



The role of the children's nurse in optimising autonomic regulation in newborn infants

The Regul8 for Newborns framework

Minette Coetzee *PhD RN*

Domains and evidence summaries

Supporting autonomic regulation in infants and children

In the provision of nursing care of newborns, supporting the infant's regulation is key. Significant advances in various disciplines indicate that the process of supporting optimal autonomic regulation in newborns is a different and more complex process than it is in older children. Emerging evidence in human biology and neuroscience indicate eight key domains within which nursing practices can support optimal autonomic regulation in newborns.

Emerging evidence in human biology and neuroscience indicates eight key domains within which children's nursing practices support optimal autonomic regulation. These are:

1. Engaged maternal presence
2. No needless pain
3. Hydration
4. Nutrition
5. Managing the microbial load
6. Skin and mucosal integrity
7. Developmentally supportive care
8. A system of action

Rationale

The Regul8 framework is built on Florence Nightingale's 1860 assertion that *"What nursing has to do ... is to put the patient in the best place for nature to act"*.¹

The rationale at the heart of this approach is that **optimal autonomic regulation** is this best place and that there is good evidence that these 8 key domains **are fundamental to nursing care of newborns that intentionally supports regulation**. Within these domains, nursing activities include assessing, anticipating change, preventing deterioration and injury, planning care in anticipation of discharge planning and providing an intentionally supportive environment.

Observing regulatory function

Autonomic regulatory function is observable through activities that nurses routinely track and monitor, including:

Vital signs:

- thermoregulation
- respiratory rates and efficiency of breathing
- cardiovascular regulation measured by cardiac rate and force

and less frequently in newborns, blood pressure **including** arterial pressure and central venous pressure

Other observations:

- blood glucose maintained within normal glycaemic range
- comfort
- emotional and behavioural regulation
- sleep-wake rhythms

1 Nightingale, F., (1865). *Notes on Nursing: What it is and what it is not & notes on nursing for the labouring classes*. Reprint, New York: Springer Publishing Company, 2010.



Engaged Maternal Presence ... and autonomic regulation

This domain centers around the importance of the engaged presence of the mother to provide co-regulation as the infant encounters the extra-uterine environment, while simultaneously experiencing the distress of illness and healthcare interventions. Newborns and infants should never be left alone in clinical settings. The presence of the mother with the child is encouraged and supported at all times.

Evidence summary

- Research in human biology and neuroscience reveals a clear link between autonomic regulation in infants and children and the presence of the mother ^{1,4}
- There is evidence that newborns and children and caregivers physiologically regulate one another through social interaction, affecting both immediate physiological status and longer-term brain structure ²
- Studies in neonates have confirmed the validity of using objective autonomic nervous system parameters to assess stress. In the paediatric ICU, measuring heart rate variability as a stress indicator confirms that mothers' intervention during procedures results in a faster recovery.¹
- There is also evidence that the quality of the interaction between the mother and the child is linked to long-term health outcomes. ^{2,3, 5, 6}
- In addition, the field of reproductive biology confirms that all of a mother's body sensations help control the different aspects of the new born physiology of the infant and small child. This is called regulation. ⁴

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No Needless Pain ... and autonomic regulation

This domain acknowledges that discomfort, pain or anxiety are inevitable for newborns who require healthcare interventions either because they are sick or very small. The domain includes caring in ways that anticipate and avoid discomfort and distress, and recognising and managing pain without hesitation. It also includes the imperative to recognise constraints to pain recognition and treatment in newborns, which can include individual or professional beliefs and perspectives or institutional policy and practice norms.

Evidence summary

- Measurement and assessment of pain in newborns is complex. A newborn's pain intensity is determined by observing behavioural indicators. These include facial expression, sleep/wake state and muscle tone in addition to physiological indicators including oxygen saturation and cardiac rate.^{1,2,7}
- The infant's gestational age and maturity of the central nervous system are key in consideration in pain and comfort assessment.¹
- Recurrent or continuous unrelieved or inadequately treated pain rapidly results in physiological and emotional dysregulation.³
- The chronic stress of unrelieved pain results in above-normal levels of interleukin-6 (IL-6), an immune-system protein that promotes inflammation.³
- Research focusing on procedural pain has resulted in an increasing understanding of pain physiology in preterm and term infants.^{4,5}
- The complexity of postoperative pain, painful conditions, or continuous pain/stress, e.g, during ventilator support in very sick NICU infants with a variety of different conditions and different clinical states are more difficult to assess in optimal ways.^{4,9}
- There is evidence of the effectiveness of sucrose and non-nutritive sucking in procedural pain management in newborns including low and very low birthweight infants.⁵
- The development of 'cooperation-independent' monitors for pain are based on autonomic nervous system indicators, the best of which reflect variability in the parasympathetic tone (heart rate variability and the analysis of the respiratory fluctuations of heart rate).^{6,8,10}

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Hydration

... and autonomic regulation

This domain is primarily focused on hydration in newborns. It acknowledges the particularly complex and precise mechanisms that regulate hydration and water homeostasis. Water composes 75–80% of the newborn's body. Their proportionately large body surface area increases risk of insensible fluid loss. Maintaining optimal fluid balance in sick or small newborns and infants is imperative because these delicately balanced mechanisms are easily disrupted, and newborns have a heightened risk of dehydration.

Evidence summary

- The regulation of water balance is essential for the maintenance of health and life. The body composition of the foetus changes during gestation with water accounting for a smaller proportion of total body weight as gestation progresses.^{1,3}
- The foetus, preterm or term newborn is in a state of relative total body water and extracellular fluid excess. After birth this excess water must be mobilized and excreted.²
- Infants have a greater percentage of fluid in the extracellular compartment compared to adults; therefore, they have greater and more rapid fluid losses. More than half of an infant's total birth weight is in the extracellular compartment.²
- The surface area of the newborn is relatively large and increases with decreasing size. Therefore, insensible water losses will be greatest with small size and decreased gestational age.²
- This knowledge and appropriate monitoring are the mainstay of management of neonatal fluid balance. Important factors to keep in mind include gestational age and special circumstances like neonates who require surgery. Factors that determine accuracy include: (1) an estimation of trans-epidermal water losses; (2) an awareness of glomerular filtration rate and how this is influenced by age, respiratory distress and medical intervention; and (3) knowledge of tubular function and its maturation and the processes of postnatal adaptation.^{2,3}
- Water has many roles in the human body, all related to maintaining homeostasis and regulation. These roles include providing substance in cell wall integrity; functioning as a solvent, substrate and reactant for all chemical bodily functions; being the transport medium for nutrients and waste products; thermoregulation; lubrication, and shock absorption.¹
- The homeostatic mechanisms which detect and regulate water/fluid balance are very sensitive and are triggered by minute changes in plasma osmolarity. In young infants, dysregulation poses a significant challenge and a greater risk of dehydration or fluid overload than in older children and adults.¹

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Nutrition

... and autonomic regulation:

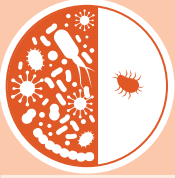
This domain is centered around maintaining optimal nutrient intake primarily with breastmilk, and while managing illness and restoring health. Establishing and maintaining feeding can be challenging for newborns, more so in healthcare encounters. Treatment regimens and hospitalisation often require infants to swallow unfamiliar substances, which may further affect appetite and intake. Supporting optimal nutrition for the newborn and infant in hospital requires sensitivity, patience and creativity.

Evidence summary

- Human milk is a dynamic source of nutrients and bioactive factors; unique in providing for the human infant's optimal growth and development. ¹
- Emerging laboratory techniques have enabled researchers to increasingly identify the multifunctional nature of human milk's bioactive components that directly contribute to immunity. This work articulates the vital and protective functions supporting infant's immature innate immune system. ^{2,3}
- The unique milieu provided by human milk to the intestine enhanced immune protection with diminished inflammation results from a complex interaction of anti-inflammatory and antioxidative factors. ⁴
- Human milk microbiome directly shapes the infant's intestinal microbiome, while the human milk oligosaccharides drive the growth of these microbes within the gut ⁴
- As the newborn infant's gastrointestinal tract and immune system develop, there is a transition in human milk over time to provide fewer immune factors and more calories and nutrients for growth. ^{4,5}
- Rather than the precautionary practice of keeping infants nil by mouth for long periods of time (e.g. in diarrheal disease), there is now good evidence for early and consistent feeding with breastmilk: ⁵
- Early feeding decreases changes in intestinal permeability induced by infection and supports better enterocyte healing and maintenance of disaccharide activity: ⁵
- There is clear evidence, directed by individual infant maturity to guide multidisciplinary clinical practitioners in successful lactation and initiation and long-term maintenance of oral feeding in preterm infants. ^{6,7}
- The risk of necrotizing enterocolitis increases in Infants who are fed formula rather than human milk. Human milk contains growth factors, antibodies and immune cells which may help prevent the condition. ^{8,9}

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Management of Microbial Load

... and autonomic regulation

This domain focuses on understanding and supporting the delicately balanced human microbiome which, in newborns, is established through the intake of the colostrum mothers produce directly after birth. This colonization of microbes has protective functions that affect the host's metabolism, immunity and response to infection. The developing and dynamic microbiome of the newborn is easily disrupted by stress, illness, and necessary treatments including antibiotic use, increasing vulnerability to pathogens.

Evidence summary

- The microbiota play a fundamental role in the induction and function of the newborn host immune system.¹
- The newborn's intestinal microbiome is a signalling hub that integrates environmental information from inputs e.g., diet, with genetic and immune signals to affect the host's metabolism, immunity and response to infection.¹
- During breast-feeding, the baby's saliva interacts with breastmilk to produce a potent combination of stimulatory and inhibitory metabolites that regulate early oral- and hence gut-microbiota.²
- Similar factors affecting the infant's or the mother's intestinal microbiomes also affect the milk microbiome. These include genetics, mode of delivery, geographic area, gestational age, maternal diet and nutrition, lactation stage and antibiotics.³
- The colon contains a vast quantity ($\times 10^{14}$) of commensal microorganisms that play an important role in enzyme production and enable the body to synthesize vitamins.⁴
- Pathogens (disease-causing organisms) are responsible for infections that can do harm to the host newborn. Microbial load and virulence of these pathogens affect the extent of the infection and the infection risk.⁵
- Prompt initiation of antibiotics to treat bacterial infections reduces morbidity and save lives. Optimising infection control measures and the use of antibiotics is critical to the effective treatment of bacterial infections; protecting infants from the harm caused by unnecessary antibiotic use is equally important, and helps to combat antibiotic resistance.⁶
- The physiological effects of critical illness and the clinical interventions of intensive care substantially alter the microbiome. In turn, the microbiome predicts infant's susceptibility to disease, and manipulation of the microbiome has prevented or modulated critical illness in animal models and clinical trials.⁷
- Microbial colonization of the upper respiratory tract occurs directly after birth and develops rapidly toward niche-specific profiles during the first weeks of life. This colonization process is strongly related to vaginal delivery as well as breastfeeding. initial early colonization after birth and subsequent development of the upper respiratory tract microbiota over the first months of life impact respiratory health.⁸

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Skin and Mucosal Integrity

... and autonomic regulation:

This domain focusses on supporting the integrity of the newborn skin and mucosa to provide the body's first line of defense and is vital for optimum innate immunity. Vigilance and skillful and proactive skincare can reduce risks to integrity arising from events such as dehydration, nutrient loss or venipuncture. The delicate skin-mucosal boundaries of nose, lips and the oropharyngeal mucosa are particularly at risk through common, traumatising and invasive interventions such as nasogastric or endotracheal tube insertion or suctioning of the airways.

Evidence summary

- Infant skin is critical to the newborn child's transition from the womb environment. The skin covers the exterior of the body, and the mucosal membranes line the interior surfaces, forming a boundary in contact with the surrounding environment. The integrity of these boundaries provides the body's first line of defense and contributes to optimum innate immunity.¹
- Newborn skin is critical to this transition and performs many functions, including: a. being a barrier to water loss, light, and irritants; b. infection control and immunosurveillance; c. resilience to mechanical trauma; d. sensation and tactile discrimination; d. thermal regulation; and e. acid mantle formation.¹
- Preventing a breach in the skin or mucosa in order to protect this integrity through preventative activities, barrier creams, dressings and moisturising further supports innate immunity.²
- Vernix facilitates well-formed stratum corneum (SC) layers of the skin in full-term infants through a variety of mechanisms including physical protection from amniotic fluid and enzymes, antimicrobial effects, skin surface pH lowering, provision of lipids, and hydration.²
- Premature infants, particularly those of very low birth weight, have a poor skin barrier with few cornified layers and deficient dermal proteins. They are at increased risk for skin damage, increased permeability to exogenous agents and infection.²
- Innate antimicrobial factors present in and on the mucosa form one arm of the innate immune system, protecting mucosal surfaces from bacterial infection. These factors can rapidly kill bacteria deposited on intact mucosal surfaces and prevent acute invasive infections.³
- The mucus layer, which is present throughout the GI tract and provides protection, lubrication, and compartmentalization, minimizing contact between the epithelium and commensal bacteria, is of vital importance in newborns.⁴
- The epithelial layers and mucus secretions of the pulmonary, genitourinary, and gastrointestinal (GI) systems all provide a complex mechanical barrier and an inherent defense against pathogens that constantly threaten the human body. Evidence suggests that these systems do not work independently, but form what is referred to as the mucosal immunologic system, an integrated network of tissue, cells, and signaling molecules⁴
- Innate immunity was previously thought to be a non-specific immunological mechanism that was engaged by peripheral organs to maintain homeostasis after stress and injury. Emerging evidence indicates that this highly organized response also takes place in the central nervous system.⁵

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Developmentally Supportive Care

... and autonomic regulation

This domain centers on providing neuro-supportive care to all newborns. It is care offered by or in partnership with the mother, caregivers and families in ways that support the newborn in supported flexion, in subdued light and low noise environments. Skin-to-skin care is ideal as it provides an environment perceived as 'safe' by the infant neurological system. This in turn supports the infant's growth and neurodevelopment. New understandings of neuronal wiring and the integration of cognitive, emotional and behavioural development show the complexity of influences on how newborns engage, respond and imitate, all setting them up to interact and learn to speak, think and regulate their responses and behaviour. This supportive awareness extends throughout the newborn period in both premature and term infants.

Evidence summary

- Technological advances in imaging and epigenetics have significantly expanded our understanding of neurodevelopment and show that supporting the process of development requires awareness of intricate vulnerabilities beyond simply monitoring growth and development. ^{1,2,3}
- Integration of the scientific knowledge bases around early childhood development has further intensified with emerging discoveries about development in the womb and in the first months of a newborn's life. ^{2,3}
- The core concepts related to child development and regulation are that: experiences build brain architecture; 'Serve and return' interaction shapes the brain; and toxic stress derails regulation and healthy development. ²
- Interventions that support neurodevelopment of newborns include skin-to-skin mother care; control of external sensory stimulation (light, noise, smells); clustering of nursing activities avoiding sleep disruption and positioning to maintain flexed supported posture or swaddling of the term and preterm infant. ⁴
- Advances in social neuroscience and interpersonal neurobiology add significant insights to attachment theory. ⁶
- Regulation and neurodevelopmental integration in children are linked to the presence of their mother or a trusted, engaged family member who facilitates regulation by their presence. ^{6,7}

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A System of Action ... and autonomic regulation

This domain is about establishing and sustaining health care systems that work for newborns - including units, facilities and health systems. Nursing care extends to supporting the functional operation of systems that are welcoming, safe, effective, timely, efficient, equitable, age-appropriate, directed by the best available evidence and provided in ways that are supportive of families and communities.

Evidence summary

- A system of action that facilitates best care in child health and paediatric healthcare services (units, clinical and larger systems) has at its core care encounters that are welcoming and safe. Encounters with newborns and their families should be engaged, supportive and facilitate restoring regulation in ways that limit perceived stress and thus enable children to better manage allostatic load.¹
- Child- and family-friendly healthcare is about ensuring best evidence-based care of children at every level of health care provision. It requires quality care of children that ensures no needless deaths, no needless injury, no needless waste, no needless waiting, no needless helplessness, and no-one left out – not children, nor their families, nor health care providers.²
- The familiar attachment patterns of protest, despair and detachment that are visible in young infants separated from their mothers are now understood to result from the loss of regulatory functions that would otherwise be provided through the mother's presence.^{1,3}
- From the preceding evidence in this document, the negative effects of the practice of separating the mother-child pair during treatment procedures and hospitalisation of the child should be clear.^{1,2,3,8}
- Separation of the mother-child pair during healthcare events, starting from the immediate newborn period, results in harmful effects of dysregulation and subsequent epigenetic changes. Clinical practice models that mitigate this include Zero Separation, Kangaroo Mother Care and Skin-to-Skin Care, and Care-Through-Family.^{1,5,6,7}
- When stress is intentionally managed and reduced for the newborn, the stress of caregiving should also be reduced, especially in the context of the high demand placed on staff in limited-resource settings.^{5,6}
- Neonatal staff should be included as experts in the design and layout upgrade of NICUs to ensure optimal design for best practice models that support infant recovery, growth and neurodevelopment.⁸
- A system of action ensures efficient care delivery and flow. It is centered around monitoring and management of practice breakdowns, resolving conflict, resolving system failures, and designing and delivering contextually appropriate care that utilises the best available evidence in conjunction with locally available resources.⁹

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About this framework

This Newborn Regul8 framework represents an approach to the provision of providing fundamental newborn and children's nursing care to newborns. The original Regul8 framework, was developed by Dr Minette Coetzee at The Harry Crossley Children's Nursing Development Unit in the Department of Paediatrics and Child Health, University of Cape Town between 2008 and 2019. Formally known as the Seven Steps, and then the Seven (Plus One) Steps, the impetus for the work was to align emerging understandings and research outcomes with current children's nursing practice. Concepts were developed through continuous exploration of emerging scientific fields and refined through a decade of teaching and learning alongside children's nursing students, practitioners and educators from across Africa.

In 2022 the framework was reconsidered to incorporate the growing evidence base from the neurodevelopment and development biology, and this second framework, known as NewbornRegul8 was developed. This adapted framework is designed to comprehensively address the major influences on regulatory function through an intentionally Afrocentric guide to newborns' nursing care planning.

This poster can be downloaded at
<https://doi.org/10.25375/uct.23500752>

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The Harry Crossley Children's Nursing Development Unit,
Department of Paediatrics and Child Health, Red Cross
War Memorial Children's Hospital Campus, Klipfontein
Road, Rondebosch, Cape Town 7700. South Africa
Tel+27 (0)63 554 5548

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