SEVERITY OF ILLNESS IN THE NEONATE:
A CONCEPT ANALYSIS

by

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A thesis submitted in conformity with the requirements
for the degree of Master of Science,
Graduate Department of Nursing Science,
University of Toronto

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ABSTRACT

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Variability in the achievement of neonatal outcomes has been attributed partly to severity of illness (SOI). SOI in the neonate has been defined inconsistently and measures may be inaccurate as a result. The purpose of this study was to develop a consistent definition of the concept from current neonatal literature. The objectives included determining the attributes of SOI, examining the antecedents and consequences, identifying related concepts, and describing the uses in the literature. A sample of 71 articles was obtained from a computer and manual search of the literature from 1990 to 2000. The design used was a concept analysis based on Rodgers' evolutionary view of concepts. The results showed that SOI is characterized primarily by instability that is measured in the physiological domain. Other attributes, suffering and disability were also identified. This study offers a beginning understanding of the concept and contributes to identifying, assessing and using SOI in clinical nursing practice.
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CHAPTER ONE

The Problem

Severity of illness (SOI) has been identified as a characteristic of the neonate that can influence neonatal outcomes. To determine the effectiveness of interventions in neonatal care and to predict the consequences of care, sources of variability must be identified and controlled in neonatal outcomes research. SOI is a concept important to neonatal care as it contributes to variability in achieving neonatal outcomes, different from traditional neonatal risk factors such as birth weight and gestational age. Although many measures of SOI in the neonate exist, these measures have been developed using diverse definitions of the concept. As a result, operational definitions and indicators have varied widely. Also, primary measures of SOI in the neonate have been derived from pediatric and adult SOI measures. This may have resulted in the development of neonatal measures of SOI that do not specifically reflect the neonatal population, as the definition of the concept and the measure were originally developed for children and adults. Inconsistencies in the way that SOI is defined have made it difficult to identify and understand the meaning of the concept in the neonatal population. A clear definition of SOI is required to produce precise and consistent measures and, therefore, accurate results of neonatal outcomes studies. In this thesis, the analysis of the concept of SOI in the neonatal population is the major focus.

Background and Significance

Preterm and sick neonates are requiring more financial and human resources as survival rates increase. There has been an increased interest in measuring outcomes of a clinical, economic and administrative nature to better manage resources (Petryshen, O'Brien
Pallas, & Shamian, 1995). The measurement of neonatal outcomes has received increasing attention among researchers, managers and clinicians in health-related disciplines including nursing (Holmgaard & Petersen, 1996; Long & Soderstrom, 1995; Petryshen & Stevens, 1995; Schraeder, Heverley, & O’Brien, 1996; Stevens, Petryshen, Hawkins, Smith & Taylor, 1996; Thigpen, 1988). Researchers have examined traditional risk factors such as gestational age and birth weight in an effort to understand variability in the achievement of neonatal outcomes (Holmgaard & Petersen, 1996; International Neonatal Network [INN], 1993; Richardson, Gray, McCormick, Workman & Goldmann, 1993; Schraeder et al., 1996). Variability in outcomes can be explained in part by these risk factors (Hack et al., 1991). SOI has been identified as a potentially important independent source of variability in the achievement of neonatal outcomes (INN, 1993; Richardson, Gray, McCormick, et al., 1993).

Nurses make clinical decisions and provide care or interventions that are intended to make a change in the condition or outcome of the neonate (Donabedian, 1988; Hegyvary, 1991; Marek, 1989; Mitchell, 1993). Clarification of the concept SOI in the neonate is necessary to find out: (a) whether the concept is identifiable in neonatal nursing practice (Chinn & Kramer, 1991; Walker & Avant, 1995), (b) how the concept might be used in practice, research and theoretical models of neonatal care (Rodgers, 1993a) and (c) the significance of the concept to neonatology in general (Rodgers, 1993a).

Developing a definition of the concept SOI can provide the basis for the development of an operational definition, selection of appropriate indicators and the development of valid instruments (Norris, 1982). Accurate measurement of SOI will allow nurses to investigate the nature of the relationship between SOI in the neonate, nursing interventions and outcomes. Identifying factors that relate to neonatal nursing care and conducting research
that relates directly to clinical practice may facilitate the development of evidence-based practice in the care of neonates.

As SOI is a potentially significant determinant of neonatal outcomes, it is important to have a clear definition of the concept. Few definitions of the concept of SOI exist in the neonatal literature. Diverse perspectives about the dimensions of SOI in the neonate have been discussed in articles for example; physiologic stability (Richardson, Gray, McCormick, et al., 1993; Yeh, Pollock, Ruttiman, Holbrook & Fields, 1984), therapeutic intensity (Gray, Richardson, McCormick, Workman-Daniels & Goldmann, 1992) and suffering and disability (Almeida & Persson, 1998). Most commonly, definitions of SOI in the neonate have been derived from pediatric and adult populations (Cullen, Civetta, Briggs & Ferrara, 1974; Knaus, Zimmerman, Wagner, Draper & Lawrence, 1981; Pollock, Ruttiman & Getson, 1988; Yeh et al., 1984) and are not made explicit in neonatal measures (Georgieff, Mills & Bhatt; 1989; Gray, Richardson, McCormick, Workman-Daniels, et al., 1992; Richardson, Gray, McCormick, et al., 1993). The definitions of SOI are generally inconsistent and diverse, and those definitions borrowed from pediatric and adult measures do not reflect neonatal characteristics. A clear definition of the concept is a necessary first step to the development of consistent, accurate measures of SOI.

Operational definitions of SOI measures differ significantly in terms of the type and number of dimensions of the concept they capture because the concept has been defined inconsistently. Proxy measures of SOI in the neonate have been commonly used, such as birth weight, gestational age, frequency of invasive procedures and therapy use (Gray, Richardson, McCormick, Workman-Daniels, et al., 1992; Johnston, Stevens, Yang & Horton, 1996; Minde, Whitelaw, Brown & Fitzhardinge, 1983). Leading neonatal SOI measures
have been derived from pediatric and adult measures and therefore, may not reflect neonatal characteristics (Georgieff et al., 1989; Gray, Richardson, McCormick, Workman-Daniels, et al., 1992; Richardson, Gray, McCormick, et al., 1993). Also, SOI measures use a variety of indicators to measure the concept that range from univariate approaches, such as length of hospital stay and mortality (Lee, Perlman, Ballantyne, Elliott, & To, 1995) to complex approaches incorporating many dimensions, such as complications and therapies (Gray, Richardson, McCormick, Workman-Daniels, et al., 1992; Minde et al., 1983). Many inconsistencies exist among measures of SOI. The development of consistent, accurate measures of SOI is reliant on the development of a clear definition of SOI.

Unclear, diverse definitions of the concept SOI, including definitions derived from children and adults, have contributed to difficulties in understanding the meaning of the concept and wide variation in operational definitions and indicators. The lack of consistency in measurement of SOI makes it very difficult to accurately measure this source of variability in neonatal outcomes studies. At the time of this analysis, no systematic review of the concept was found that specifically analyzed the concept of SOI in the neonate.
Problem

Current definitions of SOI in the neonate may fail to provide an accurate definition of the concept and to capture characteristics of the neonate that are different from children and adults: (a) SOI has been inconsistently defined in the neonatal literature, (b) some measures of SOI in the neonate have been derived from pediatric and adult measures without consideration of potential differences between the populations.

Purpose and Objectives

The overall purpose of this analysis was to develop a definition of SOI in the neonate that captures neonatal characteristics and reflects a consistent view of the concept derived from current neonatal literature. This study addressed the following research objectives:

1. To determine the essential attributes of SOI.
2. To examine the antecedents and consequences of SOI.
3. To identify concepts related to SOI.
4. To describe the uses of SOI in the literature.

Literature Review

Historically, the concept of SOI has reflected a traditional ‘medical’ perspective in answering the question ‘How sick is the individual?’. The Shorter Oxford English Dictionary on Historical Principles (1968) identified the first recorded use of the term by physicians as dating in the late 1800s. Measures of SOI in health sciences have proliferated mostly since the 1970s, beginning with adult measures. This review of the literature focused on the evolution of leading neonatal measures of SOI that have been derived from pediatric and adult measures. Other neonatal measures of SOI appeared infrequently in the literature and were not clearly derived from other measures or definitions of the concept. This
exploration of the conceptual origins of the leading neonatal measures of SOI identified: (a) definitions derived from adults and children that have heavily influenced the development of the concept and (b) issues associated with applying derived definitions of SOI to neonates.

Adult measures have employed several approaches to measuring SOI including diagnostic, disease specific, therapeutic intensity, and acute physiology (Cullen et al., 1974; Horn et al., 1985; Knaus et al., 1981; Teasdale & Jennett, 1974). The diagnostic approach to measuring SOI classified SOI on the basis of specific medical diagnoses and procedures such as Diagnosis Related Groups (DRGs) (Horn et al., 1985; Richardson & Tarnow-Mordi, 1994). Disease specific measures of SOI included indicators such as symptoms, physical findings, events and patient characteristics known to be associated with outcomes of the disease such as survival or specific morbidities. Examples of these measures included trauma scores, cardiac scores, and burn scores (Teasdale & Jennet, 1974; Teres, Lemeshow, Avrunin & Pastides, 1987; Wheeler, Van Harrison, Wolfe & Payne, 1983). Therapeutic intensity measures such as the Therapeutic Intervention Scoring System (TISS) assessed therapy use to reflect SOI (Cullen et al., 1974; Richardson & Tarnow-Mordi, 1994). TISS was introduced in 1974 and is considered a well-used indirect measure having many applications for classifying patients including (a) determining SOI, (b) establishing nurse:patient ratios, (c) assessing current utilization of hospital beds, and (d) establishing future needs of intensive care unit beds (Keene & Cullen, 1983). The acute physiology approach revolved around the idea that disturbed physiology meant a more ill neonate (Richardson & Tarnow-Mordi, 1994). The Acute Physiology and Chronic Health Evaluation (APACHE), was the first widely accepted measure of SOI for adults (Knaus et al., 1981). It was based on the assessment of probability of mortality and was identified to be a SOI index.
(Knaus et al., 1981). The APACHE was intended to classify groups of patients and to represent acute illness in hospitalized patients (Knaus et al., 1981). The measure was primarily physiology-based including 34 physiological measures from seven organ systems. Also, additional points were added for age and chronic health status.

These four approaches to assessing SOI were based on diverse assumptions, ideas, indicators, measures and uses. Definitions of SOI as a concept were not apparent in these adult measures. The evolution of these measures has focused on reducing the number of indicators, simplifying the evaluation of SOI and maintaining predictive power (Richardson & Tarnow-Mordi, 1994).

In pediatric practice, the leading measures of SOI have evolved from the APACHE (Knaus et al., 1981). The Physiologic Stability Index (PSI), developed by Yeh et al. in 1984, was the first to be derived from the APACHE (Knaus et al., 1981). The PSI measure was used primarily to assess severity of acute illness in the general pediatric intensive care population (Yeh et al., 1984). The PSI measure was physiology-based and also relied on the same number of variables (34) from seven physiologic systems as the APACHE (Knaus et al., 1981). The authors described their method as, "...directly assess[ing] severity of illness by quantitating physiologic stability." (Yeh et al., 1984, p. 445). Adjustments were made to the normal ranges for physiological indicators to accommodate differences in children. Yeh et al. (1984) made reference to other differences that existed between the child and the adult, such as the fact that children are actively growing. An explicit definition of the concept was not discussed in the Yeh et al. article (1984). Also, dimensions or indicators that might be unique to children were not identified. The pediatric measure that was developed immediately after PSI was called the Pediatric Risk of Mortality Score (PRISM) (Pollock et
al., 1988). The PRISM was derived from the PSI to reduce the number of physiologic variables required for pediatric mortality risk assessment (Pollock et al., 1988). The conceptual origin of the PSI was discussed in greater detail in the development of the PRISM measure than in the original PSI article. The basis for the PSI was the hypothesis that physiologic instability directly reflects mortality risk (Pollock et al., 1988). Because existing SOI measures were sparse and indirect, various combinations of measures were used to validate these new instruments.

In neonatology, the leading SOI measures were also derived from the PSI and APACHE. The first neonatal measure was an adapted version of the PSI (Georgieff et al., 1989). The normal ranges of variables were adjusted to reflect neonatal physiology without consideration of potential differences in the characteristics among neonates, children and adults. Following use of the adapted PSI, the Score for Neonatal Acute Physiology (SNAP) was developed (Richardson, Gray, McCormick, et al., 1993). The authors of SNAP suggested that few appropriate measures of SOI existed for neonates. Richardson, Gray, McCormick, et al. (1993) identified that adjustment using birth weight, sex and race were insufficient to reconcile variations among neonatal outcomes. Physiology-based approaches used by pediatric and adult physicians were recognized as having potential for the measurement of SOI in neonates (Richardson, Gray, McCormick, et al., 1993). The SNAP was developed for neonates using physiologic indicators and measuring, the degree of derangement from physiologic normal (Richardson, Gray, McCormick, et al., 1993). The use of physiological derangements in SNAP was similar to the PSI and the APACHE (Knaus et al., 1981; Richardson, Gray, McCormick, et al., 1993; Yeh et al., 1984). The SNAP authors identified that neonates had major differences in physiology in comparison to children.
(Richardson, Gray, McCormick, et al., 1993). They identified that low birth weight and immaturity were key differences between the two populations. Other examples of differences in the characteristics of neonatal and pediatric populations included a disparate amount of trauma, the frequency and variety of congenital anomalies and the need for chronic prolonged hospital admission to mature (Richardson, Gray, McCormick, et al., 1993). Although Richardson, Gray, McCormick, et al., 1993, identified numerous differences between neonates and children, it was not clear how the definition of the concept and the choice of indicators were changed to address these differences. Actual changes made by Richardson and colleagues to develop the SNAP measure included the removal of 13 items, addition of 5 items, adjustment to the ranges of physiologic indicators, and alteration of item weighting based on consultation with a panel of experts (Richardson & Tarnow-Mordi, 1994).

Other leading neonatal measures of SOI included the Neonatal Therapeutic Intervention Scoring System (NTISS) (Gray, Richardson, McCormick, Workman-Daniels, et al., 1992) and the Clinical Risk Index for Babies (CRIB) (INN, 1993). NTISS, a therapeutic intensity index for neonates, was designed to indirectly measure SOI regarding therapy use (Gray, Richardson, McCormick, Workman-Daniels, et al., 1992). The NTISS measure was derived directly from the adult measure, TISS, (Cullen et al., 1974; Gray, Richardson, McCormick, Workman-Daniels, et al., 1992). Another leading neonatal measure was the CRIB that was designed specifically to predict death (INN, 1993; Tarnow-Mordi et al., 1990). This score was constructed similarly to the PRISM score in pediatrics although the content was somewhat different (Pollock et al., 1988). The CRIB incorporated more diverse indicators including physiologic, congenital anomalies, birth weight and gestational age that
appeared to be more sensitive to the differences of neonates (INN, 1993). Explicit definitions of the concept were rare and often non-existent in these adult, pediatric and neonatal measures. It was much more common for SOI to be described or discussed in terms of its components or indicators in the literature than defined at the theoretical level.

As explicit definitions of the concept SOI are rare and measures of SOI vary widely in the literature, current understanding of the concept is incomplete. Logically, neonatal, pediatric and adult populations do no share the same characteristics and therefore dimensions of the concept may differ among them. Authors of neonatal SOI measures have identified specific neonatal characteristics that set the neonate apart from the other populations (Richardson, Gray, McCormick, et al., 1993). Neonatal development is characterized by rapidly developing physiological processes, neurological organization, and behavioural responses (Richardson, Gray, McCormick, et al., 1993). Issues related to maturation and rapid development are unique to the neonate. Neonatal researchers rely heavily on the measurement of birth weight and gestational age to reflect neonatal characteristics (maturation). Birth weight and gestational age can vary widely within the neonatal population. They are recognized in neonatology as indicators of vulnerability and can predict poor neonatal outcomes. Birth weight and gestational age are frequently used as risk factors in neonatal research (INN, 1993). These characteristics are unique to neonates and are not shared with children and adults. As a result, dimensions of the concept of SOI may be different in neonates than in children and adults.

**Conceptual Foundations for the Study**

This section on conceptual foundations will serve to: (a) outline two primary schools of thought, entity and dispositional, and how the ideas have influenced current thinking about
concepts; (b) outline the characteristics of concepts as they have been defined by nurse authors and identify similarities that exist among the different viewpoints; and (c) describe the evolutionary view and identify features of this view that will provide the basis for methodological decision making in this study.

The entity view (Aristotle, 1947) has dominated the evolution of concept analysis. Within this view, a concept is defined as an entity or 'thing' that matches an element of reality such as objects, ideas or words (Rodgers, 1993b). The 'essence' of the concept is considered to be a universal law that is not influenced by changes in the world (Aristotle, 1947). Implicit in this view is the idea that the critical attributes, representing the essence of the concept, are unchanging (Rodgers, 1993b). Therefore, a precise unchanging definition of the concept can be achieved and can be applied to all situations.

The dispositional theories of concepts purport that the development of a concept is dependent on its use, influenced by the habits and abilities of the person using the concept (Rodgers, 1993b). Wittgenstein (1968) focused his later writings on the use of concepts as determinants of their meaning. Ryle identified that concepts are integrally related to our ability to perform tasks such as the effective use of language such as, "What were we unable to do until we had acquired it [the concept]?") (1971, p. 448). These ideas influenced the development of other views in psychology but retained the primary features that; (a) concepts do not have rigid boundaries, and (b) necessary and sufficient conditions are not required for the concept to exist (Rodgers, 1993b). In this philosophical view, defining attributes must demonstrate some degree of association with the concept. Not all examples of the concept illustrate equally what the concept (the category defined by attributes) is. Whether a particular example of the concept falls within the category is determined by the
degree of fit of attributes between the example and the concept (category) (Morse, 1995). This view supports the idea of relativism wherein concepts are not rigid or static and are influenced by use (Morse, 1995). Also, examples of the concept demonstrate relative associations with the category that is the concept (Morse, 1995).

Contemporary philosophers such as Toulmin (1972) considered the influence of social factors in the development of concepts used in science and emphasized the relationship between concepts and scientific progress. When a society uses or takes ownership of a concept, the concepts of interest that have importance in society or solve society's problems are progressed. Concepts are developed through the process of "enculturation" through imitation, interaction or education according to Toulmin (1972). Therefore, concepts are context-dependent, (i.e. influenced by the social context surrounding the use of the concept). Also, concepts change over time based on usage, importance and ability to solve problems (Rodgers, 1993b). Thus, content and explanatory power of the concept is influenced and changed by its continual use and ongoing critical analysis (Rodgers, 1993b).

Rodgers (1993a) conceived the process of concept development as a cycle. Her evolutionary view characterized concepts as having a dynamic nature that changed with time and context and were not bound by a specific 'essence'. Significance, use and application of the concept influenced concepts in that they acquired meaning and thus evolved (Rodgers, 1993a). For example, concepts were used to solve problems and characterize phenomena that, in turn, increased their use and further enhanced concept development. Therefore, use is important in defining a concept. Increased use leads to broader application and the discovery of strengths and limitations (Rodgers, 1993a).
This approach to concept analysis was useful in refining and clarifying concepts of interest to nurses. Complex nursing phenomena related to human beings required the use of concepts that could not be separated from context, time or nature of the problem (Rodgers, 1993a). Problems were addressed by considering multiple and related factors. Therefore, nursing requires methods that consider and incorporate these influencing factors to develop definitions of concepts useful to the profession.

Concepts most commonly are identified as the building blocks of theory (Morse, 1995). Nurse authors, however, have approached concepts from a number of different perspectives (Rodgers, 1993a). Concepts have been linked to empirical reality when the concept is represented by a thing, object, property, or word (Becker, 1983; Hardy, 1974; Jacox, 1974; Keck, 1986; Kim, 1983; Walker & Avant, 1988). Other authors have focused on cognitive activities that are associated with concepts, such as idea formation, abstraction, and perception (King, 1988; Meleis, 1985; Watson, 1979). Also, language, as reflected by meaning, usage and communication, was identified as important to the development of concepts (Duldit & Giffin, 1985; Tadd & Chadwick, 1989). These perspectives contributed to our understanding of concepts and also illustrated the complexity of concepts and explained the existence of a number of different approaches to analysis. Rodgers (1993b) identified that, despite the diversity of opinion, some commonality exists. "There is a consensus that concepts are cognitive in nature and that they are comprised of attributes abstracted from reality, expressed in some form and utilized for some common purpose" (Rodgers, 1993b, p.30). Nurse researchers who have developed methods of concept analysis generally agreed that meaning of a concept was developed through use and that the identification of the concept's essential attributes contributed to a greater understanding of the nature of the
concept (Chinn & Kramer, 1991; Norris, 1982; Rodgers, 1993a; Schwartz-Barcott & Kim, 1993; Walker & Avant, 1995).

An examination of philosophical views provided the theoretical basis for understanding how a concept develops, the method chosen to analyze a particular concept and the 'product' of concept analysis (Rodgers, 1993a; 1993b). The evolutionary view (Rodgers, 1993a; Rodgers, 1993b) served as the framework for methodological decision making in this study. The evolutionary view purports that a concept (a) does not have rigid boundaries, (b) is context-dependent, (c) is time-dependent, (d) is developed based on how useful it is to the discipline, (e) applies activities of concept analysis based on the nature of the problem, and (f) is judged on how well it solves problems important to the profession (Rodgers, 1993a; 1993b). The 'product' of concept analysis, based on this philosophical view, provided essential attributes that reflected current use, significance and application of the concept within a given discipline (Rodgers, 1993a).

Summary of Conceptual Foundations

Two schools of thought, entity and dispositional, dominated theories of concepts (Aristotle, 1947; Ryle, 1971; Toulmin, 1972; Wittgenstein, 1968). Although these theories are quite different, they are not clearly divisible, “Often, there are considerable areas of overlap, and characterization of a particular viewpoint can be based only on the author’s primary emphasis.” (Rodgers, 1993b, p. 11). Additional ideas of concepts have evolved including Toulmin’s (1972) thoughts on the importance of the concept to society and how concepts develop over time based on context, use and ability to solve problems. Rodger’s (1993a) evolutionary view also considered context, time and nature of the problem to be important to concept development, particularly in relation to complex nursing phenomena.
Multiple ideas about the nature of concepts exist within the discipline of nursing. Despite diversity of opinion among nurse authors, some commonality exists including that the meaning of a concept is developed through use and that identification of essential attributes help our understanding of the concept. Rodger’s (1993a) evolutionary view was chosen to guide methodological decision making for this study based on its congruence with the characteristics of complex nursing phenomena in terms of its sensitivity to context, time, discipline, usefulness, nature of the problem and ability to solve problems. The conceptual foundation, nature of the concept SOI, purpose and objectives of the study guided the selection of the research design.
CHAPTER TWO
Methods and Procedures

Research Design

Concept analysis was selected to be the research design for this study. Five methods of concept analysis, developed in the discipline of nursing, were identified, reviewed and critiqued for the purpose of selecting a design that was congruent with the purpose and objectives of this study. The methods reviewed included (a) Walker & Avant (1995), (b) Chinn & Kramer (1991), (c) Norris (1982), (d) Schwartz-Barcott & Kim (1993), and (e) Rodgers (1993a). A common goal shared by most methods of concept analysis was to identify the essential attributes of a concept and to use the attributes to develop a definition of the concept. This goal was congruent generally with the study purpose and objectives and supported the use of concept analysis for the research design. The focus of this section was to describe concept analysis as a research design and to select an appropriate methodology.

Concept Analysis as a Method of Inquiry

Concept analysis is one of the primary methods used to synthesize knowledge (Knafl & Deatrick, 1993). A number of researchers have developed approaches to concept analysis within the discipline of nursing including, Walker & Avant (1995), Chinn & Kramer (1991), Norris (1982), Schwartz-Barcott & Kim (1986), and Rodgers (1993a). Each researcher employed a somewhat different approach to analyzing concepts, based on the purpose and particular philosophical view. Although a clear procedure was identified in each of the methods, the philosophical origins are less clear and more difficult to discern. Incorporating more than one philosophical view was common among methods of concept analysis despite
philosophical views regarding the nature and development of concepts have evolved and produced distinctly different ideas about concepts (Rodgers, 1993b).

Concept analysis generally involved identifying the essential attributes of a concept from the literature, followed by the development of a definition of the concept. Each method of concept analysis included additional procedures that provided further information about the concept, such as case examples (Walker & Avant, 1995). Additional procedures were intended to address other goals of the methods such as (a) to develop an operational definition and to measure the concept, (b) to develop theory, and (c) to integrate the literature review with empirical data (Norris, 1982; Rodgers, 1993a; Schwartz-Barcott & Kim, 1993; Walker & Avant, 1995).

Each method involved completion of a series of procedures or phases. Although ordered steps were identified, most of the methods suggested the process of analyzing a concept is iterative. The steps were not to be followed in a specific order (Rodgers, 1993a; Walker & Avant 1995). Also, the methods required an inductive approach to reasoning whereby a set of essential attributes was developed from the literature. Essential attributes were specifically identified or inferred from the literature depending on how the concept was presented. Authors made inferences about the nature of the concept from the particular definitions, examples, dimensions, and indicators they discussed and used in their work.

Critique of Methods

Five methods of concept analysis currently used in nursing were critiqued to determine their usefulness in analyzing the concept of SOI in the neonate: Walker & Avant (1995), Chinn & Kramer (1991), Norris (1982), Schwartz-Barcott & Kim (1993) and Rodgers (1993a). The methods were reviewed and the following aspects of each method are
summarized in Appendix A: (a) background (why the method was developed), (b) definition of a concept (the approach to defining concepts chosen by the authors), (c) philosophical view (basis for the development of the method), (d) primary purpose of the method, (e) secondary goals, and (f) steps of the method. In addition, the methods were critiqued for strengths and weaknesses and are summarized in Appendix A. The following paragraphs offer a concise critique of each method and identify the research design chosen for this study.

**Walker and Avant.** The Walker and Avant (1995) method has been widely used in nursing to analyze concepts. The analysis was based on an examination of the linguistic use of the word and its characteristics in the literature. The philosophical origin of the method of concept analysis developed by Walker and Avant (1995) was attributed to Wilson (1963). Wilson (1963) was concerned primarily with word use and the criteria and principles wherein a precise conceptual definition is achieved, implying that concepts are static in nature. Once discovered, the definition of a concept became universal and was therefore unchanging. These ideas were not congruent philosophically with Walker and Avant's (1995) recent assertion that the determination of essential attributes was influenced by the context and time when the concept was used. Although the philosophical perspective of the authors was evident in a discussion of the method, context and time were not specifically included in the procedure. None of the steps implied that data on conditions or context should be gathered. Walker and Avant's (1995) method described an eight-step procedure that provided a clear direction for the concept analysis. Although the process was outlined as a series of steps, the authors described the approach as iterative. In addition to identifying uses and essential attributes, Walker and Avant (1995) constructed examples for the purpose of further clarifying the concept. The use of examples to determine what the concept is and what it is
not contributed significantly to our understanding of the concept. The construction of artificial examples however, could lead potentially to researcher bias in developing cases. The identification of empirical referents was useful in developing an operational definition and instrument. This particular step was beyond the scope of this concept analysis. Walker and Avant's (1995) purpose and method of concept analysis was generally congruent with the goals of this study.

**Chinn and Kramer.** Chinn and Kramer (1991) derived their method from Wilson (1963) and Walker and Avant (1988). Wilson’s (1963) method of concept analysis is based on the premise that concepts are static and unchanging. The description of the results of the concept analysis by Chinn and Kramer (1991) as being 'tentative and guiding in nature' indicated a belief that a variety of factors influenced the results of the analysis, which is in contrast to Wilson (1963). Chinn and Kramer (1991) discussed the importance of social context and values in analyzing concepts and included this type of data in the method. The purpose of this method was to produce a tentative definition of the concept. Although congruent with the aims of this concept analysis, the purpose was unifocal and the description of the steps provided minimal direction for applying the method. The problem of researcher bias in the use of constructed examples was the same as in the Walker and Avant method (1995). This method contributed little information beyond what was presented by Walker and Avant (1995).

**Norris.** The Norris (1982) method of concept analysis was directed at the development of meaningful descriptions of phenomena important to nursing for the purpose of constructing and testing theory. Meaningful descriptions contributed to the development of concepts. Theory construction did not specifically fit the goals of this concept analysis.
Norris (1982) stated that a concept can be precisely defined, but did not discuss the philosophical basis for the method in sufficient detail. Also, the influence of context and time on the product of concept analysis was not discussed, yet the method incorporated participant observation techniques. Valuable descriptive data about the concept as it existed in context was extracted using this method. The philosophical basis for analyzing concepts was unclear. Although there were five succinct steps, the method was difficult to apply without more information to guide the process (Lackey, 1993). The method was primarily centered on observation and description of the phenomenon, systematizing the results, and developing an operational definition and model to develop hypotheses. The method was most effective when applied to more observable phenomena (Lackey, 1993). The participant observation approach, although contributing significantly to the analysis of a concept in a specific context, was not feasible within the time frame of this thesis work.

Schwartz-Barcott and Kim. Schwartz-Barcott and Kim (1993) developed a method of concept analysis to teach students how to select, develop and apply concepts and theoretical frameworks in specific clinical nursing situations. The main purpose of the analysis was to solve conceptual problems regarding definitions and measurement by refining individual concepts. This purpose was congruent with the goals of concept analysis identified in this study. The method incorporated three phases, theoretical, fieldwork and analytical. The literature review conducted in the theoretical phase, focused on the discovery of meaning and measurement issues. The goal of this phase was to produce essential attributes of a concept and a working definition. Although the purpose of the method is clear, Schwartz-Barcott and Kim (1993) did not describe adequately, the philosophical basis for the method or how the authors they referenced contributed to the development of the philosophical underpinnings
they used. The first phase was intended to discover broad uses and definitions to identify conceptual and measurement issues. Although a working definition was produced, there was a concern that the selection of a definition in this phase may be premature and prevent the researcher from being open to other possible essential attributes. The second phase involved observation of the phenomenon in the field and the third phase was used to integrate the results of the literature review with empirical data gathered from the field. The second and third phases were considered beyond the scope of the present study.

Schwartz-Barcott & Kim (1993) agreed with Rogers (1993a) and Walker & Avant (1995) regarding the use of existing literature as the basis for identifying essential attributes. They extended this examination of the concept to include verification of the conclusions discovered in the literature review by conducting a field study of experts. The integration of data in concept analysis was unique to this particular method and offered an approach to verification of findings from the literature through collecting empirical data. The nature of the concept was substantiated and the relevance of the concept to nursing was justified through the use of actual clinical examples. Although this method supports the use of the literature in uncovering the essential attributes of a concept, the fieldwork phase was not feasible for achieving the goals of this analysis.

Rodgers. The approach to concept analysis developed by Rodgers (1993a) was based on a philosophical perspective that acknowledges the changing nature of concepts. Rodgers (1993a) provided a detailed perspective, identifying that concepts are not static and that they are influenced by contextual factors and evolution of the concept over time. The primary purpose of this method was to provide a clear conceptual foundation as a guide for further inquiry and, in doing so, to maintain a useful, applicable and effective concept. The eight
steps outlined were clear. The actual method was very similar to the method described by Walker and Avant (1995). Like Walker and Avant (1995) however, it was unclear how the apparent differences in philosophical underpinnings changed the way that this method was applied. Roger’s method (1993a) did include specific reference to gathering data on surrogate terms, related concepts and interdisciplinary and temporal comparisons. Rodgers (1993a) also drew examples from the literature and from experience to further illustrate the nature of the concept. Other steps in the method remained the same as Walker & Avant (1995). Rodgers (1993a) recommended sampling from the chosen population of literature. The approach identified a manageable number of articles to be included in the analysis. Classic or landmark articles could still be identified and included in the analysis. Rodger’s (1993a) purpose and method of concept analysis were generally congruent with the goals of this study.

**Summary of Research Design**

The method selected for this concept analysis was a synthesis of three approaches developed in nursing including Rodgers (1993a), Schwartz-Barcott & Kim (1993) phase I, and Walker & Avant, (1995). These methods were selected due to the similarity of purpose and feasibility of the method. A philosophical view acknowledging the changing nature of concepts guided the development of the method. Significant factors influencing the definition of the concept were considered in the method including contextual, societal and temporal elements. Those elements of each method that were congruent with the philosophical underpinnings and study purpose and objectives were included in the concept analysis.
The following research design has been adapted from Rodgers (1993a), Schwartz-Barcott and Kim (1993) and Walker and Avant (1995). Although the steps are ordered, the process is iterative in nature and includes the following:

1. Identify and describe the context in which the concept is discussed or studied.

2. Determine essential attributes. Identify the combination of qualities or attributes of this concept that make it different from other similar concepts. Definitions of the concept, indicators used in measures of SOI, and discussion and examples of the concept in the literature provide useful insight into the characteristics that set the concept apart from others. The meaning of the concept can be inferred from this data. Words, phrases, sentences and/or descriptive passages of the data will be extracted from the text and analyzed.

3. Examine antecedents and consequences. Antecedents and consequences are events or situations that precede or follow an example of the concept. These factors are helpful in identifying whether the concept exists in a particular situation and are illustrated in empirical examples of the concept.

4. Identify concepts or terms related to the concept of interest such as concepts present in the literature that are used similarly or together with SOI in the neonate. Surrogate terms are alternative ways of expressing the concept using words not used by the student. Related terms and concepts use different words and meanings but the idea is somehow related to the concept of interest and is used frequently in the same literature as the concept of interest.

5. Describe all uses of the concept that can be discovered. Concepts can be used for different purposes such as a predictor of a particular phenomenon or the end result of a particular process. Usage reflects the nature of the concept and how health disciplines view
this concept in terms of its contribution to solving problems important to the discipline and society.

6. Identify empirical examples of neonatal SOI indices or descriptions recorded in the literature. Empirical instances of the concept found in the literature can help improve identification of the essential attributes of SOI in the neonate and our ability to identify the concept in practice.

7. Identify implications for further study from recommendations found in the literature as well as insights gained from conducting the concept analysis. Implications for further study and insights of the student will be set aside, recorded in a separate journal and reviewed following the analysis. The results of this review will be included in the final discussion section of the analysis.

Selection of the Sample

Given the enormity of the existing literature, it was not feasible to include all the articles and books that pertained to SOI in the neonate, child and adult for this thesis. The articles were limited to the neonatal population to support the purpose and objectives of this study. As concerns existed that sampling from the population of articles on SOI in the neonate may have excluded important or influential sources, all articles meeting the sampling criteria were included in the study.

The literature review was limited to articles published between January 1990 and December 2000. Important advancements in neonatology and economic pressures occurring during this time frame significantly influenced the development of SOI. Technological advancements in the ventilatory care of premature neonates including widespread use of surfactant and corticosteroids improved the outcomes of immature newborns. The cost of
neonatal care was being questioned more frequently in the face of improved survival rates. This period of time was characterized by fiscal responsibility and the need for justification of excessive resource use and spending. The need to address questions related to the effectiveness of clinical care, resource use and the cost of care justified the proliferation of neonatal outcomes studies and the development of related neonatal measures. Investigators recognized the potential relationship between outcomes and SOI. Leading measures of SOI in the neonate were developed and implemented to attempt to address issues related to different levels of SOI. This time frame best reflected current use of the concept of SOI, as it was applied to the neonatal population during the past decade.

Selection Criteria

Literature sources were selected for this analysis based on the following criteria:

1. The source focused on the neonatal population exclusively. A neonate was defined as a newborn infant preterm to one month of age (Fetus and Newborn Committee, Canadian Paediatric Society, and Committee on Fetus and Newborn, Committee on Drugs, Section on Anaesthesiology and Section on Surgery, American Academy of Pediatrics, 2000).

2. Within the source, SOI was identified as a concept of interest. The concept had to be discussed in sufficient depth to clarify and further develop understanding of the concept. Sources had to discuss theoretical or conceptual development of SOI, conceptual or operational definitions, observed dimensions of the concept, and/or SOI measures and indicators. SOI had to be discussed as a general concept: not specific to a particular disease or diagnosis.
3. Sources were drawn from the health disciplines literature: primarily articles written by nurses and physicians. These professions have made a significant contribution to the development of this concept.

4. Sources were identified from empirical literature published from January 1990 to December 2000. Limitation of the sources to the last eleven years was supported by historic and temporal influences on developments in neonatal care.

5. Sources were published in English. The inclusion of sources that required translation was not feasible. A relatively low percentage of articles were published in languages other than English (approximately 11%). Every effort was made to obtain articles that had been translated.

Procedures

**Computer Database Search.** The identification and selection of sources was conducted using primarily computer databases. Articles were selected for review from Medline, Healthstar, Cinahl, Cancerlit and Embase databases. These databases were selected because they are known to be primary sources of health literature for nurses and physicians. Criteria for the search were developed based on the MeSH classification system used in the Medline database and were applied uniformly across the five databases. The search criteria were applied to each of the five databases in the following order: (a) a set of all articles that included neonates as subjects and/or the “neonate” as a text word was identified, (b) a set of all articles that included an index of severity of illness and/or “severity of illness” as a text word was identified, (c) the neonate set and the severity of illness set were combined to create a set of articles that contained both neonates and severity of illness, (d) the combined set was limited to articles published between 1990 and 2000 and was limited to the English
Appendix B shows the specific MeSH terms used to conduct the computer database search.

In addition to the computer database search, a manual search of the reference lists of the eligible articles was conducted. As the criteria for including articles in computer databases has varied over time and the system for classifying articles has differed among databases, the completeness of a computerized literature search alone could not be guaranteed. The manual search was added to improve the thoroughness of the search.

Abstract Scan. A screening procedure was applied to all sources meeting the computer database search criteria. Abstracts of these sources were scanned for the following criteria: (a) subjects had to be neonates exclusively, no other age groups could be included in the article, and (b) SOI had to appear in the text of the abstract or had to be listed as a MeSH subject heading. If an abstract was not provided in the computer database, the article was automatically moved to the next level of review.

Reading of the Article. Each article that met the abstract scan criteria was read completely. The articles were included in the final sample as eligible articles if they met the selection criteria for the study. A decision trail was recorded for any ambiguous sources (see Appendix C). Articles that were excluded because they did not meet the selection criteria were reviewed and reported in the results section. A separate reference list of ineligible articles was kept (see Appendix E).
Review of the Reference Lists. Each reference list from the eligible articles was reviewed to identify additional articles. Each article identified was read completely. The articles from the reference lists included in the final sample, had to meet the same selection criteria as for Reading of the Article.

Data Collection

All data were extracted from the sources and entered into a single chart including description of the articles and data used to analyze the concept, SOI (see Appendix D). Data were extracted in the form of words, phrases, sentences or entire paragraphs from various parts of each source. The type of data that was collected and recorded under each heading is described in detail in the following paragraphs:

1. Year of Publication (see Appendix D, column B). Each source of data was identified by the year of publication.

2. Type of Publication (see Appendix D, column C). Each source of data was identified by type of publication. The publication type was recorded as one of the following types: (a) theoretical and/or conceptual (indicated by “T”), (b) empirical research (indicated by “R”), (c) systematic review of the literature (indicated by “L”), (d) letter/commentary (indicated by “C”), and (e) other (indicated by “O”, accompanied by an explanation).

3. Author (see Appendix D, column D). All of the authors of the source were recorded by name.

4. Definition of the Concept – Implicit or Explicit (see Appendix D, column E). Whether the source provided an implicit or explicit definition of the concept of SOI of the neonate was recorded in this column. The type of definition was indicated by an ‘E’ – explicit or an ‘I’ – implicit. Explicit definition– a plainly expressed and clear description of
an abstract idea that communicated the meaning of the concept that is usually presented to
the reader in the conceptual framework section of an article. Implicit definition— a
description of an abstract idea that was not specifically expressed as a definition. Meaning
was implied or understood, communicated by the author through discussion of the concept
and/or the measures of the concept. Dimensions of the concept were used to imply the
meaning of the concept.

5. Definition of the Concept (see Appendix D, column F). Definitions of the concept
SOI in the neonate were identified and recorded as they appeared originally in each source.
Definition of a concept is an explicit description of an abstract idea communicating the
meaning of the concept.

6. Observed Dimensions (see Appendix D, column G). Dimensions or aspects of the
concept were often incorporated into a definition of the concept and were recorded in this
section. A definition of the concept, however, did not always exist in every source.
Discussions of various aspects or dimensions of the concept occurring in all parts of a source
were examined and recorded. Identification of observed dimensions such as physiological
and behavioural aspects of a concept provided implicit information about the concept. This
type of descriptive discussion linked the conceptual to the operational definition and
contributed to identification of the defining characteristics.

7. Operational Definition (see Appendix D, column H). The operational definition
translated the concept into measurable terms by describing the procedures that indicated
whether, and to what degree the variable was present. A clear explicit operational definition
existed in some sources (e.g., a definition that described the measurable physiological and
behavioural components of SOI). Alternatively, the indicators were listed. Specific
indicators were identified and used to reflect the concept. These indicators were often discussed as domains of the concept in the text of the source, such as in the discussion or results section of an empirical study.

8. Name of the Measure and/or Indicators (see Appendix D, column I). The name of the scale or measure of SOI was extracted from the source. Whenever possible, examples of the indicators used in the scale were listed. In some cases, the content of the measure was reflected by discussion, description or use of the indicator. For example, the procedures and operations used to measure the concept were described as indicators such as blood pressure.

9. Concept Usage (see Appendix D, column I). Use of the concept was identified (e.g., part of an initial assessment, part of a theory, an independent or dependent variable, a descriptor of a population, or a control variable). Extracted data included under what conditions and for what purpose the concept was used. Concept usage also reflected the importance of this concept to health disciplines.

10. Description of Context (see Appendix D, column K). Information regarding who, where and under what circumstances the concept was discussed, was extracted. Specifically, profession of the author (Registered Nurse (RN), Physician (MD), Multiprofessional, both (RN and MD) or other), setting (acute, chronic, acute and chronic, or community), and patient characteristics (full term, preterm, both, other) were recorded.

11. Surrogate Terms (see Appendix D, column L). Terms that are used to refer to SOI were recorded. Terms having similar meanings to SOI were identified by interchangeable or overlapping usage, implicit or explicit discussion of related meanings,
and/or shared defining characteristics. Words, sentences or paragraphs that served as evidence of similar meaning or relatedness will also be recorded.

12. Empirical Examples (see Appendix D, column M). Empirical examples of the concept were extracted from the sources.

**Data Management**

Each source was numbered and read in its entirety. Data from each source were numbered and entered on the data collection chart (see Appendix E). Pertinent data were used for two different purposes, description of the sample and analysis of the concept. Descriptive data were extracted and entered on the data collection chart, columns B, C, D, E, F, I, J, K and L. Data used for the analysis of the concept were extracted from each source and entered on the data collection chart, columns F, G, H, I, J and M.

Descriptive data were analyzed and displayed in tables and figures. Data reflecting the essential attributes of SOI were grouped into categories. Each category was labeled and represented one essential attribute. Other data representing antecedents, consequences, and related factors were grouped and labeled as categories. Uses of SOI were described and summarized. Surrogate terms were displayed in table format. Empirical examples were identified and discussed in the findings. A reference list of all sources selected for the analysis was included in the reference section and marked with an asterisk. A reference list of all excluded sources was developed (see Appendix E).

**Records**

Record books were kept as an audit trail to document ideas, issues, insights and questions that arose during the study. Four separate books were kept to record information
related to the study (see Appendix D). This information was reviewed following completion of the analysis and issues were addressed in the discussion section of the thesis.

Rigor

The rigor of the data analysis was supported in three ways: (a) the descriptive data were presented in tables and graphs, (b) the process of categorizing data was checked using two verification tests, and (c) an audit trail of decision making and idea development was maintained.

Two verification tests were conducted to check the rigor of the process of categorizing data. The student (KS) reviewed the first 10 articles that met the selection criteria of the study. Data were extracted from the articles and entered on the data collection chart (see Appendix D). The student analyzed the data by sorting it into categories of essential attributes according to the data analysis procedures that follow this section. The student labeled each category of essential attributes. These data then were distributed to two clinical experts in neonatal care. Both clinical experts were clinical nurse specialist/nurse practitioners who were actively employed in neonatal intensive care units at two large teaching hospitals. The first clinical expert was given a sample of extracted data (81 pieces of data from 10 articles) to sort into the categories labeled by the student. The practitioner was provided with a set of category labels. The practitioner was asked to sort each piece of data according to the following written instructions: (a) Enclosed, please find 81 sentences, phrases or words that each represents a piece of data; (b) The data have been provided in random order on the subsequent four pages; (c) I have provided you with 10 categories of attributes that characterize the concept of SOI in the neonate; and (d) I would like you to organize the data under the categories provided.
The second clinical expert was given extracted data that had been grouped into categories by the student. This practitioner was not provided with the category labels but was asked to generate labels for each group according to the following instructions: (a) Each page contains data that has been grouped together to represent an essential attribute of SOI in the neonate; and (b) Please develop a title for each page that best reflects the essential attribute represented by the category.

An audit trail was kept to monitor decision-making and the development of ideas during the study. The record book focused on the following four areas: (a) inclusion/exclusion of data, (b) methodological decisions, (c) data analysis procedures, and (d) self-awareness of the researcher. The rationale for making decisions was included in the record. The record was used to monitor and track aspects of the evolving data analysis and supported the dependability and credibility of the concept analysis (Rodgers & Cowls, 1993).

**Data Analysis Procedures**

**Selection of the Sample**

A series of selection criteria were applied to realize the final sample of articles including a computer database search, abstract scan, complete reading of the article and reference list review. A schema was used to display the sampling process and number of articles included/excluded.

**Description of the Sample**

Data from the eligible articles (see Appendix D, columns B, C, E, I, K, J, L) were analyzed using descriptive statistics. The number of setting types was reported in the findings. Relative frequency distribution tables were used to communicate findings related to the author type, patient type, and publication type. Frequency distribution graphs were
used to display the following descriptive information: the year of publication of the articles, and the neonatal measures of SOI identified in the articles. Surrogate terms used in place of SOI were reported in table format. Conceptual definitions of SOI were identified in the eligible articles and reported in the findings.

**Analysis of the Concept**

Articles in the sample were read for content related to the concept SOI. Content pertaining to a conceptual model, definition of the concept, description of qualities or dimensions of the concept, operational definition, how the concept was measured, what indicators were used and uses of the concept were identified (see Appendix D, columns F, G, H, I, and J). Words, phrases, sentences and paragraphs related to SOI were extracted. Data were grouped together based on similar themes. Each grouping/category represented a potential attribute of the concept. The categories were labeled. Some units of data could fit into more than one category if more than one theme existed within the phrase or paragraph. To identify the critical idea/theme used to categorize the data, the key word or phrase was underlined. Individual units of data were compared to each other within each category to ensure consistency of data within categories. Inconsistent data were reorganized into new categories, related categories or removed altogether. Category labels were adjusted to fit the data. Relationships between the categories and the concept SOI were examined to determine attributes, antecedents and consequences. A definition of the concept and a conceptual model were generated, based on the categories identified. Essential attributes of the concept, antecedents, consequences, and related factors were incorporated into the definition of the concept and the conceptual model. The next section provides the results from this analysis.
CHAPTER THREE

Results

The purpose of this study was to identify the essential attributes of SOI in the neonate and to develop a definition of the concept from the literature. A sampling process was applied using a series of inclusion criteria to derive the final sample. Description of the sample of articles including the type of author, patient, setting, and publication, year of publication, measures of SOI used, surrogate terms, and definitions of the concept was undertaken to identify the context of the concept. Analysis of the content of the selected literature identified categories of data related to SOI as attributes, antecedents, consequences and related factors. Also, other findings including uses of SOI and empirical examples were discussed. Findings of the analysis were incorporated into a definition of the concept and a conceptual model. The focus of this section was to describe the context of the study using descriptive data and to present the findings from the concept analysis.

Verification Tests

Two verification tests were conducted to check the rigor of the process of categorizing data. Each verification test examined a different aspect of the process of categorizing data. Data collected from the first 10 sources (14% of the sample) were distributed to two clinical experts in neonatology.

The first clinical expert was provided with the data and the labels (derived by the student) for 10 categories and was asked to sort the data into categories representing essential attributes of the concept. Fifty-three of 81 pieces of data were sorted in agreement with the student resulting in a 65% rate of agreement between the first clinical expert and the student. Subsequently, the student discussed the sorting of data with the first clinical expert and the
rate of agreement improved. The exact percentage of agreement was not recalculated, as the student did not keep a record of each piece of data that was categorized differently following this discussion.

The second clinical expert was asked to independently generate names/labels for the categories of data. Of the 10 categories of data, 5 of the labels matched those derived by the student. The student chose to meet with the practitioner to discuss the remaining five categories and to work towards achieving a consensus. Subsequently, four of the titles were revised and a consensus was achieved in 9 of 10 category labels. Therefore, 90% agreement was achieved.

By comparing the work of the student with clinical experts in neonatology, the rigor of categorizing data was maintained. Although the first test, sorting the data into categories, showed a moderate level of agreement (65%), consensus improved after the student discussed the results of the sorting with the clinician. The student was unable to report this improvement, as the level of agreement was not recalculated. In the second test, 90% agreement was ultimately achieved. The student was not able to compare the percentage of agreement between the two verification tests because they were independent and different exercises. The percentage of agreement between the student and the clinical experts indicated that the clinicians generally supported the accuracy with which the student conducted this part of the analysis.

Selection of the Sample

In Figure 1, a schema shows the selection process for the study sample. There were two sources of eligible articles in this study, the computer database search and the review of the reference lists from eligible articles from the computer search.
Computer Database Search (n=1768)

Abstract Scan Did Not Meet Selection Criteria (n=1616)

Reading of Article Not Eligible (n=94)

Abstract Scan Met Selection Criteria (n=152)

Reading of Article Eligible (n=58)

Review of References Lists Yielded Additional Articles Eligible (n=13)

Total Articles Eligible (n=71)

Figure 1. Schema of sample selection. The study period was from 1990/01/01 to 2000/12/31.
Using the computer search criteria (described earlier), articles were identified for further review from the following five computer databases: Medline, Cinahl, Cancerlit, Healthstar, and Embase. Eleven percent of the articles identified in the computer database search were non-English and thus did not meet the search criteria (n=218). Abstracts of the articles meeting the search criteria were scanned. Articles meeting the abstract scan criteria were then read completely. Of the 152 articles that were read completely, 94 did not meet the inclusion criteria for the following reasons: (a) they did not meet age criteria, (b) the term “severity of illness” was not used explicitly in the article, (c) the measurement of SOI was isolated to a specific disease, and (d) the article did not include enough discussion of the concept. In the articles that did not meet age criteria (n=22), neonatal content could not be differentiated from pediatric content as the articles included broad age groups. Other articles did not use SOI explicitly (n=25). For example, other terms such as mortality risk, were used in place of SOI and were measured using SOI measures or SOI was used in the abstract, but was not used in the article. Articles containing disease-specific measures of SOI were excluded (n=29). These measures were narrow in scope and purpose and did not apply broadly to all neonates. Lastly, articles were excluded because they contained insufficient data (n=18). None of the sentences, phrases or words contributed to understanding of the meaning of SOI and therefore, no data could be collected and categorized from these articles.
Description of the Sample

Author, Patient and Setting Types

Contextual data included author type, patient type and setting type. Most articles were published by physicians (MDs), while a smaller number were published by nurses (RNs) (see Table 1). Multiprofessional authors were groups that included at least two different health care disciplines. When RNs authored articles with MDs, however, the term used was both RNs and MDs.

The settings for all articles were acute care settings, primarily neonatal intensive care units. All articles discussed SOI in the neonate including preterm and fullterm neonates admitted to intensive care units (see Table 2). The type of neonates most commonly written about was equally divided between preterm only and both preterm and fullterm infants.

Table 1
Relative Frequency Distribution of Author Types in Sample of Articles

<table>
<thead>
<tr>
<th>Author Type</th>
<th>f</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>MD</td>
<td>43</td>
<td>61</td>
</tr>
<tr>
<td>RN</td>
<td>11</td>
<td>16</td>
</tr>
<tr>
<td>Multiprofessional</td>
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<td>14</td>
</tr>
<tr>
<td>Other</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Both RN &amp; MD</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Table 2

Relative Frequency Distributions of Patient Types in Sample of Articles

<table>
<thead>
<tr>
<th>Patient Type</th>
<th>$f$</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Both Preterm &amp; Term</td>
<td>34</td>
<td>48</td>
</tr>
<tr>
<td>Preterm only</td>
<td>34</td>
<td>48</td>
</tr>
<tr>
<td>Fullterm only</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Unknown</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Publications: Type and Year

Of the 71 publications, the majority were research reports (see Table 3). Other types of publications included letters, literature reviews, discussion papers, annotations, and database development. The number of articles written about SOI in the neonate has steadily increased over the eleven-year study period, with the exception of a slight drop in the number of articles in the year 2000, as shown in Figure 2.
Table 3
Relative Frequency Distributions of Publication Type in Sample of Articles

<table>
<thead>
<tr>
<th>Publication Type</th>
<th>$f$</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research</td>
<td>59</td>
<td>83</td>
</tr>
<tr>
<td>Letter</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Literature Review</td>
<td>2</td>
<td>2.8</td>
</tr>
<tr>
<td>Discussion Paper</td>
<td>1</td>
<td>1.4</td>
</tr>
<tr>
<td>Annotation</td>
<td>1</td>
<td>1.4</td>
</tr>
<tr>
<td>Database Development</td>
<td>1</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Figure 2. Frequency distribution by the year of publication in the sample of articles.
 Measures

Frequency distribution of the use of neonatal SOI measures is displayed in Figure 3. A total of 21 different measures of SOI in the neonate were used in the sample of 71 articles. Each neonatal measure and its indicators are listed in Appendix F. Of the 21 measures identified, 8 neonatal measures dominated the literature including the SNAP group (4 measures) (Richardson, Gray, McCormick, et al., 1993), CRIB (Tarnow-Mordi et al., 1990), NTISS (Gray, Richardson, McCormick, Workman-Daniels, et al., 1992), TISS (Cullen et al., 1974) and PSI (Yeh et al., 1984). Together, these eight measures were used predominately (72%) in the sample of articles.

SNAP is an acronym for a neonatal SOI measure titled Score for Neonatal Acute Physiology (Richardson, Gray, McCormick, et al., 1993). The term SNAP group refers to a family of measures derived from and including the original SNAP (Richardson, Gray, McCormick, et al., 1993) including the Score for Neonatal Acute Physiology Perinatal Extension (SNAP PE) (Richardson, Phibbs, et al, 1993), Score for Neonatal Acute Physiology Vital Signs (SNAP-VS) (Roblin et al., 2000), and Score for Neonatal Acute Physiology II (SNAP II) (Cheung & Robertson, 2000). The original SNAP was used predominately (24%) in the articles on SOI in the neonate, followed by SNAP PE (10%), SNAP VS (1%), and SNAP II (1%). These percentages express the total use of the individual SNAP measures among all of the sample articles.
Figure 3. Frequency distribution of the use of neonatal SOI measures. Measures are used 100 times in 71 articles. SNAP group is composed of the following measures: SNAP = Score for Neonatal Acute Physiology, SNAP PE = SNAP Perinatal Extension, SNAP VS = SNAP Vital Signs, and SNAP II = SNAP Version II. Other additional measures consist of CRIB = Clinical Risk Index for Babies; NTISS = Neonatal Therapeutic Intervention Scoring System; TISS = Therapeutic Intervention Scoring System; PSI = Physiologic Stability Index; NMS = Neonatal Morbidity Scale; PM DRG = Pediatric Modified Diagnosis Related Groups; DRG = Diagnosis Related Groups; PRISM = Pediatric Risk of Mortality Score; APGAR = Appearance, Pulse, Grimace, Activity, Respiration; and NBRS = Neurobiologic Risk Score. "No Formal Measure" included articles using individual indicators to measure SOI. "Other" included formal measures having multiple indicators that were used infrequently in the articles. For a complete list of measure names, acronyms, and indicators see Appendix F.
Surrogate Terms

A total of 53 different terms were used to indicate SOI. Surrogate terms for SOI used in the articles, are listed in Table 4 by groups defined by the investigator. Many terms, such as severity of underlying illness, severity of acute illness, and illness severity linked severity and illness in different ways. Also, the word sick or sickness was associated with many surrogate terms used for SOI. The word, disease, was frequently used in place of illness. Risk was frequently used in place of SOI. Overall, a variation terms in the use of surrogate terms was identified from the articles.
### Table 4

**Surrogate Terms for Severity of Illness in the Neonate**

<table>
<thead>
<tr>
<th>Grouping</th>
<th>Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severity of Illness</td>
<td>severity of illness, illness severity, severity of neonatal illness, severity of underlying illness, severely ill, severely ill infant, severity of acute illness, severity, infant severity of illness, severity of infant illness, extremely severe illness, severity scores, admission severity, severity of presentation, severity level of the disorder</td>
</tr>
<tr>
<td>Sick</td>
<td>how sick, sick infants, sicker infants, extremely sick, very sick infants, sick preterm infant, sick neonate, ill infant, ill preterm infant</td>
</tr>
<tr>
<td>Risk</td>
<td>clinical risk, mortality risk, high medical risk, initial neonatal risk, risk, high-risk preterm, illness risk, risk scores, risk scoring system, health risk</td>
</tr>
<tr>
<td>Disease</td>
<td>disease severity, severity of disease, severity of underlying disease</td>
</tr>
<tr>
<td>Condition</td>
<td>condition of the newborn, actual severity of the premature infant’s medical condition, neonatal condition, immediate condition of premature newborn</td>
</tr>
<tr>
<td>Critical</td>
<td>critically ill, critical illness</td>
</tr>
<tr>
<td>Illness</td>
<td>underlying degree of illness, degree of illness</td>
</tr>
<tr>
<td>Physiological</td>
<td>physiologically unstable, physiologic stability</td>
</tr>
<tr>
<td>Health</td>
<td>health status</td>
</tr>
</tbody>
</table>
Definitions of the Concept

Two of the 71 articles used an explicit definition of the concept. These definitions of the concept were extracted from the introductory paragraphs of the articles and were not part of the conceptual framework of the studies. The definition developed by Stevens and Johnston (1994) used stability as its central idea and supported the conclusion that stability is an essential attribute of SOI. “Severity of illness was defined in terms of the infant’s physiologic stability.” (Stevens & Johnston, 1994, p. 227). Almeida and Persson (1998) identified suffering and disability as the primary attributes of SOI. “Severity of illness is concerned with suffering and disability, which are the properties of the individual.” (Almeida & Persson, 1998, p.12).

Analysis of the Concept

Definition of Severity of Illness in the Neonate

SOI is characterized primarily by instability of the neonate that manifests itself as changes in the physiological domain. Other attributes identified including suffering and disability, had less support in the literature. Antecedents to SOI, maturational and developmental factors, include characteristics of the neonate such as birth weight, gestational age and congenital anomalies. Therapeutic intervention occurs as a consequence or response to instability. Stress, capacity for behaviour and complication in the neonate are associated with SOI as related factors. A conceptual model was developed to illustrate these relationships (See Figure 4).
Figure 4. Conceptual Model of Severity of Illness.
Attributes

Instability. The label instability was chosen to reflect the primary essential attribute or characteristic of SOI. The terms, instability and stability were used consistently throughout the data, examined as two ends of a continuum. Stability as it reflects SOI, implies consistency in contrast to instability that implies potential for change or alteration to homeostasis within an organism. “The assumption of derangements of homeostasis leading to a final common pathway toward death or damage is generally reasonable.” (Richardson, Tarnow-Mordi, & Lee, 1999, p. 263). Although both terms were used in the literature, instability was selected to represent this attribute. As the primary context for SOI in the neonate was the neonatal intensive care unit, instability best reflected the condition of a neonate likely to require this level of monitoring and support.

In the data, instability and stability were consistently and clearly linked with SOI in the neonate (Davies, 1995; Johnston & Stevens, 1996; Petryshen, Stevens, Hawkins, & Stewart, 1997; Richardson, Shah, et al., 1999; Stevens & Johnston, 1994). The following examples demonstrate the use of this attribute as reflecting SOI:

1. “…by quantifying physiologic stability, the PSI provided an overall assessment of the infant’s severity of illness.” (Petryshen et al., 1997, p. 140).

2. “Severity of illness was defined in terms of the infant’s physiologic stability.” (Stevens & Johnston, 1994, p. 227).

3. “SNAP from the second 12 hours primarily indicates the effectiveness of early medical interventions and, to a certain extent, physiologic stability (or instability).” (Petridou et al., 1998, p. 1042).
4. "In contrast to APACHE & PSI, a patient may receive points for both high and low values of a single physiologic measure because this represents more extreme physiologic instability." (Richardson, Gray, McCormick, et al., 1993, p. 617)

5. "The seven systems measured (PSI) are: cardiovascular, respiratory, central nervous system, haematologic, renal, gastrointestinal, and metabolic. The higher the score, the more severe the physiologic instability." (Davies, 1995, p. 307)

6. "The frequency of bacteremia was examined, since blood cultures are performed when neonates display nonspecific signs of clinical instability such as apnea, bradycardia, temperature instability or feeding intolerance. Although bacteremia workups have never been tested formally as an index of severity of underlying illness, it is reasonable to assume that physicians are more likely to obtain blood cultures from neonates who appear more critically ill." (Freeman et al., 1990, p. 328)

7. "...the greater the severity of illness and the degree of instability of vital physiologic variables on admission to an NICU, the more likely that infant is to die." (Pharoah, 1998, p. 1070)

8. "Advancing gestation had a powerful impact on neonatal stability, with a drop of more than one SNAP point for each additional week of gestation." (Richardson, Shah, et al, 1999, p. 515)

Physiologic indicators were used to measure SOI. These physiologic indicators of instability reflected derangements in organ system functioning, for example; "A score, the PSI, has been developed that quantitates physiologic stability and therefore directly assesses SOI...The PSI score assesses a total of 34 variables from seven physiologic systems..."
modified for neonatal physiologic variables, the limits assigned depend on age.” (Davies, 1995, p. 307).

The derangements were manifested as abnormal values on tests such as laboratory tests, vital signs and physiologic assessments. The data supported this conclusion as 19 of 21 neonatal SOI measures identified in the sample used physiological indicators in their measures (see Appendix G). Derangements of physiological and laboratory parameters were used as the primary indicators of SOI and reflect changes in physiologic functioning.

Other Attributes

Suffering and Disability. Suffering and disability were identified as attributes of SOI in only one of the selected articles. Almeida and Persson (1998) offered a very different perspective than the other authors, suggesting that suffering and disability were the primary attributes of SOI, “Severity of illness is concerned with suffering and disability, which are the properties of the individual.” (Almeida & Persson, 1998, p. 12). They argued that CRIB and SNAP were developed to predict risk and measured a different but related concept, severity of disease. The characteristics, suffering and disability of the individual, were not discussed in depth by Almeida and Persson (1998) and were not identified and supported by data from other selected articles.

Antecedents

Maturation and Development. Gestational age, birth weight, and congenital anomalies are indicators of maturation and development in neonates (Davies, 1995; McKim, 1993). As such, they represent characteristics of the individual neonate. The selected data indicate that maturation and development factors have been clearly linked to SOI.
Gestational age and birth weight have been used as proxy indicators of SOI (Almeida & Persson, 1998; Richardson, Gray, McCormick, et al., 1993; Richardson & Tarnow-Mordi, 1994; Wang, Cherng & Chen, 1994). One leading measure of SOI, CRIB, incorporates birth weight, gestational age and congenital anomalies as indicators (INN, 1993). These indicators are identified as additional risk factors added to the physiology-based measure to predict risk of mortality and contribute little to the measurement of SOI (Richardson, Tarnow-Mordi, et al., 1999). Another measure, SNAP PE, also uses, "...birth weight, apgar score and small size for gestational age as additional independent predictors of outcomes." (Hanna et al., 1997), extending the SOI score (SNAP) to predict risk (Stevens et al., 1999). Congenital anomalies have also been identified as indicators of SOI that are used as separate risk factors in measures of SOI (Richardson, Tarnow-Mordi, et al., 1999; Davies, 1995). The selected literature indicates that as a characteristic of the neonate, maturation/development is related to SOI as an antecedent. The following excerpts illustrate the nature of the relationship:

1. "Lower gestational age was associated with greater severity of illness..." (Richardson, Shah, et al., 1999, p. 515).

2. "Advancing gestation had a powerful impact on neonatal stability with a drop of more than one SNAP point for each additional week of gestation." (Richardson, Shah, et al., 1999, p. 515).

3. "Factors such as assisted ventilation, oxygen needs and severity of illness differed between the age-groups. These differences were by virtue of group membership based on degree of immaturity..." (Johnston et al., 1996, p. 439).
4. "Measures of severity of illness for the period up to 48 hours of age reflected the effects of interaction among maturity, severity of illness and therapy." (Perlman et al., 1995, p. 85).

5. "...often ill, immaturity developed infant." (McKim, 1993, p. 89).

6. "...the length of hospitalization was affected by the degree of prematurity and the severity of the medical complications (the lower the birth weight the longer the stay in hospital...)") (McKim, 1993, p. 92).

7. "The assumption of derangements of homeostasis leading to a final common pathway toward death or damage is generally reasonable. However, for certain classes of patients, these assumptions may break down. The most obvious are congenital anomalies where standard physiology no longer obtains. An infant with a cyanotic congenital heart disease may show only a single abnormal value...yet may have a life-threatening illness." (Richardson, Tarnow-Mordi, et al., 1999, p. 263).

8. "Presence of a life-threatening congenital anomaly had the largest impact, adding 4.0 points [of 4 potential points to the SNAP score]." (Richardson, Shah, et al., 1999, p. 514).

9. "In the era when general neonatal surgery was making its greatest strides, illness severity [SOI] in patients with correctable but lethal congenital anomalies was determined by three factors, birth weight - used to represent gestational age or physiological maturity – associated clinically significant congenital abnormalities, and infection." (Davies, 1995, p. 306).

10. "...we cannot comment on whether diagnosis of major congenital anomalies such as lower bowel obstruction and heart defects initiated at home rather than at birth
hospitals was associated with differences in severity of illness on readmission…” (Lee et al., 1995, p. 763).

Maturation and development indicators reflected unique preexisting characteristics of the neonate, which have been shown to influence SOI in the neonate as a determinant or antecedent. These indicators may influence the degree of instability but may not directly reflect SOI.

**Consequences**

**Therapeutic Intervention.** Therapeutic intervention was discussed in great depth in the selected data. Many measures of SOI including the Neonatal Therapeutic Intervention Scoring System (NTISS) (Gray, Richardson, McCormick, Workman-Daniels, et al., 1992), Sinkin Score (Fleisher et al., 1997) and others, as well as informal measures, were composed of therapeutic indicators. The most common indicators included ventilatory assistance and length of stay. A relationship clearly exists between SOI and therapeutic intervention. “The likelihood of admission into NICU and the duration of both NICU care and hospital stay are proportional to the degree of illness.” (Roblin et al., 2000, p. 1535).

Therapeutic intervention has been described by authors as a proxy measure (Freeman et al., 1990; Lee et al., 1995) and as an indirect measure of SOI (Gray, Richardson, McCormick & Goldmann, 1995; Hazebroek, et al., 1991; Stevens, Richardson, Gray, Goldmann & McCormick, 1994). As therapeutic intervention did not reflect SOI in a direct way, it was concluded that it is not an attribute of SOI.

Therapeutic intervention has been described as a response to instability of the neonate (e.g., “…medical treatments occur after an illness has been present for some time…” [Holditch-Davis & Lee, 1993, p. 255] and “…require extensive therapeutic support to
achieve their physiological stability.” [Stevens, Richardson, et al., 1994, p. 948]). These examples indicate that therapeutic intervention logically follows SOI. Other data extracted from the selected articles described therapy as providing assistance (Roblin et al., 2000; Richardson & Tarnow-Mordi, 1994) and support to the neonate (Avila-Figueroa et al., 1998; Catlett, Miles & Holditch-Davis, 1994; Miall et al., 1999). Based on the evidence in the selected data, this author concluded that therapeutic intervention occurs as a consequence of SOI.

Related Factors

Complication. Data from the selected literature indicated that a relationship exists between SOI and complication, however the nature of the relationship was unclear. Very few articles discussed the association between SOI and complication. Different ideas about the nature of the relationship were expressed but few explained the ideas in sufficient depth to clarify whether complication was related to SOI as an attribute or a related factor. Complication was used as an indicator of SOI using diverse approaches: (a) frequency of complications (Helfrich Jones & Smyth, 1999), (b) single complication used as a proxy measure (Lee et al., 1995), and (c) twenty of the most common diseases and pathophysiological states were rated for SOI (Catlett et al., 1994; Holditch-Davis, 1990). In another article by Stevens et al. (1996), complication was identified as an indicator of functional status (functional status was identified as a related factor to SOI). The data provided support for the existence of a relationship between complication and SOI. Excerpts from the selected data that identify the relationship include: 
1. "They had significantly more medical complications, lower birth weights, and younger gestational ages at birth. They spent more days on mechanical ventilation and had higher overall illness severity." (Holditch-Davis & Lee, 1993, p. 259).

2. "Severity of illness as a consequence of NICU is often directly related to the functional status of preterm infants as measured by physiological stability and the potential for co-morbidity and/or complications." (Petryshen & Stevens, 1995, p. 1046).

3. "As proxies for severity of illness, the number of deaths and the length of stay after readmission were measured." (Lee et al., 1995, p. 760).


An association between complication and SOI was identified but the nature of the relationship was not clear. Diverse approaches to the measurement of SOI were used but were not well explained. Therefore, complication was considered a related factor that can influence and be influenced by SOI.

Capacity for Behaviour. Capacity for behaviour was identified as a related factor. A small amount of evidence was available to identify this relationship including some of the following excerpts from the data:

1. "...support for a profile of infant behavioural responses to a tissue-damaging stimulus that can be modulated by factors such as behavioural state and severity of illness." (Stevens, Johnston & Horton, 1994, p. 108).

2. "...overall severity of illness had only minor effects on the development of sleeping and waking in the preterm period." (Holditch-Davis, 1990, p. 523).
3. “Severity of illness affects the cry response to pain, not facial action or pathophysiological arousal in response to pain.” (Johnston et al., 1999, p. 588).

4. “...cry characteristics are thought to reflect the infant’s biological integrity or an index of underlying stress...due to neurological disorganization, sicker infants produce cries that are higher pitched, tense, grating, and generally more demanding than healthy infants.” (Stevens, Johnston, et al., 1994, p. 107).

5. “However, there was a significant interaction between severity of illness and behavioural state. It could be hypothesized that the physiological responses [to pain] of those infants who were in quiet sleep and most severely ill would be most affected.” (Stevens & Johnston, 1994, p. 230).

Behaviour was used as an indicator of SOI in the Apgar score, however the Apgar score was used only once on its own to measure SOI (Apgar, 1953). The Apgar was incorporated as an indicator into several other measures including SNAP PE, SNAP II and NICHD and was used more frequently; the rationale for its inclusion was unclear (Apgar, 1953; Cheung & Robertson, 2000; Richardson, Phibbs, et al., 1993; Pollock et al., 2000).

Capacity for behaviour was discussed in a limited way in the literature, as being a response to SOI or as having a relationship with SOI. Based on the selected literature, capacity for behaviour was not considered an attribute or a consequence of SOI, but a related factor.

Stress. Ideas about stress were identified from a very small amount of data. In one excerpt, degree of stress was evaluated using physiologic stability and measured using SNAP, “The Score for Neonatal Acute Physiology (SNAP) can be used to assess the level of physiological stress in critically ill infants.” (Petryshen & Stevens, 1995, p. 1047). In the second excerpt, Stevens, Johnston, et al. (1994) connected stress to neurological
disorganization, as indicated by cry characteristics, "...cry characteristics are thought to reflect the infant's biological integrity or an index of underlying stress...due to neurological disorganization, sicker infants produce cries that are higher pitched, tense, grating, and generally more demanding than healthy infants." (p. 107). Stress and SOI are linked as a measure of SOI, SNAP, is used also to measure stress. Stress is a related factor.

Uses

The significance or relevant purpose of the concept is reflected in its use (Rodgers, 1993a). The use of the concept influences the development of that concept. The use of the concept is a means of expressing the relevant attributes. SOI has been used in a variety of capacities in research. Authors have discussed other potential applications in letters, commentaries and reviews of the literature. The following paragraphs describe many uses for SOI.

Articles described potential uses in addition to actual uses. In an article that described developing a patient classification system, SOI was incorporated into the measure (Almeida & Persson, 1998). The measure was used primarily for assessing outcomes but also identified many potential uses for the measure including making decisions on staffing requirements, criteria for referring mothers and newborns, identifying staff education and training needs, standard criteria for patient information and prognostic systems for medical decision support (Almeida & Persson, 1998). Other articles summarized trends in the use of SOI including comparative studies of outcome between hospitals or individual clinicians, payment systems and the use of SOI as a basis to forgo treatment (Perlman, 1998; Richardson & Tarnow-Mordi, 1994).
In research, study groups were often stratified on SOI, such as in investigations of the incidence of interhospital transfers among insured and uninsured patients (Durbin, Giardino, Shaw, Harris, & Silber, 1997) and of the number of tests ordered by house staff physicians (Griffith, Wilson, Desai, & Rich, 1997; 1999). Many articles used or discussed SOI as a clinical outcome of care (Johnston et al., 1999; Lee et al., 1995; Petryshen & Stevens, 1995; Schibler, et al., 1998; Stevens et al., 1996; Wang et al., 1994). In one study, readmission rates and SOI were examined in neonates having been discharged home early from hospital (Lee et al., 1995). Frequently, SOI was used as a demographic variable that was compared between two grouped of patients being studied (Anand et al., 1999; Freeman et al., 1990; Johnston & Stevens, 1996; Holditch-Davis & Lee, 1993; Petryshen et al., 1997). In one study, three groups of infants receiving two different types of analgesia and a placebo were compared for SOI (Anand et al., 1999).

In other studies, SOI was considered a risk factor for mortality and was combined with other factors such as birth weight and gestational age to predict mortality (Fleisher et al., 1997; INN, 1993; Richardson et al., 1998; Richardson, Phibbs, et al., 1993; Richardson, Shah, et al., 1999; Scottish Neonatal Consultants’ Group, 1995; Stevens, Richardson, et al., 1994). Two studies compared several measures of SOI for their ability to predict morbidity and mortality (Fleisher et al., 1997; Pollack et al., 2000). SOI was also studied as a risk factor for other clinical outcomes such as bacteremia (Beck-Sague et al., 1994; Gray et al., 1995). In other research studies, SOI was used as a variable in a correlational study such as parental sensitivity and SOI and also in a correlational matrix to determine relationships between multiple technology use, SOI, and other factors (Almeida, Panerai, de Carvalho, & Lopes, 1991; Catlett et al., 1994; Hanna et al., 1997; Kratochvil, Robertson, & Kyle, 1991;
McKim, 1993; Miall et al., 1999; Shi et al., 1993; Swietlinski, Bujniewicz, & Musialik, 1992; Zahr & Cole, 1991) Another study examined the relationships between elevations of nitrite plus nitrate and SOI (Shi et al., 1993). SOI and birth weight were used as objective measures against which RN and MD estimates of mortality risk were measured (Stevens, Richardson, et al., 1994).

Reviewing the uses of the concept in the selected articles has identified the possible range of its uses. The successful application of SOI in research and practice implies that it is relevant to understanding the care requirements of neonates.

Empirical Examples

Three excerpts of SOI were extracted from the selected articles in whole sentences. Selection of an empirical example was based on its ability to reflect attributes, antecedents and consequences of SOI and to identify relationships drawn from the data about the general nature of the concept.

1. “In a number of children, postoperative complication or unsalvageable cardiac or renal anomalies leading to renal insufficiency were considered to be so serious that it was decided to discontinue treatment.”(Hazelbroek et al., 1991, p. 1061). In this example, cardiac/renal anomalies (developmental) were identified as antecedents of SOI. Postoperative complication is a related factor that influences the stability of the neonate. Evidence of renal insufficiency (instability) would likely present as derangements from physiological normal, therefore SOI exists in this example. Treatment decisions are made taking into account the SOI.

2. “Finally, in an attempt to control potential variations in admitting criteria and illness severity for neonatal versus adult patients, we identified the subset of each ICU and
NICU population with respiratory failure severe enough to require mechanical ventilation.” (Meadow, Lantos, Mokalla & Reimshisel, 1996, p. 598). Respiratory failure would likely present as derangements of respiratory indicators. The consequence of respiratory instability is therapeutic intervention through mechanical ventilation.

3. “When full-term neonates suffer asphyxia during labour or delivery, some may develop hypoxic-ischaemic encephalopathy, with outcomes ranging from complete recovery to death. Caregivers of these sick neonates have been searching for predictors of outcome to facilitate parental counseling, and to provide appropriate levels of care that may include withdrawal of therapy or initiation of neuroprotective strategies.” (Cheung & Robertson, 2000, p. 262). This example identifies the antecedent to instability, maturity of the neonate. The stressful event/complication of labour is a related factor. The resulting derangements of physiological indicators characteristic of hypoxia and ischaemia indicate the presence of instability and thus SOI. Therapeutic intervention is discussed as a consequence of the instability.

Results reported from the concept analysis will be summarized and discussed. Issues, ideas, questions and comments arising from the study findings will be identified and explored in the next chapter.
CHAPTER FOUR

Discussion

In this section issues, questions, and comments related to the study findings are discussed. Issues related to the description of the sample will be discussed first as they have an impact on the findings from each of the study objectives. Each study objective will then be discussed followed by other issues including: verification tests; lack of definitions of the concept; declining number of publications in 2000; subgroups among neonates; neonates, children and adults; empirical examples; and measures.

Description of the Sample

In this sample of 71 articles, the results showed that the concept, SOI in the neonate, was used exclusively in the neonatal intensive care setting. The primary authors were physicians, followed by nurses and multiprofessional groups. Research articles were the dominant type of publication. Researchers studied groups of preterm neonates and groups having both preterm and fullterm neonates about equally. Two articles provided explicit definitions of the concept. Of the 21 measures identified, 8 measures were used predominantly (72%). These leading measures had similar characteristics: (a) 7 of the 8 measures were directly derived from pediatric and adult measures, (b) 5 of the 8 measures were developed by the same group of physicians, (c) the essential attribute identified in 5 of 8 measures was instability measured by physiologic indicators, and (d) clear definitions of the concept were not evident in the articles describing the development of the measures.

The eight leading measures of SOI included: the SNAP (Richardson, Gray, McCormick, et al., 1993), the SNAP PE (Richardson, Phibbs, et al., 1993), the SNAP VS
(Roblin et al., 2000), the SNAP II (Cheung & Robertson, 2000), the NTISS (Gray, Richardson, McCormick, Workman-Daniels, et al., 1992); the TISS (Cullen et al., 1984); the CRIB (INN, 1993); and the PSI (Yeh et al., 1984). The SNAP group included the original SNAP and three variations of the original SNAP measure (Richardson, Gray, McCormick, et al., 1993). All of the SNAP measures were derived from the PSI, a pediatric measure, (Yeh et al., 1984) and the APACHE, an adult measure (Knaus et al., 1981). The PSI (Yeh et al., 1984) was used as a primary measure for infants and children in the literature until the SNAP measure was published by Richardson, Gray, McCormick, et al. in 1993. After 1993, the SNAP, developed specifically for neonates, was used as a primary measure. The TISS measure was developed for the adult population (Cullen et al., 1974). The NTISS (for neonates) (Gray, Richardson, McCormick, Workman-Daniels et al., 1992) was derived from the TISS. The majority of measures of SOI in the neonate used in this study have been derived from pediatric and adult measures that have significantly influenced the attributes, antecedents, consequences and related factors identified in this study.

Connections existed among the authors of the eight leading measures. Richardson and Tarnow-Mordi worked together collaboratively to publish research, review articles and letters, sharing a similar perspective regarding the nature of SOI. Other authors were linked because they derived their measure from one another. Clearly, the results of this concept analysis have been heavily influenced by a small group of physician authors.

The authors of these leading measures also shared a similar perspective with regards to the nature of the concept. The PSI and the SNAP group of measures were based on the essential attribute instability, as measured by physiologic indicators. Instability, as an attribute, was derived directly from pediatric and adult measures. The physiologic indicators
used to measure SOI in CRIB also supported the existence of a physiologic component to SOI. NTISS, derived from TISS, was clearly presented as an indirect measure of SOI and used indicators of therapeutic intervention to reflect SOI. This reflects heavily on the results of the study, specifically the main finding of the essential attribute, instability, and the support in the literature for therapeutic intervention as a consequence of SOI.

The sample represented the perspective of a small group of physician authors. These authors developed current leading measures of SOI in the neonate derived from pediatric and adult measures. The essential attribute, instability, was used in the majority of these measures. The results of the concept analysis were heavily influenced by the available literature.

**Major Study Findings**

The overall purpose of this study was to develop a definition of SOI in the neonate that captures neonatal characteristics and reflects a consistent view of the concept derived from current neonatal literature. The following research objectives were addressed by this study: (a) to determine the essential attributes of SOI, (b) to examine the antecedents and consequences of SOI, (c) to identify concepts related to SOI, and (d) to describe the uses of SOI in the literature.

In the first study objective, attributes of SOI were identified. Instability was clearly identified as an essential attribute of SOI. Other attributes, suffering and disability, although identified in the literature, were less developed than instability.

The neonatal intensive care unit (NICU) was the context for SOI in every article included in the study. Words used to describe this environment in the articles included critical and acute implying that neonates admitted to this environment are at risk for negative
outcomes. Discussions of SOI in the neonate in the literature included the terms stability and instability. These terms represent two ends of a continuum and were sometimes used interchangeably in the literature to characterize SOI.

To improve clarity in this analysis of the concept, it was important to select one of the terms to represent this attribute. Stability represents the general goal of care in the NICU however; the environment is characterized by change and fluctuation. Units are organized to identify and respond to significant changes in the condition of the neonate. Indicators used to reflect SOI focus on capturing abnormal results as opposed to evidence of normality and stability. Studies tended to focus on changes in SOI and how they affect outcomes of care. Instability was selected to reflect this attribute of SOI as it is more representative of the NICU environment and meets the needs of health care professionals addressing questions of prognosis, outcome and relationships with other concepts.

Logically, neonates are admitted to the NICU to be assessed, monitored and supported in order to manage and/or minimize the effects of instability. Authors of the PSI (Yeh et al., 1984) discussed instability as a characteristic of SOI more clearly and in greater depth than authors of subsequent measures derived from it (i.e., SNAP) (Richardson, Gray, McCormick, et al., 1993). For this reason, instability did not emerge as an attribute in the literature with the expected frequency. A possible reason for the minimal amount of discussion written about instability was the declining use of the PSI for neonates after the 1980’s. The PSI was developed for the pediatric intensive care environment (infants and children) (Yeh et al., 1984) and was replaced by newer measures (SNAP) developed specifically for neonates (Richardson, Gray, McCormick, et al., 1993). It is most likely that
the authors of SNAP transferred assumptions about instability as an attribute from the PSI and did not make them explicit in articles about SOI.

The strength of the support for instability as the primary essential attribute of SOI came from its use in measures of SOI in the neonate. The PSI (Yeh et al., 1984) and the SNAP (Richardson, Gray, McCormick et al., 1993) were identified as leading neonatal measures of SOI because they were used most frequently in the literature (43%). The physicians who developed these measures used instability to characterize SOI and in doing so, influenced the direction of the development of this concept.

The attribute, instability is commonly manifested in the physiological domain and is measured by physiological indicators (e.g., heart rate and respiratory rate). Instability is reflected by the derangements from physiological normal. Changes to the parameter either above or below the normal range count towards the measurement of instability. The worst physiological derangement for each indicator in a given time frame (i.e., the first 24 hours following admission to a neonatal intensive care unit) is used to calculate the score. The scores of all the indicators are summarized to reflect the SOI of the neonate. It is equally important however, to reflect instability by measuring the fluctuation of parameters both up and down over time. Each neonate has a certain capacity to adapt to stresses based on their maturity and development. The most serious instabilities can be indicated by prolonged periods of derangement, fluctuating both above and below normal such as with blood glucose, respiratory and cardiac parameters. Alternative approaches to measuring this concept may need to be considered.

Almeida and Persson (1998) identified suffering and disability to be attributes of SOI. Almeida and Persson (1998) did not discuss these attributes in depth. Suffering and
disability were not identified in the data from other articles included in the study. The attributes proposed by Almeida and Persson (1998) represent a significant departure from the essential attribute and other related factors identified. There was no evidence however, to refute the inclusion of these attributes. This may reflect the emergence of a new direction in the development of the concept.

The second study objective was to identify antecedents and consequences of SOI in the neonate. The antecedents identified were maturation and development. The consequence identified was therapeutic intervention.

Maturation and development are important neonatal characteristics that influence SOI. Gestational age and birth weight have been used as proxy indicators of SOI (Almeida & Persson, 1998; Richardson, Gray, McCormick, et al., 1993; Richardson & Tarnow-Mordi, 1994; Wang et al., 1994). Congenital anomalies have also been identified as indicators of SOI (Davies, 1995; Richardson, Tarnow-Mordi, et al., 1999). One leading measure, CRIB, incorporates birth weight, gestational age and congenital anomalies as indicators of SOI (INN, 1993). These indicators were described as risk factors added to physiology-based measures to predict risk of mortality (Hanna et al., 1997; Richardson, Tarnow-Mordi, et al., 1999; Stevens, et al., 1999). These characteristics of the neonate have been identified in the selected literature and influence SOI in the neonate as antecedents.

Neonates having a low birth weight or extreme immaturity (gestational age) may be more vulnerable to SOI and poor outcomes, however not all neonates experience instability as a consequence of having a low birth weight or gestational age. These patient characteristics reflect issues of vulnerability and risk and the additive effects of several factors that may contribute to SOI.
A neonate may have a serious congenital defect, yet it may not influence the SOI, as measured by physiologic indicators. A congenital anomaly may reflect risk of a more serious condition and can predispose the neonate to an outcome that may be incompatible with life. Instability may not be apparent in all cases (e.g., minimal derangements of the partial pressure of oxygen in an infant with a serious heart defect) (Davies, 1995; Perlman, 1998). Current measures of SOI using physiologic indicators may not be sensitive to the influence of congenital anomalies as an antecedent of SOI.

Therapeutic intervention was identified as a consequence of SOI in the selected literature. Relationships were identified in the data between SOI and therapeutic intervention: (a) therapy as providing assistance and support to the neonate (Avila-Figueroa et al., 1998; Catlett et al., 1994; Miall et al., 1999; Richardson & Tarnow-Mordi, 1994; Roblin et al., 2000), (b) therapeutic intervention as a response to instability of the neonate (Holditch-Davis & Lee, 1993; Stevens, Richardson, et al., 1994), and (c) therapeutic intervention as a proxy or indirect measure of SOI (Freeman et al., 1990; Gray et al., 1995; Hazebroek, et al., 1991; Lee et al., 1995; Stevens, Richardson, et al., 1994).

The relationship, therapeutic intervention as a consequence of SOI, was found to be prominent in the data. Many examples existed and facilitated the identification of this factor. Physicians who developed the SNAP were also responsible for the development of the prominent NTISS measure (Gray, Richardson, McCormick, Workman-Daniels, et al., 1992). This instrument was used extensively in the selected literature as a proxy for SOI, and measured therapeutic interventions to reflect SOI.

The third study objective was to identify concepts related to SOI. The related concepts identified were complication, capacity for behaviour and stress.
Complication was identified as a related factor to SOI, however the nature of the relationship was unclear. Complication was used as an indicator of SOI using diverse approaches: (a) frequency of complications (Helfrich Jones & Smyth, 1999), (b) single complication used as a proxy measure (Lee et al., 1995), and (c) twenty of the most common diseases and pathophysiological states were rated for SOI (Catlett et al., 1994; Holditch-Davis, 1990). Also, complication was identified as an indicator of functional status (functional status was identified as a related factor to SOI) (Stevens et al., 1996).

Minimal available data and different ideas about the nature of the relationship were expressed but few explained the ideas in sufficient depth to clarify how complication is related to SOI. Indicators of complication were used in 5 of 21 measures in combinations with indicators from other factors such as maturation/development, physiology and therapeutic intervention. Discussion did not explain how indicators of complication reflected SOI.

Capacity for behaviour was discussed in the data primarily as a response to SOI or as having a relationship with SOI. Limited discussion of this factor was present in the articles. Based on the available data, capacity for behaviour, was not considered to be an attribute or a consequence of SOI, but a related factor.

Although capacity for behaviour was discussed as a response to SOI in the select literature, the nature of the relationship between capacity for behaviour and SOI remains unclear. The lack of data and inconsistencies related to the use of capacity for behaviour as an indicator of SOI contribute to this lack of clarity. Capacity for behaviour was used as an indicator of SOI in the Apgar score (Apgar, 1953). The Apgar score was the only measure of SOI in the neonate identified in this study that incorporated indicators of behaviour (Apgar,
1953). The Apgar score measures appearance, pulse, grimace, activity and respiration at one and five minute intervals following birth (Apgar, 1953). The Apgar score was used only once on its own in the study articles, however it was incorporated into several measures of SOI that were used more frequently including the SNAP PE, SNAP II and NICHD (Pollock et al., 2000; Richardson, Phibbs, et al., 1993; Richardson, Tarnow-Mordi, et al., 1999). As the Apgar score was incorporated into some of the primary measures, there appears to be some recognition that behaviours may reflect SOI.

It is difficult to identify reasons why capacity for behaviour was discussed and used in some measures in a limited capacity in the selected articles. In the articles, 10 of 71 discussed behaviour in relation to SOI. This could have been influenced by two factors. The first factor relates to an overall reliance on physiological indicators in the sample of articles. Physiological indicators of SOI have a long history of acceptance and are considered objective measures that are reliable and valid. Behavioural indicators may not yet share that same acceptance and widespread use, despite the development of objective, reliable and valid measures for neonatal pain over the last decade that have used indicators such as cry characteristics, facial actions, body movements and posture (Stevens, Johnston, et al., 1994). Also, infant behaviour theory in relation to stress has been refined and indicators have been identified (Als, 1983). Interventions such as developmental care have been applied in the neonatal intensive care environment in response to behavioural indicators of stress (Als, 1983). Behavioural indicators have been extensively developed and used over the last decade but have not been considered or applied in the measurement of SOI with the exception of the Apgar score (Apgar, 1953).
It was noted on review of the data set for capacity for behaviour that 8 of the 10 articles that discussed behaviour in relation to SOI were authored by RNs and multiprofessional groups authored 2 of the 10 articles. This second factor indicates that overall, physician authors did not discuss behaviour in relation to SOI. The fact that the literature has been dominated by a small group of physicians may have indicated a bias towards the use of traditional objective indicators (e.g., physiological). Alternatively, there is evidence that many of the objective indicators for behaviour may have only been refined in the last decade through the development of infant behaviour theory and its application (Als, 1983). The resulting concurrent development of the leading measures of SOI in the early 1990s and objective indicators of behaviour may have led to the development of SOI measures that are reliant on physiological indicators.

It is unclear how behaviour, physiology, and SOI are linked in neonates. Evidence exists that capacity for behaviour is affected by SOI. Use of behaviour as an indicator of SOI has been minimal in the literature. Although capacity for behaviour was discussed in the select literature, the nature of the relationship between capacity for behaviour and SOI remains unclear. The use of physiological indicators to reflect SOI has dominated recent literature (1990-2000). Generally, this lack of understanding of the relationship between physiological and behavioural indicators exists between other concepts as well including pain and stress.

The category stress was represented by a very small amount of data. Petryshen & Stevens (1995) suggested that degree of stress could be evaluated using physiologic stability, as measured by SNAP. In the second excerpt, Stevens, Johnston, et al. (1994) connected stress to neurological disorganization, as indicated by cry characteristics. They identified
that cry characteristics also reflected the SOI of the neonate. This view links the idea of stress with SOI as a related factor. These authors (Petryshen & Stevens, 1995; Stevens, Johnston, et al., 1994) suggested that instability (SOI) and neurological disorganization reflect stress in the neonate. Other articles did not discuss this association. The association suggested between SOI and stress is clear in a few of the articles included in the study; further elaboration of these ideas was not found in the literature.

In the fourth study objective, uses of SOI were identified. The relevant purpose of the concept is reflected in its use and its use influences the development of the concept. SOI has been used in research independently and in combination with other risk factors to predict mortality. It has been used as a dependent variable in studies of clinical outcomes. Many researchers have been concerned about the confounding effect it may have on experimental and control groups of neonates and have employed various strategies to control or adjust for its effects. Some researchers have shown interest in the relationships that may exist between SOI and other variables. Authors also described potential uses for the concept including supporting decisions regarding the allocation of staff and resources, comparisons of hospitals and practice patterns, and prognostic systems for decision support.

As relationships between SOI and other concepts become better understood, SOI will likely retain its usefulness in neonatology. Based on its contribution to the study of outcomes and thus support for clinical decision-making in addition to the potential to support economic and administrative decision-making, SOI will likely continue to develop and evolve as a concept. The definition of SOI in the neonate and the conceptual model represent a tentative and guiding view of this concept, heavily influenced by characteristics of the available literature.
Other Issues

Verification Tests

The purpose of the verification tests was to check the rigor of the process of categorizing data. Issues associated with these tests were identified during the study including: (a) extraction and organization of data, (b) calculation of level of agreement, and (c) concurrent collection and analysis of data. These issues are addressed and recommendations for improving the process of checking the categorization of data are offered.

These tests provided the opportunity to consult with experts in neonatal care. The experience of working towards achieving a level of consensus with the practitioners involved meeting face to face and discussing each category of data and how the data related to the category label. Consensus was achieved through thoughtful discussion and the sharing of meaningful insights about the nature of the concept in the neonatal population, and the meaning conveyed in the data. The process of improving the levels of consensus revealed several areas that required revision. Clarification was necessary in two main areas: (a) some of the pieces of data were too lengthy, and (b) some of the pieces of data were too complex, (i.e. included more than one idea that might be used to classify the data). The first issue was resolved by examining the data more critically and by reducing the pieces of data extracted as much as possible. The second issue was addressed by underlining the most important idea in each piece of data to indicate which idea was being used to classify the data.

As the verification tests were different from each other in this study, the percentage of agreement achieved with each practitioner could not be compared. The strength of the results of these tests would be improved and would provide better evidence of rigor if the
following recommendations were incorporated: (a) ensuring the percentage of agreement was recalculated following discussion between the student and practitioner to accurately reflect the consensus achieved, and (b) having more practitioners engage in the tests. Having more practitioners participate in the tests would allow the percentage of agreement for each test to be compared between the practitioners. The level of agreement would be reported as an average for each test.

Some authors (Rodgers, 1993a) have expressed concerns that early examination/analysis of the data before completion of the data collection process may influence the findings in concept analysis. Rodgers (1993a) has suggested that premature conclusions may be a consequence of analyzing data concurrently with data collection. Based on this suggestion, conducting this verification test to support the rigor of the analysis may well have influenced the identification and/or labeling of the attributes. The effect of early analysis of the data on the results of the study was likely minimized by the following factors: (a) the amount of data categorized for the purpose of verification was minimal (14%) relative to the total amount of data included in the analysis, and (b) categorization of data constituted only part of the analysis procedure.

Lack of Definitions of the Concept in the Literature

Definitions of the concept, SOI, were rare in the selected literature as were conceptual framework sections that discussed SOI. Possible reasons why definitions of the concept were not included in articles written by physicians during this time frame include the belief that the concept, SOI is self-evident. This view is clearly expressed by Richardson, Tarnow-Mordi, et al. (1999), authors of leading measures of SOI in the neonate, "Illness severity is an instinctive, self-evident concept; the challenge has been how to operationalize its
measurement." (1999, p. 260). This belief is also supported by the following quotation, "Although severity of illness is a familiar medical concept, it is sometimes difficult to assess." (Pollack et al., 2000, p. 1052). These authors focused primarily on issues associated with the development of measures as development of a conceptual definition was viewed as less important.

**Declining Number of Publications in 2000**

The year of publication reflected interest in and use of the concept by health care professionals. The number of articles meeting the selection criteria showed a steady increase over the eleven-year period studied for this thesis. An exception to this observation was a slight drop in the number of articles in the year 2000. There are no clear explanations for this decline. This might be explained by a lag in publishing. At this time, the student is aware of a large research study completed in 1997 that compared different measures of SOI (Corcoran, Whyte, Thiessen, Lee & The Canadian NICU Network, 1998; Lee, Corcoran, Whyte, Thiessen & The Canadian NICU Network, 1998; Richardson & Escobar, 1998). These authors have presented results from this study at conferences but the student has not been able to identify any published articles (Corcoran, Whyte, Thiessen, Lee & The Canadian NICU Network, 1998; Lee, Corcoran, Whyte, Thiessen & The Canadian NICU Network, 1998). Abstracts from these conference presentations were published but were not included in this study, as they did not contain sufficient discussion of SOI (Corcoran et al., 1998; Lee et al., 1998). Richardson & Escobar (1998) identified additional international groups that are currently conducting neonatal research into SOI that have not yet published their work. The trend over the eleven-year period indicates that SOI is considered an important variable and
continues to be studied by health professionals. The drop in the number of articles published in the year 2000 is most likely a chance finding that is not significant or clinically important.

**Subgroups Among Neonates**

Two groups of patients were studied equally in the selected literature, the preterm neonate group, and the preterm/fullterm neonate group. Proportionately, more preterm infants were studied in the select literature, as preterm infants were part of both groups. It is possible that the preterms have been studied or discussed more frequently by authors because they are believed to be more vulnerable to SOI based on the influence of immaturity (Holditch-Davis, 1990) and thus SOI may be considered a more relevant concept for this group.

**Neonates, Children, and Adults**

Neonates, children and adults share the essential attribute of SOI, instability. This essential attribute of SOI in the neonate has been derived directly from SOI in children and adults. Authors of the leading neonatal measures derived the essential attribute directly from pediatric and adult measures. Differences between neonates, children and adults that were noted from the findings of this study include the antecedents, maturation and development that are clearly characteristics unique to the neonate.

**Empirical Examples**

Empirical examples of SOI were extracted from the literature to identify relationships among SOI, essential attributes, antecedents, consequences and related factors and to provide justification for their selection. These examples illustrated circumstances that communicate the nature of SOI in context. Each of the examples provided showed instability of the organism preceded by an antecedent patient characteristic. Instability was influenced by at
least one related factor and resulted in a treatment response (i.e., intervention or withdrawal of treatment).

No ideal example of the concept exists (Rodgers, 1993a). Some methods of concept analysis recommend the construction of an ideal example to clarify exactly what the concept is (Walker & Avant, 1995). In addition, it has been suggested that examples of what the concept is not (contrary cases) and examples that are similar but not quite the same (borderline cases) be constructed (Walker & Avant, 1995). The use of constructed cases increases the risk of introducing bias to the analysis of the concept. In this study, examples were identified from the selected literature and discussed in terms of their similarity to the findings of the concept analysis (attributes, antecedents, consequences and related factors). The expectation of a perfect match was not in keeping with the conceptual foundations of the study. Therefore, the examples illustrated varying degrees of fit with the proposed definition of the concept and findings of the study.

Measures

A large number of measures of SOI were used throughout the selected articles. The most frequently used indicators across all measures were physiology-based however, most of the measures were composite scores and included indicators from at least one other factor related to SOI. The CRIB score (INN, 1993), for example, was composed of a combination of physiological indicators and maturational/developmental indicators (birth weight, gestational age, and congenital anomalies). The data were organized to show how most of the measures, though they rely heavily on physiology-based indicators, include indicators from factors that are related to SOI as antecedents, consequences or related factors (see Appendix G). It was beyond the scope of this study to examine these leading measures in
terms of their psychometric properties – validity, reliability, and internal structure – which may ultimately provide more understanding of SOI and the relationships between types of indicators.
CHAPTER FIVE
Summary, Implications, and Conclusions

Summary

SOI in the neonate is a concept that has been used almost exclusively in the context of the NICU. Physicians conducting research have dominated writing on this topic. There is evidence that nurses are using this concept although to a lesser extent than physicians. Nurses have used SOI primarily as a clinical outcome. The neonatal SOI literature has been dominated by five measures that have all been derived from pediatric and adult measures and are based primarily on instability of the neonate manifested by physiologic indicators. Suffering and disability were also identified as attributes of SOI. Explanations of how these attributes relate to SOI were underdeveloped and unclear. Suffering and disability may represent newly emerging attributes in the development of the concept. Most composite measures have incorporated indirect indicators of SOI (e.g., antecedents, consequences and related factors). Some inconsistencies were found between the conceptualization of SOI and the composition of indicators in the measures being used. Different combinations of indicators were used reflecting instability, maturation/development, therapeutic intervention, complications and capacity for behaviour.

This study identified that instability is the essential attribute of SOI. Maturation and development was an antecedent. Therapeutic intervention was a consequence. Related factors included complication, capacity for behaviour and stress. A definition of the concept was developed to reflect the selected neonatal literature (1990-2000). A conceptual model
was developed to provide a visual display of the relationships identified in the concept analysis.

**Implications**

**Conceptual Model**

The conceptual model provided a visual display of the relationships between SOI and the attributes, antecedents, consequences and related factors that define it. The relationships identified in the model were supported to varying degrees in the literature by: definitions of the concept, examples, discussions of dimensions and the measurement of SOI. The identification of instability as an essential attribute and therapeutic intervention as a consequence was supported by the development and prominent use of several leading measures of SOI in the study articles (Gray, Richardson, McCormick, Workman-Daniels, et al, 1992; Richardson, Gray, McCormick, et al., 1993; Yeh et al, 1984). The attributes suffering and disability and the related factors, complication, capacity for behaviour and stress were not well developed. Further, the relationships between these factors and SOI were often unclear and/or conflicting in the literature. Suffering and disability, for example, were identified as attributes of SOI in only one article, and explanations of how this dimension reflected SOI and how it might be measured in neonates were insufficient. Professionals other than physicians such as nurses and multidisciplinary teams often wrote about and discussed these factors (suffering, disability, complications, capacity for behaviour and stress) in the context of other neonatal issues such as the relationship between SOI and pain (Stevens, Johnston, et al., 1994). This discussion implies that new uses for SOI may exist and require the development of other aspects of SOI.
Capacity for behaviour was identified in the concept analysis of SOI as a related factor. Several nursing articles from the selected literature provided evidence that a relationship exists between capacity for behaviour and SOI as a response to SOI (Holditch-Davis, 1990; Stevens, Johnston, et al., 1994). Behaviour was not well supported as an attribute of SOI as it was used minimally as an indicator of SOI in the selected articles and was not clearly explained by the authors. Nurse authors showed significant interest in this relationship. As infant behaviour may reflect their response to instability, further review of neonatal behaviour theory (Als, 1983) may provide further insight into the nature of the relationship between SOI and capacity for behaviour.

Most measures of SOI in the neonate identified in this study are composites of both direct and indirect indicators that reflect the many dimensions of the concept. These measures reflect multiple dimensions of SOI that are related to the concept as antecedents, consequences and related factors. Without a clearer understanding of how suffering, disability, complication, capacity for behaviour and stress are related to SOI, the accuracy of these measures in reflecting SOI is questionable. However, composite measures may be the best avenue to capture the complexity of this concept.

Most of the measures have used indicators from maturation/development (antecedent) and therapeutic intervention (consequence), to reflect SOI, such as in the CRIB score that combines indicators from an attribute (physiologic instability) and from an antecedent (maturation/development). The findings of the concept analysis are not consistent with the application of indicators in current measures of SOI. The use of indirect indicators from antecedent, consequence and related factors has influenced the measurement of SOI disproportionately (see Appendix G). Understanding of the antecedent, consequence and
related factors needs to be developed to better explain the relationships and to support development and use of indicators and potential composite measures that best reflect the concept.

The potential linkages between SOI and suffering, disability, complication, capacity for behaviour and stress require further review in the literature and elsewhere that is beyond the scope of this study.

**Clinical Nursing Practice**

Analysis of SOI has provided a beginning understanding of the concept, its essential attributes, the various factors that influence it, and its consequences. This study has provided an opportunity: (a) to recognize the concept in clinical nursing practice, (b) to identify antecedents, consequences and factors related to SOI, and (c) to determine potential uses for the concept in clinical nursing practice.

The importance of SOI to clinical practice was clearly identified in the concept analysis. The assessment of SOI can be recognized in clinical nursing practice as the routine monitoring and physiological assessment of organ systems in the neonate. Monitoring and assessment activities form an integral part of nursing practice in neonatal intensive care settings. Assessment of the neonate is important in clinical practice to identify subtle changes in SOI of the neonate that may reflect more serious outcomes, such as bacteremia (Beck-Sague et al., 1994; Freeman et al., 1990). Many different relationships between SOI and neonatal outcomes were evident in the selected literature such as the testing of SOI as a predictor of specific morbidities and mortality (Escobar et al., 1997; INN, 1993; Perlman, 1998; Stevens, Richardson, et al., 1994).
This analysis identified instability as an essential attribute of SOI. Primary measures of SOI identified in the study articles incorporated multiple physiologic indicators of instability from seven of the main organ systems including cardiovascular, respiratory, neurologic, hematologic, renal, gastrointestinal and metabolic. Derangements of those physiological indicators, both above and below normal ranges for neonates reflected instability (Richardson, Gray, McCormick, et al., 1993; Yeh et al., 1984). SOI is assessed in clinical nursing practice by measuring instability. Many physiologic indicators are commonly incorporated into clinical assessments of the neonate by nurses (Richardson, Gray, McCormick, et al., 1993; Yeh et al., 1984). Clinically useful assessment of SOI can be achieved by selecting and monitoring only those physiologic indicators specific to the patient (i.e. type of disease and associated risk of organ system failure). Early identification of SOI (instability) by nurses and an understanding of how changes in SOI are associated with specific outcomes are necessary to select and apply appropriate interventions in a timely manner. Neonatal nurses currently rely on physiological measurements in their practice to monitor the progress of the neonate towards a specific outcome and to indicate the need for intervention.

Although nurses may be able to identify a relationship between SOI and neonatal outcomes in clinical practice, the interplay of other factors with SOI and outcome may not be as readily identifiable. Analysis of the concept helped to identify factors associated with the concept, such as antecedents, consequences and related factors, which may influence the degree of SOI and possibly neonatal outcomes. Neonatal characteristics including maturation (e.g. gestational age and birth weight) and development (e.g. congenital defects) were identified to be antecedents of SOI in the analysis. Gestational age and birth weight
were frequently used as risk factors along with SOI to predict negative outcomes such as death (INN, 1993; Richardson, Gray, McCormick, et al., 1993; Richardson et al., 1998). Also, gestational age and birth weight were frequently used as indicators of SOI (Tarnow-Mordi, Mutch, Parry, Cockburn, & McIntosh, 1995; Richardson, Shah, et al., 1999). From a clinical perspective, gestational age and birth weight are considered important risk factors that reflect generally, the infant’s potential for a negative outcome. The relationship between these neonatal characteristics and SOI must be considered when selecting interventions to address specific outcomes.

Therapeutic intervention was identified in the concept analysis to be a consequence of SOI. The number and type of interventions received by the neonate were thought to be a response to the SOI. Some indirect measures of SOI, such as the NTISS, PM DRG, and NMS scores, incorporated indicators of therapeutic intervention (Gray, Richardson, McCormick, Workman-Daniels, et al., 1992; Minde et al., 1983; Schwartz, Michelman, Pezzullo, & Phibbs, 1991). In the NICU setting, it is an expectation that nurses will anticipate and identify changes in the stability of the neonate and are prepared to respond to them. Assessment and identification of SOI result in the planning and delivery of therapeutic intervention. Interventions or therapies are intended to support the neonate. The number of therapies may indirectly reflect SOI, as therapy reflects the degree of support required by the neonate to maintain or achieve stability.

The related factors identified in the concept analysis included complication, capacity for behaviour and stress. The nature of the relationship between SOI and complication lacked clarity in the selected literature. Conflicting ideas existed, making it difficult to understand how this related factor might influence SOI therefore; no specific
recommendations for clinical nursing practice could be made. This may represent an area for further study from a clinical perspective.

The association between stress and SOI in neonates received minimal attention in the literature reviewed. RN authors suggested that SOI and neurological disorganization reflected the degree of stress experienced by a neonate (Petryshen & Stevens, 1995; Stevens, Johnston, et al., 1994). Behaviours such as cry characteristics were used as indicators of neurological disorganization and stress (Stevens, Johnston, et al., 1994). As stress and SOI may be closely linked, behavioural indicators may prove useful in reflecting SOI in clinical nursing practice. Much has been written on the identification of stress in the neonate through the work of Als (1983). Nurses have used behavioural indicators to identify stress and have responded to reduce neonatal stress by implementing developmental care strategies (Als, 1983). Increased awareness of associations between behaviour, stress and SOI by nurses may reinforce the importance of using behavioural assessments in monitoring and treating neonates. The implications for clinical nursing practice may be to increase nurses' awareness of factors that may influence or be influenced by SOI in the neonate including gestational age, birth weight, congenital anomalies, therapeutic intervention, capacity for behaviour and stress.

Recognition of SOI in clinical nursing practice and knowledge of the potential associations between SOI and antecedents, consequences and related factors may help nurses begin to incorporate research evidence into their clinical practice. Many uses have been identified for SOI in the selected literature and new ones could be identified in clinical nursing practice. SOI has been used to provide information about administrative issues such as workload planning and resource use in NICUs (Almeida et al., 1991; Richardson, Gray,
McCormick, et al., 1993; Richardson & Escobar, 1998; Schwartz et al., 1991). SOI can also be used as an outcome to monitor the effects of a chosen intervention (Lee et al., 1995; Petryshen & Stevens, 1995; Petryshen et al., 1997; Stevens et al., 1996). Measurement of SOI could reflect the amelioration of stress for infants receiving various interventions (Petryshen & Stevens, 1995). SOI has been used as a clinical outcome by nurses to compare conventional versus developmental care (Stevens et al., 1996). Other studies looked at the relationship between SOI and complications common to the NICU such as bacteremia (Beck-Sague et al., 1994; Freeman et al., 1990; Gray et al., 1995). Also, relationships between SOI of the neonate and the responses of parents to the neonate were investigated (Kratochvil et al., 1991; Zahr & Cole, 1991). Nurses assess neonates to anticipate problems or issues, to respond to those problems by selecting and implementing appropriate interventions and to achieve or maintain positive outcomes. Awareness of how SOI has been used in research may influence decision-making and choice of intervention for nurses in clinical practice.

Measurement of SOI remains a challenge in the neonatal population. Leading measures of neonatal SOI have been derived from children and adults (Knaus et al., 1981; Richardson, Gray, McCormick, et al., 1993; Yeh et al., 1984). Several leading measures rely primarily on large sets of physiologic indicators that may not be practical for clinical use (see Appendix F) (Richardson, Gray, McCormick, et al., 1993; Yeh et al., 1984). Other leading measures use a mix of direct and indirect indicators from maturation and development, therapeutic interventions and instability that are not all supported by the results of this analysis as essential attributes (Gray, Richardson, McCormick, Workman-Daniels et al., 1992; INN, 1993). The development of a reliable, valid and clinically useful measure of SOI would be beneficial.
Knowledge and understanding are to be gleaned from further use of the concept in clinical nursing practice and will influence development and clarification of the concept. The results of this study may provide beginning support for what nurses already know about complex interactions in the neonatal intensive care setting and facilitate the incorporation of evidence-based practice into clinical nursing practice. Improvements in neonatal care by nurses are supported by the development of evidence-based practice related to SOI and outcomes.

Research

The nature of SOI in the neonate was examined in this study. The essential attribute, other attributes, antecedent, consequence, and related factors were identified and labeled. Finally, a definition of the concept was developed. The findings of this study were heavily influenced by the available literature including the type of author, measures used and type of publication. Some of the inconsistencies between measurement of the concept and associated dimensions may reflect: (a) a concept that has not yet been fully developed, (b) the changing needs of neonatology as a discipline, and/or (c) the differing needs of the individual disciplines within neonatology including nursing. Further research into SOI is necessary to support the evolution of the concept. Findings of the concept analysis have resulted in the following recommendations for future research:

1. Further refinement of the concept including: (a) validation of the findings of this study using focus groups of experts in neonatal care and addressing attributes, antecedents, consequences, related factors and uses for the concept in neonatal care; (b) use of qualitative methods such as participant observation as suggested by Schwartz-Barcott & Kim (1993) to study the concept in the NICU setting, to integrate the results of the literature review with the
results of qualitative methods and to determine whether the findings support the presence and frequency of the concept; (c) review of related neonatal literature for evidence of relationships between SOI and each of the following factors; complication, capacity for behaviour, stress and suffering and disability; and (d) secondary analysis of the study findings to isolate nursing articles, to identify uses for SOI in neonatal nursing practice and to identify specific research issues that might be addressed using SOI. These activities would provide a beginning point to: (a) validate the findings of this study, (b) identify what issues nurses caring for neonates have addressed using SOI and whether any limitations to its application exist and (c) clarify the relationships between SOI and each of the following factors; complication, capacity for behaviour, stress, suffering and disability.

2. Development of an operational definition and measure of SOI in the neonate including: (a) examination of the psychometric properties of current leading measures of SOI in the neonate, and (b) comparison of indicators used in leading measures in relation to indicators reflecting the attributes identified in this study. Further research will refine the concept, validate the findings of this study and facilitate the identification of appropriate indicators that reflect the complexity of SOI. The development of an accurate measure that is clinically useful to nurses will support the study of neonatal outcomes research in general and facilitate identification of other research questions that may be addressed using this measure.

Conclusions

Based on significance, importance and use in neonatal care, SOI in the neonate is a significant concept for nursing. Clinical assessments by nurses are intended to identify SOI in the neonate. Nurses select and apply interventions to effect positive change in the outcomes of neonates. Nursing decisions are made based on research evidence that includes
knowledge of the relationships between SOI and outcomes. Understanding and measurement of SOI is critical to the study of neonatal outcomes as a source of variation in achieving outcomes and as a risk factor to negative outcomes.

The analysis of this concept has provided nurses with a beginning understanding of SOI, its attributes, antecedents, consequences and related factors. Some aspects of this concept remain less clear and require further examination including complication, capacity for behaviour, stress, suffering, and disability. There is a need to review other sources of literature and to validate the study results using alternative methods such as focus groups and participant observation in order to further clarify these relationships with SOI.

In terms of clinical nursing practice, there is clearly a need to tailor physiologic and behavioural assessments reflecting SOI to risks specific to the individual neonate. Recognition of SOI in clinical nursing practice will begin to identify other potential uses of the concept for nurses.

The use of composite measures of SOI in the neonate was prominent in the study literature but rationale for inclusion of indicators representing different dimensions of SOI was not always clear. Despite this finding, composite measures are likely to be the best direction for measure development based on the complexity of the concept. Finally, efforts directed to further refinement of SOI will continue to move us towards the development of a measure of SOI in the neonate that will reflect current use of the concept and will identify the concept, relationships between outcomes and SOI and new uses for SOI that are important to neonatal nursing care and will ultimately improve patient care.
REFERENCES

References marked with an asterisk indicate studies included in the concept analysis.


Appendix A

Methods of Concept Analysis

<table>
<thead>
<tr>
<th>Philosophical View</th>
<th>Purpose</th>
<th>Secondary Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>A concept can be precisely defined. (p. (15))</td>
<td>To develop meaningful descriptions of a substantive body of knowledge for a base for future research.</td>
<td>To develop a model of operational definition.</td>
</tr>
<tr>
<td>Evidence of observation supports the concept (p. (20))</td>
<td>To develop a concept that is useful in clinical practice.</td>
<td>To classify and develop existing problems.</td>
</tr>
<tr>
<td>Primary Purpose</td>
<td>To distinguish between the defining attributes of a concept (p. (19))</td>
<td>To clarify &amp; develop a concept (p. (24))</td>
</tr>
</tbody>
</table>

**Definition of a Concept**

- A concept is a mental image of a phenomenon. A description of the phenomenon is an abstract event that is observed in the real world, i.e., a word or symbol. The term concept is used to denote the frequency of the phenomenon and the mental image (p. (11)).

<table>
<thead>
<tr>
<th>Definition of Concepts</th>
<th>Method</th>
<th>Rationalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts are cognitive in nature and their definition is subjective. (p. (10))</td>
<td>To provide a clear conceptual foundation for further study (p. (13))</td>
<td>To develop a concept that is useful in clinical practice. (p. (24))</td>
</tr>
<tr>
<td>There is a continuous process of developing a concept which indicates its appropriateness. (p. (12))</td>
<td>To address difficulties with the definition. (p. (13))</td>
<td>To provide a clear conceptual foundation for further study (p. (13))</td>
</tr>
</tbody>
</table>

|-----------|----------------------|------------------|-------------|

- Walker & Avant (1995) developed a number of concepts within a framework of explication & definition which includes operational definitions, an operational definition, and a description of a phenomenon. (p. (9))
- Rodgers (1995) developed a number of concepts within a framework of explication & definition which includes operational definitions, an operational definition, and a description of a phenomenon. (p. (10))
- Nora (1995) developed a number of concepts within a framework of explication & definition which includes operational definitions, an operational definition, and a description of a phenomenon. (p. (11))

By: Glenda, L. (1995)
|---------------|-----------------------|----------------|-------------------------------|---------------------|
| **Method**    | 1. Identify the concept & observe/describe the phenomenon repeatedly also from other disciplines  
2. Systematize the observations and descriptions  
3. Derive an operational definition of the concept  
4. Produce a model of the concept  
5. Formulate hypotheses | 1. Select a concept  
2. Determine the aims or purposes of the analysis  
3. Discover all uses of the concept  
4. Determine the defining attributes  
5. Construct model case  
6. Construct borderline, related, invented, contrary & illegitimate cases  
7. Identify antecedents & consequences  
8. Define empirical referents | 1. Identify concept of interest  
2. Identify surrogate terms  
3. Identify sample for data collection  
4. Identify the attributes of the concept  
5. Identify references, antecedents & consequences of concept  
6. Identify related concepts  
7. Identify a model case  
8. Conduct interdisciplinary & temporal comparisons | 1. Select a concept  
2. Search the literature  
3. Deal with meaning & measurement  
4. Choose a working definition  
5. Final Analytical Phase  
6. Fieldwork Phase  |
| **Strengths** | 1. 5 succinct steps  
2. Better with more observable phenomena  
3. Focus includes development of operational definition | 1. 5 clear steps  
2. Iterative process  
3. Use of examples to illustrate concept  
4. Identification of conditions  
5. Create operational definition  
6. Identify that concepts can change over time/not static | 1. Three clear phases  
2. Verification of the findings in the literature review using empirical data substantiates the nature of the concept and justifies its relevance to nursing  
3. Use of examples to illustrate concept  
4. Criteria not rigid or static | 1. 5 clear steps  
2. Includes identifying examples with other data sources  
3. Identifies importance of social context & values in the formation of meaning  
4. Criteria are tentative & guiding in nature to differ from other instances |
| **Weaknesses** | 1. Philosophical basis for ability to identify components of concept not specifically discussed - also influence of context & time are not discussed - therefore it is unclear what underlying philosophical view is used a the basis for this method  
2. Steps should be more detailed to facilitate application of the method (Lackey, 1993) | 1. Method is derived from Wilson (1983), concept can be precisely defined  
2. Language use is discussed but not whether the concept may change over time based on use - did not discuss influence of context  
3. Walker & Avant however, did identify that concepts change over time (p.37) - therefore philosophical view is unclear  
4. Potential for researcher bias in developing/identifying cases to be used for examples | 1. Actual method very similar to Walker & Avant (1995), unclear how philosophical underpinnings change the application of the method apart from the differences in use of examples  
2. Sampling of data may cause researcher to omit data considered major works may make the data more manageable, however treats each piece of data as equal which is problematic  
3. Working definition is developed very early in process may bias results by prematurely identifying characteristics | 1. Steps discussion very general  
2. Potential for researcher bias in developing/identifying cases to be used for example  
3. Does not specify whether concept can change over time |
Appendix B

Computer Database Search

Articles were selected for review from Medline, Healthstar, Cinahl, Cancerlit, and Embase databases using search criteria based on the MeSH system of classification. The following MeSH terms were used to search the five databases:

1. Explode infant, newborn/ or neonate.mp.
2. Explode severity of illness index/ or severity of illness.mp.
3. Combine 1 and 2 (intersect)
Appendix C

Record Book Sample

Problems or issues that should not be addressed during the data collection and/or analysis were identified and recorded in a record book. Information relating to the; (a) inclusion/exclusion of data, (b) methodology, (c) analysis, and (d) self-awareness of the student (personal acknowledgment of potential biases, thoughts and opinions of the student) were recorded in four separate record books and were set aside for consideration following completion of the analysis. For example, serendipitous findings were acknowledged and considered following data analysis. The following examples are from each of the four record books:

1. Inclusion/Exclusion of Data. Although article ‘X’ mentions infants in its patient population, no further discussion regarding severity of illness was included and the severity of illness measure used by the researchers was an adult measure. This article was not included in the analysis. Although the PRISM measure for severity of illness was developed for children and infants, the measure did not isolate neonates in the measure therefore; this article was not included in the concept analysis.

2. Methodology. A recommendation for organizing the study method was discovered. It suggested that the researcher should not draw any conclusions from the study until all the data is collected. Analysis should not take place simultaneously with the data collection.

3. Analysis. It was discovered during the analysis that most of the literature written on SOI in the neonate has been developed from the same group of physicians. This should be included in the discussion section of the thesis.
4. Self-awareness of the Researcher. The student has been spending a lot of time trying to decipher what the author meant by vague or confusing statements about SOI. It is likely that if the student guesses what the author is trying to say, bias will be introduced into the study.
## Appendix D

### Data Collection Form

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source ID No.</td>
<td>Year of Publication</td>
<td>Article Type</td>
<td>Author(s)</td>
<td>Conceptual Definition</td>
<td>Impl or Explicit</td>
<td>Conceptual Dimension</td>
<td>Observed Definition</td>
<td>Operational Definition</td>
<td>Name of Measure and/or Indicators</td>
<td>Concept Usage</td>
<td>Description of Context</td>
</tr>
</tbody>
</table>
Appendix E

Reference List of Ineligible Articles


Kumar, R.K., Newburger, J.W., Gauvreau, K., Kamenir, S.A., & Hornberger, L.K. (1999). Comparison of outcome when hypoplastic left heart syndrome and transposition of the great arteries are diagnosed prenatally versus when diagnosis of these two conditions is made only postnatally. *American Journal of Cardiology, 83*(12), 1649-1653.


### Appendix F

**Measures and Indicators of Severity of Illness**

<table>
<thead>
<tr>
<th>Name of Measure</th>
<th>Abbreviation</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance, Pulse, Grimace, Activity, Respiration</td>
<td>Apgar</td>
<td>Score 1 to 3 at 1 minute and 5 minutes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Color, heart rate, reflex irritability, muscle tone, respiratory effort.</td>
</tr>
<tr>
<td>Clinical Classification System</td>
<td>CCS</td>
<td>Class I Patients were not admitted to the ICU</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Class II Patients were physiologically stable and were admitted to the ICU only for monitoring or observation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Class III Patients were physiologically stable requiring intensive care nursing and monitoring.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Class IV Patients were unstable needing frequent assessment and interventions by ICU physicians and nurses.</td>
</tr>
<tr>
<td>Clinical Risk Index For Babies</td>
<td>CRIB</td>
<td>Birth weight, gestational age, min Fi02, max Fi02, max Base excess, congenital anomalies</td>
</tr>
<tr>
<td>International Classification of Diseases (9th ed.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diagnosis Related Groups</td>
<td>DRG</td>
<td>One major category devoted to neonates (MDC-15)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seven smaller categories for neonates based on death, transfer, birthweight, prematurity, major problems and respiratory distress syndrome.</td>
</tr>
<tr>
<td>Pediatric Modified Diagnosis Related Groups</td>
<td>PM DRG</td>
<td>One major pediatric modified diagnostic category includes all neonates younger than 29 days. Forty-six smaller categories for neonates based primarily on birthweight, postnatal age, or minor/major problem, deaths, transfers, and duration of mechanical ventilation.</td>
</tr>
<tr>
<td>MedisGrps Severity Classification System</td>
<td></td>
<td>Medical illness grouping system measures case mix and case mix severity clinically based approach to classifying hospital patients at admission to answer question how sick is the patient? 500 key clinical findings (KCFs) including laboratory, radiology, pathology, history and physical examination.</td>
</tr>
<tr>
<td>Neurobiologic Risk Score</td>
<td>NBRS</td>
<td>13 items – Apgar score, Pa02, ventilation, blood pH, apnea, hypotension, PDA, seizure IVH, PVL, infection, hypoglycemia, bilirubin</td>
</tr>
<tr>
<td></td>
<td>Revised NBRS</td>
<td>Apgar, Pa02, ventilation, blood pH, apnea, hypotension, IVH, and infection</td>
</tr>
<tr>
<td>Name of Measure</td>
<td>Abbreviation</td>
<td>Indicators</td>
</tr>
<tr>
<td>------------------------------------------------------</td>
<td>--------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Neonatal Medical Index</td>
<td></td>
<td>birth weight, oxygen requirements, apnea, bradycardia, ventilation requirements, Periventricular/ intraventricular hemorrhage, PDA, medication requirements, hyperbilirubinemia, major surgeries, resuscitation, meningitis, seizures, periventricular leukomalacia.</td>
</tr>
<tr>
<td>Neonatal Morbidity Scale</td>
<td></td>
<td>Convulsions, hydocephalus, intracranial hemorrhage, perinatal asphyxia, diarrhea, necrotizing enterocolitis, meningitis, sepsis, pneumothorax, apnea, respiratory distress syndrome, chronic lung-disease, cardiac failure, hyperbilirubinemia, hypoglycemia, acidosis, bleeding tendency, anemia, nil per os, tracheostomy</td>
</tr>
<tr>
<td>Neonatal Surgical Model</td>
<td></td>
<td>Birth weight, oxygen requirement (max appropriate Fi02), pH, associated anomaly.</td>
</tr>
<tr>
<td>National Institute of Child Health and Human Development Network Model</td>
<td>NICHD Network Model</td>
<td>Birthweight, small for gestational age, gender, race (black versus other), 1 minute Apgar (&lt;=3).</td>
</tr>
</tbody>
</table>
| Neonatal Intervention Scoring System                 | NTISS        | Modes of respiratory support, medications, invasive and noninvasive monitoring, operations or procedures, feedings, use of intravascular catheters and administration of transfusions. Respiratory – supp 02, ECMO, surfactant, trach care, trach placement, CPAP, endotracheal intubation, mechanical ventilation, mech vent with muscle relaxation, high-freq vent Cardiovascular – indomethacin, vol expansion, vasopressors, pacemaker, CPR. Drug Therapy – antibiotic admin, diuretic admin, steroid admin, anti convulsant admin, aminophylline admin, other med, antibiotics, diuretics, treatment of metab acidosis, k+ binding resin admin. Monitoring – frequent vital signs, cardiorespiratory monitoring, thermoregulated environment, noninvasive 02 monitoring, arterial pressure monitoring, urinary catheter, central venous pressure monitoring, quantitative intake and output, extensive phlebotomy (>10 blood draws) Metabolic/Nutrition – gavage feeding, intravenous fat emulsion, intravenous amino acid solution, phototherapy, insulin administration, potassium infusion Transfusion – intravenous gamma globulin, red blood cell transfusion (<or =15ml/kg), partial volume exchange transfusion, red blood cell transfusion (>15ml/kg), platelet transfusion, white blood cell transfusion, double volume exchange transfusion Procedural – transport of patient, single chest tube in place, minor operation, multiple chest
<table>
<thead>
<tr>
<th>Name of Measure</th>
<th>Abbreviation</th>
<th>Indicators</th>
</tr>
</thead>
</table>
| Organ System Failure                                 | OSF          | Cardiovascular System — BP, HR, Arrest, Serum pH, Inotropic infusion  
Respiratory System — RR, PaCO2, PaO2, Mechanical Ventilation, PaO2/FiO2  
Neurologic System — Glasgow Coma Scale, Pupils  
Hematologic System — Hgb, WBC, Platlets  
Renal System — BUN, Creatinine, Dialysis  
Organ system failure for one system defined by meeting one or more criteria for a given system. |
| Pediatric Risk of Mortality Score                    | PRISM        | Systolic BP, Diastolic BP, HR, RR, PaO2/FiO2, PaCO2, Glasgow Coma Scale, pupillary reactions, PTT, total bilirubin, K, Ca, Glucose, Bicarb |
| Physiologic Stability Index                          | PSI          | Cardiovascular— mean BP, HR  
Respiratory— RR, PaO2, PaO2/FiO2, PaCO2  
Neurologic — seizures, pupils  
Hematologic — WBC, Plat, PT and/or PTT, FSP  
Renal — BUN, Creat, UO  
GI — AST/ALT, Albumin  
Metabolic — Na, K, Ca, Glucose, Osmolality, pH, Bicarb(HCO3) |
| Sinkin Score                                         |              | @ 12 hours—Birth weight, gestational age, 5 minute Apgar, Peak inspiratory pressure (PIP)  
@ 10 days—Birth weight, gestational age, peak inspiratory pressure (PIP), mean arterial pressure (MAP) |
| Score for Neonatal Acute Physiology                 | SNAP         | BP, HR, RR, Temp, P02, P02/FiO2 ratio, PC02, Oxygen Index, Hct, WBC, Immature total ratio, absolute neutrophil count, plt, BUN, Creat, UO, indirect bili, direct bili, Na, K, Ca, ionized Ca, BS, pH, Bicarb, Apnea, seizures, stool guaiac |
| Score for Neonatal Acute Physiology II              | SNAP II      | Birth weight, Gestational age, 5 minute Apgar, seven physiological variables |
| Score for Neonatal Acute Physiology Perinatal Extension | SNAP-PE     | Birth weight, small for gestational age, 5 min Apgar in addition to SNAP variables |
| Score for Neonatal Acute Physiology Vital Signs     | SNAP VS      | Respiratory rate, heart rate, temperature, blood pressure, signs of seizure or apnea. |
| Therapeutic Intervention Scoring System             | TISS         | Same as NTISS |
## Appendix G

### Composite Measures of Severity Of Illness

<table>
<thead>
<tr>
<th>Leading Measures</th>
<th>Other Measures</th>
<th>Types of Indicators Grouped by Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRIB</td>
<td>Phys, M/D</td>
<td></td>
</tr>
<tr>
<td>NTISS</td>
<td>T</td>
<td></td>
</tr>
<tr>
<td>PSI</td>
<td>Phys</td>
<td></td>
</tr>
<tr>
<td>SNAP</td>
<td>Phys</td>
<td></td>
</tr>
<tr>
<td>SNAP PE</td>
<td>Phys, M./D, Behav (Apgar)</td>
<td></td>
</tr>
<tr>
<td>SNAP II</td>
<td>Phys, M/D, Behav (Apgar)</td>
<td></td>
</tr>
<tr>
<td>VS SNAP</td>
<td>Phys</td>
<td></td>
</tr>
<tr>
<td>TISS</td>
<td>T</td>
<td></td>
</tr>
<tr>
<td>Apgar</td>
<td>Phys, Behav</td>
<td></td>
</tr>
<tr>
<td>CCS</td>
<td>Phys, T</td>
<td></td>
</tr>
<tr>
<td>DRG</td>
<td>M/D, Comp, T</td>
<td></td>
</tr>
<tr>
<td>PM DRG</td>
<td>M/D, Comp, T</td>
<td></td>
</tr>
<tr>
<td>Medis</td>
<td>Phys</td>
<td></td>
</tr>
<tr>
<td>NBRS</td>
<td>Phys, Comp, T</td>
<td></td>
</tr>
<tr>
<td>NMI</td>
<td>Phys, Comp, T</td>
<td></td>
</tr>
<tr>
<td>NMS</td>
<td>Phys, Comp, T</td>
<td></td>
</tr>
<tr>
<td>NSM</td>
<td>Phys, M/D, T</td>
<td></td>
</tr>
<tr>
<td>NICHD</td>
<td>Phys, M/D, Behav</td>
<td></td>
</tr>
<tr>
<td>OSF</td>
<td>Phys, T</td>
<td></td>
</tr>
<tr>
<td>PRISM</td>
<td>Phys</td>
<td></td>
</tr>
<tr>
<td>Sinkin Score</td>
<td>Phys, M/D, T</td>
<td></td>
</tr>
</tbody>
</table>

**Key**

- **M/D** - maturational/developmental indicators
- **Behav** - examples, BW, GA and congenital anomalies
- **Phys** - examples, cry characteristics, state
- **T** - physiological, examples, heart rate, laboratory tests
- **T** - therapeutic interventions
- **T** - examples, mechanical ventilation, treatment, medications
- **Comp** - complication
- **Comp** - examples, infection, seizure