

**PRETERM INFANT CAR SEAT SAFETY AND EVIDENCE INFORMED  
NURSING LEADERSHIP IN THE NICU**

by

Catherine Moher, RN  
BHSc, University of Western Ontario, 2003  
BScN, University of Western Ontario, 2005

A Project Submitted in Partial Fulfillment of the Requirements for the Degree of  
MASTER OF NURSING

in the School of Nursing, Faculty of Human and Social Development

© Catherine Moher, 2010  
University of Victoria

All rights reserved. This project may not be reproduced in whole or in part, by photocopy or other means, without the permission of the author.

**PRETERM INFANT CAR SEAT SAFETY AND EVIDENCE INFORMED  
NURSING LEADERSHIP IN THE NICU**

by

Catherine Moher, RN  
BHSc, University of Western Ontario, 2003  
BScN, University of Western Ontario, 2005

Supervisory Committee:

Dr. Karen MacKinnon, RN, PhD, School of Nursing, Faculty of Human and Social Development  
*Committee Supervisor*

Dr. Lenora Marcellus, RN, PhD, School of Nursing, Faculty of Human and Social Development  
*Committee Member*

### **Abstract**

Motor vehicle crashes remain the leading cause of death amongst infants and children in North America. Preterm infants (<37 weeks gestational age) are often discharged from hospital weighing less than five pounds and are at risk of apnea, bradycardia and oxygen desaturation when seated in infant car seats, thus this population faces issues with safety, fit and positioning in car seats. Existing protocols in the neonatal intensive care unit (NICU) lack research support and specific guidelines for implementation resulting in inconsistencies in car seat safety practices in the NICU. This project is an integrated review of the literature concerning preterm infants and evidenced informed car seat safety in the NICU and is guided by the Promoting Action on Research Implementation in Health Services (PARiHS) framework for knowledge translation. Recommendations for practice are outlined and support for nursing leaders is offered to move this knowledge into practice. Suggestions for future research are presented to provide insight into the ongoing safety issues for this fragile population.

## Table of Contents

<b>Title Page</b> .....	<b>1</b>
<b>Supervisory Committee</b> .....	<b>2</b>
<b>Abstract</b> .....	<b>3</b>
<b>Table of Contents</b> .....	<b>4</b>
<b>Acknowledgements</b> .....	<b>5</b>
<b>INTRODUCTION</b> .....	<b>6</b>
<b>Significance to Nursing</b> .....	<b>7</b>
<b>THEORETICAL APPROACH</b> .....	<b>8</b>
<b>Evidence Informed Nursing</b> .....	<b>10</b>
<b>Promoting Action on Research Implementation in Health Services (PARIHS) Framework</b>	<b>12</b>
<b>Nursing Leadership</b> .....	<b>14</b>
<b>INTEGRATIVE LITERATURE REVIEW</b> .....	<b>15</b>
<b>Literature Search and Methodological Approach</b> .....	<b>17</b>
<b>Description and Analysis of the Literature</b> .....	<b>20</b>
<b>SUMMARY OF FINDINGS AND GAPS IDENTIFIED IN THE LITERATURE</b> .....	<b>21</b>
<b>A) Risks and Reasons:</b> .....	<b>22</b>
<b>B) Risk Prevention Strategies in the NICU</b> .....	<b>30</b>
<b>C) Innovative Solutions for Infant Car Seat Safety:</b> .....	<b>37</b>
<b>IMPLICATIONS FOR NURSING PRACTICE, EDUCATION AND RESEARCH</b> .....	<b>40</b>
<b>Nursing Education: Recommendations for NICU Policy and Practice</b> .....	<b>42</b>
<b>Nursing Research: Recommendations for Future Research</b> .....	<b>43</b>
<b>THE PARIHS FRAMEWORK: A GUIDE FOR ADVANCED PRACTICE NURSING AND EVIDENCE INFORMED NURSING PRACTICE</b> .....	<b>44</b>
<b>Identifying Evidence and Gaps in Literature and Practice</b> .....	<b>45</b>
<b>Creating a Context Conducive to Successful Implementation Through Culture, Leadership and Evaluation</b> .....	<b>47</b>
<b>Facilitation Toward Successful Implementation Through Purpose, Role, Skills and Attributes</b> .....	<b>52</b>
<b>SUMMARY AND REFLECTIONS ON THE PARIHS FRAMEWORK</b> .....	<b>53</b>
<b>CONCLUSION</b> .....	<b>55</b>
<b>REFERENCES</b> .....	<b>59</b>
<b>APPENDICES</b> .....	<b>66</b>
<b>Appendix A: Glossary of Terms</b> .....	<b>67</b>
<b>Appendix B: Reference Chart</b> .....	<b>68</b>
<b>Appendix C: Guideline Chart</b> .....	<b>97</b>
<b>Appendix D: Car Seat Safety in the NICU: Recommendations to Parents</b> .....	<b>98</b>
<b>Appendix E: Curriculum Topics to Support Nursing Staff</b> .....	<b>101</b>
<b>Appendix F: Resources for Parents and Nurses</b> .....	<b>102</b>

## Acknowledgements

The motivation to complete this project comes from a desire to gain greater knowledge and experience of nursing research, leadership and neonatal nursing practice. There are many individuals who have been on this journey with me over the last three years, whom I would like to take the opportunity to graciously thank.

First, I would like to thank my patient supervisor Dr. Karen MacKinnon. Thank you for supporting my ideas and guiding me to excellence. I am thankful for your understanding, wisdom and encouragement, it is through your hard work and dedication that I have been inspired and motivated to continue my pursuit of a Masters in Nursing. Thank you also to my committee member Dr. Lenora Marcellus for your invaluable expertise and input.

I would also like to thank my mentors, colleagues and friends in a very special way. To Dr. Brenda Vrkljan and Dr. Anne Snowdon. You have inspired me for many years, thank you for all your advice and insight. To Judy Rashotte for her private council and wisdom, you are a truly a God send. To my manager, Pat O'Flaherty and my nurse educator, Martha Mason-Ward, for motivating me and for all of the accommodations to 'make it happen'. To Debbie Aylward, Pat McCarthy and Karen Lasby, thank you for mentoring me along the way.

To the amazing library staff at The Children's Hospital of Eastern Ontario and the University of Victoria, especially Margaret Sampson and Cindy Pagnan for all of their hard work and expertise, I would have been lost without you.

I am very grateful for the financial support received in scholarships from the Children's Hospital of Eastern Ontario (Loretta McKee and Kathleen Ward Award), The Registered Nurses Association of Ontario (RNAO) and the University of Victoria (Gertrude Helen Robertson Scholarship). Without this financial support, completing this work would not have been possible.

Thank you to Mr. Jeff McLean for dreaming big with me and laughing me through the grind. Finally, I wish to thank my incredible, supportive and loving parents. Thank you Mom, for the brownies, the hugs and the Kleenex. Thank you for believing in me and pushing me forward. Thank you Dad, for inspiring me to work hard and achieve my goals.

## INTRODUCTION

In the 1970s devastating numbers of infants were killed in automotive crashes (Moch & Boria, 1993). In response, the American Academy of Pediatrics (AAP) recommended universal use of car seats for all infants in the United States (Moch & Borja, 1993). Canadian car seat legislation followed closely behind, bringing mandatory use of car seats for infants and children into effect in 1982 (Boase, Jonah & Dawson, 2004). Infants and children are less likely to die or be seriously injured in a motor vehicle accident if they are secured in a car seat appropriate for their size (Johnston, Rivara & Soderberg, 1994; Rice & Anderson, 2009). Despite these safety provisions, motor vehicle crashes remain the leading cause of death amongst infants and children in North America (Rice & Anderson, 2009; Williams & Martin, 2003). Currently, infant car seats are designed for the average full term infant (>37 weeks gestational age, weighing > five lbs), limiting the ability for preterm infants (<37 weeks gestational age, weighing <five lbs) to fit safely in infant car seats. Preterm infants are at risk for apnea, bradycardia, and oxygen desaturation and encounter positional problems while seated in infant car seats thus contributing to morbidity and mortality of this population during vehicle transportation (Bass, Mehta & Camara, 1993; Bull et al., 1999; DeGrazia, 2007; Elder, Russell, Sheppard, Purdie & Campbell, 2007).

Preterm births are on the rise in Canada (Canadian Institute for Health Information, 2009) and due to advances in health care and technology, preterm infants are being discharged from the neonatal intensive care unit (NICU) at earlier gestational ages and smaller sizes (Greenburg, 2007; Hertz, Aggarwal, Rosenfeld & Greensher, 1994). The benefit of early discharge for these infants includes reduced hospital stay, decreased exposure to nosocomial infections, decreased hospital costs and earlier parental involvement in their child's care. However, due to their small

size and underdeveloped head and neck control, preterm infants are at risk for cardio-respiratory issues while seated in the semi-up right position most common in infant car seats (Bass & Bull, 2001; Merchant, Worwa, Porter, Coleman & deRegnier, 2001; Williams & Martin, 2003).

### **Significance to Nursing**

Car seat education for parents of preterm infants is variable across Canada (Bass & Bull, 2001; Merchant et al., 2001; Williams & Martin, 2003). In the NICU, the responsibilities of registered nurses often include conducting an infant car seat challenge (ICSC) before discharge, where the infant is observed in their car seat and monitored for cardio-respiratory instability. Nurses may offer car seat safety information to parents and are most often responsible for fitting infants in car seats prior to discharge (American Academy of Pediatrics (AAP), 2009; Canadian Pediatrics Society (CPS), 2002; Mullen & Coutts, 2002). These car seat initiatives are conducted in order to assess readiness for vehicle travel and offer car seat safety education to parents . NICU nurses are uniquely positioned to offer every parent of every preterm infant accurate and comprehensive safety education prior to their first use of car seats; however nurses in Canada do not typically receive formal training in car seat safety and resources remain scarce. The AAP (1990) recommends car seat challenges for all infants <37 weeks gestation due to the known cardio-respiratory risks of preterm infants in car seats (Bass & Bull, 2001; Merchant et al., 2001; Williams & Martin, 2003). However, the AAP did not give specific guidelines as to who should be tested, the length of testing, criteria for pass or fail, or provisions in the case of a failed assessment. Therefore, car seat safety practices in the NICU remain inconsistent (Hodgman,1998; Salhab et al., 2007) and it is difficult for nursing leaders to provide adequate resources and accurate policies for nursing staff (CPS, 2000). Due to these discrepancies parents

are given a false sense of safety based on the results of the ICSC (Mullen & Coutts, 2002; Stein, 2004).

Additionally, preterm infants are often discharged home at weights less than five pounds and often do not fit properly or meet the safety standards for travel in infant car seats (Merchant et al. 2001; Transport Canada, 2008). As an alternative, car beds have been designed to accommodate infants who do not fit safely in the semi-upright position of typical infant car seats. Unfortunately there is only one type of car bed in Canada that meets the Transport Canada safety standards (Cosmo Dream Ride) and it can only be obtained directly from the manufacturer with a prescription from a medical doctor (Kinane, Murphy, Bass & Corwin, 2006; Kornhauser Cerar et al., 2009; Salhab et al, 2007). There is limited literature to support the use of car beds and the overall safety of car beds remains unsubstantiated (Kinane et al., 2006; Kornhauser et al., 2009; Salhab et al, 2007). Careful attention to car seat safety practices, access to nursing resources in the NICU and teaching about correct positioning of preterm infants in car seats is essential to provide optimal protection for preterm infant travel in vehicles (CPS, 2000; Salhab et al, 2007).

## **THEORETICAL APPROACH**

This project is grounded in nursing leadership theory relating to knowledge translation and evidence-informed nursing practice. There are many philosophies regarding knowledge translation and models for putting knowledge into practice. The Promoting Action on Research Implementation in Health Services (PARiHS) framework of knowledge translation (Kitson et al., 1998) focuses on evidence, context, and facilitation as key factors influencing knowledge uptake and practice change. The following integrated review of the literature is guided by these concepts in relation to preterm infant car seat safety in the NICU.

## **Knowledge Translation**

Knowledge translation has increased in popularity since the mid-1980s and 1990s with the rise of evidence-based medicine (Graham et al., 2006). More recently, knowledge translation was declared a fundamental element of the Canadian Institutes of Health Research (CIHR, 2000) mandate. Knowledge translation is defined as the exchange, synthesis and ethically sound application of knowledge within a complex system of interactions among researchers and users. Estabrooks and colleagues (2006) claim that knowledge translation is about turning research into action, closing the gap between knowing and doing and accelerating the capture and practical application of the knowledge uncovered by research. Essentially, knowledge translation is the practice of incorporating research and evidence into the clinical setting to enhance patient care.

In the past, a significant proportion of health research funding was invested in clinical research, while relatively little attention was given to ensuring these findings were incorporated into practice (Estabrooks, Thompson, Lovely & Hofmeyer, 2006). Graham et al. (2006) conducted a series of practice audits, performed in a variety of settings and discovered that high-quality evidence was not consistently applied to patient care. These inconsistencies in practice can be largely attributed to premature adoption of practices and/or difficulty keeping up to date with available evidence. As a result, patients may be exposed to potentially ineffective and even harmful care (Graham et al., 2006). Nursing practices should be based on the best available knowledge and should incorporate sustainable knowledge translation strategies in order to provide the best care possible.

The lack of theoretical underpinning for implementing knowledge into the health care setting has made it difficult to interpret the positive or negative effects of patient care on patient outcomes. Theory is needed for knowledge translation to develop testable and useful interventions for enhancing patient care (Estabrooks et al., 2006). When conducting this integrated literature search a great deal of time was

spent investigating knowledge translation theories in order to identify the best fit for this review.

Estabrooks et al. (2006) explains that the most critical aspect to consider when selecting a theory is to find a fit between the theoretical perspective and the context in which it is to be applied. The PARIHS model was selected for this review due to its unique focus on contextual influences in knowledge translation and the emphasis on enhancing leadership to support practice change.

Knowledge comes in many forms and is influenced by a wide variety of epistemological traditions. There are important differences among terms used in the field of knowledge translation. For the purposes of this paper, the term knowledge translation refers to terms such as evidenced informed practice, knowledge uptake, practice change and research implementation.

### **Evidence Informed Nursing**

A number of theorists and critical thinkers have come to recognize the need to challenge the status quo of nursing knowledge (Holmes, Perron, & O'Byrne, 2006; McSherry, Simmons & Abbott, 2002). Holmes and colleagues (2006) claim that many research agendas are currently dominated by one paradigm of knowledge development in which randomized control trials are portrayed as the highest valued evidence. Limiting the value of nursing research to randomized control trials alone presents the risk of excluding many other forms of nursing knowledge and oversimplifying the complexity of clinical nursing practice (Holmes et al., 2006). There is a need for the nursing profession to take ownership and give value to a wider variety of rigorous and reliable research approaches. The medical model of health care ranks randomized control trials above other types of research. However evidence informed nursing practice and the PARIHS framework value a wide variety of evidence gathered from research studies, professional knowledge and patient experiences. Each type of evidence adds a different perspective and when all types of evidence are considered together, a broad source of evidence surfaces, offering

knowledge to guide the best patient care possible.

More recently, the nursing profession has embraced a transformation of knowledge whereby many forms of valuable research (i.e. quantitative and qualitative, case studies and anecdotal reports) are evaluated and synthesized together to support evidence informed nursing practice (McSherry et al., 2002). Evidence informed nursing requires: the formation of answerable questions that arise from practice (reflection); the searching of the literature or other relevant evidence sources (information); the evaluation of the evidence for validity, generalisability and transferability (appraisal); the use of the best available evidence alongside clinical expertise and patient preferences in planning care (implementation); and the evaluation by practitioners of their own professional practice (evaluation) (McSherry et al., 2002).

Practicing evidence-informed nursing (EIN) requires knowledge in research methodology, access to multiple sources of evidence and skills for critical appraisal, facilitation and leadership (McSherry et al., 2002). Evidence-informed nursing requires knowledge and competence to interpret research reports and the ability to use findings to inform their clinical decision-making (McSherry et al., 2002). It also involves gathering a wide variety of resources and combines robust research, patient experience and clinical knowledge to provide sound guidelines for clinical care (Rycroft-Malone et al., 2004). Evidence-informed nursing is about more than just reading and interpreting research reports and collaborating expert and patient experiences, it also requires strong facilitation and leadership skills. A unique aspect of EIN is the need to support the organizational culture and context to facilitate the implementation of research into clinical practice. The PARiHS framework presents a formula for successful implementation:  $[SI = f(E, C, F)]$ . This formula suggests that *successful implementation* (SI) is a function of the relationship between the nature of *evidence* (E), the *context* (C) in which the proposed change is to be implemented and the mechanisms by which the change is *facilitated* (F) (Kitson, Harvey

& McCormack, 1998). This framework is described in greater detail in the next section. INSERT CHART OR DIAGRAM

### **Promoting Action on Research Implementation in Health Services (PARiHS) Framework**

Kitson and colleagues (1998) developed the PARiHS framework in response to the need for an approach beyond the linear process of current knowledge translation theories and to account for the important influences of context and leadership in the process of practice change. The benefit of this framework is that it can be applied to a variety of health care settings, not only the NICU as referenced in this project.

The framework originated in 1998 and since its inception, has undergone extensive conceptual clarity through multiple concept analyses (Harvey et al., 2001; Kitson et al., 2008; McCormack et al., 2001; Rycroft-Malone et al., 2003; Rycroft-Malone et al., 2004). The PARiHS framework faces limitations as a relatively new theory and researchers are involved in ongoing evaluations to establish validity and worth (Estabrooks, Thompson, Lovely & Hofmeyer, 2006; Harvey et al., 2001; Kitson et al., 2008; McCormack et al., 2001; Rycroft-Malone et al., 2003; Rycroft-Malone et al., 2004).

The PARiHS framework argues that successful research implementation is a function of the relationship between evidence, context and facilitation (Kitson et al., 2008; Rycroft-Malone, Kitson, et al., 2002). The PARiHS framework was selected to guide this project in knowledge translation because of the unique considerations of context and leadership. The mission of the PARiHS framework is aimed at providing the best available evidence to ensure the best possible care to patients (Kitson et al., 1998).

According to the PARIHS framework, research implementation occurs when a group has robust scientific evidence that matches clinician consensus and patient needs, a context supportive of change (a positive culture, strong leadership, appropriate monitoring and feedback) and skilled internal and external facilitators (Rycroft-Malone, Harvey, et al., 2002). This framework recognizes that simply discovering new research is not enough to produce change in the clinical setting. In order to influence change in practice and implement knowledge translation strategies, nursing leaders must consider the context into which the evidence is to be implemented. Also, effective leadership and facilitation skills are required for successful knowledge translation otherwise the evidence discovered through professional experience, patient perspectives and research, will remain inactive in textbooks and archives and therefore have no impact on patient care.

The framework considers the elements of evidence, context and facilitation to have a dynamic simultaneous relationship, positioned on a continuum from “high” to “low” (McCormack et al., 2001; Rycroft-Malone et al., 2002). The PARIHS framework claims that implementation of research into practice is more likely if the evidence, context and facilitation are high, meaning the evidence is well conceived, designed and executed and there is consensus about it. Implementation is also more likely in a context where there is clarity of roles, decentralized decision-making, transformational leadership and a reliance on multiple sources of information to evaluate performance. Finally practice change is more likely when facilitation mechanisms meet the needs of the situation and involve a variety of leadership strategies (McCormack et al., 2001; Rycroft-Malone et al., 2002).

The PARIHS framework is appropriate within the context of this project because car seat safety practice in the NICU remains disjointed and inconsistent, requiring leadership and

contextual considerations to improve nursing knowledge in this area based on the best available evidence. Nursing leadership strategies for discovering the best available evidence, identifying gaps in the literature and seeking changes in practice are rarely followed through, thus evidence regarding car seat safety in the NICU faces many barriers to being incorporated into the clinical setting.

### **Nursing Leadership**

Moving research evidence into practice is a dynamic process and may depend on the nursing leader's ability to effect change within a health care organization. If nursing is to succeed in providing care that is based on the best available evidence, nurse leaders have a role in engaging staff nurses in this process to pave the way for change, transform practice and improve patient care (Bradshaw, 2010).

In the NICU, contextual factors create barriers for the nursing leader in implementing evidence into practice. These factors may include: the organizational culture or climate, lack of managerial support, lack of educational support, stress, leadership style and organizational readiness for change (Estabrooks et al., 2006; McCormack et al., 2002). Barriers that inhibit the implementation of EBN include stress, limited time, heavy patient work load, inadequate staffing, limited access to resources and lack of the knowledge needed to interpret statistical analyses (Estabrooks et al., 2006; McCormack et al., 2002). Additionally, many nurses may lack the knowledge and skills to confidently conduct computer-based literature searches and utilize the research process thus limiting their motivation to actively participate in practice change initiatives.

In order to move knowledge forward into action, nurse leaders may act as facilitators to initiate and sustain evidence informed nursing processes within institutions (Rycroft-Malone et al., 2004). Research indicates that nurses who are mentored by colleagues with expertise in research and critical appraisal come to believe in the importance of EBN, gain confidence in integrating research into their practice and thus help promote its implementation (Harvey et al., 2002).

Organizational support is critical for providing the time, skills and knowledge needed to promote a supportive culture of change (Bradshaw, 2010). Nursing leaders have a role in recognizing context within a chosen setting and acting with innovative and critical minds to overcome facilitation barriers. The PARIHS framework of knowledge translation was selected for this review in an effort to demonstrate how this framework may be utilized by an Advanced Practice Nurse to overcome contextual barriers to knowledge translation and to identify leadership strategies to ensure effective knowledge translation in the clinical setting. These concepts are explored further at the end of this project. In the next section, a thorough analysis of the best available literature on preterm infant car seat safety is outlined in an integrative literature review.

## **INTEGRATIVE LITERATURE REVIEW**

Integrative reviews are the broadest category of research reviews and often include empirical and theoretical literature, depending on the purpose of the review (Whittemore, 2005). An integrative literature review is one example of a systematic literature review and is considered a research methodology in its own right, with the benefit of linking research and practice together (Polit & Beck, 2008). One of the distinct advantages of accessing the rich

integrative sampling method is the ability to offer a comprehensive and thorough exploration of the topic of interest (Whittemore, 2005). Research reviews are considered research of research and therefore should meet the same standards as primary research methodological rigour (Whittemore & Knafl, 2005). The steps involved in conducting an integrative literature reviews therefore involve problem identification, literature search, data evaluation, data analysis and presentation (a synthesis in the form of a model might be used to portray the findings from the review) (Whittemore & Knafl, 2005).

An integrative review can encompass an infinite number of variables, issues or populations; therefore, clarity of the purpose of the review is important (Whittemore, 2005). The purpose of this integrative review is to explore issues, identify challenges and offer relevant recommendations for the advancement of nursing practice in the NICU regarding preterm infant car seat safety. The clinical questions addressed in this review include:

1. What are the current nursing practices related to preterm infants and car seat safety in the NICU?
2. Based on the best available evidence, what is evidence informed nursing regarding preterm infant car seat safety in the NICU?
3. How can this knowledge be put into action in the NICU?
4. What are areas for future research aimed at promoting safe transportation of preterm infants in vehicles?

This review critically examines car seat safety in the NICU by exploring the practice of infant car seat challenges and the use of car beds. Recommendations for supporting advanced

practice nurses to enhance nursing practice and knowledge in this area are offered and suggestions to move these findings into practice are explored. The findings from this integrated literature review, follow the action principles according to the PARIHS framework. Topics for future research regarding preterm infant car seat safety in the NICU conclude this project.

### **Literature Search and Methodological Approach**

Searches for this integrated literature review began with online databases (CINAHL, Medline, Health Canada, The National Transportation Library, Joanna Briggs Systematic Review Group and Cochrane Database of Systematic Reviews). Additional searches were conducted using Google and crosschecking reference lists of relevant articles. Keywords in the search included: preterm infant, premature infant, newborn, infant car seat, car seat safety, car safety device, infant restraint system, car seats, infant safety, neonatal, infant, neonatal intensive care unit, car seat challenge, car bed, oxygen desaturation, apnea of prematurity, hospital discharge and nursing. A number of articles were found repetitively in more than one database and the National Transportation Library returned no results. The search was expanded using Google search engines, which produced relevant references to American Academy of Pediatrics (AAP), the Canadian Pediatrics Society (CPS) and Transport Canada guidelines that might have otherwise been missed.

Articles gathered were limited to those written in the English language. Literature was gathered as far back as 1982 when the initiation of car seat legislation came into effect in Canada, to the present. Documents such as randomized control trials, systematic reviews, observational studies, qualitative and descriptive studies as well as a variety of anecdotal and local evidence and government documents were included in the initial phases of the search. Documents from an international perspective (but limited to

Australia, Canada, New Zealand, UK and US) were also included initially. The decision to include literature regarding full term infants (> 37 weeks gestation) and low birth weight infants (LBW- <2500g at birth) was made because valuable evidence relevant to these populations was also found to be relevant to the preterm infant population, adding merit to the evidence base and might have otherwise been missed. Including these populations in this review offered a broad perspective on this topic and insight into areas for future research.

Exclusion criteria eliminated any information regarding infants with special needs (such as hydrocephalus, cardiac anomalies or bone deformities) in order to eliminate additional factors beyond prematurity and normal newborn development that might contribute to car seat safety. Grey literature, including unpublished manuscripts and dissertation abstracts were not included, as grey literature often requires exhaustive investments of time, yields very little new data and is not often considered relevant by researchers (Estabrooks et al., 2006). Articles were screened with an overall goal of finding relevance related to nursing practice and car seat safety in the NICU.

No report was excluded from this review based on the evaluation appointed in Appendix B and C. However, the rating was taken into consideration when offering recommendations and resources for nursing practice and not all recommendations were included. Information regarding how to select the proper car seat was not included in this discussion but is an area of focus for the future when creating resources for parents. Articles dealing with transporting patients with oxygen tanks or in special wheel chairs were not included. The AAP released guidelines for preterm infant car seat safety in 1991, 1996, 1999 and 2009; only the most recent document was included in this review. A number of editorial critiques were excluded which were anecdotal in nature and did not provide new information or strong arguments.

Articles from international perspectives were included based on their relevance to North

American practices and recommendations offered. One article from Japan was added following a review of reference lists and one article by an Australian author was excluded on the basis of the content of the article, which focused on the safety of an infant car seat that is not available in Canada (Safe-N-Sound Baby Safety Capsule).

Articles regarding misuse of car seats were beyond the focus of this review and therefore excluded. Two articles about discharge guidelines for preterm infants were excluded as the information had minimal relevance to car seat safety and did not present any new information. One anecdotal article was eliminated as it was a professional opinion based article which only referenced two articles and did not provide a strong argument. One article about implementing a car seat safety program in hospitals was eliminated, as it was more relevant to pediatric car seat use and not relevant to the preterm infant population.

Initially, thirty-five abstracts, six meta-syntheses and eight local resources were identified. Eighteen articles were added after reviewing reference lists from the forty-nine articles gathered. These articles were then screened for inclusion/exclusion criteria. By focusing the review on this inclusion and exclusion criteria, the author recognizes that some potentially relevant sources may have been excluded at this time.

Drawing on a framework of evidence informed nursing and a critical analysis of the literature developed by Long (2002), forty-five of the original sixty-seven articles remained and were printed and read by the author three times to compare data within the articles, determine the quality of the writing and to collaborate themes and trends in the literature. As a result, a final total of thirty- three articles were identified and integrated into this review. The final sample for this integrative review includes three guidelines for nursing practice based on American Academy of Pediatrics (AAP), Canadian Paediatric Society (CPS) and Transport Canada

recommendations, one governmental document, five commentary reports and twenty-five research-based articles with wide a variety of methodological designs spanning over a twenty-five year time line. Due to this diverse representation of primary sources, reports were organized into two matrices: a matrix of all research and anecdotal based articles (see Appendix B) and a matrix of the guideline recommendations from AAP, CPS and Transport Canada (see Appendix C).

Data for the Reference Chart (see Appendix B) were extracted from the primary sources and organized chronologically. Sample numbers from each study and the gestational age of participants were outlined as applicable. Methods and results were identified and summarized. Data were extracted to outline the relevance to nursing practice regarding car seat safety in the NICU. Evaluating the quality of evidence was guided by Long (2002) based on strengths and weaknesses of the overall purpose, design, sample characteristics, data collection and sampling environment, conceptual or theoretical framework, ethical considerations, findings and plans for practice knowledge development. The evidence was also given a value, high or low, in accordance with the PARIHS framework for evaluating evidence (Rycroft-Malone et al., 2003). based on rigorous research, clinical consensus, patient experience and\ or local evidence.

The Guideline Chart (see Appendix C) was developed to outline and compare three standard guidelines which are available to nurses but which currently have limited implementation into nursing practice. Strengths and weakness of each guideline were outlined and implications for nursing practice were documented, this process was also guided by Long's (2002) critical appraisal assessment criteria (see Appendix G).

## **Description and Analysis of the Literature**

The remaining thirty-three articles were synthesized in an integrated literature review to identify the best available evidence regarding preterm infant car seat safety in the NICU. Evidence-informed recommendations were gathered and a sample information sheet was developed for nurses to share with parents during discharge teaching (Appendix D). As well, a sample nursing curriculum was developed (Appendix E), which includes list of suggested topics nurses can review regarding preterm infant car seat safety and a list of current resources for use by neonatal centers in putting preterm infant car seat safety knowledge into practice (Appendix F).

## **SUMMARY OF FINDINGS AND GAPS IDENTIFIED IN THE LITERATURE**

Greenburg (2007) recognized that “our zeal to do the right thing for our patients is always best focused through the lens of careful inquiry” (p. 215). An integrated review of the literature revealed three main themes regarding preterm infant car seat safety in the NICU:

- A) Preterm and full term infant risks in car seats,
- B) Risk prevention strategies in the NICU,
- C) Innovative solutions for infant car seat safety.

Current recommendations only require preterm infants to be tested in car seats prior to discharge from the hospital; yet, gaps in the literature indicated cardio-respiratory risks in both preterm infants and full term infants while seated in infant car seats. Reasons for cardio-respiratory compromise in both populations are multi-factorial including developmental stage, physiology and small size. Yet the significance of oxygen desaturations and prolonged apnea or bradycardia episodes remains unknown.

Risk prevention strategies such as the infant car seat challenge (ICSC) and the use of car beds create alternatives for transportation of these tiny infants in vehicles but, ICSC procedures are not

standardized and wide variation in practice exists. Additionally, car beds are difficult to obtain and have not proven to be a safer alternative to infant car seats. As a result, limited resources are available for nurses and families upon discharge from the NICU, and preterm infants remain at risk while traveling in vehicles.

A number of innovative solutions for car seat safety have surfaced to improve car seat safety practices in the NICU: the creation of an insert for preterm infant car seats to prevent head and neck flexion and limit cardio-respiratory compromise in car seats or incorporating the concept of car seat orientations instead of car seat challenges into practice. More research on preterm infant car seat safety is required before applying these new strategies to the clinical setting. Critical analysis of the literature resulted in a synthesis of themes to provide insight into preterm infant car seat safety in the NICU.

#### **A) Risks and Reasons:**

##### **Preterm Infant Car Seat Safety.**

Preterm births have increased by 9% in Canada since 1982 (CIHI, 2009). In 2002, there were over 350,000 preterm births in Canada alone (CIHI, 2009). Due to advances in technology and health care, these tiny infants are being sent home from hospital at less than 37 weeks gestation and often weighing less than five pounds (Bass, 2010; Bass, Mehta & Camara, 1993; Bull & Stroup, 1985; Merchant et al., 2001). Research shows that preterm infants are at risk of injury and cardio-respiratory compromise when seated in infant car seats (Bass, Mehta & Camara, 1993; Bull & Stroup, 1985; DeGrazia, 2007; Elder et al., 2002; Kornhauser Cerar et al., 2009; Hertz et al., 1994; McMillan, 1996; Merchant et al., 2001; Mullen & Coutts, 2002; Murphy & Bridgman-Acker, 2008; Ojadi, Petrova, Mehta & Hegyi, 2005; Smith & Turner, 1990; Willet, Leuschen, Nelson & Nelson, 1986; Willet, Leuschen, Nelson & Nelson, 1989;

Young, Shapira & Finer, 1996). Even short periods of time in a car seat may be hazardous for premature infants as the frequency of adverse cardio-respiratory events increases during sleep (AAP, 2009; Hertz et al., 1994; Murphy & Bridgman-Acker, 2008; Ojadi et al., 2005). Cardio-respiratory events includes apnea (<20 seconds with no respiratory effort), bradycardia (<80 bpm) and oxygen desaturation (<85-90%) (Bass, Mehta & Camara, 1993; Bull & Stroup, 1985; Bull, Weber & Stroup, 1988; DeGrazia, 2007; Elder et al., 2002; Kornhauser Cerar et al., 2009; Hertz et al., 1994; McMillan, 1996; Merchant et al., 2001; Mullen & Coutts, 2002; Smith & Turner, 1990; Willet, Leuschen, Nelson & Nelson, 1986; Willet, Leuschen, Nelson & Nelson, 1989; Young, Shapira & Finer, 1996).

The cause of cardio-respiratory compromise in these infants has been explored in great depth and remains a multi-factorial issue. For example, preterm infants are at risk of apnea, bradycardia or oxygen desaturation due to their physiology. The preterm infant has a prominent occiput and poor head and neck control which accentuates the tendency for flexion of the head and neck (Cote, Bairam, Deschenes & Hatzakis, 2007; Smith & Turner, 1990; Tonkin et al., 2003). Dollberg and associates (2002) tested the effectiveness of limiting lateral (side to side) head movement in car seats and concluded that limiting lateral head movement did not limit the frequency of oxygen desaturation (OD) episodes. These observations suggest that the mechanism of OD in infant car seats may be due to excessive head flexion leading to restriction of the upper airway (Cote et al., 2007; Smith & Turner, 1990; Tonkin et al., 2003).

In a similar study, Tonkin and colleagues (2003) provided an insert behind the infant to prevent head and neck flexion (up and down) and found a remarkable decline in the number of OD events. Since this is the only study of its kind, future research is recommended to further explore the effectiveness of head and neck support for preterm infants in car seats. Many car seat

inserts and support devices, known as ‘after-market products’ are available for purchase.

Unfortunately, Transport Canada does not crash test car seats with “after-market products” and therefore considers any inserts or support added to a car seat to be unsafe. If more studies like Tonkin and colleagues (2003) can demonstrate the benefits of these inserts, Transport Canada might have a reason to test these products for crash safety.

Preterm infants may also be at risk of OD in an infant car seat due to their developmental stage. Typically, preterm infants experience intermittent OD leading to episodes of periodic breathing as part of normal newborn development. In their study of the effect of sleep state on breathing, Hertz et al (1994) described periodic breathing was described as three or more pauses greater than three seconds, with less than 20 seconds of normal respiration between pauses. Hertz and colleagues (1994) first discovered that episodes of periodic breathing and the amount of time spent in active sleep (deep sleep) was related to the number of significant desaturations experienced in car seats. Similarly, Ojadi and associates (2006) reported that episodes of periodic breathing and ODs often occurred in relation to each other regardless of location (car seat, car bed or crib). Together, these results indicate that the incidence of periodic breathing is likely to occur regardless of the infant’s location; however, sitting in an infant car seat may increase the risk and frequency of these events. It has been suggested that criteria to monitor periodic breathing should be added to the infant car seat challenge assessment in order to indicate the source of respiratory compromise (Hertz et al., 1994; Ojadi et al., 2005).

Rice and Anderson (2009) recognized the importance and effectiveness of infant restraint systems in infants under three years old. They compared the number of child and infant deaths in vehicle collisions over a nine year period (1996-2005). Results showed that infant car seats reduce the risk of injury and death by 74% (Rice & Anderson, 2009). However, up to 85% of car

seats are installed and used incorrectly (Rice & Anderson, 2009). Nurse leaders can contribute valuable education for parents regarding proper infant car seat use, particularly as more accurate and relevant car seat education becomes available.

Preterm infants are also at risk in car seats due to their small size. Infant car seats are designed for the average newborn (5 lbs-20 lbs) (Bass, Mehta & Camara, 1993; Hertz et al., 1994; Merchant et al., 2001; Willet et al., 1986; Willet et al., 1989). Some preterm infants are discharged home at weights less than five pounds and do not fit properly in infant car seats, thus putting the infant risks for ejection or injury in the event of a vehicle crash (Merchant et al., 2001; Murphy & Bridgman-Acker, 2008; Rice & Anderson, 2009; Tonkin, McIntosh, Hadden, Dakin, Rowley & Gunn, 2003; Williams & Martin, 2003).

The AAP (2009) recommends car seat straps and buckles should be secured over hard bones and away from soft tissues and the neck in order to avoid injury and maintain safety of infants during travel. However, many NICUs lack appropriate educational resources for parents regarding placement and fit of preterm infants in car seats, thus contributing to positioning issues and leaving preterm infants at risk.

Merchant and associates (2001), in a study on term and preterm infants, determined that 24% of preterm and four percent of term infants did not fit properly in car seats despite adding padding around the infant. Nurses and parents frequently place rolls or cloths between the baby and the car seat straps, as recommended by AAP (2009), to prevent slipping. However, the impact that this practice may have on the respiratory status of the infant has not been documented and may prevent safety in the event of a vehicle collision. Furthermore, Smith and Turner (1990) advocate the use of car seats despite the fact that fit and positioning are barriers to safety in this population as car seats are safer than riding in a caregivers arms during automobile

travel. While car seats are designed to keep infants safe during transportation in vehicles, preterm infants and some full term infants do not easily fit in car seats and nursing education remains scarce and based on limited evidence. Initiatives to address the educational needs of parents of preterm infants for vehicle transportation should be a priority in future research and knowledge translation initiatives.

### **Preterm versus Full Term Infant Car Seat Safety.**

Initiatives are in place to assess for risk factors in infants less than 37 weeks gestation, yet desaturation episodes in the full term infant population (>37 weeks gestation) have also been discovered in the research which identifies safety concerns for this population and warrants additional investigation (Bass & Bull, 2001; Bass, 2010). In 1999, the AAP Committee on Injury and Poison Prevention issued recommendations for the safe transport of newborns upon hospital discharge, advising that every hospital should ensure that newborns are positioned in car seats suitable to their maturity level and clinical condition at discharge (AAP, 1999). A number of studies have revealed that both full term and preterm infants are at risk for desaturation in infant car seats (Bass & Bull, 2001; Bass, Mehta & Camara, 1993; Bass & Mehta, 1995; Kornhauser Cerar et al., 2009; Nagase et al., 2002).

Merchant and colleagues (2001) reported a significant increase in OD in both preterm and full term infants after being observed for more than 60 minutes in an infant car seat. Based on these findings, they urged that infants be placed in car seats only for travel and that travel time be limited, especially during the first months of life (Merchant et al., 2001). Nagase and associates (2002) conducted a similar study in Japan and discovered complimentary evidence showing that full term infants are also at risk for OD in infant car seats.

In addition, Kinane and colleagues (2006) compared cardio-respiratory stability in term infants while seated in car seats versus car beds, concluding that full term infants were at equal risk of OD in both infant car seats and infant car beds. Salhab et al. (2007) investigated cardio-respiratory risks for very low birth weight infants (<2500g) and discovered similar results to Kinane et al. (2006). They concluded that regardless of gestation and size, full term and preterm infants are at equal risk of OD in car beds and car seats. Therefore, preterm and full term infants are both at risk of cardio-respiratory effects while traveling in vehicles.

Of the studies referenced, none reported episodes of apnea or bradycardia in full term infants. However, according to local data and governmental reports there are many cases of both term and preterm infant deaths each year who have died while seated in infant car seats (Bass & Bull 2002; Cote et al., 2007; Murphy & Bridgman-Acker, 2008; Tonkin, Vogel, Bennet & Gunn, 2006). The cause of these deaths was generally unknown; however, common factors included prolonged time in an infant car seat (>60 minutes) and the infant being left to sleep, unsupervised in the car seat. Based on the evidence, both preterm and term infants are at risk of cardio-respiratory compromise when they spend prolonged periods of time in car seats.

### **Significance of Oxygen Desaturations.**

The clinical significance and long-term consequences of persistent apnea, bradycardia, or oxygen desaturation remains a subject of considerable debate (Cote et al., 2008; Martin & Fandaroff, 1998). The AAP bases its recommendations for car seat safety on the premise that repetitive oxygen desaturations may lead to long-term neuro-developmental impairments, yet limited research evidence supports these claims (AAP, 2009). Alternatively, the cause of sudden

infant death syndrome (SIDS) remains widely unknown; however, there is no evidence to show a correlation between oxygen desaturation seen in the preterm infant population and SIDS.

### **Neuro-Developmental Impairment.**

Little evidence exists about the potential long-term effects for infants who may have been discharged without prior observation or monitoring in car seats (CPS, 2000). In the American Academy of Pediatrics' latest document "Safe transportation of preterm and low birth weight infants at hospital discharge" (2009), recommendations are made for proper selection and use of car seats or car beds to ensure that preterm and low birth weight infants are transported as safely as possible. The document claims that preterm infants may experience OD or episodes of apnea or bradycardia, which may result in adverse neuro-developmental outcomes, psychosocial behavior and academic achievement later in life (AAP, 2009). Only two articles were referenced in this document to support these claims and due to their focus on an older population and long term outcomes of cardio-respiratory events, these articles were not included in this review, but warrant further investigation in the future.

Martin and Fandaroff (1998) anecdotally emphasized the significance of cardio-respiratory events, claiming that prolonged symptomatic apnea in preterm infants is not associated with severe intracranial abnormalities or neurological development. Additionally, the Canadian Pediatric Society (2000) states that the significance of periodic episodes of oxygen desaturation (OD) to the overall health of the baby remains unknown. Both of these articles are outdated at this time however preterm and term infants are known to have intermittent OD episodes as part of normal newborn development and therefore the significance of these episodes remains a debated topic. For the purposes of this review, the long-term effects and significance of cardio-

respiratory compromise in infants traveling in car seats was not fully explored. However, more research in this area will be important in discovering the health risks and long-term effects of cardio-respiratory compromise for preterm infants being transported in car seats.

### **Sudden Infant Death Syndrome (SIDS).**

Preterm infants are five times more likely to die of SIDS when compared to full term infants (Hodgman, 1998). The risk to this population has been known for many years and yet the contributing factors remain obscure and difficult to identify. The only factor that has been reliably associated with risk in preterm infants is that the more immature the infant is at birth, the higher the risk of SIDS (Hodgman, 1998). While it is known that apnea of prematurity exists beyond 36 weeks gestation, it is tempting to consider that apnea of prematurity may be the reason these infants are at greater risk once discharged from the NICU. However, all published studies assessing SIDS in preterm infants found no correlation between recorded events of apnea of prematurity and SIDS (Hertz et al., 1994; Hodgman, 1998; Ojadi et al., 2005).

Furthermore, two studies indicate that periodic breathing episodes may cause oxygen desaturation but have not shown periodic breathing to be a risk factor for SIDS (Hertz et al., 1994; Ojadi et al., 2005). Martins and Fandaroff (1998) reason that bradycardia may persist in preterm infants long after their hospital discharge and that this should not be considered predictive of SIDS. Additionally, Cote and associates (2008) claim that a relationship between persistent apnea or bradycardia and SIDS has not been demonstrated.

Although no association with cardio-respiratory episodes and SIDS has been discovered in the preterm infants population, SIDS rates have not declined in very low birth weight babies as they have in larger infants (CPS, 2000). Reported incidents where infants had died in their car seats occurred when infants, both preterm and full term, had been left unsupervised, restrained in

the car seat and allowed to fall asleep (Murphy & Bridgman-Acker, 2008; Tonkin et al., 2006). These findings indicate that car seats maybe a hazardous sleep environment and therefore time spent in car seats should be limited to travel purposes. Parents should be reminded never to leave a child unsupervised in an infant car seat (McMillan, 1996; Murphy & Bridgman-Acker, 2008; Tonkin et al., 2006). Health care professionals should make parents aware that cardio-respiratory episodes in infants born prematurely are common at the time of hospital discharge and that there are no monitoring criteria currently available to predict an increased risk of SIDS (CPS, 2000; Hodgman, 1998).

#### **B) Risk Prevention Strategies in the NICU Infant Car Seat Challenge (ICSC).**

Preterm infants have been shown to be at risk for cardio-respiratory compromise while seated in infant car seats. Willet and colleagues (1986, 1989) in two studies investigating the effect of preterm infant ventilation, reported that 30-60% of preterm infants are subjected to periods of OD and bradycardia while seated in car seats. Bass et al. (1993) reported that 18% of infants less than 37 weeks gestational age experienced OD in car seats. Comparatively, Young, Shapira and Finer (1996) found 29% of preterm infants experience OD in car seats.

In response, the American Academy of Pediatrics Committee on Injury and Poison Prevention and Committee on Fetus and Newborn, developed guidelines for the safe transportation of premature infants (AAP, 1991). This document has since undergone multiple revisions (1996, 1999, 2009), yet continues to recommend that a registered nurse or physician observe each preterm infant, <less than 37 weeks gestational age, in a car safety seat prior to discharge. Nurseries throughout the United States and Canada and increasingly in the UK and

Australia, have implemented this ritual known as the infant car seat challenge (ICSC) into the discharge process from the NICU (CPS, 2000; Joffe & Hall, 2006; Tonkin et al., 2006). The car seat challenge involves placing the preterm infant, who is otherwise ready for discharge home, in a car seat where they are connected to a vital signs monitor and pulse oximeter and then observed for an extended period of time. Objective data are collected (number of apneic episodes, oxygen saturation values and bradycardia) during the challenge to determine a 'pass' or 'fail' result indicating the infant's readiness for safe travel in a car seat (AAP, 2009; Greenburg, 2007; McMillan, 1996).

Unfortunately, a lack of evidence and specific guidelines to support the implementation of this practice has resulted in wide variation of practices from hospital to hospital (Joffe & Hall, 2006; Mullen & Coutts, 2002; Williams & Martin, 2003). In Canada, the ICSC practice is not routinely conducting, mainly due to the lack of evidence to support its use (CPS, 2000; Mullen & Coutts, 2002; Young, Shapira & Finer, 1996). However, the program does exist in some centers, where it is applied with wide variation and often also includes testing full term infants with respiratory, cardiac or neurological abnormalities before discharge home (CPS, 2000).

With respect to the criteria for who should be tested, the length of the testing, criteria determining pass or fail, and guidelines for those neonates who fail the car seat challenge, Williams and Martin (2003) found that some centers tested infants based on birth weight (2500g), while other centers tested infants with respiratory compromise (recovering from chronic lung conditions, requiring oxygen or intubated for a greater than 2 days) (Young, 1996). The AAP (2009) recommends infants < 37 weeks gestation should be tested before discharge, but these guidelines exclude infants at risk of life threatening episodes in car seats such as infants

with cardiac anomalies or chronic lung disorders (Cote et al., 2007; CPS, 2000; Murphy & Bridgman-Acker, 2008; Salhab et al, 2007; Tonkin et al., 2006).

In 2003, a survey was conducted in the United States, to identify how the car seat challenge program was operating in the clinical setting (Williams & Martin, 2003). It was discovered that the majority of level I nurseries were not testing their infants before discharge home; leaving 20% of infants who are less than 37 weeks gestational age untested before discharge home, and therefore not meeting the AAP recommendations. For those centers that did have ICSC programs available, the method in which the testing was administered varied greatly. Williams and Martin (2003) speculate that poor compliance was perhaps related to the ambiguity of the original AAP recommendations.

A wide variation in the length of testing was discovered; where tests were being conducted anywhere between 30-150 minutes from hospital to hospital (Bass, Mehta & Camara, 1993; Kornhauser Cerar et al., 2009; Willet et al., 1986; Willett et al., 1989; Williams & Martin, 2003; Joffe & Hall, 2006). The new AAP (2009) recommendations suggest a period of observation for a minimum of 90 to 120 minutes or the duration of travel, whichever is longer. However, large controlled studies do not exist to justify a prolonged evaluation. To date, evidence shows that prolonged time in infant car seats results in lower oxygen saturations, which fall even lower for infants who achieve active sleep while in car seats (Hertz et al., 1994).

In addition, conducting infant car seat challenges in discharge assessments of all preterm infants has cost implications for health services. Undertaking cardio-respiratory monitoring for 90 minutes for all preterm infants can occupy a substantial proportion of nursing time (Greenburg, 2007). Furthermore, delaying hospital discharge for the infants who fail the test

could have major effects on bed occupancy and availability in neonatal units. Unfortunately there is little information to support the health benefits or economic impact of recommendations for testing infants in car seats before hospital discharge (CPS, 2000).

Joffe and Hall (2006) surveyed nurseries in the UK and reported similar results to William and Martin (2003) regarding pass or fail criteria for the ICSC. Occasionally, a discharge is delayed for a day or two until the infant is retested and passes (AAP, 2009). Some centers retested the infant in a car bed under the assumption that it is safer (CPS, 2000), while other infants may be transported home with oxygen by nasal prongs (Young, Shapira & Finer, 1996). Although oxygen is commonly used to treat preterm babies in the NICU and may be effective in some babies who might not otherwise be ready for discharge, there are no specific recommendations for this treatment, the length of treatment and/or subsequent monitoring that can be made at this time (CPS, 2000).

The Canadian Pediatric Society (CPS, 2000) recommends that infants who fail the car seat test and who are otherwise healthy, may be sent home in a car bed if repeat testing in the car bed is satisfactory. Babies with continued significant oxygen desaturation may require continued hospitalization and further investigation and management before consideration for discharge (CPS, 2000). If the practice of infant car seat challenges is to remain a standard of care for preterm infants, standardization in the length of the ICSC should be specified in order to eliminate inconsistencies in practice, prevent needless wasting of hospital resources and prevent undue stress to families preparing for discharge home.

Furthermore, pass or fail criteria remain ambiguous and directives for those who fail the challenge do not exist. Significant cardio-respiratory events have been identified as two or more

episodes of oxygen desaturation (less than 88%) for 10 seconds or more during a 90 minute monitoring period (CPS, 2000). However, it has not been shown that two or more of these episodes of oxygen saturation are predictive of significant increased risk later (CPS, 2000). Therefore the long-term implications are unclear and there is little knowledge of the threshold for adverse effects for those preterm infants who may experience recurring apnea associated with OD (CPS, 2000; Martin & Fandaroff, 1998). Lack of research evidence to support these practices may result in a false sense of safety for parents of infants who pass an evaluation, while the parents of an infant who fails the ICSC may experience disappointment and increased anxiety at time of hospital discharge (CPS, 2000).

Episodes of apnea, bradycardia and oxygen desaturation may still occur at discharge when infants are placed in a transportation device, particularly among infants who were born <34 weeks gestation or those who are recovering from chronic lung disease (Salhab et al, 2007). Therefore, a brief observation period in a transportation device is not usually sufficient to identify infants at risk. These fragile infants endure a long list of interventions before discharge home and yet no published evidence demonstrates that passing the car seat challenge predicts a safe discharge and no protocol has been validated to predict which infants are at risk (Greenburg, 2007; Stein, 2004). Interpreting the results of an infant car seat challenge is therefore daunting for nurses and physicians and the lack of evidence is further contributing to wide variations in car seat safety practices in the NICU.

For these reasons, parents should be aware of the best available evidence, be taught proper positioning and be informed of the safety risks to their infant. In the meantime many nurseries continue to use car seat challenge protocols (Joffe & Hall, 2006; Williams & Martin, 2003), perhaps under the assumption that this test represents a standard of quality care for newborn

infants as recommended by the American Academy of Pediatrics or perhaps to avoid any legal implications that might come from providing a less rigorous safety screening process before discharge (Greenburg, 2007).

### **Car Bed Versus Car Seat.**

According to the latest Transport Canada (2008) document, car beds are recommended for preterm infants (< 37 wks), for infants who have failed the infant car seat challenge and for infants who weigh < 2.2 Kg (5 lbs) at discharge. Car beds are also recommended for infants who must travel lying flat for various health conditions (casts, abnormalities, bone disorders, etc.) (Transport Canada, 2008). Car beds are crash tested and regulated according to Canadian transportation standards (Transport Canada, 2008). While car beds offer an alternative for safe transportation of preterm infants, there are many limitations to the use of car beds for this population.

For example, car beds are expensive and are not readily available in Canada (CPS, 2000; DeGrazia, 2007; Ojadi et al., 2005; Transport Canada, 2008; Willet et al., 1989). At this time, only one type of car bed is available in Canada (Cosmo Dream Ride) and it can only be obtained with a prescription from a physician or occupational therapist directly from the manufacturer. Unfortunately, even if a car bed is obtained, it may be too big to fit in the family's vehicle (Transport Canada, 2008). Future research in manufacturing should focus on improving the evaluation and certification of car beds to accommodate the population they are designed for (Stein, 2004).

The relative safety provided by car beds compared with infant car seats has not been determined (Bass & Bull, 2001). Tonkin et al. (2003) claims that car beds have been proven to

leave the infant more vulnerable to injury in the event of a collision. Transport Canada (2008) warns that in the event of a side impact, an infant in a car bed is more vulnerable to injury than an infant in a rear-facing infant seat, especially if the impact is on the side nearest the infant's head. For this reason a car bed should only be used if an infant car seat is deemed not suitable for the infant (Transport Canada, 2008). While the American Academy of Pediatrics recommends car bed use, they also support the claims of limited safety in the event of a crash, sending a conflicting message to users (AAP, 2009).

Furthermore, many studies show that a car bed is no less likely to cause oxygen desaturation than a car seat (Elder et al., 2007; Kinane et al., 2006; Kornhauser Cerar et al., 2009; Salhab et al, 2007). On the other hand, some studies show remarkable improvement in cardio-respiratory stability for infants in car beds and offer better fit for preterm infants (Bull, Weber, Stroup, 1988; Ojadi et al., 2005).

The conflicting evidence for car bed use creates confusion for nursing practice and recommendations in the NICU. For example, when traveling in a car bed, infants must lie in a supine position, which has shown to decrease the incidence of OD (Nagase, Yonetani, Uetani & Nakamura, 2002; Willet et al., 1989; Young, Shapira, & Finer, 1996). On the other hand Kinane and colleagues (2006) and Salhab et al. (2007) discovered that some preterm and term infants positioned in car beds and car safety seats seem to have similar rates of apnea, bradycardia and OD regardless of their position in a car seat or car bed. The AAP (2009) recommends the use of car beds but also notes major limitations to safety. Adding to this evidence, Kornhauser Cerar and colleagues (2009) investigated the difference in respiratory patterns in healthy term infants when placed in car beds, car seats and cribs and discovered significant desaturations occurred when infants were placed in both car beds and car seats, as compared with hospital cribs. As a

result, it was recommended that car beds and car seats should only be used for protection during travel and not as a replacement for a crib (Kornhauser Cerar et al, 2009).

Joffe and Hall (2006) investigated the legal implications for centers facing difficulty deciding on patient safety at discharge. In the UK, health care providers owe a duty of care to the infant by law. If the infant cannot be safely discharged without a suitable car bed or car seat, then the baby should not be discharged. The reasoning was that most parents will accept professional advice and would not seek discharge if it were unsafe to do so. If parents insist on unsafe discharge, the need for a referral to Social Services may arise (Joffe & Hall, 2006). This might leave some hospitals in a tough spot if a family cannot afford a car bed or one is not available for purchase and the infant has failed the infant car seat challenge test. Controversial evidence exists to support the practice of car seat challenges and the relative effectiveness of car beds. Car beds are an alternative to car seats for preterm infants at risk of cardio-respiratory instability in car seats yet their relative safety remains unknown and they remain difficult to obtain.

### **C) Innovative Solutions for Infant Car Seat Safety: Car Seat Insert.**

The long-term effects of episodes of oxygen desaturation in the preterm infant population remain unknown; however, Tonkin et al (2003) has shown dramatic results in avoiding the risk of apparently life threatening events for these infants by modifying car seats so that head flexion is unlikely. One study was conducted to observe infants in car seats for episodes of extreme flexion at the neck, leading to upper airway occlusion and increasing the risk of oxygen desaturations (Tonkin et al., 2003). It was reported that placing a simple insert in the infant car seat reduced neck flexion and decreased the incidence of OD. This evidence may indicate a

better alternative to the infant car seat challenge in reducing cardio-respiratory events in car seats. Tonkin and associates (2003) go into great detail to justify this approach:

Research has shown that the infant upper airway anatomy is very different from that of the adult. The infant has a straight spine and a large head, the occiput of which protrudes back beyond the spinal line. The infant mandible is almost horizontal with an unstable temporomandibular joint. The mouth is filled by the tongue, with no teeth to keep the jaws apart and the infant's neck is very short. Consequently when the back of the shoulders and occiput are forced into line, the head must flex forward on the neck and in most very small infants, the chin is pressed onto the chest. This in turn forces the unstable mandible upward and/or backward to carry the tongue onto the soft palate, narrowing the upper air space. (Tonkin et al., 2003, p. 910).

They discovered that that the upper airways of some infants were almost completely occluded in the car seat without the use of the insert (Tonkin et al., 2003). The results from this intervention showed a reduction in the frequency of arousals that occurred before or during episodes of obstructive breathing, from 58% without the insert, to 18% with the insert in place (Tonkin et al., 2003). These results suggest that more frequent arousals may also provide some benefit for infants responding to cardio-respiratory events. This study strongly supports the fact that the influence OD episodes are multi-factorial; airway size and head position are only two aspects of a larger issue for preterm infant car seat safety (Tonkin et al., 2003).

Current practice in the NICU involves consideration of the recommendations given to parents of infants who do not pass the ICSC including the addition of blanket rolls or inserts to provide sufficient postural support for the infant to pass the test. But few of these interventions have been tested for safety and effectiveness. While Tonkin and associates (2003) created a product which shows promising signs of improvement to infant car seat safety, the device has yet to be crash tested for safety and certification. Based on the evidence, the insert to maintain head and neck support appears to be an alternative worth researching in the future. In the meantime, parents should be taught about the risk of head and neck flexion and shown ways to reposition

their infant to prevent upper airway occlusion during vehicle travel.

### **Car Seat “Orientation”.**

Alternatively, Bass and Mehta (1995) conducted a study on term and preterm infants to determine their risk in car seats. They recommended an alternative approach to the infant car seat challenge, where health care providers would offer a car seat ‘orientation’ instead of a car seat ‘challenge’. Bass and Mehta (1995) made this recommendation because they believed that not all infants at risk could be identified. However to date the car seat challenge remains a recommendation by the American Academy of Pediatrics and remains the standard for nursing care regarding car seat safety in the NICU. . The American Academy of Pediatrics is a respected and trusted information source for parents and health care practitioners. The Canadian Pediatric Society and Transport Canada often reference the AAP in their own recommendations and rely on the AAP to provide accurate and relevant safety information to be shared as resources for parents and health care community. Therefore, the AAP should take responsibility for this position of power and influence they hold concerning preterm infant car seat safety and should revise their current policies in order to keep infants safe in vehicles.

In conclusion, preterm infants are at risk for cardio-respiratory compromise in infant car seats for a variety of reasons including physiology, development, small size and small weight, which may contribute to upper airway occlusion in infant car seats. Term infants have shown similar risks to preterm infants while positioned in infant car seats, indicating that car seats are not meeting the safety needs of their target population. Overall, preterm infants are not at an increased risk of sudden infant death syndrome while seated in infant car seats. The long-term significance of OD and neuro-developmental impairments remain unknown. Initiatives such as

the car seat challenge remain ambiguous in directives and validity; therefore, these are not reliable recommendations for preterm infants.

Car beds are not considered an easy or safe alternative for preterm infants despite recommendations from Transport Canada and should therefore be recommended with great caution. Finally, convincing evidence exists regarding the use of inserts in car seats to prevent head and neck flexion and OD, but limited research has been conducted on this topic and therefore will require further exploration to ensure the safety of preterm infants in vehicles. In the meantime, education for nurses and parents needs to be considered within the limitations of the current evidence in mind.

## **IMPLICATIONS FOR NURSING PRACTICE, EDUCATION AND RESEARCH**

Based on findings from the literature and the best available evidence, a number of innovative recommendations for car seat safety and preterm infants have been identified. The recommendations outlined in the next section are offered to guide nursing practice in the NICU and to provide parents with relevant information regarding car seat safety. Included is a list of recommendations and resources for those nurseries interested in updating their car seat safety policies and practices (Appendix E and F). See Appendix D for a sample 'Parent Information Sheet' to support development of parental education resources.

### **Nursing Practice: Recommendations for Nurses**

- **OBSERVATION:** Every infant, <37 weeks gestation, should be observed in a car seat prior to discharge (AAP, 2009). The nurse can encourage parents to take part in the car seat education

session by first allowing parents to practice securing their infant in the car seat as best as they can. The nurse could observe the process for proper fit and positioning techniques (Appendix D) and offer additional support and education as needed.

- **ORIENTATION:** The practice of infant car seat challenges remains unfounded and ambiguous based on the AAP guidelines and evidence in the literature. Until more clear directives for the ICSC are developed, a ‘Car Seat Orientation’ could be implemented in the NICU as an alternative to the 90 minute ICSC. The ‘Car Seat Orientation’ would offer parents and nurses, the opportunity to work together on the issue of car seat safety in the NICU (Greenburg, 2007). Nurses could teach parents what is known about preterm infant car seat safety based on the best available evidence, placing less emphasis on labeling infants with a ‘pass or ‘fail’. Directives for a “Car Seat Orientation’ could refer to the current AAP (2009) recommendations regarding positioning the infant in the car seat, including strap placement, use of rolls for support and education to share with parents about car seat safety (AAP, 2009; Transport Canada, 2008). Also the nurse could encourage parents to refer to manufacturer’s instructions concerning appropriate size and weight for their specific car seat (See Appendix D for a list of recommendations and resources to be shared with parents).
  
- **RESOURCES:** The AAP (2009) document entitled “ Safe Transportation of preterm and Low Birth Weight Infants at Hospital Discharge”, offers reliable information about fit and positioning but the recommendations concerning ICSC require revisions in order to be considered for implementation in the clinical setting (See Appendix D for a list of recommendations and resources to be shared with parents).

*Car Bed Quick Tips:*

- Car beds are designed for very small (<2.2 kg or 5 lbs) or premature infants (<37 weeks gestational age) who are at risk for cardio-respiratory compromise when seated in infant car seats or for infants with other conditions who must travel lying down (casts, musculoskeletal or bone abnormalities, etc.) (AAP, 2009; Transport Canada, 2008).
- FIT: The harnesses should fit snugly and no padding should be placed between the infant and the car bed or the infant and the harness system and no padding should be placed on top of the infant's head (Transport Canada, 2008).
- A rear-facing car safety seat offers better protection than a car bed in the event of a collision (AAP, 2009; Transport Canada, 2008). A better alternative might be to have an adult seated in the back seat during travel to observe the infants positioning and to adjust the head and neck position as needed during travel, rather than using a car bed.
- Car beds may only be obtained with a prescription from a physician or occupational therapist. The Cosco's Dream Ride is the only certified car bed available in Canada and is only available directly from the manufacturer (Transport Canada, 2008).

DISCONTINUING USE of CAR BED: The discharging physician should consider following-up with the patient's family doctor to determine when the infant can travel safely in an infant car seat for the individual weight, size and developmental issues of concern.

(The AAP (2009) notes that this information may need to be revised as new evidence becomes available with future research).

### **Nursing Education: Recommendations for NICU Policy and Practice**

1. Nurse leaders should be accountable for the safety needs of preterm infants and develop policies to support nursing staff in knowledge uptake and in providing access to appropriate resources for parental education. The American Academy of Pediatrics (2009) guidelines are a

good starting point for nurseries interested in offering resources for evidence informed nursing practice regarding preterm infant car seat safety. However, there are many unknowns about infant car seat safety for preterm infants including the efficacy of the car seat challenge. Stein (2004) recommends that until validated protocols and evidence-based data are available regarding car seat safety initiatives in the NICU, nursing practice should focus on the best available evidence and undergo critical analysis before being incorporated into practice (See Appendix F).

2. Nurses should be trained and informed about car seat safety in the NICU. Currently, most nurseries rely on nursing staff to conduct car seat safety initiatives and education at discharge. However, due to the inconsistencies found in the literature, many centers do not have evidence informed nursing resources available to support staff. As a result, practice in this area remains widely varied and inconsistent. See Appendix E for a sample of topics nursing leaders should offer registered nurses who are responsible for car seat safety in the NICU and see Appendix F for a sample of tips to share with parents.

3. Advanced practice nurses may choose to seek out and create a partnership with the public health unit in their region to identify resources already in use and to share the resources being offered in the NICU in an effort to keep these safety messages consistent in the clinical setting as well as in the community.

### **Nursing Research: Recommendations for Future Research**

A thorough review of the literature regarding preterm infant car seat safety in the NICU revealed a number of areas for future nursing research.

- ❖ Investigate the unique transportation needs of infants with hydrocephalus, cardiac anomalies, chronic lung disease and bone deformities as well as developing resources to share with parents would be helpful in the clinical setting for teaching parents and keeping infants with special needs safe in vehicles.
- ❖ Investigate the long-term effects of oxygen desaturations in the preterm infant population to determine if cardio-respiratory events pose a neuro-developmental risk to this population and how this relates to cardio-respiratory compromise in car seats.
- ❖ Invest more funding and research into discovering ways of supporting upper airway patency in car seats, which could eliminate the need for car seat challenge at discharge.
- ❖ Research to investigate where parents learn and how they retain health and safety information would be helpful in providing updated safety information for parents of preterm infants.
- ❖ Provide educational sessions for NICU staff according to the principles of the PARIHS framework and then evaluate the impact of introducing the educational program.
- ❖ Further to this, investigate where NICUs gather resources and information about car seat safety and what information they are currently sharing with parents could help in providing relevant information to parents in the places they are already seeking information

**THE PARIHS FRAMEWORK: A GUIDE FOR ADVANCED PRACTICE  
NURSING AND EVIDENCE INFORMED NURSING PRACTICE**

## **Identifying Evidence and Gaps in Literature and Practice**

Amidst the evolving culture of evidence informed nursing practice and the drive to provide the best patient care possible, the PARIHS framework emerges as a refreshing, thoughtful approach to knowledge translation. The only way to truly apply the PARIHS framework as it was intended, is to conduct a thorough assessment of the context and culture of the health care setting and apply the best evidence available to facilitate change in practice. In this next section, suggestions have been offered to guide advanced practice nurses with tips and strategies for applying the PARIHS framework to the clinical setting to enhance patient care and support evidence informed nursing practice.

The role of advanced practice nurses (APN) in implementing practice change and evidence informed nursing involves a number of steps. First, issues in practice must be identified and evidence must be reviewed by seeking out professional knowledge and patient experiences, combined with evidence in the literature to target gaps in practice. Next, the context and culture where the change is to occur must be assessed and understood in order to support successful implementation. Finally, the roles and skills of the nursing leaders involved must be supportive of change and make the users feel valued in order for the implementation of change to be successful.

A large part of implementing change in practice is attributed to the assessment phase, which begins with identifying a need in practice and/ or a gap in evidence. The APN must begin by identifying a need and follow up with a critical analysis of available literature. Needs in the clinical setting may be identified through discussions or feedback from nursing staff.

Next, evidence must be gathered to explore the issues identified in the needs assessment. The PARIHS framework recognizes that different forms of evidence are needed to answer different clinical questions (Rycroft-Malone, Seers, et al., 2002). In order to achieve successful practice change the PARIHS framework recommends APNs draw on well conceived, rigorous research to aid decision

making while also recognizing the valuable contributions to practice development and change recognizing that clinical experience, professional knowledge and patient experience offer valuable evidence. The merit of professional knowledge remains a debated topic, but Rycroft-Malone, Kitson and colleagues (2002) argue “incalculable value” is added by incorporating professional knowledge to support efforts towards knowledge uptake. Reflective practice is one method of exploring the practical impact of empirical research on the dynamic clinical setting and one avenue for exploring important aspects of implementation (Rycroft-Malone, 2004).

Before implementation is considered, evidence from the patient experience should also be incorporated into the evidence appraisal phase. In the example of preterm car seat safety, research has shown that car seats can save the lives of these tiny infants in the event of a vehicle collision. However the patient experience says that infants experience an increase in frequency of cardio-respiratory events while seated in infant car seats. Parents have shared that having a baby turn blue due to oxygen desaturation, even briefly, can be a frightening experience for new parents who need to also be taught how to respond to these situations. Gathering feedback from parents, or the affected patient population can be collected with patient feedback cards, discussions in the unit itself, or by applying family centered care concepts to patient care delivery systems.

Rycroft-Malone, Kitson and associates (2002) recognize that patient preferences should be part of the decision making process, however it is still unclear how to best incorporate this human based data (i.e. narrative or personal experience). Regardless, Rycroft-Malone, Kitson and colleagues (2002) argue that this evidence should be seen as a valid source of data. Further concept analysis on this topic is necessary in order to gain a greater appreciation for validating the worth of patient experience into the critical appraisal and knowledge translation process.

Next, critiquing the available literature and resources is necessary to clarify the nursing practice issues and to identify gaps in research and practice. Sometimes this step reveals unknown resources which could then be critically appraised and incorporated into practice to further enhance EBN practice. Conducting literature searches in nursing databases such as CINAHL, or meeting with a librarian for support in conducting literature searches is a great place to start gathering research evidence. Searching the World Wide Web aimlessly could be misleading; however, sometimes with directed searches, resources may be discovered that would have otherwise been missed. Expanding the search beyond the scope of the nursing profession is important to gather differing perspectives and varieties of resources. The evidence should be evaluated for merit and worth (please see “Evidence Informed Nursing: A Guide for Clinical Nurses” by McSherry, Simmons and Abbott, 2002) as a reference to conduct a literature search. Based on the findings in the literature, the goal of knowledge translation is to move research into action; therefore, the next major step to ensure successful implementation and practice change is to assess the context and overall readiness for change within the clinical setting and to apply leadership principles to support ease of knowledge uptake strategies into practice.

### **Creating a Context Conducive to Successful Implementation Through Culture, Leadership and Evaluation**

Successful implementation, according to the PARIHS framework, is a function of the relationship among the nature of evidence, the context in which the proposed change is to be implemented and the mechanisms by which the change is facilitated (Kitson et al., 1998). Each of these components should be considered simultaneously and away from hierarchy or a linear approach (Kitson et al., 1998). Health care practice occurs in a wide variety of contexts and settings which are influenced

by economic, social, political, historical, and psychosocial factors (Rycroft-Malone, Seers, et al., 2004). Context refers to the setting in which evidence is implemented and greatly influences the power of successful implementation. However, the term itself does little to reflect the complexity of the concept (McCormack et al., 2002). In the PARIHS framework, the term context is used to refer to the environment or setting in which people receive healthcare services, or the environment or setting in which the proposed change is to be implemented (Rycroft-Malone, Seers, et al., 2004).

The PARIHS framework proposes that the characteristics of a context are key to ensuring a more conducive environment to moving evidence into practice (Kitson et al., 1998). Characteristics of a strong context include environments where there is clarity of roles, decentralized decision making, valuing of staff, transformational leaders and a reliance on multiple sources of information to evaluate performance, thus making the chances of successful implementation more likely (Rycroft- Malone, Harvey, et al., 2004). According to McCormack and colleagues (2002), the concept of context has only been partially developed and will need more extensive comparison and refinement in the future in order to enhance knowledge translation in the health care. Bate (1994) as referenced in Rycroft- Malone, Kitson, et al. (2002), suggests that the best way to bring about cultural change is to understand the prevailing values and beliefs of nurses in a given context.

As an APN, assessing the context may involve gathering feedback from the nursing staff through surveys or from spending time in observation, interacting in the clinical setting and sharing in discussions with the nurses. Gathering information about the values of the unit might be obtain by asking questions such as, “How do you feel about change in the clinical setting?” or “Do you feel a sense that your clinical expertise is valued in this clinical setting?” The key to assessing the context is to identify the “ways that things are done” in that unit or culture, in order

to understand how new information or practice changes might be received in this setting. An initial concept analysis of “context” was conducted by the authors of the PARIHS framework, which discovered themes of culture, leadership and evaluation measurement (McCormack et al., 2002). In the next section, these concepts have been explored and intend to provide contextual considerations for nursing leaders who are planning practice change initiatives.

### **Culture.**

Cultures manifest themselves through the values, beliefs and assumptions rooted in institutions and organizations (McCormack et al., 2002). McCormack and colleagues (2002) expanded upon Bates’ (1994) definition of culture explaining that culture is a paradigm, a way of thinking about or viewing an organization based on assumptions, values, artifacts and creations. Cultural change is therefore more successful when the ways of thinking are fundamentally transformed; however, change may be limited if clashes of culture within an organization lead to difficult working relationships (McCormack et al., 2002). For example, in order to incorporate the evidence discovered from critiquing the literature into the clinical setting, nurse leaders will need to consider the unique clinical setting because each setting is guaranteed to have different cultures, values and contexts to consider prior to implementation of change.

Influencing the dominant ‘culture’ of an environment may be the most effective method for affecting practice changes. The characteristics of context and culture as described by McCormack and associates (2002), fall along a continuum from weak to strong, where a weak culture of change may have a lack of transparency in decision making process, lack of power and authority, lack of resources and is not receptive to change. Nurses may be more receptive to change in a context with clearly defined boundaries (physical, social, cultural, structural), transparent decision making processes, power and authority understood (McCormack et al., 2002).

Nurse leaders should consider, the values and beliefs of the particular NICU in question and take

the culture of the NICU into consideration before proceeding with proposed practice changes. APNs might reflect on the following questions: What are the values and beliefs of this unit? What is the understanding of authority and power in this unit? Who makes decisions? Is there an openness to change? The answers to these questions will be useful to the leadership aspect of practice change and knowledge translation.

### **Leadership.**

Leaders have a key role to play in transforming and influencing cultures toward a context that is ready for change (McCormack et al., 2002). McCormack et al. (2002) suggests that workers are more likely to participate in an organization when they feel valued and have choices. Transformational leaders see knowledge translation as an opportunity to support a context where nursing skills and knowledge are valued and nurses are given choices. Creating a context in the NICU that is supportive of change means transformational leaders need to encourage respect between team members and disciplines and involve nurses in decisions, especially when the outcomes will affect them directly. Advanced practice nurses may choose to create a feedback board in the staff break room where notes of encouragement between staff could be left for coworkers on a job well done, or create a suggestion box for anonymous feedback on changes that are occurring in their unit. Transformational leaders inspire staff toward a common goal by building trust and communications, leaning on emotional intelligence, empathy, motivational skills and self-confidence (McCormack et al., 2002). The APN as a transformational leader must lead by example, encouraging open communication in a nonjudgmental way to build trust and confidence in the staff, letting them know they are valued and that their feedback will contribute positively to the practice change process.

Rycroft-Malone, Harvey, et al. (2004) points out that cultures which are more conducive to facilitating change are attributed to creating a learning culture that pays attention to individuals, group

processes, and organizational systems. Nurse leaders can promote a learning culture through powerful communication skills, listening to concerns of those directly affected by practice change and acting as a mediator by pushing the issues back to the group to problem solve together. Rycroft-Malone, Harvey, et al. (2004) describes the influence of culture on knowledge translation as being characterized by decentralized decision-making, an emphasis on the relationship between leader and staff and a leadership style that is facilitative rather than authoritative. McCormack and colleagues (2002) describe the influence of the transformational leaders as a power that can bring the ‘science’ component of nursing practice together with the ‘art’ component of nursing practice, into a caring action. The leadership aspect of context can be greatly affected by the respect present between the facilitator and the staff and therefore a leadership style that is directive rather than facilitative can be a barrier to knowledge translation. In order to feel valued and important to the change process workers must be provided with feedback through evaluative processes. The next section will explore ways of providing evaluative aspects to knowledge translation initiatives.

### **Evaluation.**

Measurement is a complex but necessary aspect of context, which affects change by generating feedback based on an evaluation of performance to demonstrate whether or not changes to practice are appropriate, effective or efficient (McCormack et al., 2002). Using multiple sources of information to evaluate performance is important to gain a clear illustration of the context and to identify areas in need of change (McCormack et al., 2002). Feedback regarding performance is important at the individual, team and system level to promote a strong context for change.

As an APN, contextual factors to consider when evaluating at the individual level include the impact of practice change for nurses working in the unit. This may involve gathering feedback prior to, during and following any practice change initiatives. Furthermore, in order to measure the success of the

implementation, this feedback can then be used to diminish barriers to change and to ease the transition during the change process. For example, a “learning passport” might be designed to track the staff’s progress in adopting practice changes and serve as a means for motivating the staff to achieve all areas of the practice change. Another way to evaluate the context is by giving consideration to the impact on the multidisciplinary health care team and involving all team members in the change by delegation of roles and responsibilities and creating a context where everyone involved has a role, purpose and responsibility in the change process. Giving consideration to the system level might mean policy revisions and resource creation for the health care team to support change. With respect to car seat safety, not only should the nurses be involved in the decision making process by offering practical feedback and suggestions for improvement but this feedback should be incorporated into the resources developed for nurses, to be accessed as needed. Each of these considerations to the themes of context contributes to the ease of facilitation and successful implementation of knowledge uptake and practice change. The next section explores the role of the facilitator and leader in promoting practice change.

### **Facilitation Toward Successful Implementation Through Purpose, Role, Skills and Attributes**

Nurse leaders as facilitators have a key role in guiding individuals and teams toward openness to change and assist in applying evidence to practice. Kitson et al. (1998) explains that facilitation is a technique by which one person makes things easier for others. The role of the facilitator in the PARiHS framework is a uniquely identified role, which may be either internal or external to the organization and is concerned more with helping and enabling rather than delegating and persuading (Rycroft-Malone et al., 2002). The purpose of strong facilitation may range from a task-oriented change to addressing the situation from a holistic perspective.

The role of the facilitator is largely concerned with providing practical help and support and is more than just supportive. It is also focused on enabling by seeking and exploring inherent potential in individuals and the entire team (Harvey et al., 2002). Skills of a facilitator include a broad range of leadership and motivational skills and strong emotional intelligence (Rycroft-Malone, Harvey, et al., 2002). The research development team of innovative thinkers who created the PARIHS framework, conducted a concept analysis in 2002 to clarify the importance of facilitation in this framework. As a result limited concrete evidence was discovered to support the importance of the different skills needed for successful performance of the facilitator role (Harvey et al., 2002). However, facilitation may be interpreted as multifaceted utilizing a range of interventions such as audit and feedback, education, support, advice and team building. In the NICU, the enhancement of the skills of the facilitators will ease the process of knowledge translation and offer a more successful implementation of practice change.

## **SUMMARY AND REFLECTIONS ON THE PARIHS FRAMEWORK**

Reflecting on the PARIHS framework and its dynamic purposes and functions, I am encouraged by the opportunities this framework offers nursing leaders and the future of knowledge translation. With a greater focus on holistic nursing leadership, the PARIHS framework incorporates evidence from multiple sources and contexts and encourages multidisciplinary approaches to patient care. I am encouraged to think that advanced practice nurses who becomes familiar with this framework will hold the power to influence patient care by seeking out the best available evidence, take a unique interest in the context where the change is to occur and will be equipped to support health care teams through innovative leadership and facilitation strategies.

I think that by reviewing evidence guided by the PARIHS model I have gained a greater appreciation for the merit of using a wide variety of sources to support nursing practice. For the first time, I was able to recognize that ‘evidence’ means much more than reading a series of randomized control trials to make a case for ‘best-practice’. Instead, I discovered that some of the most rich and relevant evidence came from speaking with fellow nurses in the NICU (professional knowledge), from reviewing coroners’ reports, from comparing commentaries on car seat safety (commentaries), and from considering the health issue from the patient perspective (discussions with parents of preterm infants). The strengths of the PARIHS framework (evidence, context and facilitation) offer a strong structure for this framework to evolve from and to encourage a new wave of effective knowledge translation initiatives.

The greatest learning experience gained from conducting this project was the understanding and appreciation of the influence of context in practice. As a nursing leader, giving consideration to context is the single most effective way to gain insight into the culture of a unit and using that understanding to motivate and encourage others is one of the toughest tasks of a leader, but if achieved could be the most effective in influencing practice change.

I have experienced growth in my understanding of leadership and facilitation skills after exploring the PARiHS framework. I have gained new insight into ways of motivating people, and making people feel valued and important in the clinical team setting. The leadership skills awakened by the PARiHS framework have inspired me to apply these skills into daily advanced practice nursing and hopefully inspire others to offer the best patient care possible, knowing that our contributions are important, noticed and appreciated. I look forward to the adventures that lie ahead and to the power of influencing the best patient outcomes possible.

## **CONCLUSION**

In conclusion, due to advances in technology and health care, preterm infants are being sent home from hospital at smaller weights and gestational ages (Bass & Mehta, 1995; Bass, 2010; Merchant et al., 2001). Several nursing practices have been implemented in the NICU to address safety concerns for vehicle travel; however, research shows that while preterm infants are at a relatively greater risk for cardio-respiratory compromise when seated in infant car seats, term infants are also at risk in car seats and risks of cardio-respiratory compromise are similar between car beds and car seats for both preterm and full term infants (Bass & Bull, 1995; Bass & Bull, 2001; DeGrazia, 2007; Elder et al., 2002; Kornhauser Cesar et al., 2009; Murphy &

Bridgman-Acker, 2008; Nagase et al., 2002; Ojadi et al., 2005; Smith & Turner, 1990; Young, Shapira & Finer, 1996).

Causes of cardio-respiratory compromise in preterm infants has been explored in detail and remains a multi-factorial issue. Cardio-respiratory compromise in preterm infants has been linked to physiology (large occiput, weak head and neck muscles), development (periodic breathing, apnea of prematurity), and/or upper airway occlusion due to poor fit in the semi-reclined position which is typical in car seats. More research and education to support preterm infant upper airway stability during vehicle travel is needed in order to find safe solutions for reducing the incidence of cardio-respiratory events and safety in vehicles.

The long-term significance of cardio-respiratory events remains unknown. Normal newborn development involves frequent oxygen desaturation in the late preterm phase of development (34-37 weeks) and may continue beyond this time frame as well. Linkages to neuro-developmental delays and oxygen desaturation remain largely unfounded and no relationship between SIDS and oxygen desaturation in infancy have been identified. More research and education is needed in this area to confirm the long-term effects of cardio-respiratory compromise.

In response to the risk factors outlined in this paper, the practice of assessing infant car seat challenges were developed by the American Academy of Pediatrics (1990), recommending that all infants <37 weeks gestation be observed in a car seat prior to discharge. This practice however, remains highly inconsistent across Canada and the US due to the lack of directives regarding who should be tested, length of testing, criteria for 'pass' or 'fail' and provisions in the case of a 'failure'. The AAP (2009) continues to recommend this practice despite the lack of

evidence to support its use. Until more explicit directives are put forward and more concrete evidence exists, ICSC remains an unfounded practice, leading to continued variation in practice. Car seat orientations in the NICU may be a more reasonable practice and could be promoted as a family centered alternative. The AAP should be encouraged to revisit its guidelines and offer recommendations that are grounded in current evidence. It is important for this organization to more fully appreciate the power they have in influencing infant health and current practice in the NICU.

The use of car beds for infants who experience documented apnea, oxygen desaturation, or bradycardia or who weigh <2500g at discharge, offers an alternative to transportation in rear-facing car seats (Bull & Bass, 2001). However, car beds are expensive and not easily accessible and are not proven to be safer in the event of a vehicle collision. Further research is needed in the area of car seat and car bed manufacturing and design if this is to be offered as an alternative for safe transportation of preterm infants.

While not all safety concerns of preterm infants are known at this time, it is certain that the use of car safety seats is essential for prevention of injuries in motor vehicle crashes (Rice & Anderson, 2009). Therefore, car seat safety education remains an important education topic for parents of preterm infants. Research regarding car seat inserts to support the baby's head and neck flexion shows promising results so far for decreasing episodes of oxygen desaturation and further research is warranted (Tonkin et al., 2003). Until additional research is available regarding the potential significance of oxygen desaturation in car safety seats, consideration should be given to limiting the time newborns spend in car seats to that necessary for transportation (preferably <60 minutes) and ensuring that children are not left unattended in infant car seats (Bull & Bass, 2001).

Evidenced-informed nursing strategies offer insight into the advancement of nursing practice by moving research into action. The PARiHS framework for knowledge translation is a strong theory for supporting knowledge translation, creating a health care context that is receptive to change and evidence informed nursing practice, and recognizes the need for skilled nursing leaders dedicated to improving nursing care and better patient outcomes.

## REFERENCES

- American Academy of Pediatrics. (1990). Safe transportation of newborns discharged from the hospital. *Pediatrics*, 86, 86-487.
- American Academy of Pediatrics. (1991). Safe transportation of premature infants. *Pediatrics*, 87, 20-122.
- American Academy of Pediatrics. (1996). Safe transportation of premature and low birth weight infants. *Pediatrics*, 97(5), 758-760.
- American Academy of Pediatrics. (1999). Safe transportation of newborns at hospital discharge. *Pediatrics*, 104, 986-987.
- American Academy of Pediatrics. (2009). Safe transportation of preterm and low birth weight infants at hospital discharge. *Pediatrics*, 123, 1424-1429.
- Bass, J.L. (2010). The infant car seat challenge: determining and managing an “abnormal” result. *Pediatrics*, 125, 597-598.
- Bass, J.L., & Bull, M. (2001). Oxygen desaturation in term infants in car safety seats [commentary]. *Pediatrics*, 110, 401-402.
- Bass, J.L., Mehta, K.A. & Camara, J. (1993). Monitoring premature infants in car seats: implementing the American Academy of Pediatrics policy in a community hospital. *Pediatrics*, 91(6), 1137-1141.
- Bass, J.L. & Mehta, K.A. (1995). Oxygen desaturation of selected term infants in car seats. *Pediatrics*, 96(2), 288-290.

- Boase, P., Jonah, B.A. & Dawson, N. (2004). Occupant restraint use in Canada. *Journal of Safety Research*, 35, 223-229.
- Bradshaw, W.G. (2010). Importance of nursing leadership in advancing evidence-based nursing practice. *Neonatal Network*, 29(2), 117-122.
- Bull, M.J. & Stroup, K.B. (1985). Premature infants in car seats. *Pediatrics*, 75, 336–339.
- Bull, M.J, Weber, K. & Stroup, K.B. (1988). Automotive restraint systems for premature infants. *The Journal of Pediatrics*, 112(3), 385-388.
- Bull, M., Agran, P., Laraque D, et al. (1999). Transporting children with special health care needs. *Pediatrics*, 104, 988-92.
- Canadian Institute for Health Information. (2009). Too early, too small: a profile of small babies across Canada. Retrieved from [http://www.cihi.ca/cihiweb/dispPage.jsp?cw\\_page=PG\\_1791\\_E&cw\\_topic=1791&cw\\_rel=AR\\_1106\\_E](http://www.cihi.ca/cihiweb/dispPage.jsp?cw_page=PG_1791_E&cw_topic=1791&cw_rel=AR_1106_E)
- Canadian Pediatric Society. (2000). Assessment of babies in car seats before discharge. *Pediatric Child Health*, 5(1), 53-56.
- Cote, A., Bairam, A., Deschenes, M., & Hatzakis, G. (2008). Sudden infant deaths in sitting devices. *Archives of Disease in Childhood*. 93, 384-389.
- Dollberg, S., Yacov, G., Mimouni, F. & Ashbel, G. (2002). Effect of head support on oxygen saturation in preterm infants restrained in a car seat. *American Journal of Perinatology*, 19(2), 115-118.
- DeGrazia, M. (2007). Stability of the infant car seat challenge and risk factors for oxygen desaturation events. *Journal of Obstetric, Gynecologic, Neonatal Nursing*, 36, 300-307.

- DeGrazia, M., Guo, C.Y., Wilkinson, A.A. & Rhein, L. (2010). Weight and age as predictors for passing the infant car seat challenge. *Pediatrics*, 125, 526-531.
- Elder, D.E., Russell, L., Sheppard, D., Purdie, G.L. & Campbell, A.J. (2007). Car seat test for preterm infants: comparison with polysomnography. *Archives of Disease in Children, Fetal and Neonatal Edition*, 92, f468-472.
- Estabrooks, C.A., Thompson, D.S., Lovely, J.E. & Hofmeyer, A. (2006). A guide to knowledge translation theory. *The Journal of Continuing Education in the Health Professions*, 26, 25-26.
- Graham, I. D., J. Logan, M. B. Harrison, et al. (2006). Lost in knowledge translation: Time for a map? *Journal of Continuing Education in the Health Professions*, 26(1), 13-24.
- Greenburg, J. (2007). The challenge of car safety seats. *Journal of Pediatrics*, 150, 215-216.
- Harvey, G., Loftus-Hills, A., Rycroft-Malone, J., Titchen, A., Kitson, A., McCormack, B. & Seers, K. (2002). Getting evidence into practice: the role and function of facilitation. *Journal of Advanced Nursing*, 37(6), 577-588.
- Hertz, G., Aggarwal, R., Rosenfeld, W.N. & Greensher, J. (1994). Premature infants in car seats: effect of sleep state on breathing. *Journal of Sleep Research*, 3, 186-190.
- Holmes, D., Perron, A. & O'Byrne, P. (2006). Evidence, virulence, and the disappearance of nursing knowledge: a critique of the evidence-based dogma. *Worldviews on Evidence-Based Nursing*, 3(3), 95-102.
- Hodgman, J. E. (1998). Apnea of prematurity and risk for SIDS [commentary]. *Pediatrics*, 10(4), 969-971.

- Joffe, N. & Hall, J. (2006). Limiting the risks of apnea and bradycardia in low birth weight infants using car seats. *Journal of Neonatal Nursing*, 12, 91-96.
- Johnston, C., Rivara, F. & Soderberg, R. (1994). Children in Car Crashes: Analysis of Data for Injury and Use of Restraints. *Pediatrics*, 93(6), 960-965.
- Kinane, T.B., Murphy, J., Bass, J.L. & Corwin, M.J. (2006). Comparison of respiratory physiologic features when infants are placed in car safety seats or car beds. *Pediatrics*, 118, 522-527.
- Kitson, A., Harvey, G. & McCormack, B. (1998). Enabling the implementation of evidence based practice: a conceptual framework. *Quality in Health Care*, 7(3), 149-158.
- Kitson, A., Rycroft-Malone, J., Harvey, G., McCormack, B., Seers, K. & Titchen, A. (2008). Evaluating the successful implementation of evidence into practice using the PARIHS framework: Theoretical and practical challenges. *Implementation Science*, 3(1), 1-12.
- Kornhauser Cerar, L., Scirica, C.V., Stucin Gantar, I., Osredkar, D., Neubauer, D., & Kinane, T.B. (2009). A comparison of respiratory patterns in healthy term infants placed in car safety seats and beds. *Pediatrics*, 124(3), 396-402.
- Long, A (2002). Chapter 3: Critically appraising research studies. As referenced in McSherry, R., Simmons, M. & Abbott, P. (2002). *Evidence Informed Nursing: A Guide for Clinical Nurses* (pp. 41-64). TJ International Ltd. Padstow: Cornwall.
- Martin, R.J. & Fandaroff, A.A (1998). Neonatal apnea, bradycardia, or desaturation: does it matter? *Journal of Pediatrics*, 132(5), 758-759.
- McCormack, B., Kitson, A., Harvey, G., Rycroft-Malone, J., Titchen, A. & Seers, K. (2002). Getting evidence into practice: the meaning of context. *Journal of Advanced Nursing*,

38(1), 94-104.

McMillan, D.D. (1996). How should premature infants be assessed for car seat safety before discharge? *Pediatric Child Health*, 1(3), 197-199.

McSherry, R., Simmons, M. & Abbott, P. (2002). *Evidence Informed Nursing: A Guide for Clinical Nurses*. TJ International Ltd. Padstow: Cornwall.

Merchant, M., Worwa, C., Porter, S., Coleman, J., and deRegnier, R. (2001). Respiratory instability of term and near-term healthy newborn infants in car safety seats. *Pediatrics*, 108(3), 647-652.

Moch, J. & Borja, A. (1993). Deadly child restraints: an analysis of the legislation and defects associated with child restrain devices. *Western State University Law Review*, 20, 527-546.

Mullen, D. & Coutts, J. (2002). The car seat challenge. *Journal of Neonatal Nursing*, 8(4), 129-131.

Murphy, A. & Bridgman-Acker, K. (2008). Sudden unexpected deaths in infancy occurring in car seats. Report of the Death Committee and Deaths Under Five Committee. Retrieved from <http://www.oacas.org>.

Nagase, H., Yonetani, M., Uetani, Y. & Nakamura, H. (2002). Effects of child seats on the cardio-respiratory function of newborns. *Pediatrics International*, 44, 60-63.

Ojadi, V., Petrova, A., Mehta, R. & Hegyi, T. (2005). Risk of cardio-respiratory abnormalities in preterm infants placed in car seats: a cross sectional study. *Pediatrics*, 5(28), 1-6.

Polit, D. T. & Beck, C.T. (2008). *Nursing research: Principles and methods (8<sup>th</sup> ed.)*. Philadelphia, PA: Lippincott Williams & Wilkins.

- Rice, T. & Anderson, C. (2009). The effectiveness of child restraint systems for children aged three years or younger during motor vehicle collisions: 1996 to 2005. *American Journal of Public Health, 99*(2), 252-257.
- Rycroft-Malone, J. (2004). The PARIHS framework – a framework for guiding the implementation of evidence-based practice. *Journal of Nursing Care Quality, 19*(4), 297-304.
- Rycroft-Malone, J., Harvey, G., Kitson, A., McCormack, B., Seers, K. & Titchen, A. (2002). Getting evidence into practice: ingredients for change. *Nursing Standard, 16*(37), 38-43.
- Rycroft-Malone, J., Kitson, A., Harvey, G., McCormack, B., Seers, K., Titchen, A. & Estabrooks, C. (2002). Ingredients for change: revisiting a conceptual framework. *Quality in Healthcare, 11*(2), 174-180.
- Rycroft-Malone, J., Harvey, G., Seers, K., Kitson, A., McCormack, B., & Titchen, A. (2004). An exploration of the factors that influence the implementation of evidence into practice. *Journal of Clinical Nursing, 13*, 913-924.
- Rycroft-Malone, J., Seers, K., Titchen, A., Harvey, G., Kitson, A. & McCormack, B. (2004). What counts as evidence in evidence-based practice? *Journal of Advanced Nursing, 47*(1), 81-90.
- Salhab, W., Khattak, A., Tyson, J., Crandell, S., Sumner, J., Goodman, B., Fisher, L. & Robinson, K. (2007). Car seat or car bed for very low birth weight infants at discharge home. *The Journal of Pediatrics, 150*, 224-228.
- Stein, N. (1994). Car-seat test. *Pediatrics, 113*, 1469.

- Smith, P.A. & Turner, B.S. (1990). Positioning premature infants in car seats. *Neonatal Network*, 9(4), 11-15.
- Tonkin, S.L., McIntosh, C., Hadden, W., Dakin, C., Rowley, S., and Gunn, A. (2003). Simple car seat insert to prevent upper airway narrowing in preterm infants: a pilot study. *Pediatrics*, 112, 907-913.
- Tonkin, S.L., Vogel, S.A., Bennet, L. & Gunn, A.J. (2006). Apparently life threatening events in infant car safety seats. *British Medical Journal*, 333,1205-1206.
- Transport Canada. (2008). Transporting infants and children with special needs in personal vehicles: a best practice guide for healthcare practitioners. Retrieved from <http://www.tc.gc.ca/roadsafety/tp/TP14772/menu.htm>
- Whittemore, R. (2005). Combining evidence in nursing research: methods and implications. *Nursing Research*, 54(1), 56–62.
- Whittemore, R. & Knafl, K. (2005). The integrative review: updated methodology. *Journal of Advanced Nursing*. 52(5), p. 546-553.
- Willett, L., Leuschen, P., Nelson, L.S. & Nelson, R.M. (1986). Risk of hypoventilation in premature infants in car seats. *Journal of Pediatrics*, 109, 245–248.
- Willett, L., Leuschen, P., Nelson, L.S. & Nelson, R.M. (1989). Ventilatory changes in convalescent infants positioned in car seats. *Journal of Pediatrics*, 15, 451-455.
- Williams, L. & Martin, J. (2003). Car seat challenges: where are we in implementation of these programs? *Journal of Perinatal and Neonatal Nursing*, 17(2), 158-163.
- Young, B., Shapira, S. & Finer, N.N. (1996). Predischarge car seat safety for premature infants. *Pediatric Child Health*, 1(3), 202-205.

## **APPENDICES**

Appendix A: Glossary of Terms

Appendix B: Reference Chart

Appendix C: Guideline Chart

Appendix D: Parental Guidelines

Appendix E: Curriculum Topics to Support Nursing Staff

Appendix F: Resources for Parents and Nurses

Appendix G: Criteria for Critical Appraisal of the Literature

## Appendix A: Glossary of Terms

*Evidence informed nursing (EIN)*: requires reflection on practice, awareness of research an ability to gather and critically review the evidence, implement the evidence into practice and evaluate the effectiveness of the change in practice.

*Full term infant*: infant born at >37 weeks gestational age.

*Infant car seat challenge (ICSC)*: a procedure developed by the American Academy of Pediatrics to assess preterm infant car seat safety prior to discharge from the NICU, involving observations of infants in car seats.

*Knowledge translation (KT)*: the application of research to practice to enhance patient care.

*Low birth weight infant*: infant weighing <2500g at birth, regardless of gestational age.

*Periodic breathing*: three or more pauses greater than three seconds, with less than 20 seconds of normal respiration between pauses (Hertz, Aggarwal, Rosenfeld, Greensher, 1994).

*Preterm infant*: infant born at <37 weeks gestational age.

*Significant cardio-respiratory event*: two or more episodes of oxygen desaturation (less than 88%) for 10 seconds or more during a 90 minute monitoring period (CPS, 2000).

## Appendix B: Reference Chart

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
I. Bull & Stroup, 1985 Premature Infants in Car Seats	n= ?, gestation= ?, Wt= 2 kg	Randomized control trial	An unknown number of infants weighing 2kg were placed in a variety of car seats and assessed for fit, measurements taken, difficulties with snug straps and appropriate fit documented, suggestions made.	Purpose of the paper is not clearly defined, variables not specifically outlined, limited detail, limited consideration to reliability and validity of results, physiological responses not tracked during fitting, it is unknown if the fit is conducive to physiological stability during travel, unknown number of infants assessed,	Study findings are organized and coherent, this findings are relevant to the preterm and term infant population, suggestions for nursing and health care practices suggested.	<b>Results:</b> car seats were identified as suitable for preterm infants based on snug fit, measurements. Until car seats are crash tested with smaller dummies (<7.7 kg) it is unknown how safe car seats are for preterm infants.	LOW Evidence	Teach parents to add rolls on either side of head in car seats, parent may choose to sit in the back seat with the infant. More crash tests should be done with smaller dummies to ensure safety of car seats. Car seat loan programs may be developed to meet the safety needs of preterm infants in car seats.

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
2. Willet, Leuschen, Nelson & Nelson, 1986 Risk of Hypoventilation in Premature Infants in Car Seats	n= 30, gestation = 12 preterm with history of apnea, 8 preterm no history of apnea, 10 term	Randomized control trial	Infants were placed in car seats and observed for physiological responses (bradycardia, apnea, oxygen desaturations)	Limited exploration of results, no conceptual or theoretical basis, ethics not mentioned, no plans for implementation into practice, limited conclusions	Purpose clearly outlined, exclusion criteria and methods outlined, variables accounted for and outlined clearly, methods were appropriate for the purpose of this study	<b>Results:</b> Both groups of premature infants had significant and frequent oxygen desaturations while in the car seat. Premature infants with a history of apnea had more bradycardia events. No term infant had any of these problems. In addition, oxygen saturation trended downward from baseline for all premature infants during the recovery interval.	LOW Evidence	Currently available car seats may place premature infants at risk for significant hypoxia and ventilatory compromise.

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
3. Bull, Weber & Stroup, 1988 Automotive Restraint Systems for Premature Infants	n= ?, gestation= ?, Wt= 2.1 kg	Descriptive	A crash test dummy weighing 2.1 kg was tested in four car seats and one car bed for safety of a preterm infant in a crash	Limited references available at this time car seats tested out of date now therefore data irrelevant to present safety standards, no confounding variables accounted for in design, outcome criteria was vague, unknown what the physiological outcomes or effects on these infants would be in the event of a crash. study would need to be conducted with more up to date equipment now to be deemed relevant	Purpose was outlined and appropriate for approach of study, suggestions offered regarding practice improvement	<b>Results:</b> Infants were restrained safely in car bed, but infant experienced more movement versus car seat	LOW Evidence	Parents of preterm infants should be advised at discharge of the importance of securing their baby in a child restraint system every time they travel in a car and should be informed of the best known method considering their child's medical condition (i.e. car bed)

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
4. Willett, Leuschen, Nelson & Nelson, 1989 Ventilatory Changes in Convalescent infants positioned in Car Seats	n= 62 gestation= 'convalescent preterm infants'	Randomized control trial	Extensive multichannel polygraph recordings were obtained and pulmonary function tests were performed on 50 convalescent infants from the neonatal intensive care unit before, during, and after placement in a Cosco-Peterson First Ride car seat	Limited exploration of results, no conceptual or theoretical basis, ethics not mentioned, no plans for implementation into practice, summary offered limited conclusions, car seat assessed is now out of date	Purpose clearly outlined, Exclusion criteria and methods outlined, variables accounted for and outlined clearly, methods were appropriate for this study, using the same car seat allowed for consistency in assessing cardio-respiratory effects, large sample assessed	<b>Results:</b> 60% of premature infants had episodes of desaturations (<80%) and 25% had episodes of bradycardia (beats <80 per min)	HIGH evidence	Premature infants may have respiratory compromise of a multifactorial nature when in car seats. Further development of car seats and education is necessary if such respiratory problems are to be avoided.

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
5. Smith & Turner, 1990 The Physiological Effects of Positioning Premature Infants in Car Seats	n= 14, gestation < 36 weeks	Randomized control trial	Infants were randomly selected and observed for physiological changes over a 90 minute period (30 mins observation prone under a radiant heater, 30 mins in car seat, and 30 mins observed under radiant heater again).	This study is not based on any theoretical framework, it is unknown if ethics was involved in this study, plan for moving this research into practice is not considered.	The purpose of the study is clearly outlined, it was appropriate to have the infant act as their own control in three trials in the car seat , this study was offered as a follow up to Willett's 1989 study. The study took into consideration a specific variables and offered specific criteria for the infants who enrolled in the study, the sample population was appropriate	<b>Results:</b> preterm infants are at an increased risk of oxygen desaturation and bradycardia when seated in a car seat at a 95 degree incline, car seat might not fit preterm infant properly but is still safer than in a parents arms while traveling in the car	HIGH evidence	Preterm infant should not be placed in a 95 degree angle in a car seat, health care providers should focus on teaching parents about car seat safety and proper positioning of the infant in the car seat

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
G. Bass, Mehta & Camara, 1993, Monitoring Premature Infants in Car Seats: Implementing the American Academy of Pediatrics Policy in a Community Hospital	n= 87, gestation = 26-36 weeks	Randomized control trial	Infants <37 weeks gestation at birth were monitored for 90 mins for oxygen desaturaton, apnea or bradycardia in car seat before discharge	Difficulty accounting for variables, no conceptual or theoretical basis chosen, it is unknown if any ethical considerations were taken.	The purpose of the study was clearly outlined, data collection criteria clearly defined, large sample accessed and setting consistent with purpose, explicit methodological detail was offered and provided rigour and robustness to the data, barriers to uptake and implementation strategies offered, including rationale for procedures and outline of roles and responsibilities of each health care team member.	<b>Results:</b> Only 18.4% preterm infants had desaturations, and 25% experienced bradycardia, even full term infants experience desaturations in car seats. <b>Comment:</b> the AAP does not specify the duration of car seat testing, this study chose 90 mins of observation further investigation into this issue of preterm infant car seat safety.	HIGH evidence	A car seat monitoring program can be incorporated effectively into a Level II community hospital nursery discharge plan provided the appropriate medical policies, nursing procedures and administrative support are established to deal with the logistics of the program. Both full term and preterm infants are at risk for desaturation in infant car seats..

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
7. Hertz, Aggarwal, Rosenfeld & Greensher, 1994, Premature Infants in Car Seats: Effect of Sleep State on Breathing	n=28, gestation = preterm (<37 weeks)	Randomized control trial	Infants were randomly assigned to a car seat or prone (crib) position for one recording period and then the position was reversed for the second recording. Active and quiet sleep cycles were measured and compared with number of periodic breathing episodes.	This study is not based on any theoretical framework, plan for moving this research forward into practice is not considered.	Study was built on previous knowledge and expanded to discover new evidence about periodic breathing and car seat safety,, ethical considerations taken, Inclusion and exclusion criteria explicit, recommendations offered.	<b>Results:</b> Preterm infants have a significant increase in periodic breathing when placed in standard car seats.	HIGH evidence	Finding consistent with Willet et al 1989, periodic breathing more common when infant in 'active' sleep regardless of location (crib or car seat)

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
8. Bass & Mehta, 1995 Oxygen Desaturation of Selected Term Infants in Car Seats	n= 28, gestation > 37 weeks	Randomized control trial	Term infants, in the judgment of their pediatrician were felt to be at risk for O <sub>2</sub> desaturation or apnea, were monitored for a 90 minute period in a car seat and observed for transcutaneous oxygen desaturation, apnea, or bradycardia plus several infants who were admitted to the pediatric inpatient unit after discharge from the nursery were also monitored.	It might have been better to limit the population observed to those without significant birth defects as this may have altered the results, limited consideration was given to a control group, the infants were observed for 90 minutes in the car seat and other studies today have only observed the infant for up to 30 mins in the car seat, it is unknown how frequently data was collected during the observation period.	The purpose of the study was clearly outlined, rigorous methods were followed.	<b>Results:</b> About 29% had abnormal results (desaturations while observed in a car seat, 20% of those were infants with special needs, cardiac or upper respiratory defects). <b>Comment:</b> Universal screening of all full term infants at discharge is not practical, car seat safety should be conveyed by the pediatrician, it is not easy to say which full term infants might be at a higher risk than others.	LOW Evidence	Car seat safety education should be shared with parents, car seat use should always be enforced, car seats are not risk free but safer than riding in the parents arms

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
9. Young, Shapira & Finer, 1996, Pre-discharge Car Seat Safety Study for Premature Infants	n= 141, gestation < 37 weeks	Randomized control trial	Preterm infants (<37 weeks) were observed for 90 minutes in a crib followed by 90 minutes of observation in a car seat of the parents choice (or in a loaner if no car seat available), physiological signs were monitored continuously	Variation in the decisions to delay discharge were not explored but might offer insight into clinical decision making regarding car seat challenge failures, some decisions were made to send infants home with oxygen while others had a delayed discharge, data was collected on a continuous basis, but it is unknown to what degree the equipment was accountable for poor readings on the probes and machines.	Purpose of this study is clear, the methods were appropriate for this population and ethics was involved, the sampling method was in consideration of the AAP guidelines regarding car seat challenges and large sample accessed, therefore the population assessed was appropriate, this is one of the only studies that has indicated a plan for implementing a policy and procedure for the NICU, to address both staff and parental concerns.	<b>Results:</b> Weight and gestation were not significant factors in 'failure' of the car seat challenge, (29% failure rate), common attributes of those who failed: apnea of prematurity, male, intubation period about 2 days, inconsistencies in discharges presented (i.e.: infant who failed the crib study but passed the car seat study was still discharged home, the angle of the car seat mattered, the type of car seat was insignificant to pass or fail). Preterm infants are at risk of desaturation and bradycardia	HIGH evidence	Suggestions that instead of a total of 180 mins of observation, compared to Bull et al and Willett et al, 90 mins maybe sufficient for observation of infant in car seat. Only three NICUs in Canada performing car seat challenges in 1996, out dated advice to transport infant in front seat of car if the parent is traveling alone in the car, for infants that fail the challenge initially, the use of infant swings and feeding chairs are not recommended until 40-44 weeks of age,

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
10. Hodgman, 1998, Apnea of Prematurity and risks of SIDS	N/A	Commentary	N/A	No conclusions drawn, limited systematic synthesis of the literature, findings not confirmed as evidence at this time, weak rationale.	Findings from a variety of available sources synthesized, topic thoughtfully reflected on and evaluated.	<b>Results:</b> Although incidence of apnea and episodes of periodic breathing have been identified as risk factors for SIDS, no published studies have proven a correlation between these events and life threatening events or SIDS.	LOW evidence	Car Seat Challenges not a relevant test of 'safety' after discharge, or indicator for risk of SIDS.
11. Martin, R.J. & Fanaroff, A.A., 1998, Neonatal apnea, bradycardia, or desaturation: does it matter?	N/A	Commentary	N/A	No conclusions drawn, limited systematic synthesis of the literature, not confirmed as evidence at this time.	Findings from a variety of available sources, topic reflected and evaluated.	<b>Results:</b> Bradycardia may persist in preterm infants long after their hospital discharge. Prevailing data suggest that bradycardic episodes are not predictive of SIDS or significant neuro-developmental delays.	LOW Evidence	Car seat challenge might not be most reliable method of assessing for risk of SIDS, clarification of the purpose of the ICSC required if this practice is to be supported in the clinical setting.

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
12. Merchant, Worwa, Porter, Coleman & deRegnier, 2001, Respiratory Instability of Term and Near-Term Healthy Newborn Infants in Car Safety Seats	n= 100, gestation= <37 weeks (n=50), >37 weeks (n=50)	Randomized control trial	Infants (preterm and full term) were assessed for fit in car seat, plus physiological monitoring while infants were supine (30 minutes) and while seated in car seats (90 minutes)	No plan for implementation of this data in to practice was offered	The purpose of this study was clear, consideration given to establishing a control (monitoring infant in supine position), design appropriate given the previous studies and knowledge base available at that point in time, data collection was thorough and sampling and setting from a level I nursery was appropriate for this study, ethical considerations for this study conducted, recommendations offered	<b>Results:</b> 24% of preterm infants, 4% of full term infants did not fit in their car seats, 12% of preterm infants experience bradycardia or apnea while in car seat, 35% of families had no seat at discharge or brought car seats that were unsafe or did not fit their child despite the use of blanket rolls, preterm and full term infants are at equal risk of cardio-respiratory compromise in car seats	HIGH evidence	Policies to evaluate car seats and to teach parents how to use blanket rolls to position newborn infants properly should be part of the discharge process, parents need simple information that can be easily recalled later, manufactures should be aware of the issues of positioning and those who use their product, infants should not remain in car seats for extended periods of time, travel time should be minimized for all infants

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
13. Bass & Bull, 2001, Oxygen Desaturation in Term Infants in Car Safety Seats	N/A	Commentary	N/A	No conclusions drawn, limited systematic synthesis of the literature, not confirmed as evidence at this time	Findings from a variety of available sources, topic reflected and evaluated, commentary offered from a expert researcher	<b>Results:</b> A relationship between infant's predisposition to oxygen desaturation in car seat and apparent life-threatening events is unproven. Need for more research on the optimum design of child restraints and the effect of positioning on the respiratory physiology of young infants. At the present time, the use of car beds for infants who experience documented apnea, oxygen desaturation, or bradycardia is a necessary alternative to the use of rear-facing car safety seats for safe transportation.	HIGH evidence	Preterm, near term and term healthy newborns may experience oxygen desaturation when properly positioned upright in car safety seats. Until additional research on the potential significance of oxygen desaturation in car safety seats is available, consideration should be given to limiting the time spent in car safety seats to that necessary for transportation and ensuring children are not left unattended while in a car safety seat.

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
14. Nagase, Yonetani, Uetani & Nakamura, 2002, Effects of child seats on the cardio-respiratory function of newborns	n= 15, gestation = term newborns (>37 weeks)	Randomized control trial	Healthy term newborns were assessed for respiratory compromise in a recommended infant car seat. Heart rate, percutaneous oxygen saturation, chest impedance and nasal airflow in infants placed in each of the car seats (car seat and car bed) and also placed in the supine position on a nursery cot. Episodes of oxygen desaturation below 95% and longer than 10 seconds	While suggestions were offered to improved practice, no plan for implementation of this data in to practice was offered	The purpose of this study was clear, consideration given to establishing a control (monitoring infant in supine position), this was an appropriate design given the previous studies and knowledge base available at that point in time, data collection was thorough and sampling and setting from a level I nursery was appropriate for this study, ethical considerations for this study were conducted	<b>Results:</b> Desaturated more in car seat vs. car bed, mild desaturations most frequent in car seat (based on criteria) and moderate desaturations present in car seat but only 4 out of 15 experienced	HIGH evidence	Term infants are also at risk of desaturation while traveling in car seats, more risk seen while seated in car seats, no incidence in prone position in car bed or crib

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
15. Dollberg, Yacov, Mimouni & Ashbel, 2002, <i>Effect of Head Support on Oxygen Saturation in Preterm Infants Restrained in a Car Seat</i>	n= 155, gestation <35 weeks	Randomized control trial	Infants were observed x3 (supine, sitting in car seat and sitting in car seat with insert in place) x 20 minutes per location. Data were collected regarding percent of time oxygen saturations were below values of 90, 92, 94, or 96%	No plan for implementation in practice, only study of its kind therefore difficult to offer recommendations from this study.	Well-conceived, design considered appropriate variables, contributing evidence to part of a bigger decision, relevant study to the needs of preterm infants , conclusions drawn.	<b>Results:</b> Oxygenation was not improved in relatively healthy preterm infants placed in car seats when their head is supported to prevent lateral movements by a special apparatus.	LOW evidence	Lateral head control in infant car seat not a contributing factor to desaturations in car seat, although more studies are needed to confirm these findings.

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
16. Tonkin, McIntosh, Hadden, Dakin, Rowley & Gunn, 2003, Simple Car Seat Insert to Prevent Upper Airway Narrowing in Preterm Infants: A Pilot Study	n= 17, gestation < 37 weeks	Pilot, randomized control trial	Preterm infants who were approved for discharge were evaluated in a car seat with and without a foam insert that provided a slot for the back of the infants' head. Assessment of upper airway dimensions (x-rays), taken during quiet sleep in each position. Infants were monitored in each position for 30 minutes with continuous polygraphic recording of respiratory, cardiac, and nasal airflow activity and pulse oximetry	Infant subjects were exposed to a large amount of radiation in order to collect this data, it remains unknown how long an infant would require the use of this insert following discharge.	Purpose was outlined and appropriate for approach of study, control and variables accounted for, technical assessment conducted, minimal disruption to standard pre-discharge car seat assessment (based on AAP recommendations). Ethical considerations made, setting appropriate based on purpose and hypothesis of study, strong theoretical base, data showed strong evidence and design, lack certainty of acknowledged, conclusions drawn,	<b>Results:</b> The frequency of episodes of desaturation in a standard newborn car seat can be substantially reduced by placement of a simple foam insert that allows the infant to maintain the head in a neutral position on the trunk during sleep. Head and neck flexion is likely only one factor of a multi-factorial issue.	HIGH evidence	Data strongly support the hypothesis that flexion of the head on the body is a significant contributor to these episodes and that the mechanism is posterocephalic displacement of the mandible, leading to narrowing of the upper airway, more frequent arousals may provide some benefit for infants responding to potentially life threatening events. head and neck support, recommend delay discharge or use car bed and crash testing with insert in future.

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
17. Williams & Martin, 2003, Car Seat Challenges: Where Are We in Implementing These Programs?	n= 54 (level I, II, III centers)	Phone survey	Phone interviews 72 centers, (across 37 states (US) with a nurse manager, nurse educator, or charge nurse	It is unknown if ethical considerations were taken, limited plans for moving this data forward into practice	Interview data offered concrete feedback, and useful statistical results to illustrate the implementation of the AAP car seat challenge programs. Purpose was clearly stated, implications to practice outlined effectively, importance weighted	<b>Results:</b> Level II centers were <u>Conducting the challenges</u> mostly level II, conducted by nurses , <u>Gestation</u> of infants being tested: <37 weeks (as per AAP guidelines) <u>Length of testing:</u> 30- 90 mins <u>Features measured:</u> heart rate, respiratory rate, oxygen saturations, and apenic episodes. <u>When tested:</u> 2-3 days before DC (45%), 91% had written policies in place, <u>Recommendations following fail:</u> retested the next day or with different car seat.	HIGH evidence	Need to standardize ICSC (when to perform the testing, and what to do when an infant fails the testing). Further research on car seats and car beds

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
18. Stein, 2004, Car-Seat Test	NA	Commentary	NA	No conclusions drawn, limited systematic synthesis of the literature, not confirmed as evidence at this time, further research required	Findings from a variety of available sources, topic reflected and evaluated	<b>Results:</b> AAPs recommendations for routine testing of infants <37 weeks' gestation for car safety-seat intolerance lacks supporting evidence-based data. No studies of validated protocols or interventions are presented. Recommendations based on sensible suggestions to use car seats properly are not objectionable. However, many questions are unanswered. What if car-seat design is the source of the problem? Evidence-based studies are needed.	LOW Evidence	Controversial evidence for the car seat challenge, AAP ICSC lacks supporting evidence, no validated protocols available, more research on car beds and risks of hypoxia, do not recommend use of swings or slings in first months of life, AAP good starting point but do not recommend ICSC until validated protocols available,

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
19. Ojadi, Petrova, Mehta & Hegyi, 2005, Risk of Cardio-respiratory Abnormalities in Preterm Infants placed in Car seats: A Cross Sectional Study	n= 42, gestation= 24-35 weeks	Descriptive	Cardio-respiratory function monitored for 45 mins (before, during and after placement in car seat), monitored occurrence of periodic breathing, apnea, bradycardia and O <sub>2</sub> desaturation <90%	Limited evidence from the literature and claiming limited assessment of risk factors of car seat travel for preterm infants, limited discussion of the poor development of the AAP tool and no implications or translation to practice knowledge offered.	Consideration given to ethics, thorough data analysis used, Limitations were identified, well conceived seen as one part of the whole decision, conclusions drawn.	<b>Results:</b> (note: decreased oxygen saturation--meeting at least 1 of the following criteria: apnea≥ 20 seconds [6], bradycardia ≤ 80 beats per minute [14], or oxygen saturation <90%), Only 4.8% experiences apnea during time in car seat, 33% experience bradycardia mainly in the car seat, 21% desaturation before car seat, 79% desaturation in car seat, 16.7% after, combination 83% in car seat.	HIGH evidence	periodic breathing should be added to AAP ICSC, gestational age and weights offered unique data and linking new data to the cause of desaturations to periodic breathing, frequency of adverse cardio-respiratory events increases during sleep, supine position helpful for decreasing incidence of desaturations, need more research on car beds.

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
20. Joffe & Hall, 2006, Limiting the Risks of Apnea and Bradycardia in Low Birth Weight Infants Using Car Seats	n= 52, gestation= LBW	Telephone Survey	Authors carried out an informal telephone survey to determine what other units were doing as regard car seat testing	Level of care of each nursery not identified, survey poorly designed, lacking insight to data analysis phase (poorly conceived), acknowledge more research needs to be done.	Conclusions drawn and suggestions to future research offered as well as suggestions for current practice offered.	<b>Results:</b> Car challenge is conducted with wide variation, 36 units not conducting car seat testing, 15 conducting test that last 30-60 mins.	LOW evidence	Car challenge is conducted with wide variation, legal implications of ICSC considered (UK), recommend new design of car seat, ICSC guidelines need to be developed, crash testing with LBW dummies.

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
21. Kinane, Murphy, Bass & Corwin, 2006, Comparison of Respiratory physiologic Features When Infants are Placed in Car Safety Seats or Cr Beds	n= 67, gestation=>37 weeks	Randomized control trial	Within the first 1 week of life, 67 healthy term infants were recruited and assigned randomly to be monitored in either a car bed (33 infants) or a car safety seat (34 infants). Physiologic data, including oxygen saturation and frequency and type of apnea, were obtained and analyzed in a blinded manner.	No conceptual or theoretical basis	Purpose clearly outlined, Exclusive criteria and methods outlined, variable accounted for and outlined clearly, methods were appropriate for this study, Ethical considerations taken into consideration.	<b>Results:</b> The respiratory physiologic features of infants in the 2 car safety devices were observed to be similar. Of note, substantial periods of time with oxygen saturation of <95% were surprisingly common in both groups.	HIGH evidence	No difference in desaturations in car bed vs car seat in term population, suggest caution, only use for transportation in the car, manufacturers need to design new car seats, car seats vs car beds.

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
22. Tonkin, Vogel, Bennet & Gunn 2006, Apparently Life Threatening Events in Infant Car Safety Seats	n= 43, gestation= case reports of infants seen by medical doctor regarding episode in car seat (turning pale or cyanotic) mainly Full Term (one preterm)	Retrospective Case reports	The histories of these infants were evaluated for speed of onset, previous events, and potential contributing factors including mother's smoking and previous respiratory or gastrointestinal problems (such as reflux).The infants were closely examined for evidence of anatomical abnormalities of the face and upper airway.	Data produced was limited as this was not witnessing the initial event, variables and analysis weak and limited by lack of evidence during follow up appointment and observations recorded during this study, ethical considerations not specified, evidence inconclusive, limited recommendations for implementation into practice, further studies would be required to confirm these findings.	Purpose clearly outlined, methods outlined, sample and setting was appropriate for identifying risks for preterm infants and car seat safety.	<b>Results:</b> None of the full term infants had had any known medical complications and no infants had any previous symptoms, in all cases the event had occurred with no apparent warning.	LOW evidence	Infants should not be left unattended in car seats.

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
23. Greenburg, 2007, The Challenge of Car Safety Seats	N/A	Commentary	N/A	Limited systematic synthesis of the literature, commentary not confirmed as evidence at this time.	Findings from a variety of available sources, topic reflected and evaluated, critical thinking exemplified, recommendations offered.	<b>Results:</b> Lack of standardization of ICSC, no evidence that the ICSC confirms safety for vehicle transportation, message to parents: ICSC does not guarantee safety in car seats.	HIGH Evidence	Contributing evidence that the car seat challenge may not be the most relevant source of determining readiness for discharge, recommend limit time in car seat, long trips should be discouraged or if unavoidable, interrupted with frequent rest stops.

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
24. DeGrazia, 2007, Stability of the Infant Car Seat Challenge and Risk Factors for Oxygen Desaturation	n=49, gestation=<37 weeks	Observational	Physiological responses of preterm infants in car seat examined during two 90-minute Infant Car Seat Challenges at a tertiary health care institution	Convenience sampling does not ensure that the sample represents the premature infant population. Differences in car seat design (harness mechanisms and seat contours) may have affected the ICSC results, lack next steps for implementation in to practice.	Study clearly outlined, evaluation criteria explicit, setting, design and variables appropriately accounted for, ethical considerations taken, questions of research relevant, critical and innovative thinking evident.	<b>Results:</b> 86% of infants showed consistent results between challenge #1 vs challenge #2, (76% pass and dc home, 14% pass fail home in car bed, 5% failed both) possible risk factors for oxygen desaturation event: infants born at<34 weeks gestation and hospitalized longer than 7 days, designed guidelines to be implemented into practice.	HIGH evidence	ICSC good test for now, debate if a one time ICSC is sufficient, Car bed travel is recommended for infants with a significant car seat-related oxygen desaturation event. Health care providers must forewarn parents that all infants require adult supervision during travel regardless of ICSC results or safety de- vice used. Prolonged time in car seats should be discouraged.

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
25. Salhab et al, 2007, Car Seat or Car Bed for Very Low Birth Weight Infants at Discharge Home	n=151, gestation <37 weeks	Randomized control trial	Preterm infants (<37 weeks, IUGR) were observed for 120 minutes in a car seat followed by 120 minutes of observation in a car bed, physiological signs were monitored continuously.	No conceptual or theoretical basis.	Study clearly outlined, evaluation criteria explicit, setting, design and variables appropriately accounted for, ethical considerations taken.	<b>Results:</b> No evidence that an event is less likely in a car bed vs car seat. Risk factors for repeat events: lower gestational age and those recovering from chronic lung disease, a brief observation period in a transportation device is not sufficient to identify infants at risk, but the longer these infants remain in such devices, the more likely oxygen saturation is to fall.	HIGH Evidence	Preterm VLBW infants should be closely observed and travel time limited, irrespective of whether car beds or car seats are used.

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
26. Cote, Bairam, Deschenes & Hatzakis, 2007, Sudden Infant Deaths in Sitting Devices	n=508, gestation= birth - 12 months	Retrospective population-based cohort study	Reviewed all cases of sudden unexpected deaths in infants between birth and one year of age that occurred between 1991-2000 in Quebec to determine the incidence of sudden deaths in infants occurring in sitting devices in a population and to determine whether premature infants account for a disproportionate number of these deaths.	This study was a review of one province therefore factors of health, education, smoking within the infant environment or demographic and SES factors may be contributing bias to the results from this assessment.	Clearly outlined purpose and valuable data was discovered from this investigation.	<b>Results:</b> Few deaths occurred in car seats, <b>Comment:</b> While valuable information was discovered from this investigation, it may be indicating that while preterm infants are at an increased risk of desaturation in car seat, these episodes are not significant or predictors of life threatening episodes, car seat challenges are not related to SIDS.	HIGH Evidence	Caution should be used when placing young infants in car seats or sitting devices whether they are preterm or not. More attention should be given to infants at risk of upper airway obstruction and SIDS.

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
27. Murphy & Bridgman-Acker, 2008, Sudden Unexpected Deaths in Infancy Occurring in Car Seats	n=11, gestation= preterm, term and unknown	Retrospective Case reports	The database of the Office of the Chief Coroner of Ontario was searched for deaths occurring in infant car seats. Cases where death was attributed to natural disease were excluded.	Not confirmed as evidence at this time	Findings from a variety of available sources, topic reflected and evaluated, suggestions offered based on findings, systematic analysis conducted.	<b>Results:</b> Death was more likely in term infants when infant was left in car seat for longer than 60 mins, at home (vs travel in car) left unsupervised. Since car seats alone can compromise cardio-respiratory function in both term and preterm infants, sleeping in a car seat is likely to further increase the risk of cardio-respiratory compromise. Car seats may therefore contribute to SIDS infancy in the form of a hazardous sleeping environment.	HIGH evidence	Travel should be minimized during the first months of life. Preterm infants should undergo a car seat challenge before hospital discharge. Infants who do not pass a car seat challenge should not travel in a car safety seat. Parent education about the risk of car seats and promotion of supervision, minimization of travel and limitation of car seat use in all young infants (term as well as preterm) are likely to be beneficial in preventing infant deaths in car seats.

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
28. Rice & Anderson, 2009, The Effectiveness of Child Restraint Systems for Children Aged 3 Years or Younger During Motor Vehicle Collisions: 1996-2005	n= 5732 vehicles and 19293 occupants.	Matched Cohort Study	Conducted a matched cohort study using Fatality Analysis Reporting System (data from 1996 to 2005). Estimated death risk ratios using statistical analysis tools. Examined possible effect of modifying selected factors.	No differentiation between safety and booster seats (but would expect the magnitude of bias to be very low given that the effectiveness of booster seats is similar to that of child safety seats). Theoretical or conceptual basis not considered, no plans for implementation of findings into practice.	Thorough and sound statistical analysis conducted, sample population significant to draw conclusions, summary of evidence comprehensive.	<b>Results:</b> Child safety seats are highly effective in reducing the risk of death during severe traffic collisions and generally outperform seat belts. Parents should be encouraged to use child safety seats in favour of seat belts.	HIGH evidence	Car seat use among children aged 3 or younger greatly reduces the risk of death during traffic collisions. unrestrained children were 3 times more likely to die during collisions than were children using a child safety seat. effectiveness is greater for younger children: death risk reduction is 74% for children aged 1 year and younger and 59% for children aged 2 and 3 years.

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
29. DeGrazia, Guo, Wilkinson & Rhein, 2010, Weight and Age as Predictors for Passing the Infant Car Seat Challenge	n= 43	Retrospective	Logistical regression analysis performed on infants who failed their initial infant car seat challenge and were re-screened following discharge in a car bed. A comparison was made between the initial and repeat car seat challenges	Not confirmed as evidence at this time.	Findings from a variety of available sources, topic reflected and evaluated, suggestions offered based on findings, systematic analysis conducted.	<b>Results:</b> Neither weight nor age at initial or repeat car seat test predicted passing criteria.	HIGH evidence	Car seat challenges remain the safest method for transitioning preterm infants from a car bed to a car seat.

Citation	Subjects and Gestation	Design	Methods	Weaknesses	Strengths	Results or Comments	Level of Evidence	Relevance to Nursing Practice Knowledge
30. Bass, 2010, The Infant Car Seat Challenge: Determining and Managing an "Abnormal" Result	N/A	Commentary	N/A	Not confirmed as evidence at this time	Findings from a variety of available sources, topic reflected and evaluated, suggestions offered based on findings, systematic analysis conducted.	<b>Results:</b> Maybe two categories of pass criteria should be offered to infants in the car seat challenge: <u>Category A:</u> SpO2 of 90-92% (> 20 secs) with no apnea (>=20 secs) and no bradycardia (<80 bpm) = may be DC home in a car bed until retested and proves stable in car seat vs <u>Category B:</u> SpO2 of <90% (> 20 secs) or any episode of apnea (>=20 secs) or bradycardia (<80 bpm) = maybe tested in car bed, if fail will remain in NICU for observation and retested at a later date.	HIGH Evidence	Car seat manufacturers will need to address the challenge of developing products that provide crash protection without resulting in adverse physiologic effects on newborns (this could eliminate the burden on health care systems of testing and retesting the anxiety of parents who take home a newborn who has failed the car seat challenge.

## Appendix C: Guideline Chart

Clinical Guideline	Strengths	Weaknesses	IMPLICATIONS for NURSING PRACTICE
<b>AAP (2009) <i>Safe transportation of preterm and low birth weight infants at hospital discharge</i></b>	This document has been evolving as new research becomes available and therefore recent and relevant	This document has a bias toward conducting car seat challenges and provides vague guidelines for implementation into practice	Most widely referenced guidelines, ambiguity of recommendations needs further investigation and revisions
	Recommendations for future research offer insight into the limitations of this document	Assumes that hospital staff are trained to position infants 'properly' in car safety seat does not provide role delegation (what should nurses be responsible for, what should physicians be responsible for)	
	Wide range of resources used		
	Target audience is identified ("pediatricians and other caregivers who counsel parents of preterm and low birth weight infants about car safety seats")		
	Recommendations consistent with the literature		
<b>CPS (2000) <i>Assessment of babies for car seat safety before discharge from hospital</i></b>	Makes reference to AAP 1999, recommendations showing consistency across recommendations	Out dated document, "Revision in progress February 2009" unable to locate this document in this integrative literature search	Awaiting revisions (Feb 2009 pending)
	Article references relevant and valuable resources from a broad range	Limited indications for implementing these recommendations into practice	Plan for policies and procedures to be developed in the NICU
	Article identifies relevant practice questions	Recommendations remain very vague despite efforts to investigate evidence in the literature (no significant conclusions made)	
	Noted the obvious gap from knowledge to practice (Although some hospitals routinely assess selected babies before discharge, this does not occur in the majority of Canadian centers)	Indicated that parents should receive instructions and supervision in the placement of their infant in car seats by 'qualified health care personnel', but no specific roles identified	

Clinical Guideline	Strengths	Weaknesses	IMPLICATIONS for NURSING PRACTICE
<b>Transport Canada, 2008</b>	Most accurate and thorough reference regarding restrictions on use of car beds (Transport Canada is the authority on child restraints and therefore sets the standards for safety and use in Canada)	Extremely limited resources relevant to car seat challenges were accessed to create this report	Not conclusive or thorough enough for use in the clinical setting, will need more comprehensive review and additional information added in order to be valuable reference for the clinical setting
	Canadian specific standards for car bed use explicitly outlined	No explicit directives regarding car seat challenges	
	Parameters outlined according to the AAP	Very limited evidence reviewed and minimal evidence incorporated into recommendations	

#### **Appendix D: Car seat Safety in the NICU: Recommendations to Parents of Preterm Infants**

This information is based on the most current evidence and may be used to create car seat safety resources for parents of preterm infants and nurses in the NICU. (This information will require frequent updating as more evidence becomes available).

1. Car seats should not be used for purposes other than travel (AAP, 2009). The car seat does not make a safe bed for an infant. The Coroners report for deaths under five

considers the car seat a ‘hazardous sleeping environment’ (Murphy & Bridgman-Acker, 2008).

2. Limit the amount of time spent in infant car seats to that necessary for transportation, long trips should be discouraged and if unavoidable, interrupted with frequent stops (Greenburg, 2007; Tonkin et al, 2006).
3. Passing a car seat challenge does not guarantee safety in a car seat (Greenburg, 2007), therefore infants should never be left unattended in car seats (AAP, 2009, Murphy & Bridgman-Acker, 2008).
4. Car Seat Fit and Positioning: Proper positioning of your infant in car seats supports airway patency (Greenburg, 2007; Tonkin et al, 2003).
  - Infants are safest riding rear-facing in their car seats for as long as possible according to the weight and length allowed by the manufacturer of the seat for the greatest protection (AAP, 2009, Rice & Anderson, 2002). Most convertible car safety seats are approved for rear-facing use with infants up to 35 pounds and 36 inches (AAP, 2009).
  - Buttocks and back should be flat against the back of the car seat (AAP, 2009).
  - Most small infants require extra positioning support, blanket rolls may offer support and a more snug fit the car seat if placed on either side of the infant’s head (AAP, 2009; Transport Canada, 2008). The AAP recommends the use of blanket rolls to limit the lateral movement of the head and neck; however, studies have shown that limiting lateral movement of the head is insignificant is reducing the number of oxygen desaturations (Dollberg et al., 2002). Blankets should never be placed behind the infant or between the infant and the restraint (AAP, 2009).

- The harness must be snug and the chest clip should be positioned at the midpoint of the infant's chest, over hard bones of the sternum, not on the abdomen or in front of the neck (AAP, 2009). The harness straps should be positioned at or below the shoulders for safest fit (AAP, 2009). Multiple harness-strap slots are more accommodating for small but rapidly growing infants (AAP, 2009).
  - Infant-only car seats: 3-point or 5-point harness systems or Convertible car seats: 5-point harness systems provide greatest comfort, fit, and positioning for the preterm or low birth weight infant (AAP, 2009).
  - A car seat with a shield, abdominal pad or arm rest is not safe for infants due to potential breathing difficulties or risk of injury to infant's face and neck during a sudden stop or crash (AAP, 2009).
  - Car safety seats with the shortest distances (5.5 inches) from the crotch strap to the seat back should be selected to reduce the potential for preterm infants to slip forward, feet-first, under the harness (AAP, 2009). Placing a small blanket roll between the crotch strap and the infant may reduce the risk of sliding down in the seat with smaller infants (AAP, 2009).
  - Do not use "After-Market Products" (AAP, 2009; Transport Canada, 2008). Only products that come with the seat have been tested for safety in the event of a crash therefore only products sold by the manufacturer for use with their specific seat should be used (AAP, 2009; Transport Canada, 2008).
5. Recline: The rear-facing car safety seat should be reclined approximately 45° or as directed in the manufacturers instructions (NOTE: If the vehicle seat slopes and the seat is too upright, the infant's head may fall forward causing upper airway occlusion. A

lightweight, ‘non-compressible’ object, such as a tightly rolled blanket or pool noodle may be placed under the base of the car seat to achieve the appropriate angle. Some car safety seats have built-in angle indicators and angle adjusters to assist with achieving the proper angle (AAP, 2009).

6. Back is best: Infant car seats should never be placed in the front passenger seat of any vehicle equipped with a passenger-side front air bag because of risk of death or serious injury from the impact of the air bag. In some vehicles without rear seating positions (such a pick-up trucks), the air bag can be deactivated when the front seat is used for a child passenger (AAP, 2009).
7. Whenever possible, parents should arrange for an adult to be seated in the rear seat adjacent to the infant (AAP, 2009). Parents may have the opportunity to take an infant CPR class prior to discharge or should ask their nurse for more information about what to do if their baby stops breathing or turns blue.
8. Fitting young infants in devices such as swings, infant carriers, backpacks or slings may cause adverse cardio-respiratory effects, consideration should be given to limiting the use of these devices in the first few months of life (AAP, 2009; Bass et al, 2001).

### **Appendix E: Curriculum Topics to Support Nursing Staff**

- Positioning and fit of infant in car seat (based on AAP (2009) recommendations)
- Knowledge of car beds, safety benefits, criteria for infants needing a car bed and risks involved, how to obtain a bed if needed
- Education for parents regarding risks, fit and positioning and resources (See Appendix D)

- How and where to access additional resources to share with parents (See Appendix F).

## **Appendix F: Resources for Parents and Nurses**

### Proper Fit and Positioning, Car Seat Challenge:

- ✓ American Academy of Pediatrics. (2009): “Safe Transportation of Preterm and Low Birth Weight Infants at Hospital Discharge” (<http://www.aap.org/>).

Car Bed Info:

- ✓ “Safe Transportation for Children with Special Needs” Lovette, (2008) Journal of Pediatric Health Care 22, p.323-328.
- ✓ Transport Canada (2008): “Transporting infants and children with special needs in personal vehicles: a best practice guide for healthcare practitioners”  
<http://www.tc.gc.ca/roadsafety/tp/TP14772/menu.htm>

General Car Seat Information:

- ✓ Canadian Pediatric Society (2008): “Transportation of Infants and Children in Motor Vehicles”. Pediatric Child Health, 13(4), p.313-318. (www.cps.ca)

**Appendix G: Critical Appraisal Criteria (Long, 2002)**

	Quantitative Study	Qualitative Study
--	--------------------	-------------------

Review Area	Review Questions	
<b>Purpose</b>	<p>What are the aims of the study?</p> <p>What are the aims of the paper?</p> <p>Are these aims appropriate, given the state of knowledge in the area?</p>	
<b>Study Design</b>		
Type of Study	<p>What type of study was used?</p> <p>Is the design appropriate given the aims and knowledge in the area?</p>	
Variables	<p>Who was studied?</p> <p>What were the intervention and any comparison intervention?</p> <p>Is sufficient detail provided to reproduce these?</p>	
Measurement	<p>How are the variables measured? What are the outcome criteria?</p> <p>How valid and reliable is this measurement?</p> <p>Are the outcome measures responsive to change? Are the outcome measures appropriate and sufficiently broad to give insight into the perspective of key stakeholders (patient, professional, service)?</p> <p>Can the measures be used in routine practice?</p> <p>Was the follow up time, if any, sufficient to warrant the conclusions drawn or to see the desired effects/ outcomes?</p>	
Data Collection	What data collection methods were used?	What data collection methods were used to obtain and record the data?

	Quantitative Study	Qualitative Study
Review Area	Review Questions	
	<p>Was there substantial measurement bias?</p> <p>What role did the researcher assume in doing the fieldwork? How were possible reactivity and subjectivity effects addressed?</p> <p>Was there substantial non-response? And loss to follow up?</p> <p>Were the methods appropriate?</p>	<p>Are these appropriate?</p> <p>Are the data available for independent analysis?</p> <p>What role does the researcher play within the setting?</p> <p>Is the process of fieldwork adequately described, for example in terms of an account of how data were elicited; the type of questions; an interview guide; the length and timing of observation work; and procedures for field-note taking?</p>
Sample and Setting	<p>What is the setting and source population for the study participants?</p> <p>What are the inclusion and exclusion criteria?</p> <p>How and why were the study participants, and setting, chosen?</p> <p>Is the setting typical or representative of other settings and in what respects? If not, is this setting likely to present a stronger or weaker test of the research question?</p> <p>Is the sample appropriate given the aims of the study?</p>	<p>Within what geographical and social setting is the study carried out?</p> <p>What is the rationale for an analysis of the appropriateness of choosing this setting? Is sufficient detail given about the setting?</p> <p>Over what time period is the study conducted? Is this sufficient?</p> <p>How is the sample (informants, settings and events) selected?</p> <p>What is the size of the study and groups forming the study?</p> <p>Is the sample (informants, settings and events) appropriate to the aims of the study?</p>
Conceptual and Theoretical Base	<p>What is the underlying conceptual model or theoretical framework?</p> <p>What is the implied model of causal processes? In what way is this</p>	

	Quantitative Study	Qualitative Study
Review Area	Review Questions	
	<p>reflected in the measurements used?</p> <p>Do the authors address the possible contribution of their study to knowledge?</p>	
Ethics	<p>Was ethical committee approval obtained?</p> <p>Was informed consent obtained from study participants?</p> <p>Have ethical issues been adequately addressed?</p>	
Study Findings	<p>How was the data analysis undertaken?</p> <p>Do the findings fit with the authors' arguments and comments?</p> <p>Are the findings set in context with the other findings in the area? How do they cohere with other research?</p>	
Policy and Practice	<p>To what setting are the study's findings generalisable?</p> <p>To what population are the study's findings generalisable?</p> <p>Is the condition justified given the conduct of the study and any weaknesses identified?</p> <p>What contribution has the research made to knowledge?</p> <p>What are the implications for policy?</p> <p>What are the implications for service practice, and my own practice in particular?</p>	

	Quantitative Study	Qualitative Study
Review Area	Review Questions	
Data Analysis		<p>How are the data analyzed?</p> <p>How adequate is the description of the data analysis? Is sufficient detail given to allow for its reproduction? Are adequate steps taken to guard against selectivity in selection of data for presentation in the study?</p>
Summary Evaluation	<p>Looking across all the above areas, could the observed results have been brought about by something other than the intervention/variables studied?</p> <p>In summary what are the strengths and weaknesses of the study?</p> <p>What further research may be required? What major gaps in knowledge remain?</p> <p>What are the possible theory, policy and practice implications?</p> <p>What have I learned?</p>	
Researcher Bias		<p>Are the researcher's own preconceptions and possible biases outlined?</p> <p>How could these have affected the study in particular, the analysis and interpretation of the data?</p>