

Foundations in Newborn Care

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The Universe of Developmental Care

A New Conceptual Model for Application in the Neonatal Intensive Care Unit

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ABSTRACT

Developmental care for high-risk infants is practiced in most neonatal units around the world. Despite its wide acceptance, inconsistency in its definition and application has resulted in criticism regarding its scientific merit. The universe of developmental care model proposed in this article is the first major reformulation of neonatal developmental care theory since Als' synactive theory. Neither the developing brain nor the environment exists in isolation, and therefore are dependent on each other for all caregiving activities. Central to this model is the concept of a *shared surface*, manifested most obviously by the skin that forms the critical link between the body/organism and environment and becomes the focal point for human interactions. The components of the model and its theoretical underpinnings, its practical application and direction for future clinical practice, education, and research are presented.

KEY WORDS: developmental care, family-centered care, neonatal intensive care unit, shared surface, theoretical model

Despite major technological and scientific advances, preterm infants have a significantly greater risk than their term counterparts for a variety of medical and psychological morbidities such as chronic lung disease, intraventricular hemorrhage, learning disabilities, neurosensory deficits and behavioral problems.¹⁻⁴ In addition to immaturity and infection, emerging evidence suggests that environmental factors such as noise, bright lights, frequent handling, and painful procedures contribute to poorer outcomes for the critically ill preterm infant.⁵⁻⁷

In the 1970s, neonatal caregivers became increasingly aware of the impact of the complex neonatal intensive care unit (NICU) environment on the pre-

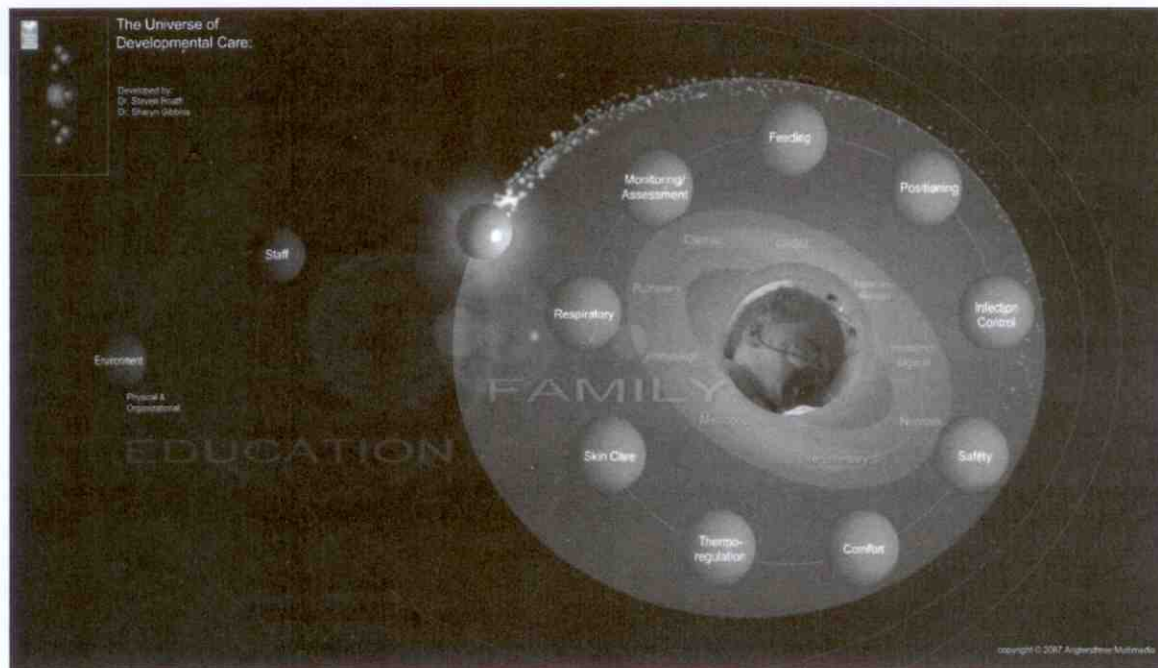
mature infant's developing nervous system while simultaneously appreciating the infant as a social being actively engaging caregivers and the external physical environment.⁸⁻¹⁰ Between 1980s and 1990s, developmental care was introduced as an infant caregiving model aimed at minimizing the adverse effects of the NICU environment on the high-risk infant.^{11,12} Despite the growing body of evidence for developmentally supportive care practices, implementation has varied from institution to institution and widespread adoption has not been achieved. In a systematic review of the effectiveness of developmental care practices, benefits included decreased length of hospitalization, decreased days of ventilation, improved weight gain, and fewer days in oxygen.⁶ Although the review highlighted the short-term benefits of developmental care, the authors indicated that further research regarding long-term benefits is required before widespread adoption is supported. It is believed that (a) differences in the definition of developmental care within each of the studies included in the review and (b) difficulties trying to isolate 1 or more variables that were considered as developmental care and linking them to long-term clinical outcomes contributed to the criticisms regarding its scientific merit. A new model of developmental care that clearly defines its tenets and offers measurable outcomes for clinicians, researchers, and families may result in consistent understanding and application in practice.

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FIGURE 1.



The universe of developmental care model. Copyright 2007, Anglersthree Multimedia. Used with permission.

The universe of developmental care (UDC) model proposed in this article is the first major reformulation of neonatal developmental care theory since Als' Synactive theory.^{11,12} On both theoretical and empirical grounds, the concept of a *shared surface* is central to this model. This surface is manifested most obviously by the skin, which forms the critical link between the body/organism and environment and is the focal point for human interactions, encompassing the family and NICU staff (Figure 1). Neither the developing brain nor the environment exist in isolation, and therefore are dependent on each other whenever caregiving activities are involved. The components of this model, its theoretical underpinnings, and implications of care are discussed in detail below.

DEVELOPMENTAL CARE AS A SHARED SURFACE INTERFACE

Developmental care has its roots in developmental neurobiology, with Als synactive theory^{11,12} and in the discipline of professional nursing, with Florence Nightingale's theories on the importance of the nurturing environment for patient care and restoration of health.¹³ Developmental care constitutes a complex dynamic system. However, when describing complex systems, the definition of *boundary* is of key importance. Without defining a boundary, one can-

not know what belongs to the system or what does not belong to the system. The boundary of a system is simultaneously the boundary of its environment. In practice, nerve endings never touch the environment and, consequently, neural elements cannot be primary determinants of the boundary of the body. The difficult task before us is to describe a neurodevelopmental surface that is *both* body and environment. In this view, the surface is not a barrier separating self and nonself or brain and environment, but a seamless union of both. This type of structure is integral to the proposed UDC model. Although individuals may start out as 2 seemingly discrete surfaces with unique boundaries, they become intimately and seamlessly connected via a shared interface when care giving occurs. There is a single, continuous, looped structure, which is both organism and environment. Each individual is affected positively or negatively by the other; wherein no interaction is without some degree of reciprocal contribution. The key is to pay close attention to the other individual's contribution to the interaction. Preterm or acutely ill infants may not contribute to an interaction in a manner that is clearly understood by others. The onus is on families and caregivers to recognize their contributions to the interactions (through physiological and behavioral responses) and provide an interaction that promotes their growth and development.

The skin participates in multiple caregiving interactions in a disease-independent manner and forms the observable boundary of the infant. As an ectodermal derivative, the outermost layer of the skin, the epidermis, shares a common embryological origin with the brain.¹⁴⁻¹⁷ From a neurodevelopmental viewpoint, the skin is the surface of the brain. By shifting the focus from the central nervous system (CNS) to the actual shared surface of care, there is greater recognition of the interactivity of all developing body systems and an appreciation of the need for individualized patient care within a complex technological environment. Translation of this approach to patient care and the implementation of change in larger healthcare arenas are practical, feasible, and, most of all, needed.

COMPONENTS OF THE UNIVERSE OF DEVELOPMENTAL CARE MODEL

The UDC model of developmentally supportive family-centered care is illustrated in Figure 1. The model emphasizes the shared surface of the caregiver and infant as the main neurodevelopmental interface. Physical properties of the environment (light, sound) as well as observations of behavior are gauged relative to this boundary. From this view, vision is touch at a distance, and core measures of efficacy in healthcare delivery incorporate this boundary in a near transparent manner. In our view, the evaluation of nursing practice and the standardization of core measures in personalized medicine are grounded and oriented by the initial consideration of the body surface. Whether the healthcare professional is providing direct patient care such as suctioning, the NICU is bright and loud, or the parent is providing comforting touch to their infant, the organism/environment interface is intimately involved and observations about comfort, tolerance, satisfaction, and safety implications are always made relative to this boundary.

Central Core

Consistent with the notion of patient-centered care, the infant occupies the central position and is the gravitational center of the model. The model captures the important cellular and molecular physiological systems of internal medicine (purple) but surrounds them with practical "planets" (gray) related to specific-care interactions at the surface of the developing infant. Family-centered care (gold) is augmented by this approach because the family, surrounded by the staff and the physical and organizational environment of the NICU, can directly influence infant care through "hands on" interaction with the infant. Just as the solar system obeys a lawful arrangement in the movement of its parts, the UDC model postulates that the infant will exhibit a regular, predictable, and lawful development of observable behaviors in response to the envi-

ronment. Understanding this development, however, absolutely requires attention to the surface of care.

Care Practices

The classical physiological systems shown in continuous purple in Figure 1 form the basis of all medical and nursing education. Undue focus on the disease rather than the patient or failure to recognize the holistic interdependence of these systems in the provision of care are significant oversights that can lead to inappropriate, inaccurate, or untimely interventions. The description of the epidermal surface in terms of its peculiar stratified architecture, its unique molecular structure, and the gravitational logic that governs the arrangement of its cellular elements are beyond the purpose of this article.^{14,18} Nevertheless, the logic put forth in previous works and the mathematical connection to the nervous system serve to ground the theoretical foundation for the model of advanced developmental care in this article.

Care practices such as positioning, feeding, comfort measures, technological interfacing, continuous assessment, respiratory support, safety measures, thermoregulation, infection control, and specific aspects of skin care all involve intentional interaction with the body surface. The practical representation of the various planets of care enables care providers to visually recognize the myriad patient touch points experienced/encountered during a hospital stay. With each care practice interaction there is the opportunity and responsibility on the part of the caregiver to integrate a developmentally supportive approach to care that recognizes the personhood of the patient and endows the caring interaction with dignity. All planets should be taken into consideration when interfacing with the baby. When attention is devoted to 1 planet, by virtue of their interdependence, other planets are affected. Similar to the belief that physiological systems are dependent on each other, care practices that involve the shared surface must value the contribution of other planets.

Family

As clinical interventions evolve to become caring interactions with the patient, the inclusion of the family in these interactions is a natural progression. As shown in the UDC model, the family planet orbits closely around the infant. This close proximity represents the true nature of the infant-family relationship within the context of the hospital/organizational environment. The partnership that must emerge between the NICU care provider and the parent/family is that of interdependency and collaboration acknowledging the unique and vital contribution of both the family and the care provider to the infant's health and well-being.^{19,20} A singular advantage of the UDC model of developmental care over previous approaches is that the family is included in the focus with the baby. It is the obligation of the caregiver to care for both child and family at the

shared surface in order to optimize development and long-term outcomes.

Staff

Beyond the infant–family microenvironment are the staff, the NICU environment, and the hospital organization as a whole. The placement of these critical components in a protective orbit around the infant–family dyad highlights the key role of the health-care community as a support network for the vulnerable, critically ill infant and family. Educational opportunities and staff training regarding the application and adoption of developmentally supportive care practices within the context of the UDC model provides a framework to operationalize this conceptual model and translate it into bedside practice.

Environment

The UDC model encompasses both the micro- and the macroenvironments. The microenvironment provides structure and support to the infant and recognizes the influence of environmental factors on the integrity and well being of the critically ill infant and family. These factors include light intensity, noise levels, design issues (ie, layout) as well as interpersonal behaviors. All these factors interface with the infant and constitute the shared environment of the caregiver and the patient, and, thus, cannot be ignored when promoting a developmentally supportive caring environment. Similarly, the macroenvironment, which includes organizational culture, communication, and collaboration between healthcare professionals/families and operational responsibility toward patient outcomes, plays a prominent role in effective process improvement strategies. Support from the macroenvironment is crucial to the implementation of change and is a critical component for successful adoption and integration of developmental supportive care as a standard of NICU care delivery.

THE UNIVERSE OF DEVELOPMENTAL CARE EXTENDS SYNACTIVE THEORY

For many years, the Synactive theory has provided the main theoretical underpinning for the practice of developmental care and the understanding of infant cues through physiologic state and motoric behaviors. The Synactive theory proposes that infant brain development proceeds in an ordered sequence with differentiation of behaviors becoming more evident with maturation. Brain development and subsequent behavioral responses take place at an individual rate, but are influenced by interactions with caregivers and the environment. This premise of the Synactive theory builds upon Brazelton's recognition that the infant is a reliable source of information and active adaptation, and attention to cues from the infant are reliable guides for modulating caregiver behaviors.^{21,22}

The major limitation of the Synactive theory is that the developing brain cannot be directly observed. Like other internal physiological systems, neither can the brain form the basis of direct care interactions nor can the brain serve as the primary foundation for understanding the means by which contact, communication, and closure occur. As the interface between the body and the environment, the skin links to the developing brain on one hand and to the external world on the other. Thus, the following practical and scientific problems are addressed in the UDC:

- The developing CNS of the premature infant cannot be compared with neural elements because nerve endings never touch the environment.^{14–17} Dynamic closure of the CNS required for feedback and learning requires closure at the periphery; such closure occurs precisely at the place of contact of the organism and the environment.
- The healthcare professional or parent cannot view the developing CNS directly; hence, behaviors must be described in terms relating to the interactive shared surface. This is also the surface of care that connects the bedside caregiver, family member, and the physical environment (light, sound, heat, fabrics, and interactions of caregivers and parents).

IMPLICATIONS OF THE UNIVERSE OF DEVELOPMENTAL CARE FOR PRACTICE

The UDC provides a practical approach for nursing care. Each planet can be clearly defined and evaluated for safety and efficacy in promoting developmental care. Each care planet has specific attributes relative to its practice domain and, as the model diagram depicts, there is a shared orbit. This shared orbit implies a lawful interrelationship among all the planets. A simple example of the UDC in practice is the removal of adhesives from the skin of an extremely low birth-weight infant. This procedure can be performed perfunctorily or, the care provider, may utilize a developmentally supportive approach positioning the infant comfortably using a facilitated tuck with nonnutritive sucking while gently removing the adhesive with a water-moistened cotton ball.^{19,23} This example demonstrates how the clinical activity in 1 “planet” can be supported through the integration of care practices from other “planets” to provide a holistic, universal framework for care delivery. The family, staff, and environmental orbits can also be used to direct nursing care. Core measures specific to each planet can be identified and strategies to meet the measures can be practiced at the individual or institutional level. Examples of how each planet can be used to enhance practice are provided in Table 1.

TABLE 1. Expanded Developmental Care Practices Within the Universe of Developmental Care Model

Monitoring/Assessment	Feeding	Positioning
Vital sign assessment	Early feeds	Supine
Behavioral assessment	Trophic	Prone
Physical examination	Donor milk	Side-lying
Electrodes	Cue-based feeds	Flexion
Invasive catheters	Nonnutritive sucking	Containment
Invasive/noninvasive monitoring	Breast milk mouth care	Midline orientation (proper body alignment)
CO ₂ monitor	Enteral feedings	Boundaries
Saturation monitor	Breast shields	Hand-to-mouth opportunity
Cerebral monitor	Bottlefeed	Safety
	Breastfeed	
	NGT feeds	
Infection Control	Safety	Comfort
Occlusive dressings	Patient ID bands	Pain assessment practices
Handwashing	Enteral only/parenteral only tubings	Pharmacological practices
Antibiotic use		Sucrose use
Prep solutions		
Antimicrobial ointments	Gentle touch	Skin-to-skin
Jewelry policies	Infant security systems	Massage therapy
Postoperative practices	Gel mattresses	Sleep regulation
Environmental issues (ventilation, garbage disposal)	Environmental issues (flooring, equipment)	Environmental factors
Thermoregulation	Skin care	Respiratory care
Humidity control	Touch	Intubation practices
Temperature probe	Soaps and emollients	CPAP interface
Swaddling	Bathing practices	Oxygen delivery systems
Plastic wrap	Cleansers and solutions	Instillations (surfactant, saline, nebulizers)
Room temperature	Adhesive removal	Suctioning practices
Solution temperature	Transdermal drug interface	
Clothing	Topical anesthetics	
Bedding	Wound care	
Family	Staff	Environment
Satisfaction	Satisfaction	Light levels
Level of involvement	Knowledge	Noise levels
Knowledge	Autonomy	Cultural, racial, religious sensitivity
Autonomy		Leadership quality

Abbreviations: CPAP, continuous positive airway pressure; NGT, nasogastric tube.

The UDC can also be used as an educational forum for developmental care. The theoretical underpinning of a shared surface can be used to highlight the critical importance of gentle touch. Educators can focus on individual planets to critically evaluate how each promotes developmental care. For example, the feeding planet could be used to educate professionals and families on the importance of cue-based feeding. Discussions about what is cue-based feeding and how to recognize infant cues of readiness can provide the basis for individualized feeding. Once individual planets are explored, the interdependence of each planet can be discussed as they relate to quality-care delivery to high-risk infants and families. The issues of cue-based feeding within 1 planet cannot be in isolation, in that attention to the comfort and safety planets should occur in synchrony.

The defined components of the UDC lend themselves to systematic evaluation. Baseline information regarding each planet can be obtained prior to the introduction of the UDC model and comparisons over time can be made. Infant outcomes such as traditional mortality and morbidity data are easily incorporated into the UDC model of care. Similarly, staff and family satisfaction as they relate to each planet can be tracked to identify future areas for change. The UDC model can be used to standardize definitions. Once definitions are understood, comparisons over time and between institutions can ensue. Audit tools, focus groups, individual interviews with professionals and/or families, or rigorous studies may be used to determine when objectives within the planets have been met.

LIMITATIONS OF THE UNIVERSE OF DEVELOPMENTAL CARE MODEL

The UDC model expands on several theoretical concepts, namely Synactive theory, Nightingale's principles of nursing practice, and the mathematical logic of epidermal structure as well as focusing on the importance of pathophysiology and environmental influences. Although the model has potential to alter the way we define developmental care, it requires validation. Studies to test individual and combined planets as they relate to infant, family, staff, and environmental outcomes are needed to strengthen the model. Further development and testing of core measures within the planets will also contribute to the testing and applicability of the model.

The major limitation of the model, however, relates not to the conceptual importance of the body surface in healthcare but, rather, to a more widespread failure to appreciate the scientific complexity and importance of the concept of a *shared* surface of care. In the UDC model, all notions appealing to 2 *self-contained* systems or entities are deemed illogi-

cal. We believe that persistent attention to the body/environment is the true scientific and logical basis for medical and nursing practice.

FUTURE DIRECTION

Developmental care has historically been underpinned by the premise that infant behaviors are the main methods of communication that guide health-care professionals in the provision of developmental therapeutic care. The behavioral observations and subsequent alteration of the caregiving environment are conceptually based on the knowledge of fetal brain and behavioral development. The limitation of such a conceptual framework, however, lies in the fact that we cannot see or directly touch the brain. Rather, we observe responses to various caregiving activities that are modulated by the infant's neurological integrity and influenced by perceptual experiences that occur at the surface of the infant.

As nurses, it is imperative that care is delivered in a safe, respectful manner, and based on the best available evidence. Since Nightingale, nursing theories have guided practice. It is believed that theories that are relevant to nursing practice will result in changes that can be sustained over time. The conceptual placement of the infant at the gravitational center while linking the infant externally via the physiological systems to the practical care planets (gray) is consistent with the shared surface of care model. It is believed that this theoretical concept will help bridge the gap between theory and practice so that developmental care is no longer an intangible item that is less important than other aspects of neonatal care.

We have argued that the shared surface interfacing the body and environment, rather than the brain, should provide the conceptual foundation for neurodevelopmental care and have proposed a new model, the *universe of developmental care*, which recognizes the multidimensionality of the caring environment and the pivotal relationship of the infant, family, and caregiver. The influences of the micro- and macroenvironments of care are clearly represented in the UDC model and provide a structural backdrop for systematic evaluation of various developmental care strategies. The proposed UDC model holds that developmental care is not a single entity that can be applied, purchased, or professed. It suggests that the integration of families and professionals to provide developmental care is based on the premise that all interactions begin at the organism-environment interface.

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References

1. Aylward GP. Neurodevelopmental outcomes of infants born prematurely. *J Dev Behav Pediatr.* 2005;26(6):427-440.
2. Bhutta AT, Anand KJ. Vulnerability of the developing brain. Neuronal mechanisms. *Clin Perinatol.* 2002;29(3):357-372.
3. Hack M. Young adult outcomes of very-low-birth-weight children. *Semin Fetal Neonatal Med.* 2006;11(2):127-137.
4. Hack M, Taylor HG, Drotar D, et al. Chronic conditions, functional limitations, and special health care needs of school-aged children born with extremely low-birth-weight in the 1990s. *JAMA.* 2005;294(3):318-325.
5. Philbin MK. The influence of auditory experience on the behavior of preterm newborns. *J Perinatol.* 2000;20(8, pt 2):S77-S87.
6. Symington A, Pinelli J. Developmental care for promoting development and preventing morbidity in preterm infants. *Cochrane Database Syst Rev.* 2006(2):CD001814.
7. Symington A, Pinelli JM. Distilling the evidence on developmental care: a systematic review. *Adv Neonatal Care.* 2002;2(4):198-221.
8. Als H, Tronick E, Lester BM, Brazelton TB. The Brazelton Neonatal Behavioral Assessment Scale (BNBAS). *J Abnorm Child Psychol.* 1977;5(3):215-231.
9. Brazelton TB. Does the neonate shape his environment? *Birth Defects Orig Artic Ser.* 1974;10(2):131-140.
10. Brazelton TB, Parker WB, Zuckerman B. Importance of behavioral assessment of the neonate. *Curr Probl Pediatr.* 1976;7(2):1-82.
11. Als H. Toward a synactive theory of development: promise for the assessment of infant individuality. *Infant Ment Health J.* 1982;3:229-243.
12. Als H. A synactive model of neonatal behavioral organization: framework for the assessment and support of the neurobehavioral development of the premature infant and his parents in the environment of the neonatal intensive care unit. *Phys Occup Ther Pediatr.* 1986;6:3-53.
13. Nightingale F. *Notes on nursing.* London: Harrison and Sons; 1859.
14. Hoath S. The skin as a neurodevelopmental interface. *NeoReviews.* 2001;2(12):e292-e301.
15. Hoath SB. Physiologic development of the skin. In: Polin RA, Fox WW, Abman SH, eds. *Fetal and neonatal physiology.* Vol 2. Philadelphia, PA: Elsevier Saunders. 2003;597-612.
16. Hoath SB, Leahy DG. The human stratum corneum as extended, covalently cross-linked biopolymer: mathematics, molecules, and medicine. *Med Hypotheses.* 2006;10:10.
17. Hoath S, Visscher M, Heaton C, Neale H. Skin science and the future of dermatology. *J Cutan Med Surg.* 1998;3(1):2-8.
18. Hoath S, Leahy D. Formation and function of the stratum corneum. In: Marks E, Leveque J-L, Voegeli R, eds. *The essential stratum corneum.* London: Martin Dunitz Ltd, 2002:31-40.
19. Naef R. Bearing witness: a moral way of engaging in the nurse-person relationship. *Nurs Philos.* 2006;7(3):146-156.
20. Nortvedt P. Subjectivity and vulnerability: reflections on the foundation of ethical sensibility. *Nurs Philos.* 2003;4(3):222-230.
21. Brazelton TB. Preface. Neonatal Intensive Care Unit Network Neurobehavioral Scale. *Pediatrics.* 2004;113(3, pt 2):632-633.
22. Als H. Developmental care in the newborn intensive care unit. *Curr Opin Pediatr.* 1998;10(2):138-142.
23. Fegran L, Helseth S, Slettebo A. Nurses as moral practitioners encountering parents in neonatal intensive care units. *Nurs Ethics.* 2006;13(1):52-64.