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Maternal and Infant Birth Characteristics as Predictors of Sudden Unexpected Infant Death

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Walden University

College of Health Sciences

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Betty Ezell

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Walden University
2020

Abstract

Maternal and Infant Birth Characteristics as Predictors of Sudden Unexpected Infant Death

by

Betty Ezell

MS, Walden University, 2013

BS, Saint Joseph's College, 1993

AS, Valencia College, 1976

Doctoral Study Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Public Health

Walden University

May 2020

Abstract

Sudden unexpected infant death (SUID) is a public health issue recognized by the United States Centers for Disease Control and Prevention (CDC) as the sudden and unexpected death of a baby less than 1 year old, often during sleep, with no obvious cause. Despite known SUID risk factors for infants and mothers, there is limited research on combinations of infant birth characteristics and mother demographics that could be indicative of a higher risk of infant death. The purpose of this cross-sectional quantitative study was to examine the extent to which infant birth characteristics, delivery characteristics, month prenatal care began, and maternal demographics predicted the occurrence of SUID. This study was grounded in social cognitive theory. The population was 14,153 full-term infants in the United States who died within 364 days of birth. Data were collected from the CDC Wonder database for the years 2013-2016 and were analyzed using logistic regression. Results showed a significant relationship between infant gestational age (p = <.001), birth weight (p = <.001), birth order (p = <.001), maternal age (p = <.001), marital status (p = <.001), educational status (p = <.001), month prenatal care began (p = <.001), infant birthplace (p = <.001), medical birth attendant (p = <.001), delivery method (p = <.001) and occurrence of SUID. Implication for positive social change could be the reduction and elimination of SUID. This research specifically could potentially benefit every parent and infant for infant survival beyond the first year of life. This research may also benefit clinicians that care for infants, providing confidence in risk factors to guard against SUID, thereby saving lives.

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Dedication

This study would not have been possible without the love, support, and unselfish sacrifice of one very special, patient, giving, earthly king of a husband: saint Thurman Ezell.

Acknowledgments

I am forever indebted to my family, extended family, and friends who gave up part of their lives to accommodate my schedule during the writing of this research paper. GOD bless you forever and ever. The guidance, direction, coaching, and patience of my dissertation committee chairperson/mentor, Dr. Diana Naser, was exceptional. I now have a lifelong friend. Together they helped me climb an unsurmountable mountain to reach this point in my academic and professional career. Thank you, Danielle Ely, National Center for Health Statistics, Division of Vital Statistics, Reproductive Statistics Branch. Thank you Timothy S. Allison-Aipa, University of Phoenix. You are outstanding professionals who gave your time and knowledge during the apex of the COVID-19 outbreak to ensure my research paper had the best elements of the selected CDC database and sound statistical analysis to confirm findings and results.

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Section 1: Foundation of the Study and Literature Review

Sudden unexpected infant death (SUID) includes infant deaths due to unknown cause, accidental suffocation, or strangulation in bed (Centers for Disease Control and Prevention [CDC], n.d.). In the United States in 2016, there were 3,600 deaths among infants in the first year of life with no obvious cause (CDC, 2017a). Of the 3,600 deaths, 1,500 (42%) were due to sudden infant death syndrome (SIDS), 1,200 (34%) were due to unknown causes, and 900 (24%) were due to accidental suffocation or strangulation in bed (CDC, 2017b).

Despite known SUID risk factors for infants and mothers, there is limited research on combinations of infant birth characteristics and mother demographics that could indicate higher risk of infant death. This public health problem was important to study to determine whether an association exists between infant birth and delivery characteristics in combination with maternal demographics that could lead to a decrease in SUID. The positive social change that could result from this study includes an elimination of infant deaths due to SUID through evaluation of characteristics that suggest a higher risk in certain infant populations when the mother's characteristics are also evaluated. This study was necessary because SUID remains one of the top nine public health crises (CDC, 2019). Section 1 provides an overview of the SUID problem, the purpose of the study, the research questions, the theoretical foundation, the nature of the study, and the literature review.

Problem Statement

In the United States in 1990, the SUID rate was 154.6 deaths per 100,000 live births; in 2016 the SUID rate was 91.4 deaths per 100,000 live births (CDC, 2017). Although the death rate has decreased in the United States, Carlin and Moon (2017) and Rubin (2018) noted that SUID remains the leading cause of death in infants. Infant risk factors for SUID are age (peak 2-4 months), sex (male), race or ethnic background (Black, Native Indian), pacifier use, prematurity, sleeping position (prone or side), recent febrile illness, exposure to tobacco smoke, sleeping surface (soft surface or bedding), thermal stress/overheating, face covered by bedding, bed sharing, sleeping alone in a room, and colder temperatures particularly in the absence of central heat (CDC, n.d.a; Fu, Moon, & Hauck, 2010)). In the current study, birth characteristics (month prenatal care began, gestational age, birth weight, birth order, multiple birth, birthplace, medical attendant, and delivery method) were investigated as predictors of SUID. These birth factors had been investigated individually or in pairings and groups but had not been investigated in the combinations addressed in this study. The more that is known about related or disparate infant birth factors, the greater the likelihood of eliminating SUID (Carlin & Moon, 2017). Although researchers studied birth characteristics in 2004–2009 and 2000-2010, the focus was on the safety of planned home births relative to neonatal mortality and the effects of plurality of birth and infant mortality (Ahrens, Rossen, Thoma, Warner, & Simon, 2017b; Cheyney et al., 2014; Jordaan, 2018; Kassa, Moon, & Colvin, 2016). However, these studies did not address combinations of infant birth characteristics as factors in infant mortality.

Programs that provide an expectant mother with infant clothing, diapers, and supplies for the newborn are not sufficient protection against SUID without also addressing preparation for a safe place for the infant to sleep to avoid (a) sleeping with adults who could roll over onto the infant causing death and (b) infants dying from suffocation by being entangled in crib linen and other objects (CDC, n.d.b). The prenatal care setting provides a good opportunity to educate expectant mothers on the increased risk of SUID (Hodges, Anderson, McKenzie, & Katz, 2018). Expectant mothers are more amenable to avoiding or decreasing behavior that increases risk factors for SUID, including alcohol consumption and illicit drug use (Ebrahimvandi, Hosseinichimeh, & Iams, 2019; Lavezzi, Ottaviani & Matturri, 2015). Prenatal care and other birth characteristics such as (a) month prenatal care began, (b) infant birth year, (c) mother's reported area of residence, (d) infant birth weight, (e) plurality or multiple birth, (f) infant live birth order, (g) gestational age at birth, (h) birthplace, (i) delivery method, (j) medical attendant at time of birth, (k) cause of infant death, (l) year of infant death, and (m) gender of infant should be evaluated to determine the extent to which the variables predict the occurrence of SUID (CDC, 2017c).

There is the potential to avert an increase in infant deaths and eliminate infant deaths due to SUID through evaluation of characteristics that suggest a higher risk in certain infant populations (Parks, Lambert, & Shapiro-Mendoza, 2017). Public health programs play a vital role as the first point of contact in which the expectant mother learns about SUID through programs goals and objectives (Khoo, 2016; Verceles &

McIntosh, 2017; The Baby Box Company, n.d.). Understanding birth characteristics can prepare caregivers and health professionals to closely monitor infants at risk for SUID.

The findings from the current study may fill a gap in the literature related to identification of infant birth characteristics as predictors of a higher risk of SUID. He, Akil, Aker, Hwang, and Ahmad (2015) studied trends in infant mortality in the southeastern United States from 2005 to 2009 by investigating the association between infant mortality and the mother's age, marital status, race, education, and duration of prenatal care. He et al. found mothers with no prenatal care had a very high overall infant death rate per 100,000 births. I will address the association between SUID and infant birth characteristics, delivery characteristics, month prenatal care began, and maternal demographics in the United States from 2013 to 2016.

Purpose of the Study

The purpose of this cross-sectional quantitative study was to determine the extent to which infant birth characteristics (gestational age, birth weight, birth order, multiple birth), delivery characteristics (infant birthplace, medical attendant, delivery method), month prenatal care began, and maternal demographics (age, marital status, race, education) predict the occurrence of SUID in infants.

Research Questions and Hypotheses

The research questions (RQs) that guided this study were the following:

RQ1: In the United States, for the years 2013-2016, to what extent do infant birth characteristics (gestational age, birth weight, birth order, and multiple birth) predict the occurrence of SUID?

$H_0$1: In the United States, for the years 2013-2016, infant birth characteristics (gestational age, birth weight, birth order, and multiple birth) do not predict the occurrence of SUID.

H_a1: In the United States, for the years 2013-2016, infant birth characteristics (gestational age, birth weight, birth order, and multiple birth) predict the occurrence of SUID.

RQ2: In the United States, for the years 2013-2016, to what extent do maternal characteristics (age, marital status, race, and education), month prenatal care began, and delivery characteristics (infant birthplace, medical birth attendant, and infant delivery method) predict the occurrence of SUID?

$H_0$2: In the United States, for the years 2013-2016, maternal characteristics (age, marital status, race, and education), month prenatal care began, and delivery characteristics (infant birthplace, medical birth attendant, and infant delivery method) do not predict the occurrence of SUID.

H_a2: In the United States, for the years 2013-2016, maternal characteristics (age, marital status, race, and education), month prenatal care began, and delivery characteristics (infant birthplace, medical birth attendant, and infant delivery method) predict the occurrence of SUID.

Theoretical Foundation for the Study

The theoretical foundation for the study was social cognitive theory as described by Nutbeam, Harris, and Wise (2010). The researchers argued that health promotion can more reliably predict and produce positive health outcomes when a theory is used in the planning and implementation of programs. Identifying birth characteristics for infants at risk for SUID may lead to interventions to reduce or eliminate the occurrence of SUID. The social cognitive theory model in health promotion has practical application and impact to the individual, community, and organization model coupled with evidence-based policymaking and a health impact assessment (Nutbeam et al., 2010). Olander, Smith, and Darwin (2018) explored pregnancy as a receptive time for changing health behavior by addressing characteristics that motivated change based on risk-related information such infant birth complications like SUID. Prenatal care is a health promotion issue with a foundation in social cognitive theory (Olander et al., 2018). Adding to studies of the behavior of mothers during the prenatal stage, Kost and Lindberg (2015) found a correlation between the health of infants and that of the mother's behaviors in the early months of the infant's life, putting infants at risk for SUID. Kost and Lindberg (2015) also showed a link between the mothers' prenatal care, birth outcomes and SUID; in essence, fewer unwanted births received early prenatal care, were breast-fed, and tended to have a low birth weight. Women change their behaviors in pregnancy, but more research is needed to determine the cause of such changes by utilizing social cognitive theory (Kost & Lindberg, 2015; Olander et al., 2018).

I used social cognitive theory to examine the relationship between infant characteristics and demographics of mother as factors that predict SUID. Brenner et al. (1998) showed the prevalence and predictors of one characteristic (prone sleep position) among inner-city infants. However, researchers have not used social cognitive theory to examine the connection between combinations of infant and maternal demographics of prenatal care, gestational age, birth weight, birthplace, birth order, multiple birth, medical attendant, and delivery type with SUID (Brenner et al., 1998).

The major theoretical propositions and major hypotheses included delineation of some assumptions that are appropriate to the application of the social cognitive theory. For example, McKenna, Middlemiss, and Tarsha (2016) found ~~that~~ infants must learn breathing control to avoid SUID. The social cognitive model suggested immature lack of developmental harmony between cortical and subcortical neural tracts necessary for breathing control also contributed to human speech breathing had the potential to make infants vulnerable to SUID (McKenna et al., 2016). McKenna et al. (2016) also found infants who failed to learn autonomic breathing while awake have an increased risk of SUID while sleeping due to failure to adapt to neural signals to breath during periods of sleep.

I examined health promotion and disease prevention from the perspective of social cognitive theory. Social cognitive theory posits a multifaceted causal structure in which self-efficacy beliefs operate with goals, outcome expectations, and perceived environmental impediments and facilitators in the regulation of human motivation, behavior, and well-being (Allegrante, Wells, & Peterson, 2019). Interventions to support behavioral self-management of chronic diseases to exercise control are a common pathway through which psychosocial influences affect health functioning (Allegrante et al., 2019). This core principle affects each of the basic processes of personal change—whether people consider changing their health habits, whether they mobilize the motivation and perseverance needed to succeed should they do so, their ability to recover from setbacks and relapses, and how well they maintain the habit changes they have achieved (Allegrante et al., 2019). Bandura (2004) saw human health as a social matter, not an individual one. A comprehensive approach to health promotion also requires changing the practices of social systems that have widespread effects on human health (Allegrante et al., 2019).

Social cognitive theory was chosen based on the rationale that health promotion and disease prevention are the foundational concepts from the perspective of social cognitive theory (Bandura, 2004). This theory posits a multifaceted causal structure in which self-efficacy beliefs operate together with goals, outcome expectations, and perceived environmental impediments and facilitators in the regulation of human motivation, behavior, and well-being (Bandura, 2004). Belief in the efficacy to control and select the psychosocial influences that affect health can lead to personal change in health habits (Bandura, 2004). Infants who succeeded in learning to control events within their environment became more adept at gaining control over other behavior and were more competent in learning additional behaviors, than were infants whose environments presented less stimulation or motivation opportunities (Bandura, 2004). Once the individual's health as a social matter was undertaken, a larger desire was that of achieving and helping others to master health promotion within the family, close friends, and the larger social system (Bandura, 2004).

Allegrante et al. (2019) referred to interventions that support behavioral self-management of chronic diseases. The social cognitive theory relates to the present study in that the social cognitive theory focuses on the promotion of self-management of health habits that keep people healthy throughout their life span (Allegrante et al., 2019). Society demands solutions to health issues through redirection of efforts to provide remedies to threatening health issues like SUID. Solutions lead to lowering of health costs and reductions in occurrences of episodes of ill health and poor outcomes (death), as is the case with SUID, resources can be directed to other national public health issues (Allegrante et al., 2019). The goal is to challenge and build on social cognitive theory by adding to the body of knowledge that focuses on health promotion and disease prevention by social cognitive means. The research questions reflect social cognitive theory by operating with a core set of variables, the mechanism through which the variables work, and the optimal ways of translating this knowledge into effective health practices. Reno and Hyder (2018) enumerated the core determinants of risk characteristics of infants and the common maternal demographics that present a pattern or trend in health risks and benefits. Different combinations of infant and maternal variables, when taken together, may point to an opportunity for improved health practices and self-efficacy in mothers and infant as well, such that the mothers control their health habits and behaviors leading to better health outcomes, including the saving of infant lives.

The current study addressed the combinations of variables that can be eliminated or controlled for SUID to save infant lives. Plans and strategies for identifying perceived combination of risks may lead to reduced social and structural impediments to curtail and eliminate SUID. Knowledge of health risks and benefits creates a precondition for change; however, if people lack knowledge about how their lifestyle habits affect their health, people have little reason to put themselves through the efforts required to change their habits (Reno & Hyder, 2018). Negative reinforcement can derail additional self-influences ~~that~~ most people use to overcome the impediments to adopting new lifestyle habits and maintaining them (Reno & Hyder, 2018). Self-efficacy is the foundation of human motivation and action. When people believe they can produce desired effects by their actions, they need little to no incentive to act or to continue new habits (Reno & Hyder, 2018).

Expected outcomes affect the health behavior of people in several ways. Outcomes can be pleasant, unpleasant, positive, negative, material acquisition, or loss of material benefits (Reno & Hyder, 2018). Behavior is also influenced by social reactions of approval and disapproval. A third set of outcomes is the positive and negative self-evaluative reactions to health behavior and health status (Reno & Hyder, 2018). People adopt personal standards and regulate their behavior by their self-evaluative reactions (Reno & Hyder, 2018). People do things that give them self-satisfaction and self-worth and refrain from behaving in ways that breed self-dissatisfaction (Reno & Hyder, 2018). Motivation is enhanced by helping people to see how habit changes are in their self-interest and the broader goals people value (Reno & Hyder, 2018). Personal goals, rooted in a value system, provide further self-incentives and guides for health habits (Reno & Hyder, 2018).

Long-term goals set the course of personal change. However, there are too many competing influences at hand for distal goals to control current behavior. Short-term attainable goals help people to succeed by enlisting effort and guiding current action. Reno and Hyder (2018) also identified perceived facilitators and obstacles as determinants of health habits. Impediments deter performance of healthful behavior. Self-efficacy beliefs must be measured against gradations of challenges to successful performance Reno and Hyder (2018). The impediments to healthful living include work pressure, tiredness, feelings of depression, anxiety, inclement weather, and more interesting things to do (Reno & Hyder, 2018).

There is a logical connection among the key elements of the social cognitive theory and mother and infant characteristics of this study. Mothers understanding of right from wrong transfer to those who are dependent on older human beings. Relevant to this study, infants are dependent upon the behavior of a mother during pregnancy and through the first year of life. The mother's actions can directly or indirectly affect the health outcome (life or death) of an infant. The social cognitive theory was applicable to the current study and research questions, as well as the instrument development and data analysis, to show combinations of infant and maternal factors, rather than individual factors, were expected to yield new evidence related to infant and maternal characteristics or factors.

Nature of the Study

A quantitative cross-sectional approach was used to answer the research questions. This method allowed for examination of the predictive relationship between birth characteristics and incidence of SUID in the United States. Data were collected from the CDC WONDER secondary data set on Infant Deaths Linked Birth/Infant Death Records for the years 2013-2016. The population for this study was children of U.S. residents under 1 year of age whose death occurred in the United States. Information from death certificates was linked to corresponding birth certificates. Data included county of mother's residence, child's age, underlying cause of death, gender, birth weight, birth plurality, birth order, gestational age at birth, period of prenatal care, maternal race and ethnicity, maternal age, maternal education, and marital status. A privacy policy went into effect in 2011 suppressing all subnational data representing zero to nine deaths or births to ensure confidentiality of information. The independent variables were the infant birth characteristics of month prenatal care began, gestational age, birth weight, multiple birth, birth order, birthplace, birth order, multiple birth, medical attendant, delivery method, and maternal characteristics (age, marital status, race, and education). The dependent variable was SUID. Data were analyzed using logistic regression.

Literature Search Strategy

The literature review included the following databases: CINAHL, Cochrane Library, ERIC (Education Resources Information Center), PsycINFO, PubMed/MEDLINE, and Web of Science. Additional databases included UpToDate (a clinical information tool providing reviewed clinical reference material on pharmaceutical information, patient handouts, and graphics provided by the VCU Health System) and ClinicalKey - FirstConsult (clinical reference resource with over 1100 medical ebooks, 600+ full-text journals from Elsevier, FirstConsult point-of-care monographs, procedural videos, drug information, practice guidelines, patient education handouts and more).

The literature search strategy for SUID consisted of names of databases and resources (data sets) with last date searched, relevant terms, search strategies for each resource, and the search terms and limits used (e.g., dates, language, etc.). In some instances, the number of results for each search strategy with notes on any individual journals were searched and recorded separately. The literature review search spanned the last five years (2015-2019) except for the inclusion of seminal studies and literature pertinent to support this current study on SUID. Only peer-reviewed, full-text articles about scholarly research were used. A literature search revealed a total of 83,500 evidence-based, peer-reviewed, articles published since 2015; after removing duplicates, I noted 42,800 contained risk factors, 37,900 were studies in the United States, and 23,000 included both infants and mothers. The articles that remained after removing duplicates totaled 116.

The process steps of my literature search included identification, screening, eligibility, and included/excluded. In the identification step, the study topic was entered into the search engines for articles and studies no older than five years. Titles, keywords, and abstracts of articles were considered for potential relevance, and the full articles were obtained for those articles deemed relevant. The articles were then subjected to data extraction and critical analysis through the use of a Microsoft Excel spreadsheet provided by the Walden Univeristy library. The spreadsheet was tested on 10 articles, and adjustments were made for content. The following information was recorded for potential use: reference list entry or citation (APA 6th ed.), author(s) last name, first initial, publication date, title (article, chapter, book, or journal), database, library, URL, DOI, keywords, course, theorists, method, study design, population/participants, sample problem, purpose, research questions, summary, results, and analysis (strengths and weaknesses compared to other studies). Other information, if readily available, included study locations, interventions, prevalences, outcomes, and conclusions. The extracted information was recorded in the same Excel spreadsheet to identify common themes or trends. SUID has been investigated in the medical profession and other health-related organizations. A systematic review of the data and meta-analysis were conducted.

The key search terms and combinations of search terms included *accidental suffocation in a sleeping environment*, *infant*, *death syndrome*, *infant mortality*, *infant safe sleep practices*, *infection*, *maternal causes*, *neuroimmunology*, *prone sleep position*, *public health*, *risk factors, safe sleep*, *sleep environment*, *sudden infant death, sudden infant death syndrome, sudden unexpected death in infancy, sudden unexpected infant death*, and *unexpected infant deaths*. The key search terms led to seminal literature and studies as well as current peer-reviewed literature. Some challenges in the search derived from key search terms that had changed over the years. The changes in terminology increased as more studies were reviewed, and additional years were added to the search for infant deaths. Caution was taken to use the phrase sudden unexpected infant death to mean death by any means that was unexplained or without explanation. Although there have been many studies related to SUID, researchers had not examined the combinations of infant characteristics and common maternal demographics.

Safe Sleep Guidelines

McMullen, Fioravanti, Brown, and Carey (2016) researched safe sleep for hospitalized infants using the American Academy of Pediatrics (AAP) safe sleep guidelines from 2011. The purpose and objective of the project was to promote the AAP safe sleep recommendations and provide role modeling of the recommendations for hemodynamically stable infants throughout their hospital stay. The study design and method were for a safe sleep educational initiative for parents and hospital staff included in the observation of infant sleep practice before and after the initiative with pre- and post-education questionnaire of nurses' knowledge, attitudes, and opinions (McMullen et al., 2016). The setting was an urban hospital with 72 pediatric beds, a 60-bed NICU, a 41-bed mother/baby unit, and 658 pediatric and obstetric nurses. All nurses received the educational intervention. The study results showed improvement from 70% to 90% ($p < 0.01$) of infants in a safe sleep position when pre- and postintervention results were compared (McMullen et al., 2016). There were improvements in knowledge and use of AAP guidelines after the educational intervention, but not as much as expected. In addition, there was inconsistency between nursing knowledge and practice about safe infant sleep. Nurses were aware of the AAP recommendations, but close to full compliance took longer than anticipated. Observation was an important part of this initiative to reinforce knowledge and role model best practice for parents (McMullen et al., 2016).

Sleutel, True, Gustus, Baldwin, and Early (2018) researched moving beyond Back to Sleep campaigns at three hospitals. Their study objectives and purpose centered on measuring changes in RN knowledge, beliefs, and practices, along with assessing the parents' recall of infant safe sleep (ISS) teaching, and a review of hospitalized infant sleep environments and safety after implementing an ISS initiative. Their study design and methods consisted of longitudinal quasi-experimental study in three hospitals in the United States. An existing infant safe sleep tool was revised and updated to align with current recommendations on sleep environments. Interventions included educating nurses, changing unit processes, and implementing crib cards and room signs. Paired questionnaires were used to survey 62 nurses before and 2 months after the intervention. Audits of 462 crib/sleep environments with parent conversations were used to assess infant sleep conditions and parents' recall of nurses teaching before and after the intervention (Sleutel et al., 2018). The results, after Bonferroni correction, showed statistically significant improvements with moderate effect sizes on eight of 19 items for nurses' knowledge/beliefs and self-reported practice. All 11 items for parents' recall of nurses teaching showed statistically significant improvements, with odds ratios ranging from 7 to 76 (Sleutel et al., 2018). Five of six real-time sleep safety conditions (from crib/sleep environment audits) had statistically significant improvements; odds ratios ranged from 8 to 83 (Sleutel et al., 2018). The researchers concluded that the updated educational tool improved nurses' and parents' knowledge and practices related to safety factors for infant sleep conditions. A 2-hour practice implication by nurses yielded statistically significant improvements with inpatient adherence to ISS recommendations (Sleutel et al., 2018). Factors critical to the success of the ISS project showed improvements in parents' recall of teaching and sleep environments that suggested the potential for long-term changes in infant safety at home (Sleutel et al., 2018).

SUID

Any modern definition of SUID, according to Byard, Shipstone, and Young (2019), should recognize that conflicting classifications of infant deaths persist, which has caused compromised research. Brownstein, Poduri, and Goldstein (2018) further agreed that mechanisms of infant deaths need clarification to eliminate confusion for parents and researchers. SUID ranks third as a cause of infant mortality, for which no cause is apparent (Brownstein, Poduri, & Goldstein, 2018).

Infant Death

Thyden, Quivk, Kinde, and Roesler (2016) studied SUID in Minnesota as a leading cause of infant mortality that could be prevented. They studied the 2014 SUID rate across subpopulations with a prevalence of risk, protective factors, and prevention opportunities. Like other researchers, the group identified SUID as the third leading cause of infant mortality and the leading cause of infant mortality among American Indians in the state. The group further defined SUID as deaths from unknown causes, SIDS, sleep-related suffocation, and death from other sleep-related causes. Extensive research led the AAP to update the safe sleeping recommendations in 1992 and the National Institute of Health launched the Back to Sleep campaign in 1994. After a rate plateau, the rate decreased slightly in 2009. A contributor to the identification of SUID deaths came about with improved death scene investigations. The Minnesota Department of Health's Infant Mortality Reduction Plan for Minnesota was to further reduce the rate of SUID in the state through better identification of the characteristics of SUID. Thyden et al. assessed maternal demographics and safe sleep factors and chronicled their findings and recommendations for preventing SUID. The research method called for the identification of SUID cases in infants younger than 1 year of age who died in 2014 using a definition developed by the CDC for its SUID Case Registry of infant deaths that occurred suddenly and unexpectedly, and whose cause was not known prior to investigation. Information was obtained from birth and death certificates, law enforcement reports, autopsy reports, death scene investigations, and medical records that had been entered into the national Child Death Review Case Report System. The SUID cases were categorized according to a classification system developed for the CDC registry. The classification system includes coding of the uncertainty about suffocation asphyxiation contribution to deaths that accounts for unknown and incomplete information about the death scene and autopsy.

The AAP formulated a definition of a safe sleep environment as one in which the infant is in a supine position on a firm sleep surface that is free of loose bedding, soft objects, and other people; researchers used the definition and criteria to calculate the incidence of SUID cases related to the sleep environment (Hamadneh, 2014; Moon & Task Force on Sudden Infant Death Syndrome, 2016). Adequate prenatal care was defined as nine or more visits during pregnancy (Hamadneh, 2014; Moon & Task Force on Sudden Infant Death Syndrome, 2016). The SUID rates per 10,000 births in 2014 were calculated by demographic groups and for the presence of certain risk or predictive factors. Race was determined by the mother's race on the infant's birth certificate. The

2012 Minnesota Pregnancy Risk Assessment Monitoring System was used to determine smoking rates during pregnancy. Findings, based on demographics, indicated 53 cases of SUID in Minnesota in 2014 for an overall rate of 7.6 deaths per 10,000 infants (younger than 1 year of age). The youngest infants were especially at risk, with 45 of the cases (85%) occurring in the first six months of life. Infants with younger mothers were also at higher risk for SUID. Those with mothers 15 to 19 years of age had a SUID rate of 29.5 per 10,000 births; mothers 20 to 24 years of age had a rate of 14.8 per 10,000 births, and mothers 25 years of age and older had a rate at or below the overall rate of 7.6 per 10,000 births. SUID rates were found to be higher among African Americans and American Indian mothers than among White and Asian mothers (Moon & Task Force on Sudden Infant Death Syndrome, 2016).

The researchers concluded that all infant deaths are tragic, especially those that could have been prevented. Many factors affect a baby's risk of SUID including social determinants of health, a caregiver's understanding of safe sleep practices and ability to consistently provide a safe sleep environment, and exposure to tobacco. Public health, law enforcement, health care practitioners and other community members all have roles in addressing risks and issues to help parents make a safer place for babies.

Cause of Infant Death

Taylor et al. (2015) studied international comparison of SUID rates using a newly proposed set of cause-of-death codes. Taylor et al. (2015) found difficulty in making comparisons among countries due to variations in death certifications, even within the same jurisdiction. The researchers' objective was to confirm consistent practices in coding deaths using the International Classification of Diseases-10 (ICD-10) codes. Within the thousands of ICD-10 codes the researches used six related to SUID from 2002 and 2010, in eight high-income countries. The results showed a great variability in how each country coded SUID, for example, the code R95 ranged from 32.6% in Japan to 72.5% in Germany. The proportion of deaths coded as accidental suffocation and strangulation in bed (W75) ranged from 1.1% in Germany to 31.7% in New Zealand. Japan consistently use the R96 code, with 44.8% of SUID attributed to that code. The lowest, overall, SUID rate was seen in the Netherlands (0.19/1000 live births (LB)), and the highest in New Zealand (1.00/1000 LB). SUID accounted for one-third to half of post neonatal mortality in 2002–2010 for all the countries except for the Netherlands. The researchers concluded that the then proposed set of ICD-10 codes encompasses the codes used in different countries for most SUID cases. Use of these codes allowed for better international comparisons and tracking of trends over time.

Kassa, Moon, and Colvin (2016), like Hitchcock (2017) studied the risk factors for sleep-related infant deaths in-home and out-of-home. In the Kassa, Moon, and Colvin (2016) study, multiple environmental risk factors associated with sleep-related infant deaths revealed little is known about differences in risk factors for deaths occurring in-home and out-of-home. This led to research that compared risk factors for in-home and out-of-home infant deaths. The researchers conducted a cross-sectional analysis of sleep-related infant deaths for years 2004 to 2014 in the National Child Fatality Review and Prevention database. The main exposure was setting (in-home versus out-of-home) at time of death. Primary outcomes were known risk factors: sleep position, sleep location (e.g., crib), objects in the environment, and bed sharing (Fu, Moon, & Hauck, 2010). Risk factors for in-home versus out-of-home deaths were compared using the $\chi 2$ test and multivariate logistic regressions. Their results in a total of 11,717 deaths were analyzed. Infants who died out-of-home were more likely to be in a stroller/car seat (adjusted odds ratio, 2.6; 95% confidence interval, 2.1–3.4; $p < .001$) and other locations (adjusted odds ratio, 1.9; 95% confidence interval, 1.5–2.3; $p < .001$), and placed prone (adjusted odds ratio, 1.2; 95% confidence interval, 1.1–1.3; $p <0.01$). Bed sharing was less common out-of-home (adjusted odds ratio, 0.7; 95% confidence interval, 0.6–0.7; $p < .001$) (Fu, Moon, & Hauck, 2010). There were no differences in sleeping on a couch/chair, or objects in the sleep environment. In conclusion, sleep-related infant deaths in the out-of-home setting have higher odds of having certain risk factors, such as prone placement for sleep and location in a stroller/car seat, rather than in a crib/bassinet. Caregivers should be educated on the importance of placing infants to sleep supine in cribs/bassinets to protect against sleep-related deaths, both in and out of the home (Kassa, Moon, & Colvin, 2016).

Risk Factors for SUID

Risk factors that could predict the occurrence of SUID associated with the mother's pregnancy include prenatal care and other birth characteristics such as a) month prenatal care began, b) infant birth year, c) mother's reported area of residence, d) infant birth weight, e) plurality or multiple birth, f) infant live birth order, g) gestational age at birth, h) birthplace, i) delivery method, j) medical attendant at time of birth, k) cause of infant death, l) year of infant death, and m) gender of infant. Birth characteristics associated with an infant's risk for SUID included age (peak 2-4 months), male, race or ethnic background (Black, Native Indian), pacifier use, prematurity, sleeping position (prone or side), recent febrile illness, exposure to tobacco smoke, sleeping surface (soft surface or bedding), thermal stress/overheating, face covered by bedding, sharing bed with others, sleeping in own room, and colder season/no central heat (Brownstein, Poduri, & Goldstein, 2018).

Infant birth risk factors have been studied by many researchers and have produced insights into interventions that addressed the more commonly known factors of SUID, but not the combination of risk factors in infants when studied in combination with that of the mother that can yield even more insight and interventions to reduce the instances of SUID in the US. Generally, infant sleep practices, such as positioning, bed linen, and clothing are targeted as post birth interventions. An advancement would be to identify which infants are most at risk for SUID to prepare for the infant's arrival and safeguarding. Parents and caregivers of infants educated in the risks and interventions are the best protection against SUID. Avoid placing infants in the prone position, especially after nursing or feeding to guard against SUID and protect the infant against suffocation or vomiting. Education should stress placing infants only in the side position briefly while well attended and most often and as exclusively as possible in the supine position. The supine sleep position is best and preferred.

Infants should not be placed in sleep furniture with soft objects (stuffed animals, pillows, quilts, blankets, sheepskins, fleece, wedges, bumper pads, etc.) to avoid an increase in the risk of SUID. These objects increase the risk of SUID when an infant maneuver into a prone position that obstructs air passages or restricts chest movement for the exchange of air. Infants become trapped in loose bedding or other objects in the sleeping space leading to suffocation, strangulation, or SUID. Caretakers are to be educated in not using an overabundance of clothing for infants in cooler weather and to use natural materials like cotton and non-synthetic fabrics. Even hats should be avoided especially when the infant is sleeping to reduce the risk of SUID (Meyer & Erler, 2011). Another practice to be avoided is that of the introduction of the Alghmatte strategy to reduce SUID, which is like an infant sleep sack or swaddling (Hamadneh, 2014). It is a traditional swaddling/clothing used for about six months to keep infants warm with only light clothing. Alghmatte is used in homes and in maternal and neonatal units in some countries. The globalization of the world leads to many people transitioning to western countries and bringing their maternal practices with them to their new home country. Although healthcare providers regard Alghmatte as a safe practice because the infant is unable to move and shift the bedding over their faces, this swaddling practice is associated with a range of health risks, including SUID.

The right sleep environment includes the right temperature and humidity, no burning of toxins, proper ventilation with or the elimination of tobacco products, reduced dependency on burning of wood, gas and kerosene as a source for heating and cooking to ensure good air quality. Many studies have shown a correlation to SUID and low socio-economic status, as these groups have more risks due to use of unsafe heating practices and homes with more risk factors. Compared to high socio-economic families, the low socio-economic families are more likely to suffer from an inability to provide safe infant sleeping environments and clothing.

Khaliq et al. (2017) assessed the knowledge and practices about breastfeeding and weaning among working and non-working mothers. The researchers concluded mothers should be encouraged to breastfeed as a positive practice in reducing SUID and other health risks. Parents were further cautioned to not bed share with infants to avoid rolling over onto the infant or smothering the infant. There seemed to be a correlation to SUID and working mothers who end breastfeeding earlier than non-working mothers (Khaliq et al., 2017). The literature supports the case for reducing SUID through a combination of infant and maternal practices focused on safe sleep practices and purposeful engineering safe infant environments.

Friedmann, Dahdouh, Kugler, Mimran, and Balayla (2017) demonstrated the association of maternal and obstetrical predictors of SUID. Their objective was to show public health initiatives, such as the “Safe to Sleep” campaign, had traditionally targeted infant risk factors for the prevention of SUID. However, controversy remains regarding maternal and obstetrical risk factors for SUID. In their study, they determined both modifiable and non-modifiable obstetrical and maternal risk factors associated with SUID in a population-based cohort study using the CDC’s Linked Birth–Infant Death data from the United States for the year 2010 (Friedmann et al., 2017). The impact of several obstetrical and maternal risk factors on the risk of overall infant mortality and SUID was estimated using unconditional regression analysis, adjusting for relevant confounders.

The results of the cohort study of 4,007,105 deliveries and 24,174 infant deaths during the first year of life, yielded 1,991 (8.2%) that were due to SUIDS (Friedmann et al., 2017). Prominent risk factors for SUIDS included (Odds Ratio (OR) [95% CI]): Black race, 1.89 [1.68–2.13]; maternal smoking, 3.56 [3.18–3.99]; maternal chronic hypertension, 1.73 [1.21–2.48]; gestational hypertension, 1.51 [1.23–1.87]; premature birth <37 weeks, 2.16 [1.82–2.55]; IUGR, 2.46 [2.14–2.82]; and being a twin, 1.81 [1.43–2.29], $p < 0.0001$ (Friedmann et al., 2017). Relative to a cohort of infants who died of other causes, risk factors with a tendency for SUID were maternal smoking, 2.48 [2.16–2.83] and being a twin, 1.52 [1.21–1.91], $p < 0.0001$. The conclusion for practice asserted that while certain socio-demographic and gestational characteristics are important risk factors, maternal smoking remains the strongest prenatal modifiable risk factor for SUID. The investigators recommended the continuation of Public Health initiatives that promote safe infant sleeping practices and smoking cessation during and after pregnancy (Friedmann et al., 2017).

Infant Birth and Delivery Characteristics

Gestational Age

Ostfeld, Schwartz-Soicher, Reichman, Teitler, and Hegyi (2017) studied prematurity and SUID in the United States. Prematurity is a strong risk factor for SUID for safe sleep education in neonatal intensive care units (NICUs). The researchers documented associations between gestational age (GA) and SUID using the 2012–2013 United States linked infant birth and death certificate period files. Specifically, rates per live births of SUID, ill-defined and unspecified causes, accidental suffocation and strangulation in bed, and overall SUID by GA in post neonatal, out-of-hospital, and autopsied cases; compared survivors and cases; and estimated logistic regression models of associations between GA and SUID. The study results indicated SUID cases were more likely than survivors to be <37 weeks' GA (22.61% vs 10.79%; $P < .0001$). SUID rates were 2.68, 1.94, 1.46, 1.16, 0.73, and 0.51 per 1,000 live births for 24 to 27, 28 to 31, 32 to 33, 34 to 36, 37 to 38, and 39 to 42 weeks GA, respectively. Logistic regression models additionally indicated declines in the risk for SUID as GA increased. Prenatal smoking, inadequate prenatal care, and demographics associated with poverty were strongly associated with SUID. As a result, gestational age as a risk factor continues to contribute to infant deaths, despite efforts by many organizations, for example., the 2011 American Academy of Pediatrics. The study recommended increased safe sleep education in the NICUs as evidenced by the inversely associated GA in 2012 to 2013, suggesting that risk of SUID associated with prematurity has multiple etiologies requiring continued investigation, including biological vulnerabilities and the efficacy of NICU education programs, and that strategies to reduce SUID should be multifaceted.

In 2015, Lavezzi, Ottaviani, and Matturri also looked at the auditory ability level of infants to determine the developmental alterations of the auditory brainstem centers as pathogenetic implications in SUID. The highlights of the study pointed to the auditory neurological structures located in the brainstem relationship to a significant high incidence of developmental cytoarchitectural alterations highlighted in SUID. These defects were related to alterations of respiratory nuclei in the brainstem and to maternal smoking. Abnormal auditory structures can affect breathing in vulnerable infants leading to SUID. The study findings led to successful campaigns to reduce risks although SUID remains the leading cause of infant death in the Western world. Even though the pathogenesis remains unexplained, brainstem abnormalities of the neuronal network that mediates breathing and protective responses to asphyxia, particularly in the arousal phase from sleep, are believed to play a fundamental role (Lavezzi, Ottaviani, & Matturri, 2015). This was notably the first study to identify, in SUID, developmental defects of specific brainstem centers involved in hearing pathways, particularly in the cochlear and vestibular nuclei, in the superior olivary complex and in the inferior colliculus, suggesting a possible influence of the acoustic system on respiratory activity. In 49 SUID cases and 20 controls, an in-depth anatomopathological examination of the autonomic nervous system was performed, with the main aim of detecting developmental alterations of brainstem structures controlling both the respiratory and auditory activities. Overall, a significantly higher incidence of cytoarchitectural alterations of both the auditory and respiratory network components were observed in SUID victims compared with matched controls. Although there was not enough evidence to presume that developmental defects of brainstem auditory structures can affect breathing, the researchers showed that developmental deficit in the control respiratory areas were frequently accompanied by alterations of auditory structures, highlighting an additional important element for understanding the pathogenetic mechanism of SUID (Lavezzi et al., 2015). That study, while not specifically related to the variables of my current study, pointed to the association between a variable - auditory response - and infants that exhibit traits related to SUID.

In yet another study related to auditory stimulus as a variable in SUID, Lancien et al. (2017) showed that low cerebrospinal fluid (CSF) hypocretin levels are present in SUID risk. Impairment in arousal mechanisms from sleep has been implicated in SUID. Hypocretin system is a major component of the wake system. Reduced hypocretin neurons have been reported in SUID infants. The CSF hypocretin levels were lower at the age of major risk for SUID. This result could underlie an increased vulnerability to SUID at specific ages. The temporal association between SUID and sleep suggested that arousal from sleep provides a protective mechanism for survival. The hypocretin system, which promotes wakefulness, has been implicated in SUID upon findings that SUID victims have fewer hypocretin neurons than infants' deaths from other causes. The study suggested that a better understanding of the role of hypocretin in SUID, is essential to better understand how this system matures and contributes to averting SUID. The study compared CSF hypocretin in children aged 2–6 months, which is the age of peak incidence for SUID, to both younger and older children.

In the study of Lancien et al. (2017), hypocretin levels were measured in CSF samples from 101 children who underwent a clinically relevant lumbar puncture. Children were separated into five age groups: 0–2 months, 3–6 months, 1–5 years, 6–10 years, and 11–18 years. Results of the Hypocretin levels were not significantly different between 1–5 years, 6–10 years, and 11–18 years. Therefore, these three groups were pooled into one group aged 1–18 years for further analysis. Between the 0–2 month, 3–6 month, and 1–18 years groups, a significant difference in CSF hypocretin levels presented ($p = 0.001$). Comparisons showed that CSF hypocretin levels in the 2–6 months age group were significantly lower than hypocretin levels in both the 0–2 month and 1–18-year group (*p* < 0.001 and *p* = 0.008, respectively), but not significantly lower between 0–2 month and 1–18-year children.

Lancien et al. (2017) concluded that the CSF hypocretin levels were lower at the age of peak incidence for SUID which conceivably point to an increased vulnerability to SUID at this specific age. The researchers in the discipline approached the problem and the strengths and weaknesses inherent in their studies using path analysis to estimate the magnitude and significance of possible causal relationships among variables. Statistical analysis was applied to the variables to assign weights to each relationship. The variable gestational age had one or more possible causative relationships to the other variables and/or to the dependent variable. Statistical analysis assigned a weight to each relationship: the higher the weight, the stronger the association. Based on the weights, a direct or indirect relationship with the dependent variable was more plausible. Finally, path analysis can only demonstrate association; causation can be suspected but cannot be determined in path analysis. The researchers analyzed the strength of the association of gestational age to SUID.

The findings of Lancien et al. (2017) suggested the variable for infant birth characteristic of gestation age showed a relationship to SUID, like studies conducted previously, that showed a one-dimensional view of SUID characteristics, of either the mother or the infant, but not in combinations of both. What is needed as meaningful to reduce the rate of SUID or eliminate it, is understanding which factors in mothers and infants when taken in combination are predictors of the potential for SUID. Further study in gestational age and the combination of risk factors is warranted.

Birth Weight

Poets (2016) researched infant apnea prematurity and SUID. As borne out in other research studies, apnea of prematurity is usually resolved on its own with the growth of the infant. The researcher acknowledged that apnea prematurity is a very common condition in preterm infants. This apnea prematurity produces intermittent hypoxemia that leads to an increased risk of SUID. Poets found that corrective measures (elevating the positioning of the infant's head, caffeine administration, and respiratory support), decreased the incidence of apnea. However, SUID remained the leading cause of death beyond the neonatal period. He concluded something else was triggering the deaths and so investigated infant prone sleep position and the mother's pre-delivery characteristic of smoking during pregnancy, specifically between 2–4 months of the infant's age. Poets further concluded, with the aid of reviewing memory monitor recordings of SUID related deaths, that bradycardia (slow heart rate), probably resulted from severe hypoxemia, as the primary factor in the events ultimately resulting in infant deaths. Preventive measures were suggested that included a safe sleep environment, in essence, supine sleep position, a smoke-free environment, avoidance of overheating, use of a sleeping bag that limited infant movement, and a room where supervision facilitated close observation, but not bed sharing (Fu, Moon, & Hauck, 2010). In other studies, with infant weight and preterm birth as variables, SUID was a higher risk and the mothers had a higher risk of having a premature preterm infant (CDC, 2014). Relative to low birth weight, the study suggested encouraging families to keep at least one year between each pregnancy to decrease the infancy risk outcomes (Ugboma & Onyearugha, 2013).

Infant Birthplace

Hitchcock (2017) studied the promotion of safe sleep for infants, specific to infant's risk based on birth location while Lu et al. (2015) studied the transformation of Title V Maternal and Child Health (MCH) Services Block Grant. The MCH Bureau of the Health Resources and Services Administration led a 21-month study to engage input from MCH stakeholders and other national, state, and local leaders, families and other partners to improve, innovate, and transform the Title V MCH Services Block Grant (Lu et al., 2015). The process helped to inform the development of new grant guidance for the next 5-year cycle beginning in fiscal year 2016. The three aims of the transformation were to reduce burden, maintain flexibility, and increase accountability. State reporting burden was reduced by aligning and streamlining the needs assessment, annual report and application; reducing the number of forms States must fill out, eliminating Health Systems Capacity Indicators, and prepopulating the annual report and application with State data using national data sources. State flexibility was maintained through the need's assessment process with State need's and priorities driving the State specific action plan using evidence-based/informed strategy measures. Accountability was increased using the three-tiered performance measurement tool, designed to help States tell a more coherent and compelling story about the impact of Title V on the health of mothers, children, and families. The ultimate success of the transformation would be in the measured ability to reduce and eliminate SUID with the changed introduced in the Title V program.

Birth Order

Ahrens, Rossen, Thoma, Warner, and Simon (2017a) in addition to birth weight also investigated birth order related to infant mortality in the US. The study purpose was to evaluate the risk of infant death during the first year of life due to injury, such as unintentional injury and homicide, by birth order in the U.S. Researchers used the national birth cohort–linked birth–infant death data (births, 2000–2010; deaths, 2000–2011), risks of infant mortality due to injury in second-, third-, fourth-, and fifth or later–born only child. In a research program involving twins and single birth infants, comparison with first-born single birth infants risk ratios were estimated using log-binomial models adjusted for maternal age, marital status, race/ethnicity, and education. The statistical analyses were conducted in 2016. Results showed approximately 40%, 32%, 16%, 7%, and 4% of single live births were first, second, third, fourth, and fifth or later born, respectively. From 2000 to 2011, a total of 15,866 infants died as a result of injury (approximately 1,442 deaths per year). This compared with first-born infants (2.9 deaths per 10,000 live births), second or later–born infants were at increased risk of infant mortality due to injury (second, 3.6 deaths; third, 4.2 deaths; fourth, 4.8 deaths; fifth or later, 6.4 deaths). The corresponding adjusted risk ratios were as follows: second, 1.84 (95% CI=1.76, 1.91); third, 2.42 (95% CI=2.30, 2.54); fourth, 2.96 (95% CI=2.77, 3.16); and fifth or later, 4.26 (95% CI=3.96, 4.57).

Ahrens et al. (2017a) concluded that single birth infants born second or later were at increased risk of mortality due to injury during their first year of life in the US. This study's findings highlighted the importance of investigating underlying mechanisms behind this increased risk. Justification for selection of birth order as a variable was based on the literature rationale that birth order influences the possibility for infant death due to SUID. Synthesis of the Ahrens et al. (2017a) study relative to the research questions continues to show a gap in analysis of the combination of infant and mother characteristics to determine the combinations of characteristics with the potential for early identification of infants at risk for SUID (Ahrens, Rossen, Thoma, Warner, & Simon, 2017a).

Multiple Birth

Ahrens et al. (2017b) researched birth order and multiple (plurality) births in infant mortality due to external causes, in the United States, 2000–2010. They found the risk of death during the first year of life due to unintentional injury and homicide was higher among twins and higher-order multiples than among single births in the United States. They used national birth cohort linked birth–infant death data (2000–2010) to evaluate the risk of infant mortality due to external causes in multiples versus single births. The risk of death from external causes during the study period was 3.6 per 10,000 live births in single births and 5.1 per 10,000 live births in multiples. Using log-binomial regression, the corresponding unadjusted risk ratio was 1.40 (95% confidence interval (CI): 1.30, 1.50). After adjustment for maternal age, marital status, race/ethnicity, and education, the risk ratio was 1.68 (95% CI: 1.56, 1.81). The researchers' analysis found infant deaths due to external causes occurred between two and seven months of age. Applying inverse probability weighting and assuming a hypothetical intervention where no infants were low birth weight, the adjusted controlled direct effect of plurality on infant mortality due to external causes was 1.64 (95% CI: 1.39, 1.97). Twins and higher-order multiples were at greater risk of infant mortality due to external causes, particularly between two and seven months of age, and this risk appeared to be mediated by factors other than low-birthweight.

Medical Birth Attendant

Rubin (2018) advanced a call to increased action considering U.S. infants still dying due to unsafe sleep conditions despite educational campaigns. Charlene Collier, MD, MPH, noticed a tragic common thread when she reviewed 30 cases of unexpected deaths of previously healthy infants that occurred in Mississippi in 2016. “What we repeatedly saw were infants sleeping in unsafe conditions, commonly with their parents in bed,” said Collier, an assistant professor of obstetrics and gynecology at the University of Mississippi and a perinatal consultant with the Mississippi Department of Health. At the time the study, it had been twenty five years since the Eunice Kennedy Shriver National Institute for Child Health and Human Development (NICHD) launched the “Back to Sleep” campaign and more than a ten years since the NICHD renamed the campaign “Safe to Sleep” to educate physicians and caregivers about safe sleep environments as well as the safe sleep position.

Jordaan (2018) reviewed the role of the midwife in facilitating continuous support during childbirth in a qualitative study. Best practices were known but inconsistent in implementation. The midwife is the ideal person to provide continuous support, but if not possible, the midwife should facilitate continuous support by qualified healthcare workers. The study investigated the role of the midwife in facilitating continuous support during childbirth. The study objective was to explore and describe the role of the midwife, providing antenatal and intrapartum care, in facilitating continuous support during childbirth according to the perspectives of midwives working in a selected public hospital and community health center in the North West Province of South Africa.

Jordaan (2018) followed an explorative, descriptive and contextual design using a qualitative descriptive research approach. The method was an all-inclusive sample of the midwives working in one selected public hospital and one clinic using face-to-face semi-structured interviews by 14 midwives, seven from the selected hospital and seven from the selected clinic. Data were analyzed qualitatively and presented in a thematic chart. The findings were delineated into two main categories with themes and sub-themes. The midwife facilitating continuous support during childbirth was the first category. The midwife's provision of antenatal and intrapartum care were the underlying themes. The second category identified roles in facilitating continuous during childbirth with facilitating and impeding/hindering factors related to continuous support during childbirth as themes. The study concluded that the two main categories with a total of four themes and 20 sub-themes were identified and illustrated the complexity of the issue. A unique finding was the recommendation by participants of mobile phone communication via 'mom-connect' as a way of facilitating continuous support during childbirth. The participants were not familiar with the use of a woman who is trained to assist another woman during childbirth and who may provide support to the family after the baby is born. Recommendations were made for research, education, practice, and policy based on the role of the midwife in facilitating continuous support during childbirth.

Kuhlmann et al. (2016) collaborated with obstetrical providers to promote infant safe sleep guidelines. Specifically, the study evaluated the effectiveness of the Safe Sleep Toolkit during obstetrical visits. Secondary objectives included improving provider and maternal knowledge of safe sleep. The method of research was obstetrical providers ($n = 11$) and staff at an outpatient clinic that were trained using the Safe Sleep Toolkit and encouraged to discuss infant safe sleep with pregnant women at their 28- or 36-week gestation appointment ($n = 111$, 56 pre- and 55 post-intervention). Provider-reported time spent counseling women on safe sleep recommendations and safe sleep knowledge was measured before and after the intervention. Surveys were conducted with women assessing safe sleep knowledge, intention to follow guidelines, and whether safe sleep was discussed at the appointment. The study results showed significantly more post-intervention women reported their provider had discussed safe sleep (78% vs 32%) ($P < .001$). Provider-reported discussions with women increased for all safe sleep guidelines (82%-90% vs 8%-12%) (all $p < .001$). Maternal knowledge surrounding unsafe sleep practices, improved for post-intervention. The researchers concluded that training obstetricians to use a toolkit to promote infant safe sleep guidelines increases the prenatal delivery of this information and improves pregnant women's knowledge and intentions regarding safe infant sleep.

Delivery Method

Hirai et al. (2018) reviewed the Collaborative Improvement and Innovation Network's (CoIIN) efforts to reduce infant mortality in the Southern US between 2011 and 2014. This study reviewed among other risk factors the infant delivery method. Study objectives included the evaluation of the impact of regions IV and VI, supported by the US Health Resources and Services Administration. An examination of pre–post change (2011–2014) for CoIIN strategies with available outcome data from vital records (early elective delivery, smoking) and the Pregnancy Risk Assessment Monitoring System (PRAM) (safe sleep) as well as preterm birth and infant mortality for regions IV and VI relative to all other regions was investigated. The researchers showed that improvements were greater in Regions IV and VI and specific to safe sleep aimed at a reduction in SUID. Regions IV and VI, for example, decreased elective delivery by 22% versus 14% in other regions, as well as back sleep position increased by 5% versus 2% in other regions (Hirai et al., 2018). Preterm birth decreased by 4%, twice that observed in other regions, but infant mortality reductions did not differ significantly (Hirai et al., 2018). The study concluded that the CoIIN approach to public health improvement showed promise in accelerating progress in intermediate outcomes and preterm birth and the impact on infant mortality may require additional strategies and sustained efforts to affect reducing SUID (Hirai et al., 2018).

Hirai et al. (2018) also evaluated the impact the program had on reducing SUID. The study method was an examination of pre and post changes of available outcome data from vital records (early elective delivery and sleep position of infants) utilizing PRAM safe sleep practices with the conclusion that since most outcomes were greater in Regions IV and VI than in other regions, the decrease in early elective delivery and back sleep position contributed to the reduction of SUID.

Simpson (2017) studied sudden unexpected postnatal collapse (SUPC) and SUID. In this noteworthy study from 2015, in the US, approximately 3,700 infants died suddenly and unexpectedly (Centers for Disease Control and Prevention [CDC], 2017). SUID has been consistently defined as the death of an infant less than one year old that occurs suddenly and unexpectedly, and whose cause of death is not immediately obvious before investigation (CDC, 2017). The majority of SUID cases are reported as one of three types: sudden infant death syndrome (SIDS), accidental suffocation and strangulation in bed (ASSB), and unknown cause (CDC, 2017). Infant deaths from SUID declined sharply during the 1990s, in part due to the Back to Sleep Campaign initiated in 1994 and remained stable since 2000 (CDC, 2017; Parks, Lambert, & Shapiro-Mendoza, 2017). However, the SUID rate increased slightly from 87.5 deaths per 100,000 live births in 2014 to 92.6 deaths per 100,000 live births in 2015. Since about 2000, types of SUID deaths have changed; deaths from ASSB and unknown causes have increased, whereas SUID deaths have decreased. The cause for the change is unknown but could be due to better data collection and stricter adherence to SUID definitions (CDC, 2017). Some of these deaths, including accidental suffocation, occur in the hospital setting after birth, although the CDC (2017) data do not report specific location and timing based on days of age. Other researchers have noted that the first two hours after birth is a time of risk and may be related to a “potentially asphyxiating position” during skin-to-skin care or breastfeeding (Simpson, 2017). These deaths are often classified as SUPC due to hours of age and health status of the newborn. Risk factors for SUPC have been identified through several large series of case reports. They include the first two hours of life, prone position of baby, asphyxiating position, skin-to-skin care, unsupervised breastfeeding during first two hours of life, a gap of >15 minutes during which the baby was unobserved by a caregiver, being unattended by clinical staff, mother and baby left alone during the recovery period, primiparous (bearing young for the first time) mothers, maternal fatigue, and maternal distractions such as smartphone use while holding the baby (Simpson, 2017). Other risk factors identified in reported cases included cesarean birth, maternal obesity, mother receiving narcotics, and lack of availability of a well-baby nursery or lack a nurse to staff the nursery. The results support recommendations of continuous bedside attendance by nurses for mothers and babies during the 2-hour recovery period, and regular (including every 30 minutes for high-risk mothers and babies) monitoring of mother–baby couplets during postpartum hospitalization (American Academy of Pediatrics, 2016; Association of Women's Health, Obstetric and Neonatal Nurses, 2010).

Vintzileos, Ananth, Kontopoulos, and Smulian (2005) investigated the general obstetrics and gynecology of the mode of delivery and risk of stillbirth and infant mortality in triplet gestations in the United States, 1995 through 1998. Seeking more current research in this area has proved to be limited therefore seminal research studies dating back to 2005 are essential to supplement this current study of combinations of infant and maternal birth characteristics and factors. The study objective and purpose of this study was to estimate the risks of stillbirth and neonatal and infant deaths in triplets, according to mode of delivery.

The Vintzileos et al. (2005) study design called for the use of “matched multiple birth” data files comprised of triple births that were delivered in the US in the years 1995 through 1998. Analyses were restricted to fetuses that were delivered at ≥24 weeks of gestation. Based on the order of the birth of the fetuses within the triplet set, the mode of delivery of triplets was assigned as cesarean-cesarean-cesarean (all cesarean), vaginal-vaginal-vaginal (all vaginal), and vaginal-cesarean-cesarean or vaginal-vaginal-cesarean (other). Associations between mode of delivery and stillbirth, neonatal deaths (within 28 days), and infant deaths (up to one year) were expressed as relative risks with 95% confidence intervals and population attributable risks, which were derived from multivariate logistic regression models that were based on the method of generalized estimated equations (with all cesarean deliveries serving as the reference). Analyses were adjusted for several confounding factors. The study results, in the population showed ninety-five percent of all triplets were delivered by cesarean delivery. Vaginal delivery (all vaginal) was associated with an increased risk for stillbirth (relative risk, 5.70; 95% CI, 3.83, 8.49) and neonatal (relative risk, 2.83; 95% CI, 1.91, 4.19) and infant (relative risk, 2.29; 95% CI, 1.61, 3.25) deaths. The population-attributable risks were 15.9% for neonatal and 12.4% for infant deaths, which implied that these proportions of deaths were in theory avoidable had these triplet fetuses all been delivered by cesarean delivery rather than delivered vaginally. The researchers concluded that Cesarean delivery of the 3 triplet fetuses was associated with the lowest neonatal and infant mortality rate. Vaginal delivery among triplet gestations should be avoided.

Maternal Risk Characteristics

Reno and Hyder (2018) identified infant mortality/birth outcomes associated with social policies, neighborhood deprivation, individual socioeconomic status (SES) as social determinants and health behavior as intermediary determinants. The evidence suggested that income inequality and social policies like maternal leave policies, may help to explain cross-country variations in infant mortality/birth outcomes. The social determinants of health as risk factors for infant mortality, specifically among African Americans, determined the extent to which research demonstrated an association between each social determinant of health and infant mortality (Reno & Hyder, 2018). Researchers conducted a systematic review using a three-step selection process led to the inclusion of 89 studies. The social ecological model was used to categorize both the search terms and findings that revealed that most studies focused on the individual and public policy levels, and most failed to account for the complexity of a combination social determinants as contributing to SUID. Additional research is needed to explore the social determinants of health that are hypothesized to affect infant mortality across all levels, applying more complex, system-level approaches (Reno & Hyder, 2018).

A more recent study by Danielson, Wallenborn, Warne, and Masho (2018) pursued a study of disparities in prenatal risk factors and birth outcomes among American Indians in North Dakota. The study objectives were an investigation of the high 20-year gap in average age at death among American Indians in North Dakota compared to whites. Geographic- and race-specific health disparities data drove policy making and interventions that were not well disseminated. The researchers conducted a retrospective method of descriptive analysis of North Dakota live births from 2007 to 2012. Period prevalence and prevalence ratios were calculated. The study results showed that infant mortality rate from 2010 to 2012 for infants born to American Indian women was 3.5 times higher than Whites with racial disparities in education, teen births, tobacco use during pregnancy, and breastfeeding initiation (Danielson, Wallenborn, Warne, & Masho, 2018). Disparities widened for inadequate prenatal care, illegal drug use during pregnancy, and infant mortality from 2007–2009 to 2010–2012 and narrowed for sexually transmitted infections and alcohol use during pregnancy (Danielson et al., 2018). The study concluded that Practice American Indians are disproportionately affected by poor pregnancy and birth outcomes in North Dakota. Future geographic-specific American Indian research is warranted to aid current and future public health interventions.

Age

Maternal demographics of mothers under 15 years through age 54 provided pathophysiological mechanisms that lead to sudden infant death syndrome (SIDS) are not completely understood. Cardiac channelopathies were well-established causative factor with long QT syndrome (LQTS) the most frequent, accounting for approximately 12% of SIDS cases (Moon, & the AAP Task Force on Sudden Infant Death Syndrome, 2016). QT refers to an interval seen in an electrocardiogram (EKG) test of heart function. Researchers focused on the prevalence of age as a determinant that induced SIDS. The study results showed LQTS can be effectively managed; thereby suggesting a correlation between the underlying QTS and SIDS cases. The suggestion was for development of a screening method that could aid in early identification of risk factors including the mother's age. Reno and Hyder (2018) reviewed the risk of infant mortality based on maternal age and showed it follows a U- shaped curve. Those born to adolescents, particularly early adolescents age 11–14 years, are at increased risk of infant mortality. Those born to women who are 40 years old, or older, are also at increased risk.

Marital Status

In the case of SUID, the mother's marital status (married, unmarried, unknown, or not stated) has been investigated and shown to have demographic risk factors that are associated with poor birth outcomes including race, socioeconomic status, maternal education level, marital status, and health behaviors such as smoking, nutrition, and prenatal care utilization. Research is limited; however, this current study included the impact of marital status of the mother relative to SUID when compared with demographic data, even though datasets on social determinants of health (SDOH) were rare. Further, primary data collection to study Infant Mortality (IM) was time- consuming and costly as IM was a relatively rare event, and it was difficult to achieve adequate power to detect a statistically significant difference in prospective studies, particularly among subgroups of women. Currently, there is a mismatch between the application of complex theories in framing IM within the context of a broader system, and the methodological approaches used to study IM (Parks, Lambert, & Shapiro-Mendoza, 2017; Reno & Hyder, 2018).

Race/Ethnicity

Parks, Lambert, and Shapiro-Mendoza (2017) reviewed racial and ethnic trends in sudden unexpected infant deaths related to rates and disparities since the Back-to-Sleep campaign. The study results showed each racial/ethnic group had a unique trend in SUID rates since the Back-to-Sleep campaign. When implementing risk-reduction strategies, it is important to consider these trends in targeting populations for prevention and developing culturally appropriate approaches for racial/ethnic communities. As with infant mortality, racial/ethnic differences in SUID rates exist; however, it is unknown whether racial/ethnic differences in SUID have changed (Parks et al., 2017). The study examined trends in SUID rates and disparities by race/ethnicity from 1995 to 2013, the time after the Back-to-Sleep campaign. In addition, demographic and maternal characteristics associated with SUID were examined by race/ethnicity, inclusive of infant sex, age at death, season of death, and gestational age at birth.

Bortz, Hegyi, and Spong (2017, p.15) reported, "Although SUID rates decreased dramatically immediately after the 1994 Back-to-Sleep campaign, they have remained relatively stable at 93.4 deaths per 100,000 live births - since 2000". The decline in SUIDs, sleep-related infant deaths differ by race, ethnicity and other determinants of health (Bortz, Hegyi, & Spong, 2017). The decline in sleep-related infant deaths differ by race and ethnicity with research results that showed differences among non-Hispanic whites, non-Hispanic blacks, Hispanics, American Indian, Alaska Natives and Asian/Pacific Islanders. Researchers analyzed birth-infant death data collected between 1995 and 2013. SUID rate with a non-Hispanic white referent group to examine racial differences in SUID (Bortz et al., 2017). The researchers compared SUID rates for 1995-1997 and 2011-2013 with an emphasis on birth characteristics and racial and/or ethnic status. According to study results, the American Indian/Alaska Natives were the mothers of infants with the highest rate of SUIDs between 1995 and 2013, with a 0.5% annual decrease, followed by non-Hispanic blacks (0.7% annual decrease). Non-Hispanic blacks experienced a significant decrease in annual rates of SUID (–0.7, 95% CI –0.42 to –0.96) (Parks et al., 2017). Researchers did not observe a corresponding decline in death rate among non-Hispanic whites. Asian/Pacific Islanders and Hispanics exhibited a lower death rate when compared with non-Hispanic whites; in 2013, the researchers observed that the SUID rate for non-Hispanic whites was twice higher than that of Hispanics and threefold higher than that of Asian/Pacific Islanders (Parks et al., 2017). Reasons for the disparities and how to eliminate them was not a part of the study. However, the researchers concluded the Back-to-Sleep campaign had not reached certain races/ethnicities (Parks et al., 2017).

Educational Status

According to Ahrens et al. (2017) and Bombard et al. (2018) the maternal educational level of mothers of SUID infants can be an important factor in determining the risk associated with the infant for SUID. Education ranges were grouped in the general classification of schools as follows: 8th grade or less; 9th-12th grade with no diploma; high school graduate or GED completed; some college credit, but not a degree; Associate degree (AA, AS); Bachelor’s degree (BA, AB, BS); Master’s degree (MA, MS); Doctorate (PHD, EdD) or Professional Degree (MD, DDS, DVM, LLB, JD);

Unknown/Not on certificate; and excluded. Mothers were surveyed with 21.6% reporting they placed their infant to sleep in other than a supine position, 61.4% shared their bed with their infant, and 38.5% reported using soft bedding (Bombard et al., 2018). The variation in sleep position was shown to be related to the educational level of the mother. The study's methods included analysis of the CDC 2009–2015 Pregnancy Risk Assessment Monitoring System (PRAMS) which measures self-reported data to describe infant sleep practices and other self-reported experiences before, during, and after pregnancy among women (Bombard et al., 2018). A selected maternal characteristic was maternal age and found mothers who followed supine sleep practice with their infants ranged from 12.2% (New York) to 33.8% (Louisiana); highest compliance was among mothers aged <25 years compared with ≥25 years, those who had completed ≤12 years compared with >12 years of education (Bombard et al., 2018). The study suggested a correlation to mothers following or not following recommended guideline for positioning infants for sleep to be more compliant based on age and educational level.

Unsafe sleep practices were most reported by younger, less educated, and racial/ethnic minority mothers (Bombard et al., 2018; Ahrens, Rossen, Thoma, Warner, & Simon, 2017). Though not accomplished with their study, priority groups were identified for clear, culturally appropriate messages to aid in keeping infants safe, as a result eliminating SUID.

Strength and Weaknesses of Researchers Approach to SUID

Current literature regarding Sudden Unexpected Infant Death (SUID) cites the history, risk factors, and recommended prevention measures. A major strength of studies is the researchers' illustrated examples of SUID prevention campaigns in the United States that shed light on the role healthcare providers can play in SUID prevention. In addition to providing baseline evidence to use in creating an effective SUID education campaign in the U.S., researchers have discussed relevant theoretical frameworks for both the studies and varying research questions.

Although there have been many studies related to SUID, seven primary studies or sources are described to support and highlight the relevance and currency of SUID as a public health problem, the gaps in literature reviews and studies, and the potential to eliminate SUID in my lifetime. Studies by Friedmann et al. (2017) on maternal and obstetrical predictors of SUID aimed to determine modifiable and non-modifiable risk factors associated with overall infant mortality in a cohort of more than seven million births. The study group reviewed a variety of Public Health initiatives, such as the "Safe to Sleep" campaign, and found traditionally targeted infants' risk factors for the prevention of SUID. However, the researchers also found the debate continued to swirl maternal and obstetrical risk factors for SUID (MacDorman & Gregory, 2015). By delineating both modifiable and non-modifiable obstetrical and maternal risk factors associated with SUID, the relationship to SUID was shown, but not in combinations of both maternal and infant characteristics.

Friedmann et al.'s (2017) method of study focused on a population-based cohort study using the CDC's Linked Birth–Infant Death data from the year 2010, in the United States. The impact of several obstetrical and maternal risk factors on overall infant mortality and SUID was estimated using unconditional regression analysis, adjusting for relevant confounders. Infant deaths due to SUID in the cohort of 4,007,105 deliveries and 24,174 infant deaths, during the first year of life, was 1,991 (8.2%) (Friedmann et al., 2017). Prominent risk factors for SUID included (OR [95% CI]): black race, 1.89 [1.68–2.13]; maternal smoking, 3.56 [3.18–3.99]; maternal chronic hypertension, 1.73 [1.21–2.48]; gestational hypertension, 1.51 [1.23–1.87]; premature birth <37 weeks, 2.16 [1.82–2.55]; fetal growth restriction or intrauterine growth restriction (IUGR) - a condition in which the fetus is smaller than expected for the number of weeks of pregnancy or small for gestational age (SGA) defined as an estimated fetal weight of less than the 10th percentile or the fetus weighs less than 90 percent of all other fetuses of the same gestational age - UGR, 2.46 [2.14–2.82]; and being a twin, 1.81 [1.43–2.29], $p < 0.0001$(Friedmann et al., 2017). By comparison, in a cohort of infant deaths from other causes, risk factors with a tendency for SUID were maternal smoking, 2.48 [2.16–2.83] and being a twin, 1.52 [1.21–1.91], $p < 0.0001$(Friedmann et al., 2017). The study conclusion illustrated that while certain socio-demographic and gestational characteristics are important risk factors, maternal smoking remained the strongest prenatal modifiable risk factor for SUID. The study results suggested and recommended continuation of Public Health initiatives that promote safe infant sleeping practices and smoking cessation during and after pregnancy (Friedmann et al., 2017).

Gollenberg and Fendley (2018) called for public health programs and the public to mount an awareness campaign specific to SUID. They, like other researchers agreed SUID remains a leading cause of infant death in the United States. Their study focused on the state of Virginia through a qualitative measure of the perceptions among community identified stakeholders regarding community resource needs to reduce SUID. Snowball sampling identified important community stakeholders to be interviewed as key informants followed by a semi-structured interview to determine resource needs to reduce SUID, and whether high-risk community members were aware of SUID risk factors (Gollenberg & Fendley, 2018). Seventy-four interviews were conducted in two geographic areas with higher than average rates of infant mortality: Winchester City, VA and Page County, VA (Gollenberg & Fendley, 2018). The interviews were completed with stakeholders in healthcare, social services, and other organizations, with four significant findings: 1) the majority of respondents perceived that high-risk community members were not aware of factors that can lead to SUID (50%) let alone that SUID is a significant public health problem; 2) participants suggested that more targeted education is needed to further reduce SUID rates in their communities (73%); 3) respondents cited the need for more detailed pervasive, strategic, and multi-channeled education if SUID is to be reduced; and 4) community leaders perception was that high-risk community members were aware of risk factors that can lead to SUID (Gollenberg & Fendley, 2018). That study, and other studies such as the one by Lu et al. (2015) encouraged maternal/child health stakeholders mount a campaign in the two Virginia counties studied to educate the stakeholders and the community, in areas that showed a very low knowledge of the definition of SUID the risks and the individuals most at risk for SUID. The potential for more community-based education as a potential solution, while promising, fell short in providing insights into specific combinations of maternal and birth factors that would promote a program to follow mothers and infants most prone to be at risk for birth and subsequent SUID infant death and the early identification of infants most at risk for SUID (Gollenberg & Fendley, 2018).

Hakeem, Oddy, Holcroft, and Abenhaim's (2015) study objectives investigated the incidence and determinants of SUID in 37 million births to measure the incidence of SUID, estimated the birth to death interval, and associated maternal and infant risk factors. The study consisted of a population-based cohort of 37,418,280 births using data from the CDC's "Linked Birth-Infant Death" and "Fetal Death" data files from 1995 to 2004 (Gollenberg & Fendley, 2018). Descriptive statistics and cox-proportional hazard models were used to estimate the adjusted effect of maternal and newborn characteristics on the risk of SUID (Gollenberg & Fendley, 2018). Their results labeled 24,101 cases of SUID identified in a 10-year period or an incidence of 6.4 cases per 10,000 births (Gollenberg & Fendley, 2018). Interestingly, the incidence, over the study period, decreased from 8.1 to 5.6 per 10,000 births, and infants ranged in age from 2-4 months, the most affected (Gollenberg & Fendley, 2018). Risk factors included maternal age less than 20 years of age, Black, non-Hispanic race, smoking, increasing parity (the number of live births by a woman compared to the number of pregnancies of a woman), inadequate prenatal care, prematurity and growth restriction (Gollenberg & Fendley, 2018; Ostfeld, Schwartz-Soicher, Reichman, Teitler, & Hegyi, 2017; Parks et al., 2017; Poets, 2016). The results of the study concluded that while the incidence of SUID in the United States has declined, SUID continued to be the leading cause of post-neonatal mortality. This study did highlight SUID as an important public health priority; yet like with other studies, it fell short, pointing to singularity of identification of risks without a comprehensive review of combinations of factors of both the mother and the infants that put the infant at a higher risk for SUID with early tracking and intervention as a priority (Gollenberg & Fendley, 2018). The study did point to the need for educational campaigns, but it did not target mothers at increased risk of giving birth to infants that would be prone to SUID; the study did not delineate an association among the highest risk factors in combination with infant birth characteristics as predictors of SUID in infants as a strategy to avert SUID (Gollenberg & Fendley, 2018). The authors suggested education to raise the mother's awareness of modifiable risk factors for SUID such as maternal smoking and inadequate prenatal care, however again, the researchers study showed no specifics in terms of the combination of both mother and infant factors as predictors of SUID (Gollenberg & Fendley, 2018).

MacDorman and Gregory (2015) provided the 2013 national vital statistics reports on fetal and perinatal mortality specific to the United States as reported by the CDC, National Center for Health Statistics, National Vital Statistics System. Their report presented fetal and perinatal mortality data by maternal age, marital status, race, Hispanic origin, and state of residence, as well as by fetal birthweight, gestational age, plurality, and gender to show trends in fetal and perinatal mortality (MacDorman & Gregory, 2015). The method of study was a descriptive tabulation of data and interpretations. Their research looked at fetal deaths at 20 weeks or more of gestation in the United States in 2013, numbered at 23,595 fetal deaths at 20 weeks, or 5.96 fetal deaths per 1,000 live births (MacDorman & Gregory, 2015). The 2012 review found there were 6.05 fetal deaths per 1,000 live births, not an appreciable difference in the year 2013. The lack of decline in fetal mortality when viewed through the lens of declines in infant mortality, meant that more fetal deaths than infant deaths occurred in the United States for 2011–2013 (although the rates were essentially the same) (MacDorman & Gregory, 2015). In 2013, the fetal mortality rate for non-Hispanic black women was 10.53, more than twice the rate for non-Hispanic white women at 4.88, and the Asian or Pacific Islander rate of 4.68 (MacDorman & Gregory, 2015). The rate for American Indian or Alaska Native women (6.22) was 27% higher, and the rate for Hispanic women (5.22) was 7% higher than the rate for non-Hispanic white women. Fetal mortality rates were highest for teenagers, women aged 35 and over, unmarried women, and women with multiple pregnancies (MacDorman & Gregory, 2015). Statistically, studies have not shown a dramatic decrease in SUID related deaths. A statistically significant outcome that assists in reducing the incidence of SUID would be a preventive strategy for assessment, early identification of the potential for SUID and the interventions that determine the combination of mother to infant characteristics that are predictors of SUID.

There are numerous independent studies on infant characteristics and mother factors that contribute to SUID; however, none have looked at the pairing of infant birth characteristics and mother factors in combination as better predictors of infants more at risk for SUID. Olander, Smith, and Darwin (2018) explored pregnancy as a receptive time for changing health behavior addressing characteristics that motivated change based on risk-related information for infant birth complications like SUID. Pregnancy was found to be a time when women are receptive to changing health behavior. However, the researchers delved beyond perception to categorize the volume of such behavioral expectations placed on women before, during and after pregnancy, or the potential complexity of behavior change. Healthcare guidelines can oversimplify health behavior, with recommendations focused on health education to evoke lifestyle changes characterized by messages intended to be delivered by health care professionals to targeted women. Researchers identified assumptions underlying into three groups: 1) pregnant women motivated by risk-related information to change their health behavior as motivation for health behavior change, 2) multiple health behaviors addressed simultaneously, and 3) changes related to improved health outcomes. Just reading through a health magazine or seeing a television public service announcement (PSA) aimed at pre-pregnant or pregnant women was investigated to propose universal recommendations for pregnant women regarding routine care guidelines, such as not smoking during pregnancy or after childbirth or the management of diabetes in pregnancy and afterwards. Although, not a study of women in the United States, a United Kingdom study paralleled similar guidelines for the numerous health behaviors expected of women before, during and after pregnancy. Among the numerous behaviors were: 1) taking of dietary supplements like, folic acid and vitamins; 2) improving nutritional status, like monitoring fiber intake and increasing fluid intake, particularly water; 3) physical activity; 4) reducing or eliminating alcohol consumption; 5) smoking cessation; 6) no illicit drug use like marijuana, cocaine, etc.; 7) medication adherence and compliance; 8) routine screening tests and examinations; 9) preparation for child birth, in essence, Lamaze coaching classes; 10) self-monitoring of indications of pre-eclampsia (elevated blood pressure) or depression; 11) recognition of active labor); and 12) infant feeding preparation and techniques (Lavezzi, Ottaviani, & Matturri, 2015). The researchers further sought to better understand behaviors and the support required by women to influence the determinants of health behavior change because of pregnancy. The investigators employed the psychological theory of promoting the developing maternal-fetal relationship, in essence, associating and developing a relationship for the mother with the infant towards the unborn baby. Research correlated behavior change relative to certain stimuli, in essence, the mother seeing the ultrasound scan, fetal movements, and listening to the baby's heartbeat in utero. Another aspect of the mother's behavior was to explore their capacity to entertain behavior change through observation of physical or psychological elements as influencers of behavior change, in essence, nausea, backache, limitations in movement with weight gain, etcetera. The results of their research indicated continued research is needed to interpret the physiological symptoms that change throughout pregnancy. Differences in responses from one pregnancy to another and even with the same pregnancy to influence behavior change suggests new avenues for research. Another notable finding was that sociodemographic variables such as education may play a role in factors like dietary changes. More investigation is needed to determine the influence of social or peer pressure in behavioral changes to protect the unborn. The health belief model or social cognitive theory are two models proven to be effective in health education and promotion of behavior changes in pregnant or soon to be pregnant women.

Stiffler, Cullen, Stephenson, Luna, and Hartman (2016) studied mothers' experiences and thoughts during periods of times when they witnessed or found their babies had stopped breathing. The researchers found that SUID was responsible for 14% of Indiana's infant mortality (Stiffler, Cullen, Stephenson, Luna, & Hartman, 2016). They performed a qualitative research study to describe mothers' experiences when death of an infant occurred suddenly and unexpectedly. Field representatives or social workers interviewed mothers from central Indiana during the child-death team investigations. The Thematic Analysis Program from the Joanna Briggs Institute was used to analyze interview data. Sixteen de-identified interview cases were extracted, and a meta-aggregate method was used that surfaced three synthesized themes: Extreme Emotional Shock, We Feel Like We're to Blame, and Working Toward Moving On (Stiffler et al., 2016). Understanding these phenomena from mothers' experience may assist in eliminating risks associated with infant deaths and inform nursing practice and policy (Stiffler et al., 2016; Taylor et al., 2015).

Literature Review Summary

While there are numerous maternal risks that have been studied with a correlation to SUID, such as alcohol abuse, sedatives and other drugs, the SUID rate continues to climb in the US, wherein the same factors are not an essential component of SUID. In some countries, for example Islamic regions, strong social, moral, and religious checks and balances curtail contributors to SUID. Religion forbids use of some substances; medications are controlled and regulated by government and religion, and recreational drugs are illegal. Tobacco is the only substance that Islamic women might abuse in pregnancy because there are still no governmental restrictions or religious objections to tobacco use. In summary, in the U.S., the most significant prenatal SUID risk factors are the high incidence of low birth weight (LBW), preterm and prematurity birth was 13%, prematurity rate was 11%, and LBW infants was 9% (Heydari et al., 2016). According to Mojibyan, Karimi, Bidaki, Rafiee, and Zare (2013) the US had the highest tobacco smoking exposure during pregnancy rate, based in part on a study of 205 women: 43 (20.97%) women exposed to secondhand smoke (SHS) during pregnancy and 162 (79.02%) women did not. Correspondingly, in SHS exposure group, 11 infants (25.6%) and non-SHS exposure group, 17 infants (10.5%) were born prematurely (< 37 weeks) ($P = 0.01$) (Mojibyan et al., 2013). Birth weight of the newborn in non-SHS exposure group was significantly greater than the newborn in SHS group (Mojibyan et al., 2013). The suggestion made was anti-smoking campaigns should be targeted at females and the significant others of expectant mothers to avert SUID. Other US studies conducted in the maternal-child health field had similar findings and suggestions, including educating parents and families regarding the risk smoking poses to the health of infants and pregnant women. It is especially important to target families with smokers and young infants less than six months of age that are at the highest risk for SUID. The US high incidence of women diagnosed with high risk pregnancies and expected to be at risk of having a preterm birth, a premature infant or an LBW infant, meant many infants faced a heightened risk of SUID. Emphasis on recommending regular prenatal care, having a balanced healthy diet during pregnancy, and avoiding short interpregnancy intervals of less than one year are essential in averting SUID.

As presented in this literature review, families with lower socioeconomic status or lower education levels have a higher risk of SUID. Lower socioeconomic families and less educated families have more children on average than middle to high socioeconomic families. Pregnant women from these groups often have unbalanced nutrition; have insufficient pregnancy care, inter-pregnancy intervals shorter than one year and may have married and become pregnant while still in their teenage years. It is therefore important that targeted tailored SUID prevention recommendations for US pregnant mothers include regular pregnancy care, balanced healthy diets during pregnancy and leaving more than one year between pregnancies.

SUID is a public health issue with variables that have been investigated separately for infants and mothers. I reviewed a combination of variables to determine which, if any, when studied together are more likely predictors of SUID. Controversy is a topic in much of the literature reviews and studies with more attention given to the infant or mother but not to both as a combination of variables. An example is the “Safe to Sleep” campaign, which looked almost exclusively at the risk factors related to the infant and not the mother. My study was an investigation into the combination of variables, when modified or not modified, contribute more predictively in SUID than combinations of other variables inclusive of infant and mother characteristics.

This current study analyzed the independent and dependent variables of SUID in infants in a cross-sectional quantitative study to determine the extent to which infant birth characteristics (month prenatal care began, gestational age, birth weight, birth place, birth order, multiple birth, medical attendant, and delivery method) when taken into combinations with the most common maternal demographics (age, marital status, race, and educational status) predict the occurrence of SUID in infants.

I engaged the United States Department of Health and Human Services (US DHHS), Centers of Disease Control and Prevention (CDC), National Center for Health Statistics (NCHS), Division of Vital Statistics (DVS) (n.d.) published records that linked infant births to infant death records from 2013-2016. This study systematically reviewed combinations of risk factors of SUID for mothers and the characteristics exhibited by infants at risk for SUID as predictors of mothers and infants at highest risk for SUID, thereby assessing the mother for interventions to prevent delivery of a high-risk infant for SUID. Within the identified database, the review of the WONDER database on Infant Deaths Linked Birth/Infant Death Records for the years 2013-2016 further defined the combinations of the highest risk characteristics.

Definition of Terms

Sudden Infant Death Syndrome (SIDS) is one of several categories associated with SUID. Other categories in SUID are accidental suffocation in a sleeping environment and other deaths from unknown causes (CDC, 2019).

Sudden Unexpected Infant Death (SUID) is a term used to describe the sudden and unexpected death of a baby less than one year old in which the cause was not obvious before investigation. These deaths often happen during sleep or in the baby’s sleep area (Parks, Lambert, & Shapiro-Mendoza, 2017; CDC, 2019)

Assumptions

Throughout this study, aspects of the study that are believed, but cannot be demonstrated to be true, yet are critical to the meaningfulness of the study include the ability to research and test for: 1) pregnant women motivated by risk-related information to change their health behavior as motivation for health behavior change, 2) whether multiple health behaviors can be addressed simultaneously, and 3) changes that can lead to improved health outcomes, regardless of the timing of influence and relative importance of the specific behaviors. The WONDER database/data set assumptions included: 1) Data collection provided counts and rates for deaths of children under one year of age, occurring within the United States to U.S. residents; 2) Information from death certificates were properly linked to corresponding birth certificates; 3) the study variables (dependent, independent, and confounded) were available by county of mother's residence, child's age, underlying cause of death, gender, birth weight, birth plurality, birth order, gestational age at birth, period of prenatal care, maternal race and ethnicity, maternal age, maternal education and marital status; 3) there was suppression of sub-national data representing zero to nine (0-9) deaths of births; 4) Assurance of Confidentiality was in place and active throughout the study; and 5) live births and infant (age under 365 days) deaths were linked to maternal residents of the United States, 2013-2016.

The reason the assumptions were necessary in the context of the study was to be consistent in defining the scope and limitations of this study compared to previous studies. The WONDER data set was reported to include: 1) a robust population of mothers and infants that would lend itself to a study of the variables listed in the study questions for SUID; 2) data integrity was ensured with consistency for data capture and reporting by the contributing state and local agencies; 3) there was ready availability of access to the data provided by the United States Department of Health and Human Services (US DHHS), Centers for Disease Control and Prevention (CDC), National Center for Health Statistics (NCHS), Division of Vital Statistics (DVS). Linked Birth/Infant Death Records 2013-2016, were compiled from data provided by the 57 vital statistics jurisdictions through the Vital Statistics Cooperative Program, using the CDC WONDER Online Database. And, lastly, with data from the WONDER dataset, specific tables, maps, charts, and data extracts, including but not limited to United States national, state and county summary counts of infant deaths, live births and infant death rates were indexed by combinations of mother and infant variables.

Scope and Delimitations

The specific aspects of the research problem addressed in the study were the independent, dependent, and covariate variables of SUID with a focus on specific combinations of infant and mother traits that were chosen to validate the potential for prediction of and elimination or reduction in SUID in the United States. This study's boundaries are specific to 1) a 4-year period from 2013-2016, 2) CDC SUID reports for only the United States, and 3) infants one year or less in age. This study excludes neonates (unborn children), infants older than 1 year of age, and infant deaths unrelated to SUID or SID causes. The theory most related to the study is the Social Cognitive Theory. This study provided external validity in the cogency, rationality, soundness, and strength of being able to apply the study's conclusions of this scientific study outside the context of this study. The extent to which the results of this study can be generalized to and across other situations, people, stimuli, and times is demonstrated. General conclusions are the expectation and goal in this research study. External validity is an important property of this study. Mathematical analysis of external validity concerns a determination of whether generalization across diverse populations is feasible and devising statistical and computational methods that produce valid generalizations.

A theory that was considered for this study, but not used, was the dialectical behavior therapy (DBT) which is a comprehensive trans-diagnostic and multi-diagnostic cognitive behavioral intervention better suited to complex clinical presentations with an opportunity to impact the emotional, cognitive, and behavioral areas. The theory was not chosen as it is more suited to treatment and research for adults, not infants. Although the theory is a modified form of cognitive behavior therapy, it is more effective in treating people with borderline personality disorders, resistant depression, binge eating, attention deficit hyperactivity disorder (ADHD), and for other age groups such as adolescents and children.

When attempting to generalize study results for the purpose of seeing if there was a fit and potential for use in the current study on SUID, application to the mothers may be possible, however when attempting to integrate the theory for risk factors in a large proportion of the SUID population it would have been difficult to validate that changes in behavior of the mother and of the infant contributed to a reduction in SUID cases.

A threat to the external validity of the SUID study lies in how the study’s findings and explanations may be generalizable. The generalizability is limited because the effect of one factor, in essence, the independent variable, depends on other factors. Therefore, all threats to external validity can be described as statistical interactions.

Certain variables (characteristics) interact with the independent variable, limiting generalizability. For example, the infant may have had other co-morbidities that are concurrent with other medical disorders that render the external validity of the study to be limited. All situational specific variables of a study potentially limit generalizability. Pre-test effects lead to the cause-effect relationships that can only be found when pre-tests are carried out, then the generality of the findings are limited. Likewise, post-test effects lead to the cause-effect relationships that can only be found when post-tests are carried out, then this also limits the generality of the findings. A study's external validity is limited by its internal validity. If a causal inference made within a study is invalid, then generalizations of that inference to other contexts will also be invalid.

Cook and Campbell (1979) influential research made a distinction between generalizing to a population and generalizing across subpopulations defined by different levels of some background factor. Lynch (1982) argued that generalization to a meaningful population is but a snapshot of history. The researcher asserts it is however possible to test the degree to which the effect of some cause on some dependent variable generalizes across subpopulations that vary in some background factor (Lynch, 1982). That requires a test of whether the treatment effect being investigated is moderated by interactions with one or more background factors. In order to neutralize threats to validity researchers need to avoid unwarranted generalizations, many of those threats can be disarmed in a systematic way, thereby enabling a valid generalization. Experimental findings from one population can be "re-processed", or "re-calibrated" to circumvent population differences and produce valid generalizations in a second population, where experiments cannot be performed. Bareinboim (2014) classified generalization problems into two categories: 1) those that lend themselves to valid re-calibration, and 2) those where external validity is theoretically impossible. A calculus-derived condition was created for a problem to enable a valid generalization and algorithms were devised that automatically produced the needed re-calibration Bareinboim (2014). This reduced the external validity problem to an exercise in graph theory and has led some philosophers to conclude that the problem is now solved.

Sampling bias is an important variant of the external validity problem that deals with selection bias. That bias is created when studies are conducted on non-representative samples of the intended population. The researcher may want to know whether the results generalize to the entire population, where attributes such as age and educational status differ substantially from those of a typical member of the population. The graph-based method of Bareinboim identified conditions under which sample selection bias can be circumvented and, when these conditions are met, the method constructs an unbiased estimator of the average causal effect in the entire population. One such instance of selection bias is ethnicity, according to Kroll et al. (2018), in which the main difference between generalization from improperly sampled studies and generalization across disparate populations lies in the fact that disparities among populations are usually caused by preexisting factors, such as age or ethnicity. The researchers further explained that selection bias is often caused by post-treatment conditions, for example, patients dropping out of the study, or patients selected by severity of injury (Kroll et al., 2018). When selection is governed by post-treatment factors, unconventional re-calibration methods are required to ensure bias-free estimation that can be obtained from a problem graph. A reweighing procedure can be introduced to eliminate or correct bias.

Significance, Summary, and Conclusions

The potential contributions of the study that advance knowledge in the discipline of public health, specific to SUID, is the recognition that although the death rate has decreased in the United States, SUID remains the leading cause of death in infants (Carlin & Moon, 2017). Recent research suggests no single trait or characteristic of the infant or the mother is enough to support the instances of SUID. Instead, this is an opportunity to engage in a multidisciplinary research approach for the further study of multiple infant and mother traits in combinations of traits. Although scores of known risk factors for infants have been identified, there is limited research in infant birth characteristics, particularly combinations of birth factors that are more likely to be indicative of a higher risk of infant death when paired with traits of the mother. SUID is significant because lives can be saved by learning the degree to which this study investigated to find linkage between the combination of infant birth characteristics and mother demographics to reduce or eliminate the risk factors that could ultimately lead to an even greater decrease in SUID. Infant characteristics and mother demographics in SUID in combination, could provide clues to predetermine which combinations of data trigger or avoid SUID. Saving more lives is the hallmark of public health, saving specific lives is the goal of SUID research.

Potential contributions of the study that advance practice and policy is significantly improving as participating states and jurisdictions work to improve data quality on SUID cases. This effort could lead to a better understanding of circumstances that may increase the risk of SUID. With the addition of more states engaged in uniform reporting of the data associated with SUID trends and circumstances there is the potential to carry out strategies identified in this current study to reduce future deaths. In addition, compilation of the data into the CDC WONDER database supports the potential for even more robust studies with collaboration with even more organizations and subject matter experts to develop standardized training materials and a reporting form for investigators. With the potential contributions more unified in data capture and reporting the potential implications for positive social change that are consistent with and bounded by the scope of the study can lead to lives saved.

Section 2: Research Design and Data Analysis

Introduction: Research Design and Data Collection

The purpose of this cross-sectional quantitative study was to examine the extent to which infant birth characteristics (gestational age, birth weight, birth order, multiple birth), delivery characteristics (infant birthplace, medical attendant, delivery method), month prenatal care began, and maternal demographics (age, marital status, race, education) predicted the occurrence of SUID. This study addressed SUID as a public health problem through a focus on combinations of infants' characteristics and mothers' demographics. In Section 2, I explain the study's design, data collection processes, data analysis procedures, threats to validity, and ethical considerations.

Research Design and Rationale

A cross-sectional quantitative approach was appropriate because the study addressed the extent to which variables predicted outcomes. The use of quantitative methodology with a large sample allowed me to generalize results to a population. The problem was identifying factors that influence an outcome, which made the quantitative approach the best choice. Of the research designs available, the one that was best suited for this study was the cross-sectional design to address the population of infants who died due to SUID and the mothers of those infants. The independent variables were infant birth characteristics (gestational age, birth weight, birth order, multiple birth), delivery characteristics (infant birthplace, medical attendant, delivery method), month prenatal care began, and maternal demographics (age, marital status, race, education) as predictors of the occurrence of SUID. The dependent variable was SUID. There were no time or resource constraints related to the design choice. The WONDER database provided the collected data; therefore, time was not a major barrier to this study.

Methodology

Population

The baseline descriptive and demographic characteristics of the sample represented the complete and geocoded birth records from 2013 to 2016. The infants were full-term infants in the United States whose cause of death was filtered to yield those who died within 364 days of birth as a result of SUID. The mothers of those infants were included in this study. The results were based on a cohort population consisting of 15,844,629 live births/deliveries, of which there were 6,167 deaths (38.93 deaths per 100,000) due to SUID from 2013 to 2016.

Sampling and Sampling Procedures

The CDC WONDER public service database was developed and operated to perform sampling based on selected variables. The public domain web site provided access to public use data and information. Access to the information was free. The only stipulation for use was proper citation credit to the authors and/or data providers. The current study did not require procedures for recruiting subjects, participation, database access permission, or use of legal or historical data or documents. The WONDER secondary data set public database did not require letters or emails for permissions to access the data. The procedure for gaining access to the data set was obtaining a unique user identification name/number and setting up a password. The login requirements were removed (retired) from all WONDER user accounts in August 2003 to make the public system accessible to all researchers in public health and population health science. Obtaining a sample population was done by simple extraction within the database based on inclusion and exclusion criteria. The inclusion criteria consisted of infants who died between birth and 364 days of life with a diagnosis of SUID.

The exclusion criteria consisted of neonates (unborn children), infants older than 1 year of age, and infant deaths unrelated to SUID or SID causes. Exclusion criteria limitations to the population study included (a) infant deaths were weighted so numbers did not exactly add to totals due to rounding and (b) there were slight differences in the number of infant deaths compared to the Linked Birth/Death Records to other vital statistics (United States Department of Health and Human Services [US DHHS], n.d.). The list of WONDER system data queries on the website home page provided real-time searches within the WONDER database that yielded immediate automated data queries in XML format over HTTP. The WONDER database determined the sample size through selection of criteria from within the database. I also had access to flat files that linked not only the birth and death records but also the cause of infant death. Further linkage was provided in the flat files that linked the infant records to those of the infant's mother. Downloads from WONDER numerical data and flat files were uploaded into IBM Statistical Package for the Social Sciences (SPSS) Version 25.0.

Data collection. Data collection for this study included counts and rates for deaths of children under 1 year of age in the United States to U.S. residents. Information from death certificates was linked to corresponding birth certificates. Data were available by county of mother's residence, child's age, underlying cause of death, gender, birth weight, birth plurality, birth order, gestational age at birth, period of prenatal care, maternal race and ethnicity, maternal age, maternal education, and marital status. On May 23, 2011, the WONDER data set privacy policy was updated to reflect a change that suppressed all subnational data representing zero to nine deaths or births.

Power analysis. Faul, Erdfelder, Lang, and Buchner (2007) and Faul, Erdfelder, Buchner, and Lang (2009) described flexible statistical analysis software used to determine sample size, including the effect size, alpha level, and calculated power. G*Power Statistical Power Analyses for Windows is used in social, behavioral, and biomedical sciences (Faul et al., 2007; Faul et al., 2009). The software computes statistical power analyses for *t* tests, *F* tests, $\chi 2$ tests, *z* tests, and some exact tests (Faul et al., 2009; Faul et al., 2007). G*Power is also used to compute effect sizes and to display graphically the results of power analyses (Faul et al., 2007; Faul et al., 2009). G*Power Version 3.1.9.4 was used for the current study's two research questions (Faul et al., 2007; Faul et al., 2009). Research Question 1's G*Power calculated sample size was 807 based on α err prob = 0.05, power (1-β err prob) = 0.80, and number of predictors = 4 (see Faul et al., 2007; Faul et al., 2009). Research Question 2's G*Power calculated sample size was 832 based on α err prob = 0.05, power (1-β err prob) = 0.80, and number of predictors = 8. Given the two sample sizes, the higher of the two (832) was the minimum sample size for this study.

The CDC proivded flat files related to the WONDER database. This provided deidentified linkage between infants and mothers for the years 2013-2016. Given the rich source of not only the WONDER database but also the associated flat files, I determined the best approach for this study would be the use of the full model (population) rather than a sample size of the population. This approach afforded a greater level of confidence in the data and precision in reviewing cases. The *p* values, odds ratio, and null hypothesis were more precise with fewer errors and greater accuracy. There was also less chance of omitting valuable cases due to missing data.

Operationalization of Variables

The first research question addressed infant independent variables that were coded and measured. Gestational Age (GA) was a measure of the age of pregnancy counted from the beginning of a woman's last menstrual period. In this study GA was coded in weeks with a mean (standard deviation) among 11 groupings. Birth weight was coded in grams between 500 and 8,165. Birth order was coded based on one child born alive to a mother through six live births. Multiple birth (plurality) was coded as single, twin, triplet, quadruplet, or quintuplet or more. The dependent variable was the presence of SUID.

The second research question addressed the independent variables of mother's age, marital status, race/ethnicity, and educational status. Mother's age was coded as under 15 years through age 54. Marital status was coded as married, unmarried, or unknown or not stated. Race/ethnicity was coded as American Indian or Alaska Native, Asian or Pacific Islander, Black or African American, or White. Educational status was coded as 8th grade or less, 9th-12th grade with no diploma, high school graduate or GED completed, some college credit but not a degree, associate's degree (AA, AS), bachelor's degree (BA, AB, BS), master's degree (MA, MS), doctorate (PHD, EdD) or professional degree (MD, DDS, DVM, LLB, JD), or unknown/not on certificate. Additional independent variables for Research Question 2 consisted of the month prenatal care began, infant birthplace, medical birth attendant, and infant delivery method. Month prenatal care began was coded as no prenatal care, 1st month to 9th month of pregnancy, or not stated/not on birth certificate. Infant birthplace was coded as in hospital, not in hospital, or unknown or not stated. Medical birth attendant was coded as certified nurse midwife (CNM), Doctor of Medicine (MD), doctor of osteopathy (DO), other, other midwife, or unknown or not stated. Infant delivery method was coded as cesarean, not stated, or vaginal. The dependent variable was the presence of SUID. Table 1 includes information about operationalization of the variables in this study.

Table 1

Operationalization of Variables

Variable name	Variable code	Measure or manipulation	Variable type	Research question number
Sudden Unexpected Infant Death (SUID)	Yes or no		Dependent, nominal	1, 2
		Infant birth characteristics		
Gestational age, weeks (w), mean (SD) (w1 groups)	Under 20 weeks; 20-27 weeks;28-31 weeks; 32-33 weeks; 34-36 weeks; 37-38 weeks; 39 weeks, 40 weeks; 41 weeks; 42 or more weeks; unknown.	Measured in weeks ranging 20-42 (M = x, SD = x)	Independent, ordinal	1
Birth weight	499 grams or less; 500 - 999 grams; 1000 - 1499 grams; 1500 - 1999 grams; 2000 - 2499 grams; 2500 - 2999 grams; 3000 - 3499 grams; 3500 - 3999 grams; 4000 - 4499 grams; 4500 - 4999 grams; 5000 - 8165 grams; not stated.	Birth weight is as reported in the medical record as computed at the time of birth, based on the Center for Disease Control's (CDC) weight and age growth charts.	Independent, ordinal	1
Birth order	One child born alive to mother through six live births, and Not stated.		Independent, ordinal	1
Multiple birth (plurality)	Single; twin; triplet; quadruplet; quintuplet or more.	Indicated if more than one infant shared the gestation and birth.	Independent, categorical, nominal	1
		Maternal common demographics		
Age	Under 15 years; 5-year age groups through age 54.	Measured in years with a range of 15-54	Independent, categorical, nominal	2
Marital status	Married; unmarried; unknown or not stated.		Independent, categorical, nominal	2
Race/ethnicity	American Indian or Alaska Native; Asian or Pacific Islander; Black or African		Independent, categorical,	2

Variable name	Variable code	Measure or manipulation	Variable type	Research question number
	American; White		nominal	
Educational status	8th grade or less; 9th-12th grade with no diploma; high school graduate or GED completed; some college credit, but not a degree; associate degree (AA, AS); bachelor's degree (BA, AB, BS); master's degree (MA, MS); doctorate (PHD, EdD) or professional degree (MD, DDS, DVM, LLB, JD); unknown/not on certificate; excluded		Independent, categorical, nominal	2
		Maternal delivery factors		
Month prenatal care began	No prenatal care; 1st month - 9th month of pregnancy; not stated/not on certificate; excluded.		Independent, categorical, ordinal	2
Infant birthplace	In hospital; not in hospital; unknown or not stated. Birthplace data are derived from the "BFACIL3" variable in the years 2003 and later.	"1" = In hospital "2" = Not in hospital "3" = Unknown or not stated	Independent, categorical, nominal	2
Medical birth attendant	Certified nurse midwife (CNM); doctor of medicine (MD); doctor of osteopathy (DO); other; other midwife; unknown or not stated.	"1"= doctor of medicine (MD); "2" = doctor of osteopathy (DO); "3" certified nurse midwife (CNM); "4" = other midwife; "5"= other; "9" = unknown or not stated. Data are derived from the "attend" variable in the years 2003 and later.	Independent, categorical, nominal	2
Infant delivery method	Cesarean, not stated, and vaginal.	Indicates whether the baby was born by Cesarean section or vaginal birth. Method of delivery data are derived from the "DMETH_REC" variable in the years 2003 and later.	Independent, categorical, nominal	2

Note. Source: United States Department of Health and Human Services (US DHHS), Centers for Disease Control and Prevention (CDC), National Center for Health Statistics (NCHS), Division of Vital Statistics (DVS). Linked Birth / Infant Death Records 1995-2016, as compiled from data provided by the 57 vital statistics jurisdictions through the Vital Statistics Cooperative Program, on CDC WONDER Online Database. Variables: Infant birth characteristics: gestational age, birth weight, birth order, and multiple birth. Maternal demographics: age, marital status, race/ethnicity, and educational status. Maternal delivery factors: month prenatal care began, and delivery characteristics (infant birthplace, medical birth attendant, and infant delivery method).

Information from death certificates was linked to corresponding birth certificates. Data were available by county of mother's residence, child's age, underlying cause of death, gender, birth weight, birth plurality, birth order, gestational age at birth, period of prenatal care, maternal race and ethnicity, maternal age, maternal education, and marital status. A privacy policy effective May 23, 2011 showed all subnational data representing zero to nine deaths or births as suppressed. The population consisted of infants born in regions with a region code and number of births: Census Region 1: Northeast 2,520,616; Census Region 2: Midwest 3,332,027; Census Region 3: South 6,131,086, and Census

Region 4: West 3,860,900 for a total of 15,844,629. The population comprising the data set included live births in the United States for the years 2013-2016. The rate of SUID was calculated as 39.85 deaths per 100,00 live births as queried on February 16, 2019. Each birth record represented one living baby.

Data Analysis Plan

As with any data analysis the researcher anticipated the potential to require data screening and cleaning (Dziadkowiec, Callahan, Ozkaynak, Reeder, & Welton, 2016). SPSS v 25 was used to analyze the data. Several of the covariates of interest contained missing values. Because records with missing values are excluded from regression analyses, imputation of missing values generally produced less biased results and was used as recommended. In preparation for conducting the multivariate analyses, multiple imputation to ascribe missing values was used. An important assumption was that some data was missing completely at random (MCAR) therefore there was the probability of missing data on the dependent variable unrelated to other independent variables as well as the dependent variable itself (Peugh & Enders, 2004). Listwise removed all data for a case that had one or more missing values. The WONDER database provided imputed or considered cases via an algorithmic method. Pairwise deletion on the other hand attempted to minimize the loss that occurs in listwise deletions by measuring the strength of the relationship between two variables. Simply, for each pair of variables for which data was available, the correlation coefficient took that data into account, maximizing all data available. This increased the power of the analyses and assumed the missing data were MCAR. The disadvantage was the standard of errors computed by most software packages uses the average sample size across analyses which produce standard of errors that are underestimated or overestimated. This study mitigated that using the full population of infants that died related to SUID (Little, 1992; Marsh, 1998; Wothke, 1993; Peugh, 2004; Bollen & Long (Eds.).

The research questions that guided the study were:

RQ1: In the U.S., for the years 2013-2016, to what extent do infant birth characteristics (gestational age, birth weight, birth order, and multiple birth) predict the occurrence of Sudden Unexpected Infant Death (SUID)?

$H_0$1 In the U.S., for the years 2013-2016, infant birth characteristics (gestational age, birth weight, birth order, and multiple birth) do not predict the occurrence of Sudden Unexpected Infant Death (SUID)?

H_a1 In the U.S., for the years 2013-2016, infant birth characteristics (gestational age, birth weight, birth order, and multiple birth) predict the occurrence of Sudden Unexpected Infant Death (SUID)?

RQ2: In the U.S., for the years 2013-2016, to what extent do maternal demographics of age, marital status, race, education, maternal delivery factors (month prenatal care began, medical birth attendant, infant birthplace, and infant delivery method) predict the occurrence of Sudden Unexpected Infant Death (SUID)?

$H_0$2 In the U.S., for the years 2013-2016, maternal demographics of age, marital status, race, education, maternal delivery factors (month prenatal care began, medical birth attendant, infant birthplace, and infant delivery method) do not predict the occurrence of Sudden Unexpected Infant Death (SUID)?

*H*a2 In the U.S., for the years 2013-2016, maternal demographics of age, marital status, race, education, maternal delivery factors (month prenatal care began, medical birth attendant, infant birthplace, and infant delivery method) predict the occurrence of Sudden Unexpected Infant Death (SUID)?

The statistical test used to answer the two research questions was logistic regression. Logistic regression did not require a linear relationship between the dependent and independent variables, the error terms did not need to be normally distributed, homoscedasticity was not required, and finally, the dependent variable in logistic regression was not measured on an interval or ratio scale. Assumptions that applied: 1) the dependent variable was binary with independent variables that are categorical; 2) observations were independent of each other; 3) little or no multicollinearity (not too highly correlated) among the independent variables; and 4) linearity of independent variables. This analysis did not require the dependent and independent variables be related linearly, it did require the independent variables be linearly related to the odds, and a large sample size (population minimum of 10 cases) was met. The interpretation of the odds ratio showed how much it deviated from 1, for example., an odds ratio of 0.75 meant that in one group the outcome is 25% less likely; an odds ratio of 1.33 meant that in one group the outcome was 33% more likely. With an odds ratio less than 1, a reversal of the foregoing or restructured coding of the response variable was needed to get the odds ratio larger than 1, prior to establishing an interpretation. Results were deemed statistically significant if the *p* value was less than or equal to .05, in which case the null hypothesis was rejected.

Threats to Validity

Any factors that could affect the SUID study results and generalization were considered threats and had the potential to lead to false results. The specific aspects of the research problem addressed in the study were the independent, dependent, and covariate variables of SUID with a focus on specific combinations of infant and mother traits that were chosen to validate the potential for prediction, reduction, and elimination of SUID in the United States. This study's boundaries were specific to 1) a 4-year period from 2013-2016, 2) CDC SUID reports for only the United States, 3) infants 1 year or less in age, and 4) the mothers of the specified infants. Study results were said to be generalized if there was a fit and potential for use in the current study on SUID that can be applied to the infants and their mothers.

Internal Validity

Threats to internal validity appropriate to this study included testing, statistical regression, experimental mortality, and selection-maturation interaction. Internal validity was concerned with minimizing the effects of extraneous or confounding factors that interfered with interpretation of the results of the study (Campbell & Stanley, 1963; Cook & Campbell, 1979; Tappen, 2015). The threat to internal validity, when the terms reliability and validity were used to define rigor further as credibility and dependability (internal validity), transferability (external validity), dependability (reliability), and confirmability (objectivity) (Cook & Campbell, 1979).

External Validity

Threats to external validity (for example, testing reactivity, interaction effects of selection and experimental variables, specificity of variables, reactive effects of experimental arrangements, and multiple-treatment interference, as appropriate to a study) and how they were addressed as essential components. These factors could affect results and generalization of the results. Statistically, anything that may lead to a false result is a threat to the validity of the study. The use of a cross-sectional, quantitative design using a key independent and dependent variables for the SUID study in infants focused on the extent to which infant birth characteristics (month prenatal care began, gestational age, birth weight, birth place, birth order, multiple birth, medical attendant, and delivery method) when taken in combinations with the most common maternal demographics (age, marital status, race, and education) predicted the occurrence of SUID in infants. A threat to the external validity of the SUID study manifested in how the study's findings and explanations are generalizable. The generalizability was limited because the effect of one factor, in essence the independent variable SUID, depended on other factors. Therefore, all threats to external validity were described as statistical interactions. Certain variables (characteristics) interacted with the independent variable, limiting generalizability. For example, the infant that had other co-morbidities concurrent with any number of medical disorders that rendered the external validity of the study to be limited. All situational specific variables of a study potentially limit generalizability. A study's external validity is limited by its internal validity. If a causal inference made within a study is invalid, then generalizations of that inference to other contexts are also invalid.

Sampling bias was an important variant of the external validity problem that dealt with selection bias created when studies were conducted on non-representative samples of the intended population. The researcher wanted to know whether the results generalized to the entire population, where attributes such as age and educational status differ substantially from those of a typical member of the population. Pearl and Bareinboim (2014; 2019) cited the graph-based method of conditions under which sample selection bias can be circumvented and, when these conditions are met, the method constructs an unbiased estimator of the average causal effect in the entire population. One such instance of selection bias is ethnicity, according to Kroll et al. (2018), the main difference between generalization from improperly sampled studies and generalization across disparate populations was that disparities among populations are usually caused by preexisting factors, such as age or ethnicity.

Statistical Conclusion Validity

Type 1 and Type 2 errors are a part of any testing process, perfect validity does not exist therefore 100% certainty that a study's conclusions are correct is not possible. Statistical Conclusion Validity (SCV) refers to the formulation of reasonable conclusions based on the data. Threats to SCV can lead to incorrect conclusions about relationships. Threats include: 1) Fishing [mining the data and repeating tests to find significance], 2) Results incorrectly concluding there is a relationship when in fact there is not, 3) Low statistical power that incorrectly conclude there is no relationship between variables, 4)

Poor reliability of treatment implementation when standard procedures and protocols are not used leading to underestimated effects, 5) Random irrelevancies in the setting or any distraction, 6) Restriction of range that lead to incorrect estimates, 7) Unreliable measures that results in over- or underestimating the size of the relationship between variables, and 8) Violated assumptions for tests that cause a multitude of problems including over- or underestimating effects. Research validity was used to analyze research and test designing experiments and analyzes data using a model comparison perspective (Westfall & Yarkoni, 2016; Maxwell, Delaney, & Kelley, 2017).

Ethical Procedures

Prior to any data analysis, Walden University's Institutional Review Board [IRB] approved this study (IRB approval # 10-18-19-0295633). Agreements to gain access to a secondary data set was not required as the CDC's WONDER secondary data base was used. It is a free access, public data base requiring no written permission. The only request was that the data base be properly cited in presentations and research papers. There were no human participants in this SUID study or ethical concerns related to data collection as described in the secondary data set materials such as participants refusing participation or early withdrawal from the study and response to any predictable adverse events because the SUID study used a secondary data set and no human participants. There were no personal identifiers, therefore the database was anonymous and confidential. Data from the CDC WONDER data set contained deidentified data. The procedure for data storage, dissemination, access, and timing of data destructions included electronically maintaining and storing the data on a personal computer with a unique user identification and was password protected. The data will be protected in this manner for five years and then destroyed. The student is the only person with access to the actual extracted data for this study.

Summary

Sudden unexpected infant death (SUID) is a world health issue. In the United States numerous studies attempted to determine combinations of risk factors related to the infant. Likewise, various studies attempted to determine combinations of risk factors related to the mother of an infant at high risk for SUID. This study used the CDC's WONDER database of infant deaths at less than 365 days diagnosed as SUID related. The design and methodology of the process of inquiry was the quantitative research study approach. This study's uniqueness was in studying distinct combinations of both the infant's characteristics and the mother's common demographics as predictors of infants most at risk for SUID. The information learned may provide insight into saving infant lives, or at the minimum reduce the risk of SUID. The study spanned the years 2013-2016 for infant birth characteristics (gestational age, birth weight, birth order, and multiple birth) and mother common demographics (age, marital status, race, and education), month prenatal care began, and delivery characteristics (infant birthplace, medical birth attendant, and infant delivery method) that have the potential to predict the occurrence of SUID. The ultimate decrease in incidences and the approach of the loftier goal of eliminating SUID is promising. Data were analyzed using logistic regression. Section 3 consisted of the SUID study presentation of the results and findings including a detailed explanation of the data collection from the secondary data set.

Section 3: Presentation of the Results and Findings

The purpose of this cross-sectional quantitative study was to examine the extent to which infant birth characteristics (gestational age, birth weight, birth order, multiple birth), delivery characteristics (infant birthplace, medical attendant, delivery method), month prenatal care began, and maternal demographics (age, marital status, race, education) predicted the occurrence of SUID. This study was guided by two research questions that targeted a U.S. population for the years 2013-2016. The results included baseline descriptive statistics, demographic characteristics of the representative population, basic univariate analyses, evaluation of the statistical assumptions, statistical analysis organized by research question with associated hypotheses, and statistics including associated probability values and confidence intervals.

Data Collection

Data were collected from the CDC WONDER data set for the years 2013 through 2016. There were no deviations from the study plan presented in Section 2 relative to the data set. Because nonprobability sampling is used to support external validity, the proportion of the sample population to the larger population includes statistics to describe the participants in a study so that readers can assess the generalizability of the study findings to their clinical practice (Pickering, 2017). Table 2 shows the death, births, and death rates due to SUID from 2013-2016 (CDC, 2019).

Justification for the inclusion of covariates in the analysis was represented by the fact that there were two distinct groups, infants and their mothers, that were likely to differ. Primary analysis controlled for many predictors of the outcome of SUID and was carried out irrespective of any differences, or lack of them, between study groups. Infants included in the study were those who made up the category of SUID. Infant deaths were coded by autopsy as sudden infant death, an unknown cause, accidental suffocation, or strangulation in bed. The cause of death was determined by a death scene investigation or a complete postmortem examination that included histology, microbiology, toxicology, and a multidisciplinary medical review (CDC, n.d.c).

Results

Data for SUID were analyzed from the CDC WONDER database for the years 2013-2016 using SPSS Version 25.0. Descriptive statistics are provided in Table 2 and Table 3. Table 2 shows the frequency of occurrence of SUID by U.S. region. Table 3 shows SUID deaths by type by year for 2013-2016.

Table 2

SUID Deaths, Births, and Death Rates by Region 2013-2016

Census region	Deaths	Births	Death rates per 100,000
Census region 1: northeast	530	2,520,616	21.03
Census region 2: midwest	1,915	3,332,027	54.47
Census region 3: south	2,864	6,131,086	46.71
Census region 4: west	1,005	3,860,900	26.03
Total	6,314	15,844,629	39.85

Source: United States Department of Health and Human Services (US DHHS), Centers for Disease Control and Prevention (CDC), National Center for Health Statistics (NCHS), Division of Vital Statistics (DVS). Linked Birth / Infant Death Records 2013-2016, as compiled from data provided by the 57 vital statistics jurisdictions through the Vital Statistics Cooperative Program, on CDC WONDER Online Database flat files.

Table 3

SUID Deaths by Type by Year 2013-2016

Cause of death by year 2013-2016	Year 2013	Year 2014	Year 2015	Year 2016
Sudden infant death syndrome (SIDS)	1556	1536	1583	1494
Unattended death, unknown cause	1040	1077	1184	1238
Accidental suffocation and strangulation in bed (ASSB)	815	855	918	857
Total	3411	3468	3685	3589
4-Year total = 14,153				

Source: United States Department of Health and Human Services (US DHHS), Centers for Disease Control and Prevention (CDC), National Center for Health Statistics (NCHS), Division of Vital Statistics (DVS). Linked Birth / Infant Death Records 2013-2016, as compiled from data provided by the 57 vital statistics jurisdictions through the Vital Statistics Cooperative Program, on CDC WONDER Online Database flat files.

Data Analysis for Research Questions - Year 2013

RQ1: In the United States, for the year 2013, to what extent do infant birth characteristics (gestational age, birth weight, birth order, and multiple birth) predict the occurrence of SUID?

A logistic regression was performed with SUID as the dependent variable and infant birth characteristics as the predictor variables. A total of 22,738 (97.83%) cases were analyzed (see Table 4) and the full model significantly predicted SUID (χ^2= 4793.574, df = 23,237, p < .001), as shown in Table 5. Therefore, the null hypothesis was rejected. Table 5 shows the model accounted for between 21% (Cox & Snell R^2) and 36% (Nagelkerke R^2) of the variance in SUID, with 99.87% of non-SUID successfully predicted (see Table 6). However, .68% of the predictions for SUID were accurate (see Table 6). Overall, 85.11% of the predictions were accurate (see Table 6). Table 7 gives the coefficients and the Wald statistic and associated degrees of freedom and probability values for each of the predictor variables. Findings showed that only infant's gestational age, birth weight, and birth order reliably predicted SUID. The values of the coefficients revealed that an increase in infant's gestational age was associated with a decrease in the odds of SUID by a factor of .97 (95% CI -.04 and -.03), that an increase in infant's birth weight was associated with an increase in the odds of SUID by a factor of 5.81 (95% CI 1.70 and 1.83), and that an increase in infant's birth order (plurality) was associated with an increase in the odds of SUID by a factor of 1.14 (95% CI -.02 and .28), as shown in Table 7.

Table 4

RQ1 2013 Case Processing Summary

Unweighted cases	N	Percent
Included in analysis	22738	97.38
Missing cases	504	2.17
Total	23242	100.00

Table 5

RQ1 2013 Model Summary

Step 1	χ^2	*df*	*p*	Cox & Snell R^2	Nagelkerke R^2
Model	4793.57	23237	<.001	.21	.36

Table 6

RQ1 2013 Classification Table

			Predicted		
			SUID		Percentage
	Observed		No	Yes	correct
Step 1	SUID	No	19329	26	99.87
		Yes	3360	23	.68
	Overall percentage				85.11

Table 7

RQ1 2013 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% CI for Exp(B) Lower	Upper
Step 1	Infant's gestational age	-.04	.002	165.38	1	<.001	.97	-.04	-.03
	Infant's birth weight	1.76	.03	2580.69	1	<.001	5.81	1.70	1.83
	Infant's birth order	.08	.01	44.21	1	<.001	1.09	.06	.11
	Infant's multiple birth (plurality)	.13	.08	2.64	1	.083	1.14	-.02	.28
	Constant	-5.88	.14	1595.63	1	<.001	.003	-6.15	-5.60

RQ2: In the United States, for the year 2013, to what extent do maternal characteristics (age, marital status, race, and education), month prenatal care began, and delivery characteristics (infant birthplace, medical birth attendant, and infant delivery method) predict the occurrence of SUID?

A logistic regression was performed with SUID as the dependent variable and maternal characteristics, month prenatal care began, and delivery characteristics as the predictor variables. A total of 19,957 (85.87%) cases were analyzed (see Table 8) and the full model significantly predicted SUID (χ^2= 788.54, *df* = 20908, $p < .001$), as shown in Table 9. Therefore, the null hypothesis was rejected. Table 9 shows the model accounted for between 4% (Cox & Snell R^2) and 6% (Nagelkerke R^2) of the variance in SUID, with 100% of non-SUID successfully predicted (see Table 10). However, 0% of the predictions for SUID were accurate (see Table 10). Overall, 85.19% of the predictions were accurate (see Table 10). Table 11 gives the coefficients and the Wald statistic and associated degrees of freedom and probability values for each of the predictor variables.

Findings showed that all predictors in the model reliably predicted SUID. The values of the coefficients revealed that

1. An increase in mother's age was associated with a decrease in the odds of SUID by a factor of .96 (95% CI -.05 and -.03).
2. Married mothers were .65 times less likely to be associated with SUID compared to unmarried mothers (95% CI -.52 and -.33).
3. White (single race) mothers were 1.14 times more likely to be associated with SUID compared to non-White (single race) mothers (95% CI .04 and .21).
4. An increase in mother's educational status was associated with a decrease in the odds of SUID by a factor of .87 (95% CI -.16 and -.11).
5. Mothers whose prenatal care began 1^{st} to 3^{rd} month of pregnancy were .86 times less likely to be associated with SUID compared to mothers whose prenatal care began 4^{th} to 6^{th} month of pregnancy and later (95% CI -.23 and -.07).
6. Mothers whose infant's birthplace was a hospital were 2.56 times more likely to be associated with SUID compared to mothers whose infant's birthplace was not a hospital (95% CI .55 and 1.33).
7. Mothers whose medical birth attendant was an MD were .67 times less likely to be associated with SUID compared to mothers whose birth attendant was not an MD (95% CI -.52 and -.28).
8. Mothers whose infant delivery method was vaginal (excludes vaginal after previous C-section) were 1.23 times more likely to be associated with SUID

compared to mothers whose infant delivery method was not vaginal (includes vaginal after previous C-section; 95% CI -1.19 and -.33).

Table 8

RQ2 2013 Case Processing Summary

Unweighted cases	N	Percent
Included in analysis	19957	85.87
Missing cases	3285	14.13
Total	23242	100.00

Table 9

RQ2 2013 Model Summary

Step 1	χ^2	*df*	*p*	Cox & Snell R^2	Nagelkerke R^2
Model	788.54	20908	<.001	.04	.06

Table 10

RQ2 2013 Classification Table

			Predicted		
			SUID		Percentage
	Observed		No	Yes	correct
Step 1	SUID	No	17001	0	100.00
		Yes	2956	0	.00
	Overall percentage				85.19

Table 11

RQ2 2013 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% CI for Exp(B) Lower	Upper
Step 1	Mother's age	-.04	.004	110.73	1	<.001	.96	-.05	-.03
	Mother's marital status	-.43	.05	78.90	1	<.001	.65	-52	-.33
	Mother's race/ethnicity	.13	.04	8.71	1	.003	1.14	.04	.21
	Mother's educational status	-.14	.01	105.71	1	<.001	.87	-.16	-.11
	Mother's month prenatal care began	-.15	.04	13.27	1	<.001	.86	-.23	-.07
	Mother's infant birthplace	.94	0.20	22.61	1	<.001	2.56	.55	1.33
	Mother's medical birth attendant	-40	.06	43.33	1	<.001	.67	-.52	-.28
	Mother's infant delivery method	.21	.04	24.68	1	<.001	1.23	.13	.29
	Constant	-.76	.22	12.16	1	<.001	.47	-1.19	-.33

Data Analysis for Research Questions - Year 2014

RQ1: In the United States, for the year 2014, to what extent do infant birth characteristics (gestational age, birth weight, birth order, and multiple birth) predict the occurrence of SUID?

A logistic regression was performed with SUID as the dependent variable and infant birth characteristics as the predictor variables. A total of 23,085 (100.00%) cases were analyzed (see Table 12) and the full model significantly predicted SUID (χ^2= 5024.618, *df* = 23,080, *p* < .001), as shown in Table 13. Therefore, the null hypothesis was rejected. Table 13 shows the model accounted for between 21% (Cox & Snell R^2) and 37% (Nagelkerke R^2) of the variance in SUID, with 99.67% of non-SUID successfully predicted (see Table 14). However, 1.21% of the predictions for SUID were accurate (see Table 14). Overall, 84.88% of the predictions were accurate (see Table 14).

Table 15 gives the coefficients and the Wald statistic and associated degrees of freedom and probability values for each of the predictor variables. Findings showed that all predictors in the model reliably predicted SUID. The values of the coefficients revealed that an increase in infant's gestational age was associated with a decrease in the odds of SUID by a factor of .97 (95% CI .96 and .97), that an increase in infant's birth weight was associated with an increase in the odds of SUID by a factor of 6.17 (95% CI 5.76 and 6.61), that an increase in infant's birth order was associated with an increase in the odds of SUID by a factor of 1.10 (95% CI 1.01 and 1.13), and that an increase in infant's multiple births (plurality) was associated with an increase in the odds of SUID by a factor of 1.39 (95% CI 1.20 and 1.60), as shown in Table 15.

Table 12

RQ1 2014 Case Processing Summary

Unweighted cases	N	Percent
Included in analysis	23085	100.00
Missing cases	0	.00
Total	23085	100.00

Table 13

RQ1 2014 Model Summary

Step 1	χ^2	*Df*	*p*	Cox & Snell R^2	Nagelkerke R^2
Model	5024.618	23080	<.001	.21	.37

Table 14

RQ1 2014 Classification Table

			Predicted		
			SUID		Percentage correct
	Observed		No	Yes	
Step 1	SUID	No	19553	64	99.67
		Yes	3426	42	1.21
	Overall percentage				84.88

Table 15

RQ1 2014 Variables in the Equation

								95% CI for Exp(B)	
		B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Step 1	Infant's gestational age	-.03	.003	159.609	1	<.001	.97	.96	.97
	Infant's birth weight	1.82	.04	2712.536	1	<.001	6.17	5.76	6.61
	Infant's birth order	.09	.01	55.078	1	<.001	1.10	1.07	1.13
	Infant's multiple birth (plurality)	.33	.07	20.162	1	<.001	1.39	1.20	1.60
	Constant	-6.24	.14	1916.729	1	<.001	.002	.001	.003

RQ2: In the U.S., for the year 2014, to what extent do maternal characteristics (age, marital status, race, and education), month prenatal care began, and delivery characteristics (infant birthplace, medical birth attendant, and infant delivery method) predict the occurrence of SUID?

A logistic regression was performed with SUID as the dependent variable and maternal characteristics, month prenatal care began, and delivery characteristics as the predictor variables. A total of 21,325 (92.38%) cases were analyzed (Table 16) and the full model significantly predicted SUID (χ^2= 919.206, *df* = 22229, p < .001) (Table 17). Thus, the null hypothesis is rejected. Table 17 shows the model accounted for between 4% (Cox & Snell R^2) and 7% (Nagelkerke R^2) of the variance in SUID, with 100% of non-SUID successfully predicted (Table 18). However, 0% of the predictions for SUID were accurate (Table 18). Overall, 84.71% of the predictions were accurate (Table 18). Table 19 gives the coefficients and the Wald statistic and associated degrees of freedom and probability values for each of the predictor variables. This shows that all predictors in the model reliably predicted SUID. The values of the coefficients reveal:

1. that an increase in mother's age is associated with a decrease in the odds of SUID by a factor of .96 (95% CI .95 and .97),
2. Married mothers were .68 times less likely to be associated with SUID compared to unmarried mothers (95% CI .62 and .74),
3. White (single race) mothers were 1.12 times more likely to be associated with SUID compared to non-White mothers (95% CI 1.03 and 1.21),
4. that an increase in mother's educational status is associated with a decrease in the odds of SUID by a factor of .86 (95% CI .84 and .89),
5. Mothers who had no prenatal visits were .48 times less likely to be associated with SUID compared to mothers who had 1 or more prenatal visits (95% CI .40 and .57),
6. Mothers whose infant's birthplace was a hospital were 1.77 times more likely to be associated with SUID compared to mothers whose infant's birthplace was not a hospital (95% CI 1.25and 2.51),
7. Mothers whose medical birth attendant was a Doctor of Medicine (MD) were .64 times less likely to be associated with SUID compared to mothers whose birth attendant was not a Doctor of Medicine (MD) (95% CI .57and .72), and

8. Mothers whose infant delivery method was vaginal (excludes vaginal after previous C-section) were 1.31 times more likely to be associated with SUID compared to mothers whose infant delivery method was not vaginal (includes vaginal after previous C-section) (95% CI 1.21 and 1.42).

Table 16

RQ2 2014 Case Processing Summary

Unweighted cases	N	Percent
Included in analysis	21325	92.38
Missing cases	1760	7.62
Total	23085	100.00

Table 17

RQ2 2014 Model Summary

Step 1	χ^2	*df*	*p*	Cox & Snell R^2	Nagelkerke R^2
Model	919.21	22229	<.001	.04	.06

Table 18

RQ2 2014 Classification Table

			Predicted		
			SUID		Percentage correct
	Observed		No	Yes	
Step 1	SUID	No	18065	0	100.00
		Yes	3260	0	.00
	Overall percentage				84.71

Table 19

RQ2 2014 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% CI for Exp(B) Lower	Upper
Step 1	Mother's age	-.04	.004	135.47	1	<.001	.96	.95	.97
	Mother's marital status	-.39	.05	72.80	1	<.001	.68	.62	.74
	Mother's race/ethnicity	.11	.04	7.27	1	.007	1.12	1.03	.1.21
	Mother's educational status	-.15	.01	128.58	1	<.001	.86	.84	.89
	Mother's month prenatal care began	-.74	.09	65.52	1	<.001	.48	.40	.57
	Mother's infant birthplace	.57	0.18	10.42	1	.001	1.77	1.25	2.51
	Mother's medical birth attendant	-.44	.06	59.95	1	<.001	.64	.57	.72
	Mother's infant delivery method	.27	.04	44.60	1	<.001	1.31	1.21	1.42
	Constant	-.30	.20	2.22	1	.136	.74	.50	1.10

Data Analysis for Research Questions - Year 2015

RQ1: In the U.S., for the year 2015, to what extent do infant birth characteristics (gestational age, birth weight, birth order, and multiple birth) predict the occurrence of Sudden Unexpected Infant Death (SUID)?

$H_0$1 In the U.S., for the year 2015, infant birth characteristics do not predict the occurrence of SUID.

H_a1 In the U.S., for the year 2015, infant birth characteristics predict the occurrence of SUID.

A logistic regression was performed with SUID as the dependent variable and infant birth characteristics as the predictor variables. A total of 23,347 (100.00%) cases were analyzed (Table 20) and the full model significantly predicted SUID (χ^2= 5275.035, df = 23,342, p < .001) (Table 21). Thus, the null hypothesis is rejected. Table 21 shows the model accounted for between 22% (Cox & Snell R^2) and 38% (Nagelkerke R^2) of the variance in SUID, with 99.35% of non-SUID successfully predicted (Table 22). However, 3.87% of the predictions for SUID were accurate (Table 22). Overall, 84.36% of the predictions were accurate (Table 22). Table 23 gives the coefficients and the Wald statistic and associated degrees of freedom and probability values for each of the predictor variables. This shows that all predictors in the model reliably predicted SUID. The values of the coefficients reveal:

1. that an increase in infant's gestational age is associated with a decrease in the odds of SUID by a factor of .97 (95% CI .96 and .97),
2. that an increase in infant's birth weight is associated with an increase in the odds of SUID by a factor of 6.18 (95% CI 5.78 and 6.61),
3. that an increase in infant's birth order is associated with an increase in the odds of SUID by a factor of 1.10 (95% CI 1.07 and 1.12),
4. and that an increase in infant's multiple births (plurality) is associated with an increase in the odds of SUID by a factor of 1.20 (95% CI 1.03 and 1.40) (Table 23).

Table 20

RQ1 2015 Case Processing Summary

Unweighted cases	N	Percent
Included in analysis	23347	100.00
Missing cases	0	.00
Total	23347	100.00

Table 21

RQ1 2015 Model Summary

Step 1	χ^2	*Df*	*p*	Cox & Snell R^2	Nagelkerke R^2
Model	5275.035	23342	<.001	.22	.38

Table 22

RQ1 2015 Classification Table

			Predicted		
			SUID		Percentage correct
	Observed		No	Yes	
Step 1	SUID	No	19554	128	99.35
		Yes	3523	142	3.87
	Overall percentage				84.36

Table 23

RQ1 2015 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% CI for Exp(B) Lower	95% CI for Exp(B) Upper
Step 1	Infant's gestational age	-.03	.003	180.55	1	<.001	.97	.96	.97
	Infant's birth weight	1.82	.03	2841.96	1	<.001	6.18	5.78	6.61
	Infant's birth order	.09	.01	56.53	1	<.001	1.10	1.07	1.12
	Infant's multiple birth (plurality)	.18	.08	5.28	1	.022	1.20	1.03	1.40
	Constant	-6.04	.14	1781.56	1	<.001	.002	.002	.003

RQ2: In the U.S., for the year 2015, to what extent do maternal characteristics (age, marital status, race, and education), month prenatal care began, and delivery characteristics (infant birthplace, medical birth attendant, and infant delivery method) predict the occurrence of SUID?

$H_0$2 In the U.S., for the year 2015, maternal characteristics, month prenatal care began, and delivery characteristics do not predict the occurrence of SUID.

H_a2 In the U.S., for the year 2015, maternal characteristics, month prenatal care began, and delivery characteristics predict the occurrence of SUID.

A logistic regression was performed with SUID as the dependent variable and maternal characteristics, month prenatal care began, and delivery characteristics as the predictor variables. A total of 22,944 (98.27%) cases were analyzed (Table 24) and the full model significantly predicted SUID (χ^2= 971.821, df = 22935, p < .001) (Table 25). Thus, the null hypothesis is rejected. Table 25 shows the model accounted for between 4% (Cox & Snell R^2) and 7% (Nagelkerke R^2) of the variance in SUID, with 100% of non-SUID successfully predicted (Table 26). However, 0% of the predictions for SUID were accurate (Table 26). Overall, 84.30% of the predictions were accurate (Table 26). Table 27 gives the coefficients and the Wald statistic and associated degrees of freedom and probability values for each of the predictor variables. This shows that all predictors (except for Mother’s race/ethnicity) in the model reliably predicted SUID. The values of the coefficients reveal:

1. that an increase in mother’s age is associated with a decrease in the odds of SUID by a factor of .96 (95% CI .95 and .97),
2. Married mothers were .63 times less likely to be associated with SUID compared to unmarried mothers (95% CI .58 and .68),
3. that an increase in mother’s educational status is associated with a decrease in the odds of SUID by a factor of .86 (95% CI .84 and .88),

4. Mothers who had no prenatal visits were .46 times less likely to be associated with SUID compared to mothers who had 1 or more prenatal visits (95% CI .39 and .55),
5. Mothers whose infant's birthplace was a hospital were 2.01 times more likely to be associated with SUID compared to mothers whose infant's birthplace was not a hospital (95% CI 1.42 and 2.83),
6. Mothers whose medical birth attendant was a Doctor of Medicine (MD) were .70 times less likely to be associated with SUID compared to mothers whose birth attendant was not a Doctor of Medicine (MD) (95% CI .63 and .78), and
7. Mothers whose infant delivery method was vaginal (excludes vaginal after previous C-section) were 1.24 times more likely to be associated with SUID compared to mothers whose infant delivery method was not vaginal (includes vaginal after previous C-section) (95% CI 1.15 and 1.34).

Table 24

RQ2 2015 Case Processing Summary

Unweighted cases	N	Percent
Included in analysis	22944	98.27
Missing cases	403	1.73
Total	23347	100.00

Table 25

RQ2 2015 Model Summary

Step 1	χ^2	*df*	*p*	Cox & Snell R^2	Nagelkerke R^2
Model	971.821	22935	<.001	.04	.07

Table 26

RQ2 2015 Classification Table

			Predicted		
			SUID		Percentage
	Observed		No	Yes	correct
Step 1	SUID	No	19341	0	100.00
		Yes	3603	0	.00
	Overall percentage				84.30

Table 27

RQ2 2015 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% CI for Exp(B) Lower	Upper
Step 1	Mother's age	-0.04	0.00	127.39	1	< .001	0.96	0.96	0.97
	Mother's marital status	-0.47	0.04	113.99	1	< .001	0.63	0.58	0.68
	Mother's race/ethnicity	0.04	0.04	1.09	1	0.296	1.04	0.97	1.13
	Mother's educational status	-0.15	0.01	138.98	1	< .001	0.86	0.84	0.88
	Mother's month prenatal care began	-0.77	0.09	76.31	1	< .001	0.46	0.39	0.55
	Mother's infant birthplace	0.70	0.18	15.80	1	< .001	2.01	1.42	2.83
	Mother's medical birth attendant	-0.35	0.06	40.95	1	< .001	0.70	0.63	0.78
	Mother's infant delivery method	0.21	0.04	30.69	1	< .001	1.24	1.15	1.34
	Constant	-0.40	0.20	4.15	1	0.042	0.67	0.45	0.99

Data Analysis for Research Questions - Year 2016

RQ1: In the U.S., for the year 2016, to what extent do infant birth characteristics (gestational age, birth weight, birth order, and multiple birth) predict the occurrence of Sudden Unexpected Infant Death (SUID)?

$H_0$1 In the U.S., for the year 2016, infant birth characteristics do not predict the occurrence of SUID.

H_a1 In the U.S., for the year 2016, infant birth characteristics predict the occurrence of SUID.

A logistic regression was performed with SUID as the dependent variable and infant birth characteristics as the predictor variables. A total of 23,079 (100.00%) cases were analyzed (Table 28) and the full model significantly predicted SUID (χ^2= 4752.59, *df* = 23,074, $p < .001$) (Table 29). Thus, the null hypothesis is rejected. Table 29 shows the model accounted for between 21% (Cox & Snell R^2) and 36% (Nagelkerke R^2) of the variance in SUID, with 99.33% of non-SUID successfully predicted (Table 30). However, 3.96% of the predictions for SUID were accurate (Table 30). Overall, 84.50% of the predictions were accurate (Table 30). Table 31 gives the coefficients and the Wald statistic and associated degrees of freedom and probability values for each of the predictor variables. This shows that all predictors in the model reliably predicted SUID. The values of the coefficients reveal:

1. that an increase in infant's gestational age is associated with a decrease in the odds of SUID by a factor of .97 (95% CI .96 and .97),
2. that an increase in infant's birth weight is associated with an increase in the odds of SUID by a factor of 5.65 (95% CI 5.29 and 6.03),
3. that an increase in infant's birth order is associated with an increase in the odds of SUID by a factor of 1.09 (95% CI 1.06 and 1.11),
4. and that an increase in infant's multiple births (plurality) is associated with an increase in the odds of SUID by a factor of 1.40 (95% CI 1.21 and 1.61) (Table 31).

Table 28

RQ1 2016 Case Processing Summary

Unweighted cases	N	Percent
Included in analysis	23079	100.00
Missing cases	0	.00
Total	23079	100.00

Table 29

RQ1 2016 Model Summary

Step 1	χ^2	*Df*	*p*	Cox & Snell R^2	Nagelkerke R^2
Model	4752.59	23074	<.001	.21	.36

Table 30

RQ1 2016 Classification Table

			Predicted		
			SUID		Percentage
	Observed		No	Yes	correct
Step 1	SUID	No	19360	130	99.33
		Yes	3447	142	3.96
	Overall percentage				84.50

Table 31

RQ1 2016 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% CI for Exp(B) Lower	Upper
Step 1	Infant's gestational age	-0.03	0.00	173.60	1	<.001	0.97	0.96	0.97
	Infant's birth weight	1.73	0.03	2676.92	1	<.001	5.65	5.29	6.03
	Infant's birth order	0.08	0.01	44.04	1	<.001	1.09	1.06	1.11
	Infant's multiple birth (plurality)	0.33	0.07	21.08	1	<.001	1.40	1.21	1.61
	Constant	-6.04	.14	1895.76	1	<.001	.003	.002	.003

RQ2: In the U.S., for the year 2016, to what extent do maternal characteristics (age, marital status, race, and education), month prenatal care began, and delivery characteristics (infant birthplace, medical birth attendant, and infant delivery method) predict the occurrence of SUID?

$H_0$2 In the U.S., for the year 2016, maternal characteristics, month prenatal care began, and delivery characteristics do not predict the occurrence of SUID.

H_a2 In the U.S., for the year 2016, maternal characteristics, month prenatal care began, and delivery characteristics predict the occurrence of SUID.

A logistic regression was performed with SUID as the dependent variable and maternal characteristics, month prenatal care began, and delivery characteristics as the predictor variables. A total of 23,060 (99.92%) cases were analyzed (Table 32) and the full model significantly predicted SUID (χ^2= 915.055, df = 23051, p < .001) (Table 33). Thus, the null hypothesis is rejected. Table 33 shows the model accounted for between 4% (Cox & Snell R^2) and 7% (Nagelkerke R^2) of the variance in SUID, with 100% of non-SUID successfully predicted (Table 34). However, 0% of the predictions for SUID were accurate (Table 34). Overall, 84.46% of the predictions were accurate (Table 34). Table 35 gives the coefficients and the Wald statistic and associated degrees of freedom and probability values for each of the predictor variables. This shows that all predictors (except for Mother's race/ethnicity) in the model reliably predicted SUID. The values of the coefficients reveal:

1. that an increase in mother's age is associated with a decrease in the odds of SUID by a factor of .96 (95% CI .96 and .97),
2. Married mothers were .65 times less likely to be associated with SUID compared to unmarried mothers (95% CI .60 and .71),
3. that an increase in mother's educational status is associated with a decrease in the odds of SUID by a factor of .86 (95% CI .84 and .49),
4. Mothers who had no prenatal visits were .48 times less likely to be associated with SUID compared to mothers who had 1 or more prenatal visits (95% CI .41 and .57),
5. Mothers whose infant's birthplace was a hospital were 1.48 times more likely to be associated with SUID compared to mothers whose infant's birthplace was not a hospital (95% CI 1.10 and 1.99),
6. Mothers whose medical birth attendant was a Doctor of Medicine (MD) were .75 times less likely to be associated with SUID compared to mothers whose birth attendant was not a Doctor of Medicine (MD) (95% CI .67 and .84), and
7. Mothers whose infant delivery method was vaginal (excludes vaginal after previous C-section) were 1.31 times more likely to be associated with SUID

compared to mothers whose infant delivery method was not vaginal (includes vaginal after previous C-section) (95% CI 1.22 and 1.41).

Table 32

RQ2 2016 Case Processing Summary

Unweighted cases	N	Percent
Included in analysis	23060	99.92
Missing cases	19	.08
Total	23079	100.00

Table 33

RQ2 2016 Model Summary

Step 1	χ^2	*df*	*p*	Cox & Snell R^2	Nagelkerke R^2
Model	915.055	23051	<.001	.04	.07

Table 34

RQ2 2016 Classification Table

			Predicted		
			SUID		Percentage
	Observed		No	Yes	correct
Step 1	SUID	No	19476	0	100.00
		Yes	3584	0	.00
	Overall percentage				84.46

Table 35

RQ2 2016 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% CI for Exp(B) Lower	Upper
Step 1	Mother's age	-0.04	0.00	120.33	1	< .001	0.96	0.96	0.97
	Mother's marital status	-0.44	0.04	100.75	1	< .001	0.65	0.60	0.71
	Mother's race/ethnicity	0.02	0.04	0.39	1	0.532	1.03	0.95	1.11
	Mother's educational status	-0.15	0.01	142.44	1	< .001	0.86	0.84	0.89
	Mother's month prenatal care began	-0.73	0.09	72.44	1	< .001	0.48	0.41	0.57
	Mother's infant birthplace	0.39	0.15	6.58	1	0.010	1.48	1.10	1.99
	Mother's medical birth attendant	-0.29	0.06	26.85	1	< .001	0.75	0.67	0.84
	Mother's infant delivery method	0.27	0.04	49.07	1	< .001	1.31	1.22	1.41
	Constant	-0.23	0.18	1.66	1	0.198	0.80	0.96	0.97

Table 36 summarizes the infant and mother variables by year distinguishing key findings and significance.

Table 36

Infant and Mother Variables Output Summary

	2013			2014			2015			2016		
Characteristics (variables) I = infant M = mother	B	*P* value	Exp (B)	B	*P* value	Exp (B)	B	*P* value	Exp (B)	B	*P* value	Exp (B)
Gestational age (I)	-.04	<.001	.97	-.03	<.001	.97	-.03	<.001	.97	-0.03	<.001	0.97
Birth weight (I)	1.76	<.001	5.81	1.82	<.001	6.17	1.82	<.001	6.18	1.73	<.001	5.65
Birth order (I)	.08	<.001	1.09	.09	<.001	1.10	.09	<.001	1.10	0.08	<.001	1.09
Multiple birth / plurality (I)	.13	.083	1.14	.33	<.001	1.39	.18	.022	1.20	0.33	<.001	1.40
Age (M)	-.04	<.001	.96	-.04	<.001	.96	-0.04	< .001	0.96	-0.04	< .001	0.96
Marital status (M)	-.43	<.001	.65	-.39	<.001	.68	-0.47	< .001	0.63	-0.44	< .001	0.65
Race/ethnicity (M)	.13	.003	1.14	.11	.007	1.12	0.04	0.296	1.04	0.02	0.532	1.03
Educational status (M)	-.14	<.001	.87	-.15	<.001	.86	-0.15	< .001	0.86	-0.15	< .001	0.86
Month prenatal care began (M)	-.15	<.001	.86	-.74	<.001	.48	-0.77	< .001	0.46	-0.73	< .001	0.48
Infant birthplace (M)	.94	<.001	2.56	.57	.001	1.77	0.70	< .001	2.01	0.39	0.010	1.48
Medical birth attendant (M)	-40	<.001	.67	-.44	<.001	.64	-0.35	< .001	0.70	-0.29	< .001	0.75
Delivery method (M)	.21	<.001	1.23	.27	<.001	1.31	0.21	< .001	1.24	0.27	< .001	1.31

Data analysis for research question one (2013), for variables related to infant characteristics of gestational age (*p* = <.001), birth weight (p = <.001), and birth order (p = <.001), were significant, therefore the null hypothesis was rejected, thereby reliably predicted SUID. An increase in infant’s gestational age was associated with a decrease in the odds of SUID, and an increase in infant’s birth weight was associated with increased odds of SUID, An increase in infant’s multiple birth (plurality) (*p* = .083) was not significant in the odds of SUID, therefore the null hypothesis was not rejected. For the same year, data analysis for research question two for variables related to maternal characteristics of age ($p = <.001$), marital status ($p = <.001$), education ($p = <.001$), month prenatal care began ($p = <.001$), and infant birthplace ($p = <.001$), medical birth attendant ($p = <.001$), and delivery method ($p = <.001$), were significant, therefore the null hypothesis was rejected. Race/ethnicity ($p = .003$), was not significant for SUID and therefore the null hypothesis was not rejected. As mother's age increased the odds of SUID decreased. Married mothers were less likely associated with SUID. White (single race) were more likely associated with SUID that non-White (single race) mothers. An increase in mother's educational status was associated with a decrease in the odds of SUID. When prenatal care began 1^{st} to 3^{rd} month of pregnancy it was less likely SUID occurred. When mothers gave birth in a hospital SUID was more likely. Mothers whose medical birth attendant was a Doctor of Medicine (MD) were less likely to be associated with SUID. Mothers whose infant delivery method was vaginal were more likely to be associated with SUID.

Data analysis for research question one (2014), for variables related to infant characteristics of gestational age ($p = <.001$), birth weight ($p = <.001$), birth order (p = <.001), and multiple birth/plurality ($p = <.001$), were significant, therefore the null hypothesis was rejected, thereby reliably predicted SUID. An increase in infant's gestational age, infant's birth weight, infant's birth order, and infant's multiple birth (plurality)were associated with an increase in the odds of SUID. For the same year (2014), data analysis for research question two for variables related to maternal characteristics of age ($p = <.001$), marital status ($p = <.001$), education ($p = <.001$), month prenatal care began (*p* = <.001), medical birth attendant (*p* = <.001), and delivery method (*p* = <.001), were significant, therefore the null hypothesis was rejected. Infant birthplace (*p* = .001) and race/ethnicity (*p* = .007), were not significant for SUID, therefore the null hypothesis was not rejected.

Data analysis for research question one (2015), for infant characteristics of gestational age (*p* = <.001), birth weight (*p* = <.001), and birth order (*p* = <.001), were significant, therefore the null hypothesis was rejected. Infant multiple birth (plurality) (*p* = <.022) was not significant for SUID, therefore the null hypothesis was not rejected. For the same year (2015), data analysis for research question two for variables related to maternal characteristics of age (*p* = <.001), marital status (*p* = <.001), education (*p* = <.001), month prenatal care began (*p* = <.001), infant birthplace (*p* = <.001), medical birth attendant (*p* = <.001), and delivery method (*p* = <.001), were significant for SUID, therefore the null hypothesis was rejected. Infant multiple birth (plurality) (*p* = <.022), and race/ethnicity (*p* = 0.296), were not significant for SUID, therefore the null hypothesis was not rejected. An increase in infant's gestational age is associated with a decrease in the odds of SUID. An increase in infant's birth weight, infant's birth order, and infant's multiple births (plurality) was associated with an increase in the odds of SUID. Mothers who had no prenatal visits were .46 times less likely to be associated with SUID. Mothers whose infant's birthplace was a hospital were 2.01 times more likely to be associated with SUID.

Data analysis for research question one (2016), for infant birth characteristics of gestational age (*p* = <.001), birth weight (*p* = <.001), birth order (*p* = <.001), and multiple birth (plurality) (*p* = <.001) showed an increase in infant's gestational age was associated with a decrease in the odds of SUID. An increase in infant's birth weight, infant's birth order, and infant's multiple births (plurality) was associated with an increase in the odds of SUID. During the same year, for research question two, maternal characteristics of maternal age (*p* = <.001), marital status (*p* = <.001), educational status (*p* = <.001), month prenatal care began (*p* = <.001), medical birth attendant (*p* = <.001), and delivery method (*p* = <.001) were significant for SUID, therefore the null hypothesis was therefore rejected. All maternal predictors, except for race/ethnicity and infant birthplace, reliably predicted SUID. An increase in mother's age was associated with a decrease in the odds of SUID. Married mothers, mothers with a higher educational status, mothers whose medical birth attendant was a medical doctor were less likely to be associated with SUID. Mothers that had no prenatal visits, whose infant's birthplace was a hospital, and infant delivery method was vaginal were more likely to be associated with SUID.

Summary

The CDC Wonder public service secondary dataset was used for this research to help determine the extent to which infant birth characteristics (gestational age, birth weight, birth order, multiple birth), delivery characteristics (infant birthplace, medical attendant, delivery method), month prenatal care began, and maternal demographics (age, marital status, race, education) predict the occurrence of SUID in infants. Full-term live births among a population of 15,844,629 yielded 6,167 SUID related deaths (38.93 deaths per 100,000) from 2013-2016. Results showed a significant relationship between infant gestational age (*p* = <.001), birth weight (*p* = <.001), birth order (*p* = <.001), maternal age (p = <.001), marital status (p = <.001), educational status (p = <.001), month prenatal care began (p = <.001), infant birthplace (p = <.001), medical birth attendant (p = <.001), delivery method (p = <.001), and occurrence of SUID. The fourth and final section of this study describes the application of the study to professional practice and inference for social change and includes an interpretation of findings, limitations, and recommendations.

Section 4: Application to Professional Practice and Implications for Social Change

The purpose of this cross-sectional quantitative study was to examine the extent to which infant birth characteristics (gestational age, birth weight, birth order, multiple birth), delivery characteristics (infant birthplace, medical attendant, delivery method), month prenatal care began, and maternal demographics (age, marital status, race, education) predicted the occurrence of SUID. Results showed a significant relationship between infant gestational age, birth weight, birth order, maternal age, marital status, educational status, month prenatal care began, infant birthplace, medical birth attendant, delivery method, and occurrence of SUID. Approaches to reduce the incidence of SUID would be a preventive strategy for assessment, early identification of the potential for SUID, and interventions to determine the combination of and infant characteristics that are predictors of SUID.

Interpretation of the Findings

In this study, I examined the core determinants of risk characteristics of infants and the common maternal demographics that present a pattern or trend in health risks for SUID. Different combinations of infant and maternal variables, when taken together, may point to an opportunity for improved health practices and self-efficacy not only in mothers but in infants as well, so that mothers can control those modifiable behaviors that increase the risk for SUID. The results of my study confirmed some findings from previous studies and provided new information.

SUID as a serious public health problem. There is a need to consider infant and maternal characteristics as predictors of SUID in combination rather than as separate infant or maternal risk factors. The results of my study confirmed Reno and Hyder’s (2018) finding that core determinants of risk characteristics of infants and the common maternal demographics presented a pattern or trend in health risks and benefits. Friedmann et al. (2017) concluded that maternal and obstetrical predictors of SUID identified modifiable and nonmodifiable risk factors associated with SUID. Maternal risk factors of race/ethnicity contributed to SUID. My study also confirmed the study of MacDorman and Gregory (2015) who delineated both modifiable and nonmodifiable obstetrical and maternal risk factors associated with SUID but excluded infant characteristics.

In addition, the results of my study added new knowledge related to infant characteristics. Friedmann et al.'s (2017) population-based cohort study, like my study, included the CDC linked birth–infant death data, although their study data are now 10 years old. Friedmann et al. (2017) used unconditional regression analysis and showed a SUID death rate of 8.2%. The results of my study added new information showing significance for infant gestational age, birth weight, birth order, maternal age, marital status, educational status, month prenatal care began, infant birthplace, medical birth attendant, and delivery method. I also concluded, based on the findings of my study, that sociodemographic and gestational characteristics are important risk factors in SUID.

Hakeem et al. (2015) investigated the incidence and determinants of SUID in 37 million births to measure the incidence of SUID in a population-based cohort from the CDC's linked birth-infant death and fetal death data files from 1995 to 2004. Gollenberg and Fendley (2018) used models to estimate the adjusted effect of maternal and newborn characteristics on the risk of SUID. Their study focused on maternal age less than 20 years, Black non-Hispanic race, smoking, increasing parity, inadequate prenatal care, prematurity, and growth restriction (Gollenberg & Fendley, 2018). The study fell short, pointing to singularity of identification of risks without a comprehensive review of combinations of factors of both the mother and the infants. My results showed the identification of infants at higher risk to be those with inadequate prenatal care and infants of mothers younger than age 20.

MacDorman and Gregory (2015) provided the 2013 national vital statistics reports on fetal and perinatal mortality by maternal age, marital status, race, Hispanic origin, state of residence, and infant characteristics of fetal birth weight, gestational age, plurality, and gender for infant deaths at 20 weeks or more of gestation. Fetal mortality was higher than infant mortality, and higher for non-Hispanic Black women at twice the rate for non-Hispanic White women at 4.88 (MacDorman & Gregory, 2015).

Olander et al. (2018) explored pregnancy as a receptive time for changing health behavior addressing characteristics that motivated change based on risk-related information for infant birth complications like SUID. Lavezzi et al. (2015) sought to better understand behaviors and the support required by women to influence the determinants of health behavior change because of pregnancy. Stiffler et al. (2016) studied mothers' experiences and thoughts during periods of times when they witnessed or found their babies had stopped breathing and found that SUID was responsible for 14% of Indiana's infant mortality.

Social cognitive theory was chosen as the framework for current study based on the rationale that health promotion and disease prevention are the foundational concepts of the perspective of this model. Self-efficacy beliefs facilitate regulation of human motivation, behavior, and well-being. Behavioral self-management of health habits can redirect efforts to provide remedies to threatening health issues like SUID. My goal was to challenge and build on existing precepts by adding to the body of knowledge that focuses on health promotion and disease prevention by social cognitive means. The research questions reflected the social cognitive theory by addressing a core set of variables, the mechanism through which the variables work, and the optimal ways of translating this knowledge into effective health policies and practices.

The connection between the key elements of social cognitive theory and the current study include the infant being dependent on the behavior of a mother during pregnancy and through the first year of life. The mother's actions can directly or indirectly affect the health outcome (life or death) of an infant. The social cognitive theory related to the research questions in that unique combinations of infant and maternal factors, rather than single individual factors, are expected to yield new evidence related to a combination of infant and maternal characteristics or factors. A social change outcome that assists in reducing the incidence of SUID would be a preventive strategy for assessment, early identification of the potential for SUID, and interventions to determine the combination of mother and infant characteristics that are predictors of SUID. The study findings confirmed incorporating social cognitive theory to introduce behavior changes in pregnant or soon to be pregnant women. Social cognitive theory was used to explain the relationship between infant characteristics and demographics of the mother as factors that contribute to SUID. The study findings suggested that through social cognitive theory, combinations of infant and maternal demographics are better predictors of SUID.

Limitations of the Study

Limitations to generalizability, trustworthiness, validity, and reliability were not issues with the secondary data set. In my study, I examined a combination of infant/mother variables. However, three main limitations surfaced during the study. First, the estimation of gestational age was subject to error due to reliance on the mother's reported last menstrual period rather than an obstetric estimate of gestation. Second, the race/ethnicity categorization was limited by the inherent heterogeneity of cultural practices and biological factors in the available racial/ethnic groupings. Third, complete information was not always available in the death record. The capture of complete information at the time of infant demise could be improved by educating medical examiners and physicians on the importance of an improvement in death scene investigations.

The most time-consuming part of my research came during the data collection, analysis, and reporting stage. Though the WONDER database was provided by the CDC, the United States was in crisis due to the COVID-19 pandemic, and available resources had been shifted to mandatory data requirements related to the pandemic. This resulted in a time delay in gaining direct contact with my assigned CDC contact.

Recommendations

Future studies could include different variables and both qualitative and quantitative methodology to address infant birth location and birth order (Johnston, 2017). Such investigations could add to the knowledge base for more specific recommendations on interventions to reduce the incidence of SUID. Researchers could begin with the current study finding that place of birth was significant; qualitative interviews could yield additional information on how mothers chose their birth delivery location. Social cognitive theory could provide a framework for additional quantitative and qualitative research.

In support of the public health professional practice, the CDC (2007) published a 48-page curriculum guide for SUID to standardize (a) investigative tools and equipment, (b) systematic activities at the death scene, (b) documenting and evaluating the body, (d) establishing infant profile information, and (e) completing the scene investigation. These actions, along with similar standardization of documentation by pathologists, could improve the ability to perform retrospective studies that uncover, confirm, or provide new information to promote standardization of education and training to mothers, fathers, care givers, and SUID investigators. Before the forensic autopsy is performed, a 25-item mandatory data collection is used to research cases of SUID (CDC, 2007). Some items of importance include evidence or absence of asphyxia, shared sleep surfaces, change in sleep conditions, hyperthermia/hypothermia, scene hazards, unsafe sleeping conditions, diet, hospitalizations, previous medical diagnosis, life-threatening events, medical care, recent fall or injury; religious, cultural, or ethnic remedies; cause of death other than SIDS; prior sibling deaths; previous encounters with police or social service agencies; request for tissue or organ donation; objection to autopsy; preterminal resuscitative treatment; death due to trauma (injury), poisoning, or intoxication; suspicious circumstances; other alerts circumstances surrounding the death; and pathologist contact information (CDC, 2007). A quantitative study to address the completeness of the documentation could provide information related to improving or fine-tuning the assessment guide. Information from a quantitative study could add to the ongoing validation of known risks and could also lead to the identification of new risks that could be mitigated to eliminate SUID.

Implications for Professional Practice and Social Change

Because a combination of risk factors could lead to the formulation of social and structural impediments to the changes needed to curtail and eliminate SUID, education and motivation for a healthier infant may prove to be enough to induce modifiable changes to eliminate SUID. When people believe there is an expectation that there is improvement in health based on their actions, there is incentive to act or to continue new habits. Actions can be negative or positive in meeting social cognitive behavior that can lead to positive change. Prenatal self-evaluation can assess the health status and environment of the mother and project the health status and environment of the infant to mitigate risk of SUID. Different combinations of infant and maternal variables, when taken together, can point to an opportunity for improved health practices and self-efficacy not only in mothers but in the infant as well, such that the mothers influence the health of themselves and their infants, thereby saving their infants' lives.

The results of my study could be shared with health care professionals to review maternal and infant birth intake medical records to update or create existing infant SUID risk tools. This could provide an opportunity to align infant and mother assessment tools that may lead to public health interventions that could include educating parents, physicians, nurses, and other caregivers to equip these individuals with predictors and processes that can reduce SUID. Infant charts and cribs can be coded to alert caregivers to the early signs and symptoms for infants at risk for SUID. Early identification of symptoms could lead to early interventions to guard against SUID. Signs in the mother's hospital room and at home can alert parents, other family members, friends, and visitors to additional early warning signs. Infant monitors or sleep pads can alert healthcare providers and care givers to infant deficits in breaths per minute, apnea (absence of breath) and non-movement. These interventions, when taken together can save lives. Physician, nurse and parent conversations can help provide information about assessment of infant sleep conditions in order to provide valuable alerts that may signal trouble. This could lead to an action to avoid a death. The same combinations of variables used in this research study could be analyzed on a rolling four-year basis to see if there are lesser or stronger predictors of the potential for SUID. SUID assessment tools can be refined yearly to capture more subtle signs and symptoms of at-risk infants and mothers of those infants. This could allow for earlier identification of SUID risk and provide education for the mother during pregnancy using repetitive learning practice sessions with the newborn as a way of encouraging best practices to decrease and eliminate SUID. One such practice is that of the use of Baby Box program.

Recommendations to prevent SUID are many with the priority being identification of an early warning tracking and intervention tool. Educational campaigns targeting mothers at increased risk of giving birth to infants that would be prone to SUID, focused on the highest risk factors of the combination of infant and mother characteristics as predictors of SUID could be useful. Additionally, intensification of public health policies, programs, and education of the public to mount an awareness campaign specific to SUID for a more targeted approach based on the social cognitive theory purposed to educate and modify behaviors is needed (Gollenberg & Fendley, 2018).

The findings and results of this study have implications for introducing prescriptive recommendations to professional practice and potential positive social change. The social cognitive theory served as the foundation for the study asserting health promotion within a public health platform could reliably predict SUID and possibly produce positive health outcomes when used in the planning and implementation of programs. Interventions when introduced early could reduce or even eliminate the occurrence of SUID. The practical application and impact to the infant, parents, and the community of caregivers coupled with policy making reforms can impact health outcomes and save lives. Expectant parents are particularly receptive to changing health behavior addressing characteristics that motivate change based on risk-related information that can be gathered early into the mother's prenatal visits, infant, and mother early behaviors beginning with birth.

Conclusion

Children in the United States are dying from SUID in greater numbers than in the rest of the industrialized world. The results of this study confirm a relationship between infant and mother characteristics of infant gestational age, birth weight, and birth order, combined with mother characteristics of age, marital status, educational status, month prenatal care began, infant birthplace, medical attendant, and delivery method. Education of stakeholders (parents, caregivers, and health professionals) is needed to prospectively identify infants more at risk for SUID and prepare parents for the diligence required to save lives and eventually eliminate SUID. Actionable interventions are needed to save infant lives and eliminate SUID. The potential positive social change that could result from this study would be an elimination of infant deaths due to SUID through evaluation of characteristics that suggest a higher risk in certain infant populations when assessment of the mother's characteristics is also simultaneously evaluated. This study needed to be done because one infant death is one too many and SUID remains a public health crisis.

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