On average, obese mothers stayed 0.30 days longer in the hospital postnatally compared to mothers with a healthy BMI.

Two of the most recent studies utilize postpartum length of stay as the outcome of analysis. Although these studies focus specifically on risk factors that influence severe maternal morbidity, maternal morbidity was defined as the presence of a comorbidity/complication and an extended length of stay. Mhyre, Bateman, and Leffert (2011) conducted a study to determine the extent to which preexisting maternal medical and obstetric conditions are identified before the time of admission to the labor and delivery suite predict near-miss maternal morbidity or death. Near-miss morbidity was

defined as the presence of a medical/obstetric complication plus either a length of stay greater than 7 days or discharge to a facility other than home. Using data derived from the Nationwide Inpatient Sample, 4,550 maternal hospital admissions for delivery in the years 2003-2006 were identified as being complicated by a near-miss morbidity/mortality event. Of these, 3,996 (87.9%) remained in the hospital longer than 7 days and 775 (17%) were discharged or transferred to a medical facility, and 226 (5.8%) died during the delivery-hospitalization. The most common complications were disseminated intravascular coagulation, acute liver disease, acute respiratory distress syndrome, and acute heart failure. One of more of these complications was present in 68.4% of the patients. Similar to other studies, women older than 34 years and non-Hispanic black women were disproportionately represented among patients with near-miss morbidity/mortality. Further findings indicate most of the near-miss morbidity events occurred in patients with high-risk conditions generally identifiable at the time of admission to the labor unit suggesting that opportunities exist to improve outcomes by triaging high-risk women to delivery centers with increased capacity to deliver intensive antepartum and peripartum care.

Similarly, in a population-based case-control study, Gray, Wallace, Nelson, Reed, & Schiff (2012) identified risk factors for severe maternal morbidity occurring antepartum, intrapartum, and postpartum. Using linked birth certificate and hospital discharge data from Washington State (1987-2008), the authors identified 9485 women who had a hospitalization of at least three days or were transferred from another facility and had one or more pregnancy complication or comorbidity. Maternal age, race, smoking during pregnancy, parity, pre-existing medical conditions, multiple birth, prior

cesarean delivery, and body mass index were assessed as risk factors with logistic regression to estimate odds ratios and 95% confidence intervals, adjusted for education and delivery per source. Findings indicate women with severe maternal morbidity were more likely to be older (35-39 years), non-White race/ethnicity, unmarried, of lower level of education, to be at the extremes of parity (i.e. nulliparous or 3+ pregnancies), to have a pre-existing medical condition and to be on Medicaid/Medicare compared to controls. Women were also more likely to have a multiple birth, cesarean section, low birthweight or preterm infant, and to have received adequate prenatal care. The most common severe maternal morbidities were transfusion, hysterectomy, and respiratory failure. Women with a pre-existing condition were two times the risk of severe maternal morbidity than those without any risk factors.

In summary, studies conducted during the last decade to evaluate variables that effect maternal length of stay have found a significant relationship between maternal risk factors and maternal adverse outcomes. Women in certain socio-demographic groups, with obstetric/medical complications or pre-existing comorbidities are at increased odds of remaining hospitalized for a longer period of time further effecting family dynamics and infant bonding as well as hospital logistics and finances. California's diverse population and its high number of Medi-Cal deliveries make for a unique study cohort. With over 500,000 deliveries per year, 1 in 8 births in the US occur in California. Due to the different practice patterns regarding maternal care in California, it is imperative to understand the population served here. The present study aims to answer the question of what risk factors are present that may affect maternal length of stay. As previous studies indicate many of the high-risk factors adverse maternal outcomes are identifiable prior to

delivery, an understanding of these risks can help identify measures to be taken to minimize their effect. The study results can provide much needed evidence to develop policies on early identification and appropriate care to decrease that risk.

Conceptual Framework

Childbearing brings with it some inherent risk for complications and although any woman can experience these adverse events, some pregnant women are of increased concern. Women with identifiable antecedent factors are at greater risk for experiencing life-threatening events or death during pregnancy, labor, or delivery. It is these factors and their potential adverse effects that led to the development of this conceptual framework (Figure 2). The framework, derived from the empirical literature, identifies the independent variables that have been shown to affect the occurrence of adverse maternal health outcomes in any population and the effects of these variables on maternal length of stay which often times include additional care requirements such as admission to adult intensive care unit, transfusion, hysterectomy, need for respiratory support, and stabilization.

Maternal Risk-Factors

Various risk factors contribute to the occurrence of complications during pregnancy, labor, or delivery. These factors can be incorporated into two basic groups: those that cannot be changed (e.g., age, race, parity, and previous pregnancy/medical history) and those that can be potentially modified (e.g., stress, obesity, present medical conditions, peripartum care). These risk factors include demographic, behavioral and psychosocial, prenatal care, obstetrical and medical, and peripartum care. Demographic factors can directly affect these outcomes as well as exacerbate the effects of other risks.

Demographic risk factors. Studies have shown that women of advanced maternal age (>35 years) during pregnancy have higher morbidity rates than the regular population (18-34 years) (Salihu, Shumpert, Slay, Kirby, & Alexander, 2003) as do women with low-socioeconomic status (below or at national poverty level) (Usta et al., 2005). Women of lower-socioeconomic status during pregnancy may not access prenatal or specialty care as needed due to the high cost of care. Cleary-Goldman et al. (2005), in a prospective study of 36,056 pregnancies showed placenta previa, placental abruption, cesarean section, and perinatal mortality were all increased in older mothers. These pregnancy complications can increase the risk of severe hemorrhage at or after the time of delivery.

Artificial reproductive therapy, specifically ovum donation more common in older women, can also pose a threat to maternal health outcomes. In a study by Simchen, Shulman, Wiser, Zilberberg, and Schiff (2009) of 42 women >35 years, hypertensive complications, diabetes in pregnancy, and hospitalizations during pregnancy were all higher than in the 417 control pregnancies. It has also been noted that population specific factors, such as nonwhite race and urban residence affect risk status. Mortality and morbidity, as well as adverse maternal health outcomes, are more common among black and Hispanic women than white (Callaghan et al. 2008; Graham et al., 2007). In their prospective study of 862,723 deliveries in California, Guendelman, Thornton, Gould, and Hosang (2005) found although Mexican-born women were significantly less likely to have maternal morbidities than White, non-Latina women, they are more likely to have complications that reflect their intrapartum care including hemorrhage, lacerations, and infections. Furthermore, the authors noted that although

Maternal Factors Outcome Variable

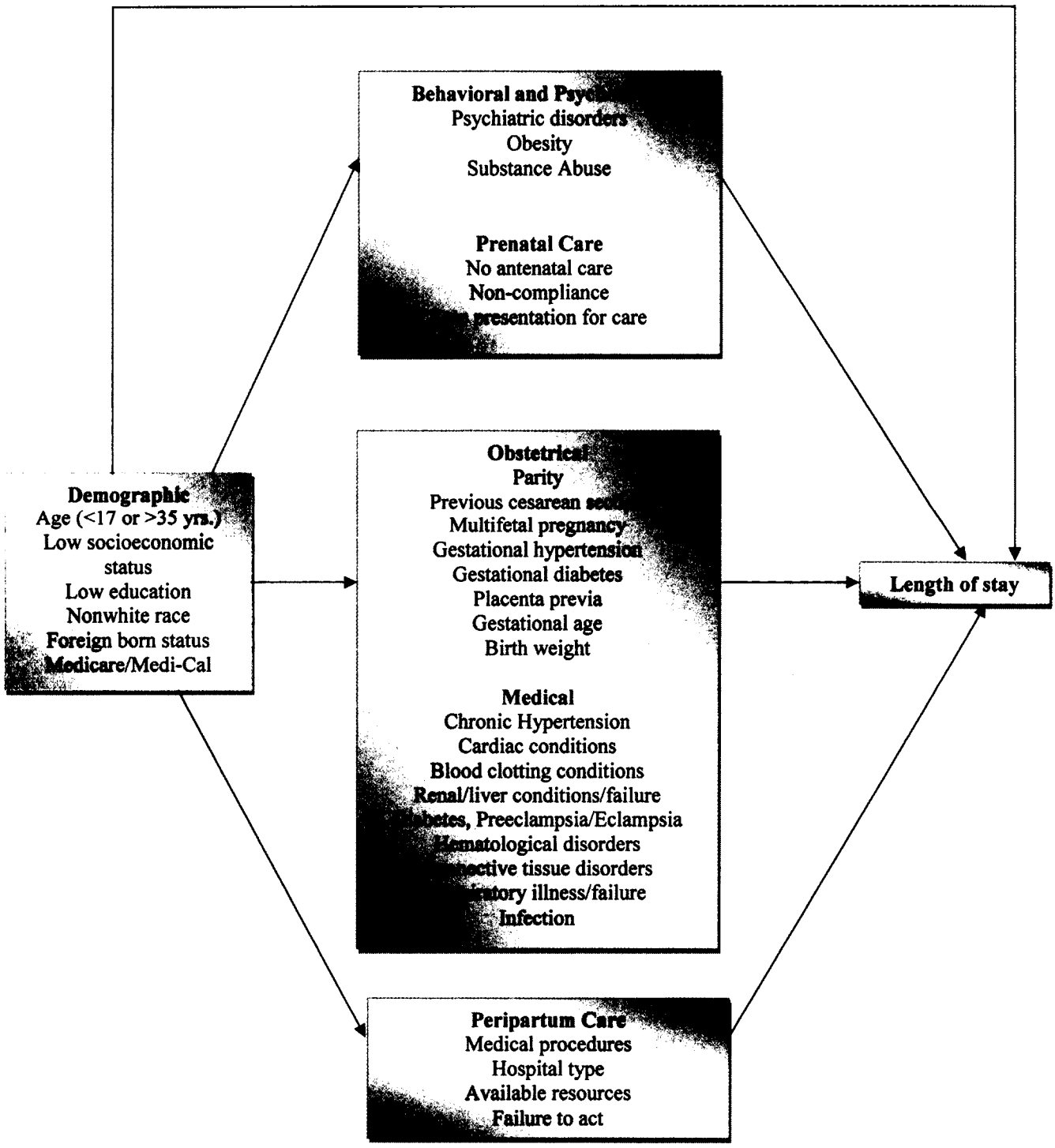

Figure 2. Conceptual model: Identifying risk factors that affect maternal outcome

most women began prenatal care during the first trimester; the Mexican-born group was twice as likely to delay prenatal care until the fifth month or later. In a similar study, Tucker et al., (2007) using national data sets, determined black women did not have significantly greater prevalence rates for preeclampsia, eclampsia, abruptio placentae, placenta previa, and hemorrhage, but were 2 to 3 times more likely to die from them than were white women. Gould, Madden, Qin and Chavez (2003) further noted an increased risk for adverse perinatal outcomes among US-born blacks and foreign-born Hispanic mothers on the basis of higher levels of inadequate prenatal care, teen births, Medi-Cal paid delivery, and lower levels of maternal and paternal education. Urban inner-city populations are at increased risk of receiving inadequate prenatal care thus increasing the risk for adverse outcomes (Attar et al., 2006).

Behavioral and psychosocial risk factors. Several behavioral and psychosocial risk factors are associated with maternal mortality and morbidity. Kavanaugh et al., (2009) noted mental illness contributed to death in 16.5% of cases of pregnancy-associated maternal mortality in Virginia with 50% considered preventable. Untreated psychiatric disorders during and after pregnancy can lead to the inability to recognize signs of physical illness, to seek medical care, and failure to follow up with treatments (Gold & Marcus, 2008). On the other hand, the presence of social support during pregnancy tends to improve outcomes by reducing the level of stress (Nicholson et al., 2006).

Additionally, maternal behavioral factors have been associated with adverse maternal health outcomes. In their population-based cohort study of 10,134 obese

pregnant women, moderately obese women had an increased risk of transient hypertension in pregnancy, antepartum venous thromboembolism, labor induction, cesarean delivery, and wound infection. Goffman et al. (2007) also found obese women were three times more likely to die or suffer severe morbidity than normal weight women. Substance abuse is also a recognized risk factor for poor maternal and neonatal outcomes, specifically placental abruption and hemorrhage, as well as preterm birth and low birth weight (Kennare, Heard, & Chan, 2005). The odds of maternal death are increased with any drug use compared to no drug use during pregnancy (Wolfe, Davis, Guydish, & Delucchi, 2005).

Prenatal care risk factors. Comprehensive prenatal care consists of a series of health services that includes three important components: early and continued risk assessment, health promotion, and medical and psychosocial interventions and follow-up (Johnson, Gregory, & Niebyl, 2007). Although findings on the efficacy of prenatal care have been mixed (Goffman et al., 2007), experts in obstetrics agree early entry into prenatal care and consistent care throughout pregnancy can help identify risk factors and potential means to minimize their overall effects. Women at risk can be educated about their pregnancy status, necessary treatments can be started, and continuous monitoring for worsening conditions can be completed. Early recognition and treatment of potential risks can minimize their effect on maternal health outcomes at delivery.

Obstetrical risk factors. Obstetrical risk factors include complications of pregnancy, labor and/or delivery that increase the risk of adverse maternal health outcomes: hemorrhage (Selo-Ojeme, Omosaiye, Battacharjee, & Kadir, 2005), preeclampsia/eclampsia (Osinaike, Amanor-Boadu, & Sanusi, 2006; Zwart et al., 2010),

multifetal pregnancy (ACOG, 2004; Panchal, Arria, & Harris, 2000), peripartum hysterectomy (Wright et al., 2010), and septicemia (Lawton et al., 2010). Parity and mode of delivery have also been associated with poor outcome overall. Aliyu, Jolly, Ehiri, and Salihu (2005) completed a meta-analysis of available research to evaluate the evidence on maternal outcomes in high parity women. Although findings were not consistent, the preponderance of the evidence seems to point to a heightened risk for gestational diabetes, hypertension, placental complications, and operative delivery with increasing birth order. In a multi-center case control study conducted by Jung et al. (2010), the association between parity and risk of hemorrhagic stroke was examined. The authors reported women with parity of 2, 3 or >4 had significantly higher risk for hemorrhage stroke, intracerebral hemorrhage, and subarachnoid hemorrhage when compared with nulliparous and uniparous women. In a prospective cohort study of 30,132 women who had cesarean delivery without labor, Silver and associates (2006) found risks of placenta accreta, cystotomy, bowel injury, ureteral injury, ileus, the need for postoperative ventilation, intensive care unit admission, hysterectomy, blood transfusion, and duration of hospital stay increased significantly with the increasing number of cesarean deliveries. The authors strongly encouraged counseling of all women on the number of intended pregnancies when elective cesarean section is being considered. Goffman et al. (2007) also found an increasing number of prior pregnancies were associated with an increasing risk. For each additional pregnancy, the odds ratio for adverse outcome was 1.3 (95% confidence interval 1.1 to 1.5).

Medical risk factors. A previous history of medical risk factors or those occurring in the present pregnancy at times can lead to adverse maternal health outcomes. In a

cross-sectional study using the nationwide Inpatient Sample of Healthcare Cost and Utilization Project, Kuklina and colleagues (2009) found the overall prevalence of hypertensive disorders among delivery hospitalizations increased significantly from 1998 to 2006 (67.2/1000 deliveries vs. 81.4/1000 deliveries in 2006). Furthermore, these hospitalizations were associated with 57% of hospitalizations with acute renal failure, 27% of hospitalizations with disseminated intravascular coagulation, and 30% of hospitalizations with ventilation, pulmonary edema, cerebrovascular disorders, and respiratory distress syndrome. In their study on 69 near-miss cases and 8 mortality cases, Goffman et al. (2007) also found similar results within one large delivery facility. The findings indicated a past history of a significant medical condition was associated with maternal death or near-miss (odds ratio 2.7, 95% confidence interval 1.5 to 4.8).

Maternal Health Outcomes Post-Delivery

Among the 4.2 million deliveries in the US in 2008, 94.1% listed some type of pregnancy complication (Elixhauser & Wier, 2011). Studies on maternal risk factors during pregnancy and birth show evidence of increased risk for admission to the intensive care unit and/or extended length of stay. In their retrospective outcome audit of 29 cases of pregnant women admitted to a New Zealand Intensive Care Unit (ICU), Lawton and associates (2009) identified the most common reasons for transfer to the ICU were need for invasive vascular monitoring, hypotension, blood loss, and disseminated intravascular coagulation. Twenty of the 29 women received blood transfusions. Many of the women had multiple complications and organ-system dysfunction. Ten of the 29 cases (35%) were deemed preventable with better recognition and treatment of ensuing complications. In a similar retrospective cohort study Vasquez et al. (2007) reviewed a

series of critically ill obstetric patients admitted to the ICU to assess the type of diseases, acuity, and interventions required, as well as maternal mortality rates to identify risks associated with maternal death. The authors found during the study period, 161 obstetric patients were admitted to the ICU of which 41% required mechanical ventilation, 63% were admitted during the postpartum period, and 74% were due to obstetric causes including hypertension, hemorrhage, and septic abortion. Adult respiratory distress syndrome, shock, and multi-organ system failure were present in a majority of cases. Furthermore, 54 patients had underlying diseases of which the most frequent were chronic hypertension, diabetes, and HIV infection. Co-morbidities have the potential of complicating an already complex recovery process. Madan et al. (2009), in a population-based case-control study using data from a perinatal linked database in New Jersey of 15,447 ICU admissions and 23 maternal deaths further identified predictors for ICU admission including preeclampsia, eclampsia, placenta previa, acute renal failure, and cesarean delivery. Diabetics and patients with connective tissue disorders were three times more likely to get admitted to the ICU and patients with hematological disorders and multifetal pregnancies were four times more likely to be admitted to the ICU. Preexisting medical conditions can potentially worsen during pregnancy and also increase the woman's risk for complications leading to ICU admission. Saravanakumar, Davies, Lewis, and Cooper (2008), in a UK study of women admitted to the obstetric high dependency unit, recognized that the increased rate of high dependency unit admissions was predominately related to massive obstetric hemorrhage and hypertensive disorders of pregnancy. Of the non-obstetric causes, maternal cardiac disease was the most common indication for prolonged monitoring and care. In addition, the analysis revealed an

increasing trend in the last decade of overall obstetric ICU admission. Similar to the US, more women are being adversely affected by complications during pregnancy. Consistent findings, including hemorrhage and hypertension as ICU required diagnoses, were noted by Zeeman et al. (2003) and Zwart et al. (2010).

Population-based data sources for admission to intensive care units with adequate numbers for analysis are cumbersome and difficult to obtain. It can be assumed that women with complications/comorbidities requiring more extensive care would need to remain hospitalized for longer than the normal mandated time. Stranges, Wier, and Elixhauser (2012) in their Healthcare Cost and Utilization Project (H-CUP) report maternal stays for vaginal deliveries tended to be shorter and less expensive than C-section stays. The mean length of stay was 2.6 days and ranged from 1.9 days for vaginal deliveries to 4.5 days for C-sections with complications. The vast majority of both types of stays listed at least one complicating condition (91.3% for vaginal, 99.9% for cesarean section).

State of the Science

As noted earlier, several studies have been conducted to determine the effects of risk factors on perinatal outcomes. The majority of these studies focused on neonatal transport and regionalization, as well as maternal risk factors on neonatal outcomes. These studies, although important in establishing the need for risk-appropriate care, do not address the issue of the pregnant woman's health outcomes. Healthy mothers produce healthy babies. Maternal risk factors including demographic, behavioral and psychosocial, prenatal care, obstetric and medical, have been shown to effect adverse outcomes. Many of the studies reviewed noted their presence in women admitted to the

ICU, but did not address their effect in increasing or decreasing the relative risk. Studies using California birth cohort data noted the increased prevalence of complications during pregnancy, but did not focus on the factors that influence that trend. There is also a lack of studies on women of lower socioeconomic status who are at highest risk for adverse outcomes. This study investigated risk factors that affect maternal outcomes of a specified high-risk population including women on Medicaid.

CHAPTER III

Methodology

The purpose of this study was to identify the maternal risk factors that have predictive value in determining adverse maternal outcomes in order to support the development of maternal risk-appropriate care. Predictive variables for this study included demographic, behavioral and psychosocial, prenatal, as well as obstetrical and medical risk factors. Adverse maternal outcomes included extended length of stay (>48 hours for vaginal and > 72 hours for cesarean delivery). This chapter presents a description of the research design, sample and sampling, procedures, measurement, and data analysis techniques. Limitations of the study as well as human subjects protection are discussed. The specific aims of this study were to:

- identify patterns of high-risk factors present in cases with an extended length of stay.
- describe the relationship between selected sociodemographic variables, presence of obstetric/medical comorbidities and complications and an extended length of stay.

Design

A descriptive, correlational design employing linked secondary data sets was used for this study. The main purpose was to identify patterns and describe risk factors that have been documented in the literature as effecting maternal delivery outcomes while exploring possible relationships among these factors. Correlational research seeks to

understand relationships among two or more variables. Although correlations cannot reveal causal relationships, it is often an efficient and effective means of analyzing a large amount of data about a problem area (Polit & Beck, 2008). A correlational relationship simply indicates an association between variables and can be helpful in identifying patterns that exist or determining if one or more variables can predict other variables.

Although the data used for this study were not collected as part of a research study, the key concepts related to secondary data analysis still apply. Research that involves the use of previously collected data to answer new questions is considered secondary data analysis (Doolan & Froelicher, 2009). In the fields of epidemiology and public health, secondary data analysis is common. There are several advantages, as well as disadvantages to the use of existing data sets. One major advantage is economy, including the use of resources, energy, and time (Boslaugh, 2007). Since the data has already been collected, significant savings in salaries, transportation, time spent in collecting data, and effort is achieved. The study of adverse maternal outcomes may appear punitive and hospitals may be averse to allowing access. The researcher does not need to gain access (including institutional review board approval) to individual medical records in order to obtain the needed information. As such, for this study the research questions could be answered quickly and efficiently using data collected beforehand. In addition, specifically as it relates to the present study, the amount of data available may be more substantial and span a larger geographic area (Boslaugh, 2007). Although maternal adverse outcomes have increased over the last decade, the total numbers within any one health care facility remain relatively small making analysis difficult. Use of a

large data base improves the acquisition of a substantial sample size allowing for better analysis and eventual generalizability. As always, when vulnerable populations, including pregnant women, are the populace of interest special attention must be given to the research design and informed consent (Hearst, Grady, Barron, & Kerlikowske, 2001). With secondary data analysis, women are not approached for participation and consent.

Although advantages to the use of secondary data sets are apparent, limitations still exist. The major disadvantage lies within the data itself. The data may not have been collected to answer the specific research question of interest, therefore, information important to the study may be lacking (Boslaugh, 2007). The selection of data points, the completeness of the data, and how it was recorded and cleaned are also concerns in the overall quality of secondary data sets for which the researcher has no control (Hearst et al., 2001). It is important to consider what problems might have been encountered in the data collection process when analyzing an existing data base and attempt to statistically control for these threats to validity as much as possible (Doolan & Froelicher, 2009).

Sample and Setting

The study population consisted of all women in California delivering infants between January 2008 and December 2009 with a specific focus on women whose primary payor source was Medi-Cal. Medicaid is a significant financer of maternal and child health care services nation-wide. In 2003, approximately 1.5 million births (41%) in the US were paid for by the Medicaid program (Martin et al., 2009). Each year California's Medicaid program, known as Medi-Cal, is responsible for financing between 41% and 46% of all births in the state. The most recent available report in 2006, identified 232,241 maternal beneficiaries of Medi-Cal services (CDHCS, 2010). Non

Medi-Cal births for the same time frame were 329,916. Key findings from this report indicated Medi-Cal mothers who gave birth were younger, had greater parity (2 or more previous births), were less likely to receive first trimester prenatal care, and were more likely to deliver infants prematurely than privately funded mothers. In addition, a large segment of the Medi-Cal mothers were of Hispanic or African American ethnicity, foreign-born, with less than a high school education.

Sample Size

The total number of births in California for the study years was 1,021,857. The total number of Medi-Cal recipients for the study year was 492,663 with 5,016 of these women experiencing an extended length of stay. The research questions required correlational and regression analysis to explore the effects of the predictor variables on maternal delivery outcome. According to Tabachnick and Fidell (2007), a minimum of 20 cases is recommended for each predictor in the model. With approximately 10 independent variables and 1dependent variable, the sample size for this study should be 400 to obtain statistical significance. On the other hand, Polit and Beck (2008) suggest a better way to estimate sample size is to perform a power analysis. For 10 variables with a moderate effect size (R^2 + .13) and a power of .80 and α = .05, a sample of 136 mothers is needed to detect a moderate population effect size with a 5% chance of a Type 1 error and a 20% chance of a Type 2 error.

Procedure

Using probabilistic linkage techniques that allow the identification of records that are most likely to be matches, maternal delivery data from the California Office of Statewide Health Planning and Development (OSHPD) were linked to the birth master

files of the Office of Vital Statistics (OVS). OSHPD data, voluntarily submitted by hospitals, included demographics, delivery mode, diagnoses, procedures, type of discharge, source of payment, length of stay, and hospital type. Vital statistics data, gathered from birth certificates completed prior to or following discharge and submitted to OVS within 30 days of birth, included parity, post-pregnancy weight, co-morbidities, and gestational age at delivery. Inaccuracy in personal identifiers may result in non-linking records. Records without matched data sets were excluded from this study. The *International Classification of Diseases, 9th revision, Clinical Modification* (ICD-9-CM) diagnostic and procedural codes were used to identify various diagnoses and outcomes (PMIC, 2005).

Measurements

The measures used in this study were derived from extensive review of the literature and were collected from a large data base of state reported statistics. The data base is comprised of individual items collected and linked using probabilistic record linkages from admission/discharge information and birth certificate data. The linkage between OSHPD and vital statistics databases has been studied previously and has been found to be 97-100% accurate for linkage of the 2 databases (Danielsen, 2000; Gilbert, Jacoby, Xing, Danielsen, & Smith, 2010; Phibbs et al., 2007; Srinivas, Fager, & Lorch, 2010). No standardized measures were used. Predictor variables were chosen based on their availability within the existing data set and were grouped into categories that include socio-demographic, obstetrical and medical co-morbidities, and complications. Modifiable variables were of significant interest since these may be affected by policy and practice changes.

Independent Variables

Data was collected and overall frequencies determined to describe the population as a whole. Socio-demographic data included age, education level, race/ethnicity, prenatal care, payor source, and foreign born status. The variables were categorized as follows: age in years (<18, 18-24, 25-59, 30-34, >35), education level (some high school, high school/GED, some college, college grad, graduate, unknown), race/ethnicity (Hispanic, White, Black, Asian, Pacific Islander, American Indian/Alaskan Native, Other, Unknown), prenatal care (first, second, third, none, missing), and payor source (private, Medi-Cal, None/Uninsured, Other, missing). Foreign born status was dichotomized (yes/no). The obstetric categorical variables included parity (nulliparous, 1-3 previous births, 4 or more births), gestational age in weeks (<20, 20-29, 30-36, 37-40, and >40), and birth weight in grams (<2500, 2500-4000, >4000), the dichotomous variables of complications included previous cesarean section, multiple gestation, gestational diabetes, gestational hypertension, and placenta previa (yes/no). The medical/comorbidity variables of depression, substance use, chronic hypertension, cardiac conditions, liver disorders, renal conditions, diabetes, asthma, hematological or connective tissue disorders were also dichotomous (yes/no). Delivery BMI was categorized as underweight, normal, overweight, obese I and II, obese III and missing. Obstetrical/medical complication variables were dichotomized and included infection, renal failure, respiratory failure, obstetric shock, cerebrovascular disorders, pulmonary embolism, mild preeclampsia, eclampsia/severe preeclampsia, puerperal infection, cardiac events/procedures, other puerperal complications, hemorrhage, hysterectomy, mechanical ventilation, transfusion, and invasive hemodynamic monitoring (yes/no).

Dependent Variables

Given that length of stay varies by delivery type, women were first stratified into mode of delivery (vaginal vs. cesarean section). Since some women giving birth may stay an additional day for minor events or for reasons related to the newborn, the dependent variable of extended length of stay for vaginal delivery was categorized as normal (0-3 days), moderate (4 days), and excessive (5 or greater days). Cesarean delivery was categorized as normal (0-4 days), moderate (5 days), and excessive (6 or greater days).

Data Analysis

The statistical analysis included descriptive, inferential, and regression analysis. Techniques were chosen based on the nature of the research aims and questions, number of independent and dependent variables, and the measurement required for each of the identified variables. The statistical tests included a) univariate analysis to study the frequency and distribution of cases of each predictor variable and outcome, b) Wald Chi-square (x^2) to determine the significance in distribution within each categorical risk factor, and c) multiple logistic regression to determine the influence of independent predictors on risk of extended length of stay and to determine odds ratio (OR). These analyses allowed examination of the associations between risk factors and extended length of stay while controlling for confounding factors (Leone et al., 2010). SAS version 9.2 statistical software (SAS Institute Inc., Cary, NC) was used for data management and analysis.

Descriptive statistics were calculated to summarize the profile variables of socio-demographics, behavioral/psychosocial, prenatal, and obstetrical/medical as well as the

outcome variable of length of stay. Univariate analysis was also helpful in cleaning and checking the quality of the data in the sets (Munro, 2005).

To identify patterns in high-risk factors and extended length of stay, descriptive statistics (mean and percentages) were computed to summarize the frequency in their occurrence. Chi-square was conducted to examine whether there is significant difference in distribution within each categorical predictor variable based on outcome. Chi-square was also used to test the fit of models in logistic regression (Munro, 2005). Initial modeling was conducted and all variables were noted to be significant. Next, groups of related variables were examined along with length of stay to determine the effect of individual maternal risk factors on length of stay and by type of delivery. Using the predictor variables showing the most relational significance a multivariable model to identify best subsets that affect the probability of a particular outcome was developed. Univariate analysis was conducted to summarize the frequency in variable occurrence as well as to determine whether there is significant difference in distribution within each categorical predictor variable based on outcome. Foreign born status and educational status were no longer significant and these variables were deleted prior to final analysis. American Indian/Alaskan Native also showed no significance, possibly due to small numbers within that category and was combined with Other. Prenatal care was collapsed into first trimester, other trimester, and none as second and third trimester showed no significance. Parity was dichotomized as nulliparous and non-nulliparous. BMI obese variable was collapsed to include obese I and obese II-III leaving underweight, normal weight, overweight, and missing as is. Less than 20 weeks was deleted as a category as no significance was found due to small numbers. Due to small cell size which makes for

unstable estimates, pulmonary embolism was removed. All other variables remained the same. Table 1 lists the variables included in the final analysis.

Demographic	Obstetric Conditions	Medical Comorbidities	Medical Complications
Age	Parity	Depression	Renal failure
Education	Previous cesarean	Substance use	Respiratory failure
Race/ethnicity	Multifetal pregnancy	Pre-pregnancy BMI	OB shock
Birthplace	Gestational hypertension	Diabetes	CV disorders
Prenatal care initiation	Gestational diabetes	Coagulation disorders	Mild preeclampsia
Payer source	Placenta previa	Chronic hypertension	Eclampsia
	Gestational age	Renal conditions	Puerperal infections
	Birth weight	Liver conditions	Cardiac events
		Asthma	Infection
		Lupus	Other puerperal conditions
		Cardiac conditions	Hemorrhage
			Hysterectomy
			Ventilation
			Transfusion
			Hemodynamic monitoring

Table 1. Independent variables

In order to examine the influence of the variables on extended length of stay, multiple logistic regression was performed. Logistic regression is used to determine which variables affect the probability of a particular binomial outcome (Munro, 2005). The data was analyzed by determining odds ratios (ORs) and 95% confidence intervals (CIs). Odds ratios were used to estimate relative risk. To build the multivariable logistic model, all variables whose univariate association with prolonged LOS was $p \leq 0.05$ were included. In some cases, multiple categories of potentially important risk factors (i.e. month of prenatal care initiation, race) that did not have $p \leq 0.05$ were combined. The new combinations were examined to determine any significant relationship with length of stay. In the final analysis all potential risk factors with a $p \leq 0.05$ were included.

Limitations of the Study

As described previously, use of administrative databases encompasses particular limitations. Certain information important in identifying associations was not contained within the data sets, and chart review to abstract this data was not available to confirm areas of interest including socioeconomic and marital status. Other variables shown in the literature to affect maternal outcomes such as urban/rural residence, type of hospital, delivery volume, and available resources although available in the dataset was beyond the time and scope of this study. The quality of the data depended on the accuracy and completeness of the information recorded on the certificates and of the quality control procedures employed in the coding process (Madan et al., 2009). Therefore, bias is inevitable due to misclassification and under-reporting by the health care facility.

Protection of Human Subjects

Request for data usage was made through a collaborative research proposal with the California Perinatal Quality Care Collaborative (CPQCC). Permission to use CPQCC linked data sets was granted. In addition, IRB approval was obtained from the University of San Diego. Non-confidential data files without personal identifiers were utilized, therefore the study was exempt from State review because of its use of de-identified data. Nevertheless, strict guidelines to protect the confidentiality of the data was followed including keeping data in a secure location and sharing information with individuals identified on the initial data request. The data was only used for the purposes of this study and were not provided to any other agency or person.

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CHAPTER IV

Manuscript #1

Perinatal Regionalization: Changing Trends in Maternity Care

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Abstract: With recent advances in perinatal and neonatal medicine, the risk of mortality for the pregnant woman and/or her newborn has been markedly reduced. This improvement has been achieved in part because of the advent of new technologies and treatment modalities over the past century. Regionalization, that is, the identification and appropriate referral of women with high-risk pregnancies and the stabilization and transport of ill neonates to a hospital better equipped and staffed to care for them, has also been an integral part of the reduction of morbidity and mortality in the United States. Even so, the U.S. lags behind many other industrialized nations in overall maternal mortality rates, which have seen little change over the past 5 years. The purpose of this paper is to describe the evolution of regionalization, discuss the trends and practice changes that have influenced the present day perinatal arena, and provide recommendations for an improved system of care.

Introduction

The face of perinatal care has changed dramatically over the past century and with it, the care provided to mothers and their newborns. Prior to the 1950's, babies born prematurely or with congenital anomalies had little chance of survival. The United States has seen a dramatic decrease in maternal mortality rates since the early 1900's, primarily due to prevention and treatment of infection and hemorrhage. Regionalization, that is, the identification and appropriate referral of high-risk pregnancies and the stabilization and transport of ill neonates to hospitals better equipped to care for them (Kirby, 1996) has been credited as one of the major reasons for the decline in both maternal and neonatal morbidity and mortality. Although components of regionalization exist in most States within the U.S., there remains a lack of consistency in implementation of such programs. The purpose of this paper is to describe the historical foundations and the evolution of regionalized perinatal care, and detail the impact that changes in regionalization of perinatal care have had on maternal/newborn health outcomes. In addition, the implications for policy development and health care reform will be discussed.

Background

The concept of improving patient care outcomes through regionalized systems of perinatal care emerged in the United States in the 1970's. It gained interest within obstetrical and pediatric communities as technological advancements provided new opportunities for treatment and survival. In 1977, in response to the challenges of a changing climate for delivery of perinatal care, the Committee on Perinatal Health and the March of Dimes proposed a model system for regionalized perinatal care in their

landmark paper *Toward Improving the Outcomes of Pregnancy.* Key elements of this forum included preconception and interconception care, structure and accountability, availability of perinatal providers, use of a perinatal data program, and most importantly, ambulatory and inpatient perinatal care including well-defined and augmented levels of maternal and neonatal care (I, II, and III). These three levels were based on a facility's ability to provide care and treatment for maternal and neonatal complications arising during pregnancy, labor, and/or delivery. Unfortunately, these definitions of levels of care are more specific to setting minimum staffing, occupancy, and equipment standards for neonatal units rather than obstetric units providing care to high-risk mothers. This lack of specificity for risk-appropriate maternal care in March of Dimes' landmark document has led to inconsistencies in administrative guidelines, recommendations, and the provision of quality care based on the woman's own needs and not strictly the needs of her unborn baby.

The committee described the concept of regional care as "the development, within a geographic area, of a coordinated, cooperative system of maternal and perinatal health care in which, by mutual agreements between hospitals and physicians based on population needs, the degree of complexity of maternal and perinatal care each hospital is capable of providing is identified to accomplish the following objectives: provision of quality care to all pregnant women and newborns, maximum utilization of highly trained perinatal personnel, intensive care facilities, and assurance of reasonable cost effectiveness" (The National Foundation - March of Dimes, 1977). Simply put, it is suggested that pregnant women be cared for in a facility appropriate to their level of risk. As a result, regional perinatal centers were established, and they developed formal

relationships with smaller community hospitals (Van Mullen et al., 2004). Arrangements were made to transfer high-risk women antenatally or newborn infants postnatally if they required a higher level of care. Reports in the literature have consistently supported the benefits of such arrangements, including improved outcomes for mother/fetus, as well as better survival rates for high-risk infants (Bode, O'Shea, Metzguer, & Stiles, 2001; Samuelson, Buehler, Norris, & Sadek, 2002; Warner, Musial, Chenier, & Donovan, 2004).

Unfortunately, the existence of multiple level-of-care standards and regulations, market competition and forces including the advent of managed care, as well as the proliferation of technology in diagnostic testing and therapeutic modalities have blurred the definition of risk-appropriate perinatal care and prevented the comprehensive adoption and maintenance of perinatal regionalization (Sinkin, Fisher, Dozier, & Dye, 2005; Wall, Handler, & Park, 2004). Hospitals no longer referred to the established levels of care when evaluating their perinatal service capabilities thereby increasing variations in practice and decreasing quality care opportunities. These changes effected urban areas more significantly due to the density of available services within reach if immediate/emergent care was necessary (Samuelson et al., 2002). Indeed, many hospital systems have developed perinatal regionalization programs within their own organizations that cross traditional geographic lines and pre-existing regional relationships, further weakening cooperation between all hospitals. Notably, the dramatic growth of NICUs, especially in smaller hospitals, added to the de-regionalization of perinatal care as an increased availability of resources to care for the at-risk newborn were made readily available (Gould, Marks, & Chavez, 2002; Staebler, 2011). Deliveries

began to shift from Level III centers to Level II facilities with the retention of more and more mothers at lower level, lower volume hospitals (Yeast, Poskin, Stockbauer, & Shaffer, 1998). Although referral and transfer agreements may exist, these changes have limited the opportunities for collaborative evidence-based practice, outreach education, research, and quality improvement, as well as increased the unnecessary duplication of services and cost. De-regionalization has proven detrimental as several studies have shown an association between the increase in the number of very-low-birth-weight (VLBW) infants born in hospitals without a level III nursery and higher mortality risk.

Regionalization in the United States

The widespread availability of effective technology and highly trained personnel, as well as financial incentives brought about by managed care, led to a dramatic expansion of community NICUs and the reduction of high-risk births at Regional centers in California (Gould et al., 2002). Strengths and limitations exist within this changing face of regionalization. The study concluded survival rates of the VLBW infants were comparable in Community and Regional NICU hospitals, but lower in other levels of care. Gould, Sarnoff, Liu, Bell, & Chavez (1999) noted the odds of inappropriate delivery site ranged from 0.37 to 2.75 across California's nine geographic perinatal regions with the overall state average of 10.5% deliveries of very-low-birth weight infants being born at primary care hospitals. This finding emphasizes the need for a more extensive analysis of regional prenatal referral and transfer practices for high-risk pregnant women, especially in regions where the majority of births take place at primary care hospitals.

Although many states embraced the concept of regionalization, gaps in care still

exist. Formal definitions of levels of care for providers, hospitals, and services exist for neonates within CCS however no similar maternal/fetal care definitions exist. Title 22 of the California State Code of Regulations and Guidelines for Perinatal Care [standards of the American Academy of Pediatrics (AAP) and American College of Obstetrics and Gynecology (ACOG)] both refer to maternal levels of care, but without the specificity needed to define appropriate setting, provider, and competency required for individual patients or complications. The Guidelines recommend "early and ongoing risk assessment to prevent, recognize, and treat conditions associated with morbidity and mortality" and "improve linkages between levels of care through effective mechanisms for referral and consultation". Other standard setting organizations including the AAP, although supportive of risk-appropriate care for pregnant women, focus their attention on the care of the infant once delivered. As a result, research is limited on maternal levels of care and compared to neonatal levels of care, maternal levels are ill-defined and poorly implemented.

Only a few states, including Washington, Tennessee, New York, and Arizona have developed extensive guidelines for levels of care specific to obstetrical patients based on services and capabilities. Arizona has one of the most comprehensive programs having the greatest impact on perinatal health outcomes. Regionalization in Arizona began in the 1970's and with support from the Arizona Perinatal Trust and Arizona Perinatal Program, as well as cooperation between hospitals, transport companies, and nursing continues to the present (Clement, 2005). Statewide, maternal levels of care are defined as basic, intermediate, and intensive, based on pregnancy diagnosis and management needs, abilities to provide respiratory support and stabilization, and

arrangements for follow-up. These guidelines were developed to help hospitals assess the type of patient best suited to their facility's capabilities and scope of care. There is evidence that great gains can be made in maternal health by ensuring women with pregnancy complications can quickly reach a facility where they can receive high-quality obstetric care (Mostello, Droll, Bierig, Cruz-Flores, & Leet, 2003; Murray & Pearson, 2006).

Results of Perinatal Regionalization

The overall goal of risk-appropriate perinatal care is to achieve optimal pregnancy and birth outcomes through early risk identification, care in a setting appropriate for level of risk, and transport when necessary to reduce the adverse consequences of risk (Pasquier et al., 2005). Evidence supporting the need for risk-appropriate neonatal care has been well documented. At-risk infants born outside a Level III hospital have a significantly increased likelihood of neonatal death (Cifuentes et al., 2002), chronic lung disease (Chung, Fang, Chung, Hwang, & Chen, 2009), and intraventricular hemorrhage (Palmer et al., 2005) as opposed to those born at a Level III hospital. Other studies have shown an increased odds of death for very low birth weight and very preterm infants born outside a Level III hospital (Laswell, Barfield, Rochat, & Blackmon, 2010; Merlo et al., 2005; Warner et al., 2004). Although improved neonatal outcomes are associated with appropriate levels of care, definitions and criteria for neonatal levels of care, and mechanisms for measuring and improving neonatal risk-appropriate care vary widely across states. Blackmon, Barfield, and Stark (2009), searched internet sites for all 50 states and Washington, DC to describe how states designate hospital neonatal services levels. Of the 50 states, only 33 used some sort of designation to describe the levels of

neonatal services available. In a similar study, Nowakowski et al. (2010) examined and compared state models of perinatal regionalization and risk-appropriate care. The study identified mechanisms of measurement for risk-appropriate care in seven states and found variation in level definition, clinical capacity, and population served. Some states define additional sub-levels of care based on patient volume and only a few include transport requirements in the definition. An assessment of California's maternal-fetal and neonatal systems of care (Regional Perinatal Programs of California [RPPC], 2004) showed wide variability in policies, training/education, consultation, and joint review of outcome data. It would stand to reason, if levels of care and practice standards are inconsistently and inadequately defined and followed with a well-studied and financed neonatal population, even more difficulties arise when attempting similar designations for maternal care.

Unlike the neonatal realm, few studies have been conducted on regionalization and maternal health outcomes over the past ten years. Those that have been conducted indicate similar results in improved maternal outcomes can be obtained when at-risk mothers are delivered in high-volume tertiary facilities where emergency services and resources are available (Fournier, Dumont, Tourigny, Dunkley, & Drame, 2009; Mostello et al., 2003; Wright et al., 2010). Trends in maternal mortality rates in California, as well as the United States have fluctuated over the years. Nearly 550,000 women give birth in California annually. After several decades of declining rates of maternal mortality, rates began to rise in 1999. Notably, rates of maternal deaths rose from 8.0 deaths per 100,000 live births in 1999 to 16.9 deaths per 100,000 live births in 2006 (The California Pregnancy-Associated Mortality Review, 2011). Although direct correlation is difficult to establish, this trend parallels the rise and fall of perinatal regionalization.

Barriers to Perinatal Regionalization

Barriers to timely transfer to a higher level of care have been documented. Wall and colleagues (2004) examined the effect of hospital factors including reimbursement sources and teaching status on the rate of non-transfer of very low birth weight babies. Of the 2,904 very low birth weight infants born from 1989-1996, 1172 (40.4%) were not transferred. After adjusting for individual risk factors, several hospital factors associated with non-transfer included birth in a Level II+ hospital, high Medicaid revenues, high HMO revenues, and status as a teaching hospital. With the proliferation in the availability of neonatologists able to care for smaller infants at Level II facilities and the increase in economic demand, many Level II facilities believe they are adequately staffed to care for lower birth weight babies.

Sinkin et al. (2005) supported these findings noting despite a well-regionalized organization for perinatal care in New York, where pre-existing written protocols for transfer between institutions are established independent of insurance status, managed care influences decisions on the nature, and location of care delivery. In contrast, Dobrez, Gerber, & Budetti (2006) conducted a study of reported deliveries in 615 facilities in Washington, California, North Carolina, and Illinois across a 10-year period to describe trends in regionalization. Findings indicated both Illinois and North Carolina showed strong signs of increasing regionalization with a higher percentage of births in Level III hospitals. Washington showed very little change, but already had a highly regionalized system of care prior to the study. California on the other hand showed a de-regionalized system of care with little change in the percentages of high-risk births at Level III facilities. The percentages of very low birth weight neonates delivered at Level

III hospitals were substantially lower than the goal of 90% set by Healthy People 2010 and 2020. Although HMOs have increased substantially in all four states, it was not found to affect the extent of regionalization and/or delivery at a lower level facility.

Changing Trends in Maternal Outcomes

Maternal and neonatal mortality rates are the most widely used indicators of the health of a nation. The death of a woman during pregnancy or in the postpartum period is relatively rare occurrence, but the number of high-risk pregnancies due to maternal or neonatal complications has significantly increased over the past decade (Kuklina at al., 2009) leading to an increased number of adverse maternal health outcomes post-delivery. Among the 4.2 million deliveries in the U.S. in 2008, 94.1 percent listed some type of pregnancy complication (Elixhauser & Wier, 2011). Maternal mortality rates have tripled from 1996 to 2006 and are 4.5 times higher than the Healthy People 2010 benchmark (CMQCC, 2009) and continue to be so for 2020.

Mortality and Morbidity

Over the past several years studies have shown an increasing trend in the presence of complications that affect morbidity and mortality rates. Evidence suggests that an increased risk for death can be found in certain high-risk women including those who are black, older, with no prenatal care (Berg, Chang Callaghan, & Whitehead, 2003; California Mortality Review, 2011). The leading causes of death are cardiomyopathy, embolism, hemorrhage, hypertension in pregnancy, cerebrovascular accidents, and other pre-existing medical conditions such as cardiac disease and diabetes. These complications are often preventable with the availability of appropriate resources including earlier identification and rapid, aggressive treatment (Berg, Harper, Atkinson et

al., 2005; CA Mortality Review, 2011; Clark et al., 2008; Geller, Cox, & Kilpatrick, 2006).

Although significant, pregnancy-related death continues to be a relatively rare occurrence. Due to the lack of data sources available that truly examine the conditions surrounding the events that contribute to mortality, individual states must investigate each death in detail to determine cause and preventability. This can be a time consuming and demanding process. Furthermore, the number of maternal deaths is substantially underestimated (Horon, 2005) adding to the difficulty in obtaining accurate information. Maternal mortality is just the tip of the iceberg. Under the surface lies a host of maternal morbidities that effect maternal health and newborn outcomes. Maternal morbidity is more frequent and often preventable, yet little attention has been given to identifying factors leading to complications. Evidence shows the incidence of maternal complications and comorbidities continues to increase (Berg, MacKay, Qin, & Callaghan, 2009; Kuklina et al., 2009; Lu, Fleege, Fridman, Gregory, & Korst, 2011). Possible factors effecting this change in rate may include changes in the underlying risk profiles of women (i.e. age, parity, obesity, previous c/s) and changes in clinical practice (i.e. inductions and cesarean sections). Substantial disparities in maternal morbidity across racial-ethnic groups may further influence maternal morbidity. Non-Hispanic black mothers were more likely to have hypertension (1 in 10), Asian Pacific Islander mothers were more likely to have diabetes (1 in 10), and hypertension and diabetes increased by nearly 50% among Native American mothers (Lu et al., 2011). Guendelman et al. (2006) found black women suffered more combined morbidities than white women (24.2% versus 21.3%, respectively) and Asian women stand a higher risk of deliveries with major

lacerations, postpartum hemorrhage, and major puerperal infections. A 2008 report from the CDC found nationwide, non-Hispanic African-American women had a maternal mortality rate of 36.1 per 100,000 live births compared to a rate of 9.6 for White women, and 8.5 for Hispanic women. In California, from 2006-2008, African-American women were almost four times more likely to die from pregnancy-related causes with 46.1 deaths per 100,000 live births, compared to 12.8 for Hispanic women, 12.4 for White women, and 9.3 for Asian women. The gap in maternal mortality rates widened drastically over the last five decades when the rate of African-American deaths was only 2.3 times more likely than White deaths (California Pregnancy-Associated Mortality Review, 2011). These rates have often been associated with demographic variables such as age, educational level, marital status and residence. Fang, Madhavan, & Alderman (2000) found although these factors were correlated with adverse outcomes for unmarried non-white women with less than a high school education living in low income communities, similar results did not have significant impact on black women's rates of death. Other explanations for these racial health disparities include the higher rates of pre-existing medical conditions in African American women including obesity, hypertension, and diabetes, as well as decreased health care access due to poverty (California Pregnancy-Associated Mortality Review, 2011). Characterizing such factors is valuable for monitoring the quality of care and for assessing the incidence of life-threatening complications. Reviewing pregnancy complications and determining the factors associated with them has the potential for improving health outcomes by providing information to influence providers' decision-making process, as well as overall health policy (Callaghan, MacKay, & Berg, 2008).

Strategies for Change

Health care reform initiatives and incentives have already begun to influence practice and pregnancy care. Obstetric healthcare providers have a prime opportunity to be at the forefront of defining maternal risk-appropriate care and aligning financial incentives for hospitals and health care providers that encourage coordination of services, supportive preventive care to avoid problems, early detection, and appropriate intervention including antenatal risk assessment and timely maternal and neonatal transport.

In 2010, the Patient Protection and Affordable Care Act (ACA) was enacted as a means to address and improve health care access and outcomes for all residents in the US (Pub.L.111-148). Although no regulations in this act address pregnancy and perinatal regionalization specifically, there are several components and provisions that can and will impact health care delivery to women before, during, and after pregnancy. The primary objective of the ACA is to improve healthcare access (Johnson, 2010) which in turn assures coverage for more women of childbearing age. For women at-risk, including those of lower socio-economic status, the ACA expands Medicaid eligibility to 133% of the poverty level (Lu, 2010). In addition, the ACA prohibits discrimination based on sex, whereby insurers set higher premiums for women than men, and increases coverage for young women by allowing them to remain on their parents' health insurance policy until 27 years of age. Furthermore, the ACA prohibits lifetime caps on coverage, cancelation of coverage, or denial of coverage based on pre-existing conditions including pregnancy, and bans the restriction of visits or services allotted (Kaiser Family Foundation, 2011).

A second objective of the ACA is to improve the healthcare delivery system (Johnson, 2010). Not only does the ACA aim to expand community health centers, it assures direct access to OB-GYNs without requiring a referral or preauthorization, and funds community-based interdisciplinary teams to provide support services to OB-GYN practices. It also establishes a care coordination network program to help providers coordinate and integrate services for low-income uninsured and underinsured populations (Kaiser Family Foundation, 2011). Other provisions related to women's health include national home visiting programs for high-risk families during pregnancy and infancy, funding for research related to postpartum depression and psychosis, and funding for programs to educate adolescents on pregnancy prevention.

As was previously addressed, low-income women as well as those of a racial/ethnic minority are at higher risk for poor pregnancy outcome due to pre-existing health conditions and decreased health care access related to poverty. The provisions implemented in the ACA can begin to minimize the barriers to health care access due to poverty thereby reducing health disparities. With the rising rates of morbidity during pregnancy, women with pre-existing conditions can get the care needed to minimize the effects of this risk on the mother as well as the newborn, and can be reassured their care will continue regardless of the occurrence of medical complications during pregnancy. Continuity of care provides a seamless transition from preconception to pregnancy, encouraging early initiation of and compliance with prenatal care, and allowing for timely recognition and treatment of risks including those of socio-demographic origin. Continuous coverage also ensures availability of appropriate follow-up care during postpartum and interconception. The establishment of community health care teams and

collaborative care networks to support not only providers, but the pregnant and parenting family reinforces the concept of regionalization. This is accomplished through the identification and suitable referral of high-risk women to appropriate resources such as ultrasound, genetic screening, mental health, and maternal-fetal specialists without fear of reimbursement issues.

Although the ACA has made progress in closing the gaps in coverage for women, it identifies only broad categories within maternity and newborn care without the specificity needed to ensure continuous coverage for comprehensive women's healthcare over the life course (Lu, 2010). This lack of specificity continues to perpetuate the same limitations established with the original forum of the 1970's. Over 500,000 births occur in California annually, 1 in 8 births nationally, in over 300 hospitals, medical centers and other facilities across 164,000 square miles (perinatalprofiles.berekely.edu). As such, implementation of a standardized method of assessment, consultation, and transfer of high-risk mothers is challenging at best. In 2011, the California Chapter of the March of Dimes, and the Community Perinatal Network, Regional Perinatal Programs of California, began collaborating on a project funded by the March of Dimes to implement maternal risk-appropriate care in California. The project brought together key stakeholders throughout the state, including physicians, nurses, and organizational leaders, as well as representatives from the Department of Public Health, to identify barriers to and strategies for the provision of high-quality maternal care. Ultimately, it was determined that in order to improve the provision of risk-appropriate maternal care, a three pronged approach should be taken to address patient, facility and public health level strategies. These strategies included standardized risk assessment, facility accreditation

based on capability and resources, patient education and empowerment, as well as public policy advocacy and the implementation of specific, well-defined maternal levels of care.

Patient-level strategies. This includes identifying high-risk women before or after admission to the hospital, determining the required facility capabilities, and educating both the family and health care providers on potential risk reduction and treatment strategies. With the increasing number of pregnant women with chronic or acute medical conditions, obesity, and previous cesarean section, guidelines that assist providers and nurses in identifying women at risk and the resources necessary for their ongoing care is essential for minimizing adverse outcomes. The intent is not to dictate care practice, but to support the provider in decision-making and available treatment choices, as well as, provide for ongoing assessment of patient status and resources available within that facility allowing for timely implementation of risk reduction strategies, consultation and/or transfer as necessary to optimize care. Facilities without the necessary capabilities, including staffing and equipment, would not be able to provide increasingly complex care and therefore would best be suited for pregnant women with few or no risks (Hankins et al., 2012). Guidelines would be specific for medical conditions most prevalent in the US and strongly supported by the literature, including preterm labor, placenta previa/acreta or hemorrhage, severe preeclampsia, cardiovascular disease, and extreme obesity, and can be used as quick references to determine risk status, evaluate what resources are required to provide care, and match risk to resources. Trigger points that alert staff or providers to evaluate patient status and determine the best approach to care, similar to a safety checklist that requires staff to stop and think about what is needed (further assessment, equipment, medical criteria for consultation, involvement of other

departments, etc.), can be included. Similar work has been completed in the areas of trauma, stroke, and myocardial infarction that defined patient care needs and appropriate site of care. These efforts resulted in significant improvement in overall morbidity and mortality rates for these populations (Bobrow & Kern, 2009; Schwamm et al., 2008).

Facility-level strategies. This includes basic definitions of maternal levels of care from which hospitals can be identified, implementing standards of practice, and voluntary accreditation of hospitals. Although many professional organizations support the need for specialized maternity care (ACOG Guidelines for Perinatal Care, Title 22 California State Code of Regulations), none have the specificity needed to identify facility capabilities for an increasingly risky population. Historically, levels of perinatal care have emphasized the needs of the fetus and neonate forgoing the potential needs of the mother herself (Hankins et al., 2012). Gestational age tends to be the determining factor when deciding care modalities and appropriate site. While many times prematurity is indeed the issue at hand, effecting only the newborn, other times the mother is ill, compromising the well-being of both her and her unborn child. Therefore, maternal levels of care must consider facility capabilities in providing specialized attention, including intensive care, to the pregnant patient. Several states have developed guidelines for levels of care that include the high-risk obstetric population based on services and capabilities, but many still do not define what "high-risk" encompasses leaving the decision regarding necessary treatment to the provider. To address this, maternal levels of care should include conditions that increase the risk for poor outcome and the treatment needs to minimize risk. Hospitals can then be identified by their

capabilities, including staffing, equipment, support services, and ongoing educational support and quality improvement.

Once maternal levels of care have been defined, hospitals can self-identify what level they choose to maintain based on available resources. Voluntary accreditation of facilities has been used successfully by the Arizona Perinatal Trust whereby hospitals maintain certification through annual surveys that determine compliance with standards. Hospitals are incentivized by public reports on accreditation standings as well as higher reimbursement for Medicaid patients. In California, Regional Cooperation Agreements (RCA) exist between facilities transferring the at-risk neonate. Higher level facilities are required to provide ongoing education, consultation, and feedback, as well as assistance with transport, to lower level facilities. These agreements should be expanded to include maternal care similar to what currently exists for NICUs. RCAs, enhanced outreach, and designated maternal transport teams are required for successful risk-appropriate care and implementation of standards of practice. The availability of designated maternal transport teams would ease the burden on primary hospitals and decrease liability and risk. Designated maternal transport teams would be able to provide more skilled assessment and assistance with plan of care and need for transport similar to rapid response teams available in-house.

Public Health-level strategies. This includes advocacy for regulations to support risk-appropriate care, education of women so as to empower them to be involved in care decisions, and changing the reimbursement incentives for appropriate care and delivery. Although voluntary hospital accreditation and the promotion of coordinated care may be effective means to implement change, the use of legislative and regulatory mandates has

proven to be much more successful. At this time, Title 22 as the only regulatory document for health care, has no criteria for maternal critical care. Statute changes to include a high-risk maternal category are needed for universal implementation of risk-appropriate care. Since the condition of the mother effects the outcome of the newborn, organizations that regulate neonatal levels of care such as the California Children's Services can incorporate maternal standards into their regulations to influence change. Full review of hospital core measures that include maternal outcomes by the Joint Commission on the Accreditation of Healthcare Organizations would improve the provision of appropriate care. Public reporting can help consumer decision-making and incentivize providers to improve performance.

The consumer of health care, in this case the pregnant woman, also plays an important role in effecting change. Decision-making is an integral part of a woman's childbirth experience from the timing of conception to the timing of delivery to decisions regarding postpartum and newborn care. Although the trend in today's health care arena is for shared decision-making processes between physician and patient, without adequate support, at-risk pregnant women may be influenced by the norms set forth by society, be it family, friends or physician. Decision-making, in general, is an important concern as internet access has provided more opportunities for informed choice to occur. Pregnant women who are adequately informed about their risk status and pregnancy/birth needs are empowered to influence decisions on the appropriate site of delivery and can further enhance the outcomes for both her and her newborn.

Reimbursement continues to be a driving force in change. Health insurance plans often limit choices on site of delivery and reimbursement of services rendered.

Discussions with third-party payors is essential as additional costs incurred by higher risk patients may be offset by improved long-term outcomes and cost containment (Hankins et al., 2012). At the federal level, 24 potentially preventable conditions (Healthcare Acquired Conditions) were identified whereby the treatment required for care will not be reimbursed (USDHHS, 2011). Within the neonatal community, reimbursement based on identified best practices, will be issued when hospitals are working on an organized quality improvement program and fall within an established acceptable range. Currently, obstetric conditions are excluded but will most likely be incorporated into standards of practice in the near future. Facilities need to begin considering changes that will enhance pay-for-performance linked outcomes.

Conclusion

In order to preserve the impact regionalization has had on birth outcomes, careful assessment and referral to risk appropriate care should be strengthened. Risk appropriate care includes: access to preconception/interconception care, appropriate prenatal monitoring and intervention, availability of consultation and referral to appropriate specialists, competent labor and delivery management including transport to a higher level facility for high risk women and their infants, and assessment at time of birth to identify issues requiring advanced diagnostic, therapeutic, or support services. The components of risk appropriate care must be supported by state agencies, professional organizations, organizers of hospital and health systems, and payers for the system to accomplish its goal of optimizing the outcome of pregnancy. A common classification system for levels of maternal care across the nation is required to identify standards for the provision of care, to facilitate transfer of patients from one center to another, and

streamline planning and allocation of resources. Health care professionals can work together to ensure that the needs of high-risk women are matched to optimal health care to minimize maternal-fetal risk. State legislature and regulatory bodies must recognize and commit to the need for standards and definitions, determine what these standards will be, and incorporate them into perinatal care standards of practice tied to reimbursement and hospital licensing and certification. Without the political will for change, the needs of high-risk pregnant women will continue to be minimized, opportunities for improving quality care will be missed, and maternal morbidity/mortality will continue to increase.

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Manuscript #2

Understanding the Concept of Maternal Risk during Pregnancy

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Abstract: Although mortality during pregnancy is a relatively rare occurrence, serious maternal morbidities are increasingly present in today's pregnant population. Risk factors have been identified that may increase the potential for morbidities and subsequent care modalities have been implemented to decrease this risk. Even so, differences in the perception and understanding of risk during pregnancy can hinder the ability to provide consistent risk-appropriate care. For nurses in the perinatal arena, answers to the questions of who is at risk and how to identify those at particularly high risk provides the operational basis for appropriate risk-assessment of all pregnant women. A better understanding of risk will allow the formulation of care modalities specific to the needs of the population. Therefore, the purpose of this paper is to provide an analysis of the concept of risk using the Walker and Avant method, to clarify the meaning of risk and to explore implications for practice as well as future research of this concept.

Introduction to the Concept

The process of pregnancy and birth, albeit a major life event, is a natural, developmental, physiological stage. Although the woman's body goes through extraordinary physical changes to adapt to the needs of the growing fetus, the majority of women do so without medical concern. For a small percentage of women, the changes that occur trigger a cascade of events that can lead to tragic results including maternal mortality and morbidity. Complications during pregnancy can pose a serious risk to both maternal and fetal health (Elixhauser & Wier, 2011). The death of a woman during pregnancy or in the postpartum period is relatively rare occurrence, but the number of high-risk pregnancies due to maternal or neonatal complications has significantly increased over the past decade (Kuklina et al., 2009) leading to an increased number of adverse maternal health outcomes post-delivery. Among the 4.2 million deliveries in the U.S. in 2008, 94.1 percent listed some type of pregnancy complication (Elixhauser & Wier, 2011). The overall goal of risk-appropriate maternal care is to achieve optimal pregnancy and birth outcomes through early risk identification, care in a setting appropriate for level of risk and transport when necessary. As such, much of the research in obstetrics has focused on finding answers to the questions of who is at risk and how do health care professionals recognize and minimize the effects of these risks. For nurses in the perinatal arena, answers to these questions provide the operational basis for appropriate risk-assessment of all pregnant women. Unfortunately, understanding the concept of maternal risk during pregnancy varies between providers and pregnant women as well as among providers themselves. For the pregnant woman, coping strategies, the context in which the risk occurs, and previous life experiences play a larger role in

influencing her perception of risk than does the statistical analysis used by health care providers (Carolan, 2008; Heaman, Gupton, & Gregory, 2004). Differences in perceptions of risk can potentially result in miscommunication between provider and patient and increase the risk of inadequate or incomplete care (Lee, Ayers, & Holden, 2012). A better understanding of risk will allow the formulation of care modalities specific to the needs of the population. Therefore, the purpose of this paper is to provide an analysis of the concept of risk, to clarify the meaning of risk and to explore implications for future research of this concept.

Identification of Uses of the Concept

The concept of risk has been defined by a variety of sources and used in a variety of forums. The earliest use of the concept can be found in Homer's Rhapsody M of Odyssey (Greek rizikon) meaning "root, stone" and later used in Latin (riscus) for the term "cliff". In these forms the concept can be seen in terms of space and can be implicitly viewed as a place of potential danger (Det Norske Veritas, 2010). In later writings, risk is used as a difficulty to avoid at sea (French – risqué) and further evolvement in the 18th Century Exploration Age describes risk (Italian - risicare) as sailing into uncharted waters or daring to explore the world (Det Norske Veritas, 2010). Again, the connotation is one of danger and chance.

Random House Webster's College Dictionary (2000) defines risk as exposure to the chance of injury or loss as in *risk for fetal demise*, to expose to the chance of injury or loss as in *risk one's life*, and to venture upon or take the chance of as in *to risk a fall*. Webster further identifies the idiom, at risk, as in imminent danger of injury, damage or loss (*homes at risk of flooding*). Other idioms of the concept risk are identified in

medicine including risk factor and risk-taking behavior. Risk factors are anything environmental or organic which has a strong association with the onset and progress of a disease or injury such as heavy smoking as a cardiac risk factor (Taber's Cyclopedic Medical Dictionary, 2005). Risk-taking behavior is defined as behaviors of a person who tends to choose challenging tasks with relatively low probability of success such as drinking and driving safely (Kent, 2006). Furthermore, risk is used in health care to define the possibility/probability an adverse consequence will occur as in *risk for infection or death* (Stegman, 2005; Towers, Bonebrake, Padilla, & Rumney, 2000; Cifuentes et al., 2002). This particular definition is used frequently when weighing the benefits of a mode of treatment against its potential unfavorable outcome (risk-benefit analysis).

Other industries have used the concept of risk to define various aspects of their fields. Insurance companies define risk as the quantifiable likelihood of loss (Investopedia, 2010). Webster (2002) defines insurance risk as the hazard or chance of loss, the degree of probability of such a loss, the amount that the insurance company may lose, a person or thing with reference to the hazard involved to the insurer, and the type of loss against which a policy is drawn. These definitions have led to the development of risk management techniques to prevent and/or minimize the potential for loss. Health care organizations utilize risk management to defend their assets against the threats posed by legal liability (Taber's Cyclopedic Medical Dictionary, 2005). Business uses the concept risk to identify transactions that may yield less than expected returns including mortgage risk, market risk and interest rate risk (Hull, 2009). The armed forces use risk to evaluate avenues for minimal loss of human life and maximum strategic victory

(Knighton, 2004). Theologians view faith in God as a means of alleviating the fears surrounding uncertainty and risk (Gregersen, 2003). Faith and hope ease the concerns regarding everyday risk (i.e. someone may break into your home). The mathematical explanation of uncertainty through probability and the law of averages is the classical concept of risk widely used in scientific and economic theory (Knighton, 2004). Research itself uses the concept of risk to identify the likelihood for potential bias and errors (Huck, 2008).

Day-to-day decisions are made based on the probability that a projected outcome will occur. For most, actions that increase the chance of adverse outcomes are avoided and paths of minimal chance are taken. When under the influence of pain, psychological stress, or alcohol/drugs, these decision-making abilities are decreased thus clouding one's ability to make the right choice. In health care, education is provided so that an informed decision for best possible outcome, one based on the evidence available, can be made.

The concept of uncertainty is related to risk, although slightly different as it does not include the potential for loss or injury. Webster (2002) defines uncertainty as an instance of doubt or hesitancy, vague or indistinct, and not known. While there is some doubt or lack of knowledge regarding the potentials inherent in risk, the outcomes of risk are viewed in terms of losses generated. The measure of uncertainty refers only to the fact that many potential outcomes are possible, but no harm or loss will occur.

Defining Attributes of the Concept

The defining attributes of risk are the chance of injury/loss, a cognitive recognition of these chances and the decision making processes that come from a thoughtful analysis of the potential losses and the probabilities that such losses will occur.

Actions involved in risk take into consideration the possibility of adverse outcomes. Decisions are made based on the fact that potential injuries or losses may come about from those decisions. Individuals therefore take into consideration these "risks" when determining a course of action or inaction. Health care professionals also judge the potential for adverse outcomes when implementing interventions to prevent or minimize injury or loss. Beliefs and attitudes about the likelihood or degree of harm occurring plays a large part in how health care providers' and pregnant women make decisions (Fishbein, 2008).

Identification of Model Cases

Walker and Avant (2005) define model cases as those examples of the concept that demonstrate all the defining attributes. The following model cases display the chance of injury or loss, the recognition that these chances exist and the decision making processes involving the potential benefit and harm.

> Case 1: A 36-year old primiparous woman arrives on the labor and delivery unit at 28 weeks gestation. She is complaining of headache and epigastric pain. Her blood pressure is 160/90. The nurse identifies the potential for eclampsia and recognizes the fact that the facility does not have the capability to perform appropriate resuscitation measures including adequate blood products, emergency cesarean section, and obstetric critical care. She contacts the physician to discuss potential transfer of the woman to a higher level facility.
>
> Case 2: A newborn girl delivered at term to a diabetic mother at a primary level hospital. The newborn's blood sugar levels have been normal, but the infant has progressively shown signs of respiratory distress (i.e. flaring nostrils, grunting and

intercostal retractions). Oxygen has been provided by mask, but the symptoms continue for two hours. The nurse recognizes the need for further interventions that the nursery is unable to provide. She notifies the physician and discusses the situation and options with the parents.

Case 3: A pregnant 26-year old woman comes to the prenatal clinic for her first visit. She states she has been smoking one pack of cigarettes per day. The nurse identifies the potential harm of smoking on fetal development and discusses these dangers along with smoking cessation resources with the mother.

In the first case there is the chance of harm to the mother related to possible eclamptic seizure, recognition that the facility cannot support the needs of a pre-eclamptic pregnant woman thus increasing the potential for harm and the need for consultation based on weighing the possibilities or potentials. In the second case the chance of harm exists with the infant of a diabetic mother, recognition that unless further interventions are implemented the condition will worsen, and the potential harm of keeping or transferring the infant is discussed with the physician and parents. In the final case, smoking is a known risk factor for low birth weight, the risk was recognized by the nurse and education was provided to the mother to assist in the decision to continue or stop smoking. In all of these cases, the decision making process is based on the recognition that injury or harm are possible and this recognition of "risk" guides the "next steps".

Identification of Additional Cases

Providing borderline, related and contrary cases allows one to clarify what the

concept is like, what the concept is similar to and what the concept is not (Shattell, 2004). The following borderline case is an example where some, but not all of the defining attributes are present. In this case, the first critical attribute of chance for injury is present (hemorrhage and pulmonary embolism), the nurse recognized the potential for further bleeding, but the information was not used in the decision-making process.

> A 41-year old Spanish speaking multiparous woman has a precipitous delivery of a 9 lb. 1 oz. baby boy. There is heavy bleeding immediately following the delivery, but this is controlled by medications. One hour later the patient is restless and short of breath. The nurse performs a fundal check to assess for uterine atony with minimal lochia noted.

The following related case is an example where similarities between this and the model case are present, but the defining attributes are absent (Walker & Avant, 2005). Related cases shed light on concepts that may be used incorrectly in place of the concept of risk. As stated previously, the concept of uncertainty is similar as many potential outcomes are present, but the chance of loss or injury is not.

> A woman calls the registered nurse at the free clinic to find out if the lab results from her serum pregnancy test are available. She is uncertain whether or not the results will require further follow-up with her OB/GYN nurse practitioner.

A contrary case provides clarity regarding what the concept is not (Walker & Avant, 2005). In this example none of the defining characteristics are present and it is clear that no chance of harm/injury is recognizable.

A 28-year old primiparous woman delivered a 7 1/2 pound baby girl. The baby is pink with a strong cry and moving all extremities well. The baby is immediately placed

on the mother's chest and begins to breastfeed. Both parents are gazing and smiling at the baby.

Identification of Antecedents and Consequences

Walker & Avant (2005) define antecedents as events or incidents that occur prior to the concept and consequences as those events or incidents that occur as a result of the concept. The antecedent to the concept of risk is the ability to understand the situation and cognitive ability to think about the potential consequences and adverse outcomes. If a pregnant adolescent woman does not know the signs of preterm labor, she is unable to understand the likelihood of a preterm delivery. Due to her cognitive developmental stage as a concrete thinker, she has minimal ability to see herself in the future (Ladewig, London & Davidson, 2009). Adolescent decision making abilities may not be rational as teens do not take the time to look at the results of their decisions and learn from them. Therefore, capacity for cognitive reasoning is an antecedent of risk. Prior experiences of the event or incident are also necessary to risk. A nurse who has never dealt with or learned about pulmonary embolism may not recognize the signs and therefore delay intervention. In order for there to be a recognition of the potential harm and an adequate decision-making process the individual must have the capability for understanding whether this is gained through education or experience (Fishbein, 2008).

Consequences of risk include the actual action taken as a result of the decision-making process. In the model case provided earlier, the nurse discussed the situation with the physician and parents, but no course of action was taken. The consequence of this transaction would be the actual transfer of that mother to a higher level of care. Similarly, in the second case presented, the newborn infant would be transferred to an

appropriate facility capable of ongoing care and in the third case, the woman would be referred to a smoking cessation program. Actual harm is also a consequence of risk. If the physician chose not to transfer the mother (inaction), the pregnancy could have terminated in a preterm delivery at a facility incapable of the level of resuscitation required with its subsequent harm/injury to the newborn. The final consequence of risk could be no harm (Shattell, 2004). In these same model cases, the health care team could have chosen not to transfer the "at-risk" patient and no harm/injury occurred from that action (i.e. the mother did not deliver, the newborn got better, and the woman smoked and had an 8 lb. baby).

Definition of Empirical Referents

Empirical referents are examples of actual phenomena that indicate the presence of the concept of interest (Walker & Avant, 2005). It is the means by which the concept is identified and measured. The measurement of risk is three-fold; risk assessment, recognition of provider/facility capabilities to provide for needs, and measures of behaviors that determine appropriate decision-making processes. One, the presence or absence of risk must be determined. This is usually done by the use of risk-assessment (Gibson, Bailey & Ferguson, 2001). If the phenomena, event or condition does not possess the potential for harm or injury, then risk is not present. On the other hand, if an adverse outcome is possible, then a level of risk is present. In perinatal health care, women should be assessed at their first prenatal visit and periodically throughout their pregnancy, labor, and delivery for the presence of risk factors that increase the chance for adverse outcome, predominately injury to the woman or her newborn. Interventions are then implemented to prevent or minimize the consequences of risk (Samuelson, Buehler,

Norris, & Sadek, 2002) . Second, risk is measured by the ability of the provider/facility to recognize the risk whether through improved education or experience. Consequences can often be prevented when healthcare providers are appropriately educated to meet the unique needs of the patients they serve (Murray & Pearson, 2006). Finally, if a risk is present, determination of the presence of appropriate resources and the ability to provide the required care must be taken into consideration when deciding on a course of action (Warner, Musial, Chenier, & Donavan, 2004).

Implications for Practice

The presence of risk is a common phenomenon in the health care arena. In order to improve the outcomes of pregnancy, nurses must be involved in the decision-making process around risk and develop evidence-based guidelines for levels of care specific to obstetric patients. A thorough understanding of risk allows for the development of an individualized plan of care for each pregnant woman and empowers the nurse to advocate for appropriate care. The Joint Commission on Accreditation of Healthcare Organizations mandates that nurses participate, contribute, and measure issues related to quality care in their patients (Fleschler et al., 2001). Many times, nurses are the first line of defense in assessing for risk and preventing adverse outcomes. Accurate and complete documentation regarding obstetric and medical co-morbidities, as well as assessment findings must be communicated to the health care provider promptly and assertively. Identification tools, educational programs, and screening strategies can assist nurses in identifying risk factors and preventing potential medical complications of high-risk pregnant women. The earlier and more complete the assessment of risk the better appropriate care services can be matched with the patient along the continuum of care.

Hospitals need to develop guidelines for systematic identification of women at risk for adverse outcomes and ensure the availability of appropriate resources required to provide care. Policies that support recommended criteria for transport and enhanced communication between referring and receiving institutions must be instituted. Collaboration and communication between nurses in the obstetric department and the intensive care unit ensure prompt response to emergencies.

Perinatal nurses are in a position to influence a pregnant woman's actions in recognizing her risk status through increased education. The nurse can teach the woman to become involved in her pregnancy, to improve her awareness of early signs of complications, and to access appropriate services thus improving overall outcome. In addition, with an increasing number of women deemed "at risk", it is important for nurses to understand and respond to the pregnant woman's comprehension of risk, as well as assess maternal psychosocial/familial needs to minimize concerns surrounding the plan of care. Once identified, at-risk pregnant women, providers, and delivery sites can be matched according to level of need, resources available, and capacity to provide risk-appropriate care.

Implications for Future Research

Future research on the concept of risk will provide information that directs the development of practice standards and policies to maintain risk appropriate care. A thorough understanding of what risk means can help nurses identify who is at risk and how to intervene to remove or minimize these risks. Research is limited on maternal risk as well as maternal levels of care, and compared to neonatal levels of care, maternal levels are ill-defined and poorly implemented. In order to improve the outcomes of

pregnancy, nurses must be involved in the decision-making process around risk and develop evidence-based guidelines for levels of care specific to obstetrical patients.

A proposed study around the concept of maternal-fetal risk would be both descriptive and correlational. First, the concept of maternal-fetal risk and risk-appropriate care would be defined. Questions may include the following: What pregnancy-related complications increase the risk for poor maternal/neonatal outcomes? What are the interventions to mitigate these risks and how are they implemented? Information gained from these questions would add to the body of knowledge and improve the recognition of these elements of risk and subsequent requirements for care to minimize the potential for adverse outcomes. Second, determination of the extent of the issue regarding maternal-fetal risk appropriate care needs to be addressed. Unfortunately, data sources regarding maternal outcomes are limited or non-existent. Neonatal outcomes have been used as a proxy for maternal-fetal care evaluation (Bode, O'Shea, Metzguer, & Stiles, 2001). As such, the proposed study would use birth certificate data regarding very low birth weight (< 1500 grams) births and type of facility (primary, community, intermediate, and regional) where birth occurred to determine whether infants at risk for adverse outcome are being delivered at the appropriate place. This information can be used to develop risk assessment tools, educational programs for nurses to improve recognition, and guidelines for practice as well as policies to assist in the decision making process.

Conclusion

Each day nurses use their knowledge and skills to identify potential factors that may cause injury or harm to the patient. The earlier these aspects are recognized the

better the nurse can initiate the decision-making process to ameliorate the risk. The overall goal is to achieve optimal pregnancy outcomes through early risk identification, care in a setting appropriate for the level of risk and transport if necessary to reduce the adverse consequences of risk (Pasquier et al., 2005). A thorough understanding of risk allows for the development of an individualized plan of care for each pregnant woman and empowers the nurse to advocate for risk appropriate care. Furthermore, health care professionals must work together to define maternal levels of care and develop guidelines for consistent implementation of practice standards to maintain an effective system of care that minimizes maternal-fetal risk.

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Manuscript #3

Mothers at Risk: Factors Effecting Maternal Postpartum Length of Stay

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Abstract

Background: The emphasis in perinatal research over the past decade focused on neonatal outcomes especially with increasing rates of prematurity and low birth weight. Increasing trends over the past several years show maternal death and morbidity due to complications in pregnancy, labor, delivery, and the postpartum period to be a much more prevalent problem than previously assumed. These complications are often times preventable when appropriate resources and prompt treatment are available. As complications increase, the likelihood of longer postpartum stays due to the need for more extensive care will also increase.

Objective: To determine what risk factors identifiable during pregnancy, delivery, or postpartum have the greatest odds of increasing the woman's length of hospitalization stay. Determining the factors influencing the hospitalization period may help decrease the length of hospital stay, reduce costs, and improve efficiency of obstetrical units.

Methods: A population-based, descriptive, correlational design employing linked secondary data sets was used for this study. All women in California delivering infants between January 2008 through December 2009 were included and maternal admission/discharge data were linked to the newborn's birth certificate file. Records were excluded from facilities that do not report hospital discharge data as well as those with missing study variables. The final N for the study was 1,021,441 linked records.

Results: Women with an extended length of stay (ELOS) were more likely to be at the extremes of age (<18 or >35), Black or Pacific Islander, nulliparous, MediCal recipients, and have had no prenatal care as compared to women with a normal length of stay (LOS). Women with an ELOS were also more likely than normal (LOS) to have obstetric

conditions such as multiple gestation, placenta previa/abruption, and delivery a low-birth weight or preterm infant. At least one comorbidity or complication was present in 17% of pregnancies and multiple comorbidities/complications were seen in 1%. Chronic hypertension was associated with extended length of stay for both modes of delivery (OR 5.9 [4.4-7.9] vaginal; OR 3.6 [3.1-4.2] cesarean). Puerperal infections (OR 6.9 [5.7-8.2]), eclampsia (OR 17.1 [13.8-21.6]), and transfusion (OR 11.7 [9.2-17.8]) were among the most prevalent of complications and conferred the highest odds of an excessive length of stay for vaginal deliveries. Similarly, these complications as well as cerebrovascular conditions (OR 15.3 [11.9-19.6]) were seen most frequently in cesarean section births. Women who were obese or overweight delivering by cesarean section were at significantly lower risk for an ELOS than women with a normal BMI.

Conclusion: Various risk factors contribute to the occurrence of complications during pregnancy, birth, and the postpartum period. They are common and can have a significant impact on the mother as well as the health care system by increasing the length of stay as well as cost. The earlier these factors are recognized the sooner the provider can initiate the decision making process to mitigate the risk. Health care facilities need to develop guidelines for systematic identification of women at risk for adverse outcomes and ensure the availability of appropriate resources required to provide care.

Introduction

Although the birth rate in the United States has been declining in recent years, approximately 4 million women continue to give birth annually, making childbirth the most common reason for hospitalization and, as a result, one of the main contributors to overall health care utilization and costs (Podulka, Stranges, & Steiner, 2011). In 2008, the average charge for delivery hospitalization was $8,300 with aggregate annual charges totaling over $33 billion. Charges for cesarean sections with complications averaged $15,500, more than double the average for an uncomplicated vaginal birth (Podulka et al, 2011). Greater than 500,000 of those births, one in eight births nationally, occur in California. The majority of these births remain low risk with minimal, if any, significant adverse outcome.

Only 10% of births are considered at-risk for complications, but it is these births that continue to thwart the efforts of healthcare providers to improve the quality of care available to pregnant women. Increasing trends over the past several years show maternal death and morbidity due to complications in pregnancy, labor, delivery, or the postpartum period to be a serious and prevalent problem (Berg, MacKay, Qin, & Callaghan, 2009; Callaghan, Creanga, & Kuklina, 2012; Kuklina et al., 2009; Lyndon, Lee, Gilbert, Gould, & Lee, 2012). These complications are often times preventable with the availability of appropriate resources (Clark et al., 2008; Geller, Cox, & Kilpatrick, 2006). Although maternal death is the most tragic of obstetric events, it continues to be a rare event. Maternal morbidity poses a greater impact on the economic, psychological, and physical health of the woman and her family, yet it has not been the focus of measurement or research as there is no systematic collection of data available (Bruce et

al., 2012). As complications related to pregnancy, labor, and delivery increase, the likelihood of longer postpartum stays due the need for more extensive care will also increase.

Several studies have been published regarding early discharge and maternal outcomes (Liu et al., 2002; Madden et al., 2002), but few have been conducted during the last decade on the contributing factors associated with an extended length of stay. Determining the factors influencing the hospitalization period can add to our understanding of the effects of perinatal risk factors on maternal outcomes. The present study looks at risk factors affecting maternal length of stay. As previous studies indicate, many of the high-risk factors prompting adverse maternal outcomes are identifiable prior to delivery. An understanding of these risks can help identify measures to be taken to minimize their effect. The study findings provide needed evidence to develop policies on early identification and appropriate care to decrease risk.

Methods

Design and Source of Data

A population-based, descriptive, correlational design employing linked secondary data sets was used for this study. Using probabilistic linkage techniques that allow for the identification of records most likely to be matches, maternal delivery data from the California Office of Statewide Health Planning and Development (OSHPD) were linked to the birth statistical master files of the Office of Vital Statistics (OVS). OSHPD data, voluntarily submitted by hospitals within the State of California, included demographics, delivery mode, diagnoses, procedures, type of discharge, source of payment, length of stay, and hospital type. Vital statistics data, gathered from birth certificates completed

prior to or following discharge and submitted to OVS within 30 days of birth, included educational level, race/ethnicity, mother's birth date, parity, pre- and post-pregnancy weight, initiation of prenatal care, co-morbidities, gestational age, and birth weight at delivery. Records without matched data sets were excluded from this study. The linkage between OSHPD and vital statistics databases has been studied previously and has been found to be 97-100% accurate (Danielsen, 2000; Herrchen, Gould, & Nesbitt, 1997; Srinivas, Gager, & Lorch, 2010).

Request for data usage was made through a collaborative research proposal with the California Perinatal Quality Care Collaborative (CPQCC). Permission to use CPQCC linked data sets was granted. The Institutional Review Board of the University of San Diego approved this study. OSHPD developed and executed the linkage strategy. Data analysis was provided by CPQCC under grant support from the Hahn School of Nursing and Health Science, University of San Diego.

Study Sample

The study population consisted of all women in California delivering infants from January 2008 through December 2009 (N = 1,079,318 live births). Records were excluded from facilities that do not report hospital discharge data (military hospitals and freestanding birth centers), which represented 3.4% of total records. Of these records, 21,428 (2% of linked records) were further excluded for the following reasons: duplicate mothers (mothers of multiples), missing MCH code (non-birthing facility), invalid postpartum length of stay (negative values), maternal age <11 or >59 years, missing insurance status, height extremes relevant for BMI calculations (<48 inches or >84 inches), missing parity, gestational age <17 or >47 weeks, birth weight <227 or >8165

grams (NCHS criteria), hospitals less than 50 births, and missing foreign born status. Leaving a final study cohort of 1,021,441 linked records.

Study Variables

Postpartum length of stay (PPLOS) was determined by subtracting the birth date from the discharge date and was our primary outcome. Because length of stay varies by delivery type, mothers were first stratified into mode of delivery (vaginal/assisted versus cesarean section). To accommodate additional hospital days for minor events, or for reasons related to the newborn, the dependent variable of extended length of stay (ELOS) for vaginal delivery was defined as normal (0-3 days), moderate (4 days), and excessive (5 or more days). Cesarean delivery was categorized as normal (0-4 days), moderate (5 days), and excessive (6 or more days).

1. Predictor variables for prolonged length of stay were chosen based on their availability within the existing data set and were grouped into categories that include socio-demographic, obstetrical, co-morbidities, and complications. Maternal characteristics included age, race, level of education, payer source, parity, foreign born status, and initiation of prenatal care. Although marital, socioeconomic status, and smoking have been shown to increase maternal risk (Gray, Wallace, Nelson, Reed, & Schiff, 2012) these items are inconsistently completed on the birth certificate and were not included in this study.
2. The *International Classification of Diseases, 9th revision, Clinical Modification* (ICD-9-CM) diagnostic and procedural codes were used to identify various diagnoses and outcomes (Berg, MacKay et al., 2009; Callaghan, MacKay, & Berg, 2008; Gregory, Fridman, Shah, & Korst, 2009;

Gray et al., 2012). Mothers were considered positive for obstetrical complications if they had ICD-9 diagnosis codes for gestational diabetes, gestational hypertension, mild preeclampsia, placenta previa/abruption, multiple gestation, or eclampsia/severe preeclampsia. Mothers were considered positive for co-morbidities if they had ICD-9 diagnosis codes for depression, substance use, asthma, chronic hypertension, diabetes, coagulation disorders, lupus, or cardiac, renal, or liver conditions. Body mass index was calculated using maternal weight and height at delivery. Mothers were considered positive for complications if they had ICD-9 diagnosis codes for puerperal infections, cerebrovascular disorders, other puerperal complications, hemorrhage, respiratory failure, obstetric shock, cardiac events, renal failure, or infection or ICD-9 procedure codes for transfusion, hysterectomy, mechanical ventilation, or hemodynamic monitoring.

3. Preterm and low birth weight births were determined based on birth weight and gestational age obtained from the birth certificates.

Statistical Methods

The statistical analyses included descriptive, inferential, and regression procedures and included a) univariate analysis to study the frequency and distribution of cases of each predictor variable and outcome, b) Wald Chi-square (x^2) with significance level $p \leq 0.05$ to determine the significance in distribution within each categorical risk factor, and c) multiple logistic regression to determine the influence of independent predictors on risk of extended length of stay and to determine odds ratio (OR) with 95% confidence intervals. To build the multivariable logistic model, all variables whose

univariate association with prolonged LOS was $p \leq 0.05$ were included. In some cases, multiple categories of potentially important risk factors (i.e. month of prenatal care initiation, race) that did not have $p \leq 0.05$ were combined. The new combinations were examined to determine any significant relationship with length of stay. In the final analysis all potential risk factors with a $p \leq 0.05$ were included. SAS 9.2 (SAS Institute Inc., Cary, NC) was used for data management and analyses.

Results

Between 2008 and 2009, there were 1,021,441 live births in California with linked records. Maternal sociodemographic characteristics are reported in Table 1. The majority of women who gave birth during the study period were: 18-24 years old, high school graduates, Latina, MediCal recipients, born in the United States, multiparous (1-3 children), and entered into prenatal care during the first trimester. 32.8% were delivered by cesarean section and tended to be older (30-34 years) than those delivering vaginally. The total number of mothers experiencing an extended length of stay (ELOS) was 9,724 with an overall rate of 5.89/1000 live births for moderate and 3.63/1000 live births for excessive. The rate of extended length of stay was higher among mothers delivering by cesarean section than vaginally (20.36/1000 births versus. 4.23/1000 births, respectively) (Table 2).

Demographic Characteristics

Women with an ELOS were more likely to be at the extremes of age (<18 or >35), Black or Pacific Islander, nulliparous, MediCal recipients, and have had no prenatal care as compared to women with a normal length of stay (LOS) (Table 2). Women with an ELOS were also more likely than normal LOS women to have obstetric conditions

such as multiple gestation, placenta previa/abruption, and deliver a low-birth weight or preterm infant (Table 3). Although women with gestational diabetes or hypertension were more likely to have an ELOS, this was more pronounced for moderate than excessive stays. Non-obese women comprised 45% of the study population (48.3% vaginal and 39.6% cesarean section). Of those women with abnormal weight, the majority of both vaginal and cesarean section deliveries were considered overweight (BMI 25-29.9) (Table 4). Overweight and obese women (BMI 30-39.9) delivering vaginally were more likely to encounter a moderate length of stay than normal weight women. Extremely obese women (BMI >40) as well as underweight women (BMI <18.5) with cesarean sections were more likely to experience an extended length of stay than normal weight women.

Complications/Comorbidities

At least one comorbidity was present in 7% of pregnancies, and multiple comorbidities were seen in 1%. For women with an ELOS, nearly 22% had at least one comorbidity and 6% had more than one. The most common comorbidities for both modes of delivery were depression, asthma, chronic hypertension, coagulation disorders, and diabetes, and women with a cesarean section experienced these comorbidities more frequently (Table 4). Women with these conditions were more often hospitalized for an extended length of time as compared to women without these conditions *($p < .0001$).* At least one complication occurred in 8% of pregnancies and 1% of pregnancies had more than one complication. For women with an ELOS, nearly 35% had at least one complication and 24% had more than one. The most common complications seen in both vaginal and cesarean section births were hemorrhage, puerperal infections, mild

preeclampsia, eclampsia, and transfusion. With the exception of hemorrhage, women undergoing cesarean section experienced complications almost twice as frequently. Hemorrhage was present more frequently in vaginal deliveries (2.8%) than in cesarean section (1.9%). Eclampsia was present in four times the number of cesarean than in vaginal deliveries (2.23%, 0.53%, respectively). In addition, other puerperal complications were seen in approximately 0.8% of cesarean sections as compared to 0.4% of vaginal deliveries. Women with these complications were also more often hospitalized for an extended length of time than women without these complications *($p<.0001$).* It is important to note that these comorbidities and complications were not necessarily the result of the mode of delivery itself, but rather may have influenced the decision to deliver by cesarean section.

Extended Length of Stay

In the multivariate analysis, education and foreign born status were not associated with an ELOS. Older women (>30 years) were at increased risk of an ELOS as compared with women aged 25-29 for both vaginal and cesarean section deliveries (Table 5). Women <18 years were at 38% increased risk for an excessive stay when delivering by cesarean section (OR 1.38 [CI 1.07-1.79]). Non-White women were also at increased risk of ELOS compared to White women, with Black and Pacific Islander women at highest risk. Asian race was significantly associated with an excessive stay for cesarean section only (OR 1.19 [CI 1.01-1.43]. Latinas were noted to have increased odds of an ELOS for both modes of delivery as were women who refused to state their racial preference. Women delivering vaginally and receiving MediCal had a 1.7 times greater risk for excessive stay and 1.4 times the risk for cesarean section births compared to

women with private insurance. Timing of prenatal care, either none/missing or late, was not found to be significant except for a moderate length of stay for vaginal deliveries (OR 1.2 [CI 1.02-1.29]. Multiparous women were at 68% - 84% decreased risk for an excessive stay for both vaginal and cesarean section when compared to nulliparous women. Women with gestational hypertension, delivering vaginally after a cesarean section, and those with babies of gestational age of 30-36 weeks had more than two times the risk of an ELOS, both moderate and excessive, as women without these obstetric conditions. Women with a multiple birth were at 2.7 times greater risk for a moderate stay after a vaginal birth and 1.3 times greater risk after a cesarean section. Women delivering by cesarean section at 20-29 weeks gestation had nearly four times greater risk of an excessive stay than women delivering at term (OR 3.77 [CI 3.08-4.64]). Women with a repeat cesarean section were at significantly decreased risk for a moderate or excessive stay (OR 0.77 [0.70, 0.85]; OR 0.78 [0.69, 0.88], respectively). Underweight women with cesarean section were at increased risk of an excessive stay (OR 1.29 [CI 1.02, 1.63]. Women who were obese (all categories) or overweight delivering by cesarean section were at significantly lower risk than women with a normal BMI.

The majority of the comorbidity and complication variables were significantly associated with both moderate and excessive stay for both modes of delivery when compared to women without these issues present (Table 6). Odds for an ELOS for women with any comorbidity ranged from 1.3 for a moderate stay for women with asthma delivering by cesarean section to 5.9 for an excessive stay for women with chronic hypertension delivering vaginally. Despite the fact women delivering by cesarean section with chronic hypertension were at a lower risk for an extended length of

stay than women with this disorder who delivered vaginally, the risk remained elevated (OR 3.26 [CI 2.88-3.69] moderate; OR 3.57 [CI 3.05-4.17] excessive). Although depression and asthma presented more frequently they carried less odds for ELOS than other conditions like cardiac, renal, and liver that had 2 to 4 times greater risk.

Odds for an ELOS for women with any pregnancy complications ranged from 1.5 for an excessive stay for women delivering by cesarean section with hemorrhage to 130.4 for an excessive stay for women delivering vaginally with an infection. Hemorrhage carried the least amount of risk for cesarean section deliveries (OR 1.56 [CI 1.35-1.79] moderate; 1.52 [CI 1.27-1.80] excessive) and infection carried the greatest risk for vaginal deliveries (OR 74.49 [CI 38.53-144.04] moderate; OR 130.36 [CI 67.29-252.52] excessive). Overall, women delivering by cesarean section were at lower odds of any complication than those women delivering vaginally, except for cerebrovascular disorders and mechanical ventilation. As with cesarean deliveries, hemorrhage carried the least amount of risk for vaginal deliveries (OR 1.70 [CI 1.44-2.02] moderate; OR 1.57 [CI 1.23-1.97] excessive), but transfusion carried a greater risk for excessive in vaginal deliveries than cesarean section (OR 11.68 [CI 9.21-14.81] vaginal vs. OR 6.07 CI [5.41-6.80] cesarean). Transfusion and eclampsia were also associated with a significant risk of excessive stay for both modes of delivery. Women with cardiac events had a reduced risk for an excessive stay when delivered by cesarean section (OR 0.39 [CI 0.25-0.63]).

Discussion

The rates of maternal mortality and morbidity have risen over the past decade prompting increased scrutiny of the provision of quality care. In this population-based study, 17% of women giving birth during the study period had at complications or pre-

existing conditions. Other studies indicated the rate of morbidity during and after pregnancy ranges from 28.6% to 68.4% (Berg et al., 2009; Mhyre, Bateman, & Leffert, 2011). One percent of the women in our study experienced some type of extended length of stay; cesarean section deliveries had 2.5 times greater risk for longer postpartum stays than vaginal deliveries.

Similar to other studies, advanced maternal age (>35 years), non-White race/ethnicity, and women on MediCal are strong indicators of risk for maternal morbidity, defined as an extended length of stay. Studies have shown women of advanced maternal age (>35 years) during pregnancy have higher morbidity rates than the regular population (18-34 years) (Cleary-Goldman et al., 2005) as do black and Hispanic women (Callaghan, MacKay, & Berg, 2008; Goffman, Madden, Harrison, Merkatz, & Chazotte, 2007). Black women are at three to four times greater risk of death from pregnancy complications than white women (Tucker, Berg, Callaghan, & Hsia, 2007). This increased risk may be a result of higher levels of inadequate prenatal care, teen births, Medi-Cal paid delivery, and lower levels of maternal and paternal education (Gould, Madan, Qin, & Chavez, 2003). Other explanations for these racial health disparities include the higher rates of pre-existing medical conditions in African American women including obesity, hypertension, and diabetes, as well as decreased health care access due to poverty (California Pregnancy-Associated Mortality Review, 2011). Although other studies have found Asian women to be at higher risk of deliveries with major lacerations, postpartum hemorrhage, and major puerperal infections (Lyndon et al., 2012; Guendelman, Thornton, Gould, & Hosang, 2006) this did not hold true for the current study. Asian women were not shown to be at significantly higher risk for

extended length of stay compared to White women. This may be due to the blending of all Asian ethnicities into one category with some ethnicities being lower risk than others (Qin & Gould, 2010). However, Pacific Islander women were at nearly twice the risk for excessive length of stay. Further investigation into the contributing factors that increase the prevalence of these conditions in the non-White population would allow for appropriate interventions to reduce this disparity.

Several behavioral and psychosocial risk factors are associated with maternal mortality and morbidity. In one study, mental illness was a contributing factor in 16.5% of cases of pregnancy-associated maternal mortality, with 50% considered preventable (Kavanaugh et al., 2009). Untreated psychiatric disorders during and after pregnancy can lead to the inability to recognize signs of physical illness, to seek medical care, and failure to follow up with treatments (Gold & Marcus, 2008). Substance abuse is also a recognized risk factor for poor maternal and neonatal outcomes, specifically placental abruption and hemorrhage, as well as preterm birth and low birth weight with the odds of maternal death increasing with any drug use compared to no drug use during pregnancy (Kennare, Heard, & Chan, 2005; Wolfe, Davis, Guydish, & Delucchi, 2005). In the present study, women with depression were at 1.5 to 1.8 times greater risk of an extended length of stay, and women with a history of drug use during pregnancy had two to three times greater risk for an extended length of stay. These two categories are often times under reported.

Contrary to other reports regarding maternal pre-pregnancy BMI and adverse outcomes women who were overweight or obese in any category had a significantly decreased risk of extended length of stay when delivering by cesarean section. Women

with a BMI of 25-29 who delivered vaginally had 1.2 times greater risk of a moderate length of stay than normal weight women. No other weight categories for vaginal deliveries were noted to be significant factors in an extended length of stay. This may be due to the increased awareness among providers to the risk for hemorrhage, hypertension, diabetes, venous thromboembolism, wound infection, cesarean section, and increased length of stay that women with a BMI >40 may experience during and after pregnancy (Goffman et al., 2007; Mamun et al., 2011; Robinson, O'Connell, Joseph, & Mcleod, 2005). Education and practice changes have been implemented to reduce these risks and providers are more likely to anticipate complications more readily with this population. In addition, although findings on the efficacy of prenatal care have been mixed (Goffman et al., 2007), experts in obstetrics agree that early entry into prenatal care and consistent care throughout pregnancy can help identify risk factors and provide potential means to minimize their overall effects.

In this study, women with no prenatal care or late entry into prenatal care did not have an increased risk for an extended length of stay. This may be due to 45% of the study population being foreign born. Foreign born women tend not to seek prenatal care and are usually healthier overall than their native born counterparts (Flores, Simonsen, Manuck, Dyer, & Turok, 2012). Lastly, multiparity has been associated with poor maternal outcome including a heightened risk for placental complications, hypertension, and hemorrhagic stroke (Guendelman et al., 2006; Jung, Bae, Park, & Yoon, 2010). For each additional pregnancy, the odds ratio for adverse outcome was 1.3 (95% CI 1.1 to 1.5) (Goffman et al., 2007). In this study, multiparous women had a significant decreased risk for extended length of stay.

Overall, the most common comorbidities associated with an ELOS for vaginal deliveries were BMI (overweight and obese I-II), depression, coagulation disorders, and chronic hypertension. Likewise, common comorbidities for cesarean sections were BMI (overweight and obese I-III), depression, coagulation disorders, chronic hypertension, and asthma, all occurring at a prevalence rate of 5% or greater. The most common complications associated with an ELOS for both modes of delivery were hemorrhage, puerperal infections, mild preeclampsia, eclampsia, and transfusion. Although the complications of infection, renal failure, mechanical ventilation, obstetric shock, and respiratory failure occurred less frequently in the overall population, women with these complications had a higher prevalence rate for an excessive stay for both modes of delivery. These results are consistent with other studies in which similar comorbidities and complications were linked to maternal morbidity and mortality including chronic hypertension, and obstetric infections (Bruce et al., 2012); transfusion, renal failure, obstetric shock, respiratory failure (Callaghan et al., 2012); pre-eclampsia, eclampsia, and hysterectomy (Callaghan, 2008; Gray et al., 2012; Zwart, Dupuis, Richters, Ory, & van Roosmalen, 2010); coagulation issues, acute liver disease, acute respiratory distress syndrome, acute heart failure (Mhyre et al., 2011); multifetal pregnancy (Panchal, Arria, & Harris, 2000); and septicemia (Lawton et al., 2010).

Women in the study who had even one comorbid condition had significantly increased ELOS regardless of delivery type. Although many of these conditions may not be amenable to change, they are useful in the identification of women who require added vigilance during the labor and delivery process, as well as during the postpartum period. Similarly, women with one complication of birth were five to seven times greater risk

(cesarean) and seven to nine times greater risk (vaginal) of an ELOS compared to those without complications. Multiple risk factors increase the potential for a poor outcome. Generally, conditions that lead to these complications are identifiable at the time of admission to the labor or postpartum unit, suggesting opportunities exist to improve outcomes by triaging high-risk women to delivery centers with increased capability to provide intensive intra-partum and postpartum care.

The increased length of stay observed in this study is similar to other case-control studies in which women with pre-existing conditions were two times the risk for severe maternal morbidity (length of stay > 3 days) as compared with those without (Gray et al., 2012) and a significant increase in length of stay was noted in women with multiple social problems, obstetric complications, and medical conditions (Elattar, Selamat, Robson, & Loughney, 2008). Further findings showed that while major maternal illness such as infection, preeclampsia, hemorrhage, and perineal trauma strongly influences the length of stay for individual patients, relatively minor conditions such as anemia are more common and therefore have a greater influence on bed occupancy (Elattar et al., 2008). In addition, women with previous or current complications were three to four times more likely to be admitted to the ICU with higher rates for eclampsia, (OR 6.8 [CI 5.4-8.6]), acute renal failure (OR 22.1 [CI 13.3-36.6]), and placental abruption (OR 8.9 [CI 8.3-9.6]) (Madan et al., 2009). Interestingly, eclampsia risk in our study was higher for vaginal deliveries at OR 17.2 [CI 13.8– 21.2]; renal failure was less at OR 15.8 [CI 6.7-33.9]. Although this study did not include ICU admission, research has shown high-risk mothers may require more extensive care including blood replacement and mechanical ventilation, as well as transfer to the intensive care unit due to complications arising from

obstetric hemorrhage, hypertensive disorders of pregnancy, acute renal failure, multifetal pregnancy, and diabetes (Zwart et al., 2010; Vasquez et al., 2007; Zeeman, Wendel, & Cunningham, 2003). Even though the frequency of procedures related to intensive care (ventilation, hemodynamic monitoring) was minimal in this study, women with these procedures were still more than 2 to 4 times greater risk for mechanical ventilation in both modes of delivery, and 10 to 17 times the risk with hemodynamic monitoring for vaginal deliveries. Interestingly, cardiac events were either not significant for an extended length of stay or had a protective factor in cesarean sections. This may be due to the poor outcome overall of women with a cardiac event such as myocardial infarction and the higher rate of mortality in these cases (CPAMR, 2011).

This study had several limitations. First, the use of administrative databases encompasses particular limitations. The quality of the data depended on the accuracy and completeness of the information recorded on the certificates and of the quality control procedures employed in the coding process (Madan et al., 2009). Therefore, bias is inevitable due to misclassification and under-reporting by the health care facility. Second, certain information important in identifying associations was not contained within the data sets, and chart review to abstract this data was not available to confirm areas of interest including socioeconomic and marital status. Previous studies have indicated maternal outcomes are also affected by provider and health care system factors, which this study did not address (Clark et al., 2008; Geller et al., 2008). In a statewide review of pregnancy related mortality in North Carolina, 40% of pregnancy-related deaths were potentially preventable (Berg, Harper et al., 2005). Changes in several areas, including preconception care, patient actions, system factors, and quality of care

contribute to the preventability of death. In a similar review of California's pregnancy-related mortality, more than a third of the deaths were determined to have had a good-to-strong chance of being prevented (CPAMR, 2011). Eighty-seven percent of deaths had at least one factor related to the patient, the health care professional, or the health care facility that contributed in some way to the fatal outcome (CPAMR, 2011). These findings support the need for further research and the dissemination of findings in order to educate health care providers at all levels in the appropriate assessment and treatment of at-risk pregnant women. Other variables shown in the literature to affect maternal outcomes such as urban/rural residence, type of hospital, delivery volume, and available resources although available in the dataset were beyond the time and scope of this study.

Third, although ICD-9-CM codes were used to identify comorbidities and complications, these codes do not fully assess the severity of these conditions (Callaghan et al., 2008). However, the outcome variable of extended length of stay as operationally defined could act as a proxy for severity with the assumption that only women with severe complications required continuous hospitalization and care. Finally, this study used a polychotomous outcome design which may have caused over stratification of the logistic regression model. Although a binomial outcome may have allowed for stronger conclusions, due to the differences between mode of delivery and length of stay, stratifying the variables into moderate and excessive allowed for a better analysis of these nuances.

Various risk factors contribute to the occurrence of complications during pregnancy, birth, and the postpartum period. As the study results show, they are common and can have a significant impact on the mother as well as the health care system by

increasing the length of stay and thus increasing utilization and cost. While the majority of perinatal complications can be cared for adequately at any facility providing obstetric care, there are many for which a higher level of care is required, and subsequent transport of the mother is necessary. The earlier these factors are recognized the sooner the provider can initiate the decision making process to mitigate the risk. Furthermore, access to prenatal care, although important to identify and minimize risks prior to delivery, was not a significant factor in length of stay indicating that many of the complications/comorbidities identified may increase or occur during the labor and/or delivery period. Health care facilities need to develop guidelines for systematic identification of women at risk for adverse outcomes and ensure the availability of appropriate resources required to provide care. Policies that support recommended criteria for transport and enhanced communication between referring and receiving institutions are recommended. Costs associated with adverse maternal outcomes can be astronomical related to the number of inpatient days accrued and professional ancillary fees (Diehl-Svrjcek & Richardson, 2005). Women with identifiable risk factors would benefit from increased vigilance and prompt treatment to minimize adverse outcomes, as well as decrease cost.

Table 1. Maternal characteristics (N=1,021,441)

Characteristic	Total N (%)	
	Vaginal n = 686,238 (67.2%)	Cesarean n = 335,203 (32.8%)
Maternal age		
<18	25,981 (3.8)	6,456 (1.9)
18-24	210,752 (30.7)	76,668 (22.9)
25-39	188,658 (27.5)	84,907 (25.3)
30-34	159,999 (23.2)	88,424 (26.4)
>35	100,848 (14.7)	78,748 (23.5)
Education		
Some HS	179,412 (26.1)	82,126 (24.5)
HS grad	181,507 (26.5)	83,596 (24.9)
Some college	149,989 (21.9)	75,809 (22.6)
College grad	101,911 (14.9)	53,550 (16/0)
Grad degree	51,706 (7.5)	29,061 (8.7)
Unknown	21,713 (3.2)	11,061 (3.3)
Race		
White	183,185 (26.7)	90,046 (26.9)
Black	36,735 (5.4)	21,553 (6.4)
Asian	66,410 (9.7)	30,453 (9.1)
Pacific Islander	22,084 (3.2)	12,126 (3.6)
Latina	364,435 (53.1)	173,614 (51.8)
AI/Alaskan	3,043 (0.44)	1,507 (0.45)
Other	511 (0.07)	298 (0.09)
Unknown	9,835 (1.4)	5,606 (1.7)
Foreign Born		
Yes	297,194 (43.3)	150,406 (44.9)
Payor		
Medi-Cal	334,020 (48.7)	158,444 (47.3)
Private	316,565 (46.1)	159,355 (47.5)
None/Uninsured	14,018 (2.0)	6,183 (1.8)
Other	21,635 (3.2)	11,221 (3.4)
Prenatal Care		
None	3,403 (0.5)	1,158 (0.35)
First trimester	552,278 (80.5)	276,880 (82.6)
Second trimester	98,650 (14.4)	42,902 (12.8)
Third trimester	18,982 (2.8)	8,081 (2.4)
Parity		
Nulliparous	275,920 (40.2)	131,988 (39.4)
1-3	378,310 (55.1)	188,468 (56.2)
4 or more	32,008 (4.7)	14,747 (4.4)

Table 2. Maternal characteristics by length of stay

	Column percent					
Characteristic	Vaginal			Cesarean		
	Normal n=683,338	Moderate n=1,842	Excessive n=1,058	Normal n=328,379	Moderate n=4,175	Excessive n=2,649
Maternal age						
<18	3.8	5.2	5.0	1.9	2.7	3.3
18-24	30.7	28.3	32.7	22.9	21.8	22.8
25-39	27.5	23.1	19.0	25.4	21.7	20.1
30-34	23.3	22.8	22.5	26.4	24.0	24.0
>35	14.7	20.6	20.8	23.4	30.0	29.6
Race						
White	26.7	22.1	18.6	26.9	25.8	21.0
Black	5.3	8.7	10.1	6.3	12.3	13.8
Asian	9.7	8.6	7.4	9.1	8.4	8.6
Pacific Islander	3.2	4.6	5.3	3.6	4.7	5.2
Latina	53.1	53.3	56.2	52.0	45.6	48.9
AI/Alaskan	0.4	0.6	0.3	0.5	0.6	0.5
Other	0.1	0.2	0.2	0.1	0.1	0.1
Payor						
Medi-Cal	48.7	51.2	58.4	47.2	49.0	53.0
Private	46.2	44.7	36.1	47.6	45.6	41.6
None/Uninsured	2.0	1.4	2.0	1.9	1.7	2.0
Other	3.2	2.7	3.5	3.3	3.8	3.4
Prenatal Care						
None	0.5	0.6	2.1	0.3	0.8	1.2
First trimester	80.5	78.1	76.1	82.6	82.5	80.5
Second trimester	14.4	16.5	15.8	12.8	12.5	12.6
Third trimester	2.8	3.2	3.6	2.4	1.9	2.0
Parity						
Nulliparous	4.2	51.6	51.5	39.1	52.3	50.3
1-3	55.2	42.8	41.4	56.5	41.8	42.7
4 or more	4.7	5.6	7.1	4.4	5.8	7.0

Vaginal moderate LOS = 4 days, excessive LOS = 5 or greater days
Cesarean moderate LOS = 5 days, excessive LOS = 6 or greater days
*all variables significant at p<.0001

Table 3. Maternal obstetric characteristics by length of stay

	Column percent					
Characteristic	Vaginal			Cesarean		
	Normal n=683,338	Moderate n=1,842	Excessive n=1,058	Normal n=328,379	Moderate n=4,175	Excessive n=2,649
Gestational diabetes	5.8	9.0	7.6	9.5	12.1	9.9
Gestational HTN	2.1	6.5	5.5	3.4	8.7	7.9
Previous c/section	1.9	5.3	3.6	46.2	27.8	27.4
Previa/abruption	0.8	2.9	2.5	46.2	27.8	27.4
Multiple gestation	0.5	3.3	2.3	3.9	11.6	9.3
Birth weight						
<2500 g	4.3	15.1	18.8	8.5	34.8	39.0
2500-3999 g	88.5	77.7	74.4	80.9	56.3	54.6
>4000 g	7.2	7.2	6.8	10.6	9.0	6.4
Gestational age						
20-29 weeks	0.4	1.3	1.9	1.1	7.0	9.8
30-36 weeks	5.6	19.0	21.6	9.9	33.0	35.8
37-40 weeks	85.3	72.0	68.4	82.0	0.7	0.4
>40 weeks	8.0	7.3	7.4	6.5	5.3	4.7

Vaginal moderate LOS = 4 days, excessive LOS = 5 or greater days
Cesarean moderate LOS = 5 days, excessive LOS = 6 or greater days
*all variables significant at p<.0001

Table 4. Maternal morbidities/mortalities by length of stay

	Rate/1000 live births							
Characteristic	Vaginal				Cesarean			
	Normal	Moderate	Excessive	%	Normal	Moderate	Excessive	%
BMI								
Overweight	228.2	0.7	0.4	22.9	240.8	2.8	1.8	24.6
Obese I-II	137.1	0.5	0.2	13.8	205.7	2.5	1.5	20.1
Underweight	42.4	0.1	0.1	4.3	26.5	0.4	0.3	2.7
Obese III	17.8	0.07	0.03	1.8	41.7	0.6	0.5	4.3
Depression	22.9	0.1	0.1	2.2	26.1	0.7	0.6	2.7
Asthma	20.9	0.1	0.1	2.1	27.5	0.6	0.4	2.9
Chronic HTN	8.5	0.1	0.1	0.9	21.5	1.1	0.8	2.4
Coag disorders	5.6	0.1	0.1	0.6	10.0	0.6	0.8	1.1
Diabetes	4.5	0.1	0.03	0.5	15.6	0.6	0.3	1.6
Cardiac conditions	3.2	0.04	0.1	0.33	5.0	0.3	0.5	0.6
Substance use	2.1	0.03	0.02	0.22	1.2	0.01	0.02	0.13
Renal conditions	1.2	0.01	0.02	0.13	1.7	0.1	0.1	0.19
Lupus	0.9	0.0	0.01	0.09	1.6	0.1	0.1	0.18
Liver conditions	0.8	0.01	0.01	0.08	1.1	0.03	0.1	0.13
Hemorrhage	27.3	0.4	0.4	2.8	16.7	1.1	1.2	1.9
Puerperal infections	24.9	0.4	0.3	2.6	42.9	1.9	1.8	4.7
Mild preeclampsia	14.6	0.2	0.1	1.5	25.1	1.1	0.6	2.7
Eclampsia	4.8	0.3	0.2	0.5	18.7	2.2	1.2	2.2
Transfusion	4.3	0.4	0.3	0.49	12.1	1.6	1.9	1.6
Cerebrovascular	4.1	0.1	0.1	0.43	2.7	0.2	0.7	0.4
Puerperal comp	3.2	0.1	0.1	0.35	6.7	0.5	0.7	0.8
Respiratory failure	0.1	0.04	0.1	0.02	1.4	0.3	1.0	0.3
Hysterectomy	0.1	0.1	0.1	0.02	1.4	0.4	0.5	0.2
Mechanical vent	0.1	0.03	0.1	0.01	0.5	0.2	0.7	0.2
Obstetric shock	0.1	0.02	0.1	0.01	0.3	0.1	0.3	0.1
Cardiac events	0.1	0.01	0.02	0.01	0.5	0.1	0.3	0.1
Renal failure	0.04	0.01	0.04	0.01	0.3	0.1	0.5	0.1
Infection	0.04	0.03	0.1	0.01	0.2	0.1	0.4	0.1
HD monitoring	0.04	0.01	0.02	0.01	0.1	0.02	0.1	0.02

Vaginal moderate LOS = 4 days, excessive LOS = 5 or greater days
Cesarean moderate LOS = 5 days, excessive LOS = 6 or greater days
*all variables significant at p<.0001

Table 5. Maternal and obstetric risk factors associated with extended length of stay

	Vaginal		Cesarean	
	Moderate OR [95% CI]	Excessive OR [95% CI]	Moderate OR [95% CI]	Excessive OR [95% CI]
Maternal age				
<18	1.06 [0.84-1.35]	1.15 [0.82-1.59]	1.11 [0.90-1.37]	1.38 [1.07-1.79]
30-34	1.21 [1.05-1.39]	1.49 [1.21-1.82]	1.11 [1.01-1.22]	1.21 [1.06-1.38]
>35	1.53 [1.32-1.77]	1.77 [1.43-2.19]	1.45 [1.32-1.59]	1.59 [1.41-1.82]
Race				
Black	1.64 [1.35-1.99]	1.99 [1.53-2.59]	1.65 [1.47-1.85]	2.06 [1.76-2.39]
Asian	1.01 [0.83-1.23]	0.84 [0.62-1.12]	0.96 [0.84-1.08]	1.19 [1.01-1.43]
PI	1.29 [1.01-1.65]	1.68 [1.21-2.32]	1.09 [0.93-1.27]	1.36 [1.10-1.68]
Latina	1.24 [1.09-1.42]	1.41 [1.17-1.69]	0.95 [0.87-1.03]	1.17 [1.03-1.32]
Payor				
Medi-Cal	1.18 [1.06-1.33]	1.69 [1.45-1.99]	1.37 [1.27-1.48]	1.41 [1.28-1.57]
Parity				
Multiparous	0.64 [0.58-0.72]	0.68 [0.58-0.79]	0.84 [0.77-0.92]	0.87 [0.77-0.98]
Gestational HTN				
	2.77 [2.28-3.37]	2.46 [1.85-3.28]	2.83 [2.52-3.17]	2.59 [2.21-3.05]
Gestational DM				
	1.21 [1.02-1.44]	0.97 [0.75-1.26]	1.16 [1.04-1.28]	0.86 [0.75-0.99]
Multiple Gestation				
	2.68 [1.99-3.59]	1.56 [0.98-2.49]	1.34 [1.19-1.49]	1.02 [0.87-1.19]
Previous C/section				
	2.88 [2.31-3.59]	1.74 [1.21-2.49]	0.77 [0.70-0.85]	0.78 [0.69-0.88]
Birth weight				
<2500 grams	1.31 [1.09-1.56]	1.41 [1.12-1.79]	1.67 [1.50-1.86]	1.55 [1.35-1.78]
Gestational age				
20-29 weeks	0.91 [0.56-1.47]	1.01 [0.57-1.81]	2.79 [2.37-3.29]	3.78 [3.08-4.64]
30-36 weeks	2.03 [1.73-2.37]	2.15 [1.75-2.66]	2.00 [1.81-2.20]	2.39 [2.10-2.74]
Body Mass Index				
Obese I	1.20 [1.03-1.40]	0.88 [0.70-1.12]	0.85 [0.76-0.94]	0.86 [0.75-0.99]
Obese II, III	1.06 [0.87-1.29]	0.77 [0.57-1.05]	0.84 [0.75-0.93]	1.00 [0.86-1.16]
Overweight	1.14 [1.01-1.29]	1.02 [0.86-1.20]	0.87 [0.80-0.95]	1.29 [1.02-1.63]
Underweight	0.99 [0.77-1.27]	0.89 [0.63-1.26]	1.07 [0.89-1.29]	1.28 [1.02-1.63]

Vaginal moderate LOS = 4 days, excessive LOS = 5 or greater days
Cesarean moderate LOS = 5 days, excessive LOS = 6 or greater days

Table 6. Comorbidities/complications associated with extended length of stay

	Vaginal		Cesarean	
	Moderate OR [95% CI]	Excessive OR [95% CI]	Moderate OR [95% CI]	Excessive OR [95% CI]
Depression	1.40 [1.11-1.77]	1.67 [1.25-2.23]	1.52 [1.32-1.76]	1.89 [1.59-2.26]
Asthma	1.20 [0.93-1.56]	1.22 [0.87-1.73]	1.24 [1.06-1.44]	1.35 [1.11-1.63]
Chronic HTN	4.17 [3.31-5.26]	5.89 [4.39-7.88]	3.26 [2.88-3.69]	3.57 [3.05-4.17]
Coag Disorders	1.73 [1.31-2.29]	1.82 [1.31-2.54]	1.26 [1.07-1.49]	1.40 [1.15-1.71]
Diabetes	2.60 [1.90-3.56]	1.65 [1.01-2.67]	1.72 [1.46-2.02]	1.38 [1.10-1.73]
Cardiac Conditions	2.38 [1.59-3.57]	3.04 [1.92-4.80]	2.39 [1.92-2.99]	3.38 [2.66-4.31]
Substance Use	2.89 [1.72-4.86]	3.34 [1.81-6.15]	0.85 [0.52-1.38]	1.59 [1.01-2.49]
Renal Conditions	2.47 [1.24-4.95]	3.60 [1.69-7.63]	2.98 [2.05-4.33]	3.06 [1.99-4.71]
Lupus	1.79 [0.84-3.84]	3.19 [1.48-6.89]	1.72 [1.14-2.60]	2.11 [1.33-3.33]
Liver Conditions	2.93 [1.35-6.36]	2.34 [0.81-6.73]	1.02 [0.56-1.85]	2.26 [1.31-3.89]
Hemorrhage	1.70 [1.44-2.02]	1.57 [1.26-1.97]	1.56 [1.35-1.79]	1.52 [1.27-1.80]
Puerperal infections	3.44 [1.24-9.53]	6.85 [5.72-8.19]	3.80 [3.45-4.18]	6.07 [5.41-6.80]
Mild preeclampsia	4.79 [4.02-5.69]	3.98 [3.07-5.17]	3.27 [2.91-3.69]	3.26 [2.78-3.83]
Eclampsia	11.14 [9.3-13.4]	17.08[13.8-21.6]	5.51 [4.98-6.09]	5.10 [4.47-5.82]
Transfusion	10.39 [8.6-12.6]	11.69 [9.21-17.8]	4.27 [3.77-4.83]	6.07 [5.27-6.97]
Cerebrovascular	2.70 [1.81-4.03]	9.22 [6.55-12.98]	3.53 [2.57-4.86]	15.32 [11.9-19.6]
Other puerperal	7.18 [5.57-9.26]	12.49 [9.51-16.4]	3.56 [2.98-4.25]	5.16 [4.27-6.25]
Resp failure	15.84 [8.3-30.2]	30.59 [16.4-57.1]	2.98 [2.25-3.97]	6.49 [4.99-8.43]
Cardiac events	3.44 [1.24-9.53]	1.10 [0.36-3.23]	0.81 [0.47-1.39]	0.39 [0.25-0.63]
Renal failure	5.72 [2.31-14.2]	15.03 [6.66-33.9]	2.37 [1.55-3.63]	7.75 [5.36-11.19]

Vaginal moderate LOS = 4 days, excessive LOS = 5 or greater days
Cesarean moderate LOS = 5 days, excessive LOS = 6 or greater days

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Appendix B

Letter of Support

CMQCC
CALIFORNIA MATERNAL
CARE COLLABORATIVE

November 8, 2011

To: Institutional Review Board, University of San Diego

From: Barbara Murphy RN MSN, Operational Director, California Maternal Quality Care Collaborative (CMQCC)

I have discussed the research project, "Risk-Appropriate Maternal Care: Identifying Risk Factors that Effect Maternal Outcome" with Lucy Van Otterloo, RN, MSN. I understand that Ms. Van Otterloo is conducting this study as part of her doctoral dissertation in Nursing at the University of San Diego. I am delighted to support her in this valuable endeavor. Her research has been approved by members of the Executive Committee and she may use the de-identified linked birth certificate/admission discharge data provided by the California Maternal Quality Care Collaborative for her study.

It is a pleasure to be of assistance in supporting this research project.

Sincerely,

Barbara Murphy, RN MSN

Operational Director

California Maternal Quality Care Collaborative