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 ORIGINAL ARTICLE

The Importance of Skincare for Neonates and Infants: An Algorithm

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ABSTRACT

Background: The skin of neonates and infants undergoes a maturation process from birth and is susceptible to barrier disruption. The current algorithm follows a US-based consensus paper on skincare approaches using gentle cleansers and moisturizers in neonatal and healthy infant skin. This summary provides clinical information for pediatric dermatologists, dermatologists, and pediatric healthcare providers treating neonates and infants.

Methods: The project used a modified Delphi process comprising virtual discussions followed by an online follow-up replacing the use of a questionnaire. During the virtual meeting, the systematic literature review results and a draft algorithm addressing over-the-counter skincare for neonates and infants with healthy skin were discussed and adopted using evidence coupled with the expert opinion and experience of the panel.

Results: The algorithm addresses three clinical signs: xerosis, erythema, and erosion/bulla. A growing body of evidence recognizes the benefits of ongoing daily use of non-alkaline cleansers and ceramides containing moisturizers to reduce inflammation and maintain a healthy skin barrier function. Diaper rash is common in infants presenting as erythema or, in more severe cases, skin erosion. Skin protection with a barrier cream and frequent diaper changes using disposable diapers resolves most cases; however, if the rash continuous despite appropriate care, rule out a *candida* infection.

Conclusion: The current algorithm focuses on neonatal and infant healthy skin that can benefit from skincare. When applied from birth onwards, gentle cleansers and moisturizers containing barrier lipids help maintain the protective skin barrier.

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INTRODUCTION

At birth, human skin is structurally and functionally immature, with elevated skin surface pH, lower lipid content, and lower resistance to chemicals and pathogens.[1-5] From birth, the dynamic skin maturation process takes two years or longer, during which the neonate and infant skin is susceptible to barrier disruption.[1-3]

Compared to the adult stratum corneum (SC), the infant skin barrier is thinner and more subject to higher trans-epidermal water loss (TEWL) and skin conductance.[2-7]

The SC and supra-papillary epidermis structures were thinner in infants than adults in two systematic reviews, indicating a continuous structural maturation process of the infant skin.[6,7] These reviews further showed a functional maturation process of the infant skin expressed by a higher TEWL and elevated skin surface conductance values for infant skin than adults.[6,7]

Further studies comparing SC properties of infants and adults also showed higher TEWL and conductance rates and a significantly thinner supra-papillary epidermis for infants compared to adults at three months to twenty-four months.[2-4] These studies also showed that the proteolytic enzymatic activity was higher for infants than adult skin.[2-4]

In utero, the epidermis' final differentiation and the SC formation in the last trimester coincide with vernix caseosa covering the fetal skin surface.[8] The lipid content of vernix caseosa comprises cholesterol (52.8%), free fatty acids (27.7%), and ceramides (20.1%).[8] The vernix caseosa increases hydration, suppleness and decreases skin surface pH facilitating bacterial commensal development.[8-11]

Neonates and infants are particularly vulnerable to transcutaneous toxin exposure as they have a high surface-to-weight ratio, immature epidermis, and a compromised skin barrier.[12] Depending on systemic absorption, topical agents, which are harmless for adults, may cause respiratory distress, neurological toxicity, and even death in the neonatal and infants age groups.[13] Topical agents that may cause toxic reactions include isopropanol, benzocaine, pyrethrin, hexachlorophene, and salicylic acid, among others.[13]

During the skin's maturation process, the SC barrier of neonates and infants is especially vulnerable.[14] Exposure to common irritants, including saliva, nasal secretions, urine, feces, fecal enzymes, dirt, and microbial pathogens for long periods can lead to discomfort, irritation, infection, and skin barrier disruption.[14] Furthermore, the epidermal unsaturated fatty acids are easily extracted during cleansing, compromising SC barrier function.[15]

In neonatal and infant skin, the ratio of free fatty acids/cholesterol/ceramides (CERs) is not static.[14] Without the proper CERs ratio, the SC barrier function can become incompetent impairing barrier homeostasis, leading to dryness, irritation, erythema, and itching.[16]

There is a growing body of evidence supporting safe and effective skincare starting early in life. The evidence recognizes the benefits of ongoing daily use of non-alkaline cleansers and ceramides containing moisturizers to reduce inflammation and maintain skin barrier function.[14] When applied from birth onwards, gentle cleansers and moisturizers containing barrier lipids help maintain the protective skin barrier and soothe the skin with long-term moisturizing benefits.[14]

Scope

The current algorithm follows a US-based consensus paper on skincare approaches using gentle cleansers and moisturizers in neonatal and healthy infant skin.[14] The algorithm applies the recommendations discussed in the consensus paper to provide clinical information for pediatric dermatologists, dermatologists, and pediatric healthcare providers treating neonates and infants.[14] Other skin conditions that differ from neonatal and infant healthy skin are outside the scope of this publication.

MATERIALS AND METHODS

Literature Review

A systematic literature review explored present clinical guidelines and clinical research on skincare regimens for neonatal and infant healthy skin. Priority was given to studies addressing skin barrier function in newborns and infants and the clinical and quality of life (QoL) benefits of skincare in this population. Excluded were duplications, articles of insufficient quality [small sample size, poor methodology], and the latest version was used in the case of a review article. The results of the searches on 13–15 January 2020 for the consensus paper[14] were updated with searches on 01–02 October 2020. PubMed and on Google Scholar, as a secondary source, were searched for English-language literature (2010–2020) using the following terms:

Pediatric skin; maturation; skin physiology of neonates and Infants; vernix; infant skin barrier physiology; function; pathology; dysfunction; epidermal maturation's markers; erythema in neonates and infants; skin breakdown in neonates and infants; diaper care, umbilical cord care, protection infant skin barrier; fragility of epidermis in infants; depletion of stratum corneum lipids; cleansers; moisturizers; emollients; skincare in newborns and infants; ceramides; ceramide containing skincare; skin maturation and moisturization.

The selected publications were manually reviewed for additional sources by LS and AA and then graded using the American Academy of Dermatology evidence-based guideline development process.[17-19] For grading study type: A = clinical double-blind, randomized controlled trial [RCT] of high quality, B = RCT of lesser quality, and C = comparative trial with severe methodologic limitations.[19] For grading clinical evidence, four grades apply [1 = further research is unlikely to change confidence in the estimate of effect, to 4 = any estimate of effect is very uncertain].[19]

The searches yielded 106 papers deemed clinically relevant to healthy neonatal and infant skin, the use of over-the-counter (OTC) skincare, and ceramides containing skincare. After excluding duplicates and articles not related to neonatal and infant skin or OTC skincare, the summary included fifty-one publications. The selected articles comprised sixteen clinical studies (Table 1), fourteen systematic reviews, consensus papers or guidelines (Table 2), and twenty-one others.

Development of the Algorithm

The project used a modified Delphi process, a communication technique for interactive decision-making for medical projects.[17,18] The process entailed preparing the project, selecting the panel, and conducting systematic literature searches followed by two steps (Figure 1). Step 1 has been completed and yielded the consensus paper.[14]

TABLE 1.

Grading of Clinical Studies		
Reference	**Clinical Study Type**	**Grading**
Liu Q, et al, *Hindawi Biomed Research Int* 2018[1]	Cohort on infant barrier structure	B2
Nikolovski J et al, *J Invest Dermatol* 2008[2]	Clinical research study on barrier properties	C2
Fluhr JW et al, Br J Dermatol 2014[3]	Study on epidermal maturation markers in infancy	B2
Boiten WA et al, *J Lipid Research* 2018[8]	Study using tape-stripping and TEWL to assess lipid organization	C2
Dominguez-Bello MG et al, *Proc Natl Acad Sci USA* 2010[10]	Multiplexed 16S rRNA gene pyrosequencing to characterize bacterial communities from mothers and their newborn babies, four born vaginally and six born via Cesarean section	B2
Sahle FF et al, *Skin Pharmacol Physiol* 2015[16]	Research study on SC lipids and topical lipid substitution	B2
Younge NE et al, *Microbiome* 2018[24]	A cross-sectional study on preterm and term infants to characterize the skin microbiota	B2
Chittrock J et al, *Br J Dermatol* 2014[27]	Study on the development of SC protease activity and NMF from birth to 4 weeks of age compared to adults	A2
Kelleher M et al, *J Allergy Clin Immunol* 2015[32]	Skin barrier dysfunction in neonates predicts AD	B2
Lavender T et al, *J Obstet Gynecol Neonatal Nurs* 2013[33]	RCT including biophysical measurements on bathing with a cleanser and water versus water alone	A2
Garcia Bartels N et al, *Pediatr Dermatol* 2010[37]	RCT on neonatal skin barrier function	A2
Mack MC et al, *Pediatric Dermatol*[39]	Water-holding and transport properties of skin stratum corneum of infants and toddlers	A2
Yuan C et al, *BioMed Research Inter* 2017[40]	Developmental changes in ceramides and in protein secondary structure of the SC	A2
Kircik LH et al, *J Clin Aesthet Dermatol* 2011[42]	A sub-analysis of clinical efficacy and safety of a ceramide containing emulsion	B2
Lynde CW et al, *Cutis* 2014[43]	Cohort study using a ceramide containing cleanser and moisturizer in AD	B2
Gras-Le Guen C et al, *Pediatrics* 2017[49]	Dry care versus antiseptics for umbilical cord care	B2
	Total 16: A2:5, B2:9, C2:2	

A = Randomized, double-blind clinical trial of high quality
B = Randomized clinical trial of lesser quality
C = Comparative trial with severe methodologic limitations
1 = Further research is unlikely to change confidence in the estimate of effect
2 = Further research is likely to have an important effect on confidence in the estimate of effect and may change the estimate
3 = Further research is very likely to have an important effect on confidence in the estimate of effect and is likely to change the estimate
4 = Any estimate of effect is very uncertain.

Step 2 comprised the development of the neonates and infants' skincare algorithm. To that end, the panel comprised of four pediatric dermatologists, one dermatologist, two pediatricians, and one basic scientist from the US convened a virtual meeting on February 5, 2021. The virtual discussion was followed by an online follow-up replacing the use of a questionnaire.[17] During this meeting, the systematic literature review results addressing OTC skincare for neonates and infants with healthy skin were discussed and adopted using evidence coupled with the expert opinion and experience of the panel. During the meeting in three small groups using virtual breakout rooms, the panel discussed and adapted the draft algorithm that was prepared by LS and AA based on the results of the literature searches. The breakout session was followed by presenting the three adapted versions of the algorithm to the group. An online process was then used to fine-tune the algorithm, reach consensus, and prepare and review a manuscript for publication.

The Algorithm

Figure 2A shows the algorithm which uses the Neonatal Skin Condition Score (NSCS), a validated scale to assess skin condition.[20] The NSCS includes three clinical signs: 1) Xerosis, 2) Erythema, and 3) Skin breakdown.[20] A 3-point scale is used to score the skin condition per sign [1 = normal, no signs, 2 = visible signs, 3 = extensive signs] (Table 3).[20] After scoring per sign, the total score for all three signs is calculated. A perfect score equals three, and the worst score equals nine. If a neonate or infant scores a single score of three of one sign area or a combined score of six and above, a physician must be notified. A dermatology referral may be appropriate in this case.[20-23]

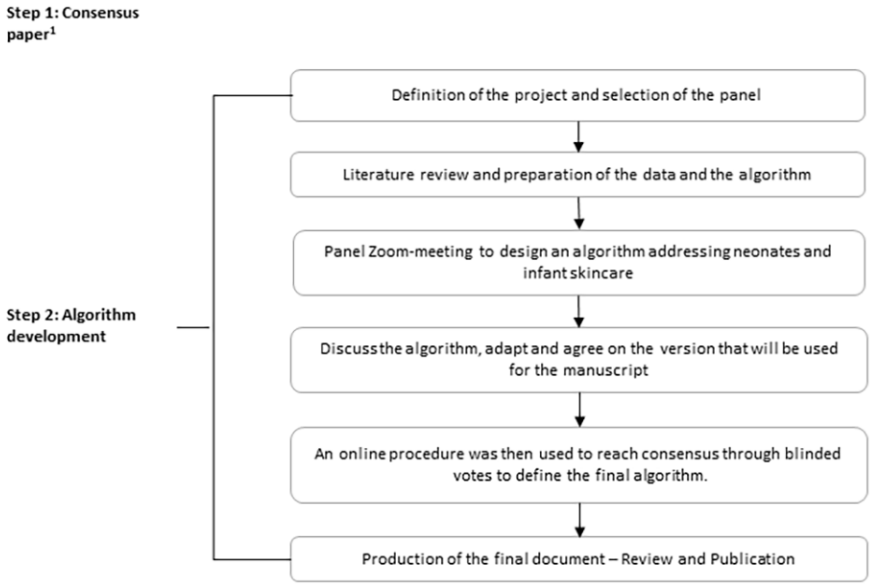
According to the panel, the NSCS scoring system initially developed to assess the skin condition of neonates is also applicable for infants. However, the cause of xerosis, erythema, and skin breakdown may be different.

TABLE 2.

Grading of Systematic Reviews, Guidelines, and Consensus Papers		
Reference	**Clinical Study Type**	**Grading**
Ludriksone et al, *Arch Dermatol Research* 2014[6]	Skin barrier function in infancy: A systematic review	A1
Kottner J et al, *Arch Dermatol Research* 2013[7]	Transepidermal water loss in young and aged healthy humans: a systematic review and meta-analysis	A1
Blume-Peytavi U et al, *Pediatr Dermatol* 2012[9]	Best practice review on skincare for neonates	B2
Cices A et al, *Am J Clin Dermatol* 2017[12]	Poisoning through pediatric skin	C2
Schachner et al, *J Drugs Dermatol* 2020[14]	Consensus on ceramide containing skincare for neonates and infants	C3
Alwood et al, *NPCHN* 2011[21]	Skincare guidelines for infant's 23–30 week 'gestation	C3
Cooke A et al, *British J Midwifery* 2018[34]	A systematic review and meta-analysis of skincare in newborns	B2
Blume-Peytavi U et al, *J Eur Acad Dermatol Venereol* 2009[35]	Consensus on bathing and cleansing in newborns	C2
Crozier K et al, *Evidence-Based Midwifery* 2010[36]	Structured literature review on skincare for neonates and infants	C3
Lynde CW et al, *J Drugs Dermatol* 2020[41]	A systematic review of SC pH in inflammatory conditions	C2
Clemison J et al, *Cochrane Database of Systematic Reviews* 2016[45]	A systematic review on cleansing products for neonatal skincare	B2
WHO 2014[47]	Postnatal Care of the Mother and Newborn	C3
Leante Castellanos JL et al, *An Ped* 2019[50]	Recommendations for umbilical cord care	C2
Schachner LA et al, *J Drugs Dermatol* 2021[51]	Consensus impetigo treatment and antimicrobial resistance	A2
	Total 14: A1:2, A2:1, B2:3, C2:4, C3:4	

Neonatal, Paediatric and Child Health Nursing (NPCHN)
A = Randomized, double-blind clinical trial of high quality
B = Randomized clinical trial of lesser quality
C = Comparative trial with severe methodologic limitations
1 = Further research is unlikely to change confidence in the estimate of effect
2 = Further research is likely to have an important effect on confidence in the estimate of effect and may change the estimate
3 = Further research is very likely to have an important effect on confidence in the estimate of effect and is likely to change the estimate
4 = Any estimate of effect is very uncertain.

FIGURE 1. Steps in the process of algorithm development.



Step 1 of the process yielded publication of the consensus paper.[1]
The selected literature has to be clinically relevant to the algorithm.

FIGURE 2A. Algorithm for skincare in neonatal and infant skin.

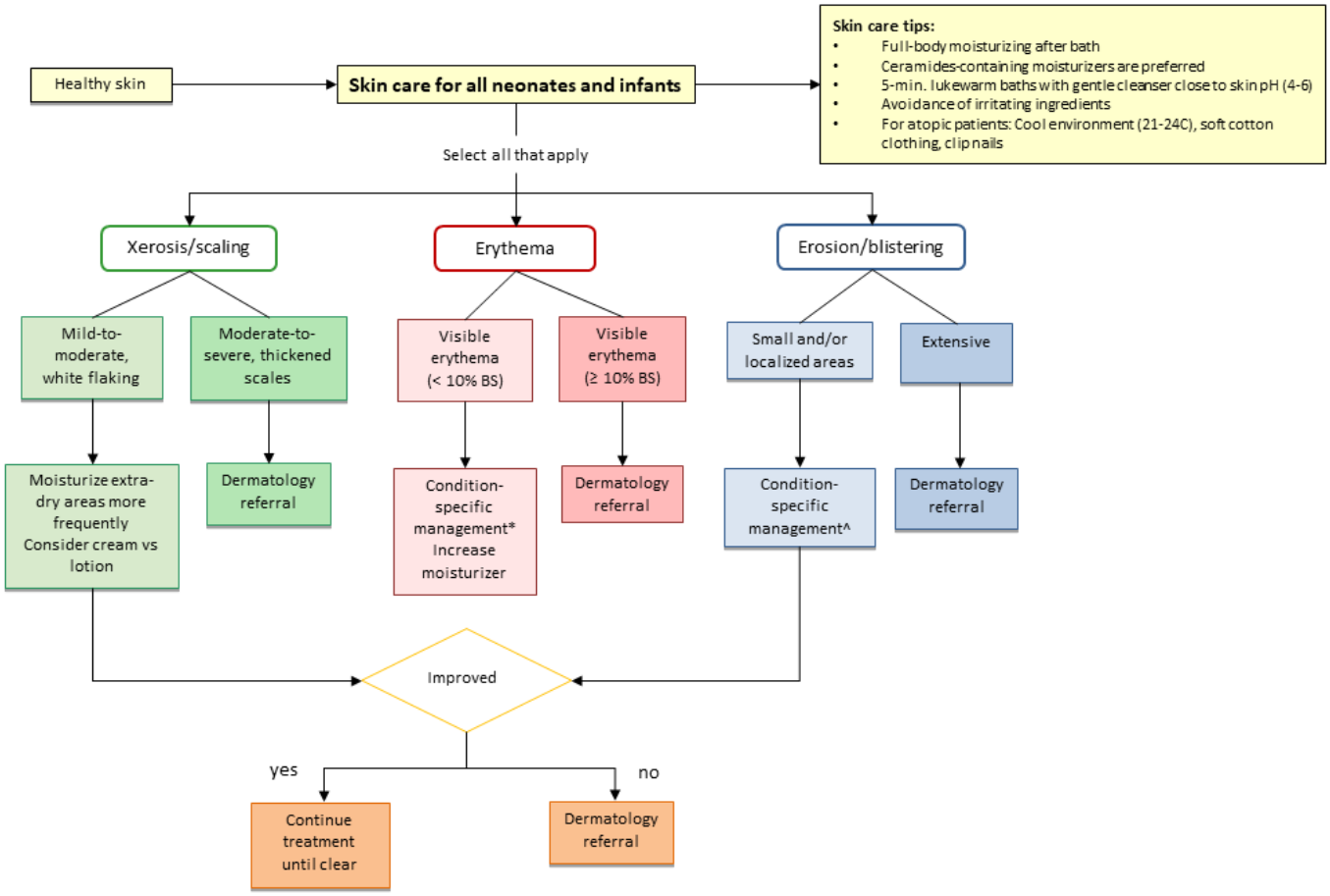


*Fig 2B, †Fig 2C
The scoring system of the Association of Women's Health, Obstetric and Neonatal Nurses (AWHONN) and the National Association of Neonatal Nurses (NANN) (copyright 2018) was adapted from a visual scoring system (Lane & Drost, 1993).[20,21]

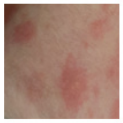
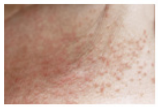
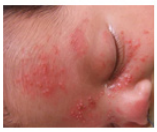
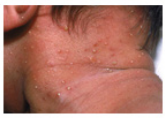
SC Differences Between Premature and Term Neonates

Term neonates have a well-developed SC containing 10–20 layers.[5,21] In premature neonates, depending on the neonate's gestation age, the SC may only have 2–3 layers.[5,21] The immaturity of the SC may result in increased moisture and heat loss leading to electrolyte imbalance, reduced thermoregulation, and increased infection risk.[3-6,21] Cohesiveness of the epidermis to the dermis differs in premature and term infants. Fibrils providing the cohesion between the epidermis and dermis are fewer and more widely spaced in preterm neonates.[3-6,21] This decreased cohesion increases the risk of skin injury, and thus the use of adhesives on the skin of neonates, especially premature babies, should be limited. If the adhesive used forms a stronger bond with the epidermis than the epidermis to the dermis, skin breakdown is likely.[21-23]

Differences in the skin surface pH also exist between premature and term newborns.[4-8,21] A slightly acidic skin surface plays an essential role in the maturation and maintenance of the SC, also inhibiting the growth of pathogenic microorganisms.[21] The vernix caseosa layer on the skin helps maintain skin hydration, thermoregulation, and skin acidification.[8] Premature infants of varying gestational ages and term infants are born with a more alkaline skin surface (pH >6.0).[21-23] For term infants, this usually falls to less than pH 5.0 within the first three days of life, providing a functional SC barrier.[21-23] Due to an immature skin structure and the reduced or negligible amount of vernix caseosa, the premature infant, has an alkaline skin surface for a more extended period.[5,8] The skin pH of a premature infant may take one week to decrease to pH 5.5 and up to a month to reach pH 5.1 and is therefore even more susceptible to xerosis, skin irritation, and infection at this time.[4,21-24]

An unbalanced skin microbiome may also play a role in the newborn period.[24]The skin microbiome in infants born vaginally has shown to be different from those delivered by Caesarean section. The clinical relevance of this finding needs further research regarding the potential of resultant dermatoses, which may benefit from skincare containing SC lipids such as ceramides.[14,16,24,25]

FIGURE 2B. Erythema specific management of neonates up to 11 months.

	Erythema	Clinical Features	Duration Treatment
	Erythema Toxicum Neonatorum	Various combinations of erythematous macules (flat red patches), papules (small bumps) and pustules.	Typically lasts for several days, requires no treatment.
	Miliaria	1–3 papules or vesicles. Location: typically, truncal and/or in areas of occlusion.	Remove from heated humid environment. Cool bathing or apply cool compresses. Topical steroids may be used to facilitate relief.
	Neonatal cephalic pustulosis Pityrosoprum Folliculitis	Erythematous dome shaped papules and superficial non-pruritic pustules arise in crops. Location: cheeks, nose and forehead, neck, upper chest.	Will resolve within weeks without treatment. If extensive, can treat with topical antifungals.
	Transient neonatal pustular melanosis	More common in infants with skin of color. Small pustules that resolve into hyperpigmented macules.	Gradually fade without treatment over several weeks to months.

The Neonatal Skin Condition Score[20,21] (NSCS) Erythema:
1 = no evidence erythema 2 = visible erythema 40% body surface 3 = visible erythema >SO% body surface

FIGURE 2C. Erosion and bullae specific management.

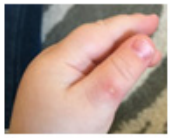
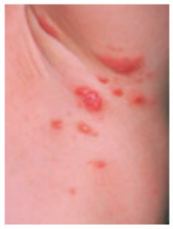
	Erythema	Clinical Features	Duration Treatment
	Mechanical trauma bullae (sucking, friction)	Bullae occur just below that stratum granulosum	Closed blisters cleanse the skin using a gentle cleanser and lukewarm water followed by the application of a moisturizer. For open blisters, a dressing may be needed. Select a dressing depending on the wound bed condition and exudate levels. Various dressings may be used, such as a foam dressing, a hydrofiber dressing or a non-adherent wound contact layer, including silicone-coated dressings.[48] The frequency of dressing change depends on exudate level.
	Burns and scalds	Painful erythema, bullae positiev capillary refill	On open burn, blisters cut the hydrofiber dressing to shape and leave in place until epithelialization is complete.
	Bullous scabies	Pruritic erythematous papules and burrows. Distinguish from diaper rash in ages 3–6 months.	Permethrin with two applications one week apart for infants older than 2 months of age. Lindane when there are concerns on neurotoxity.[46]

TABLE 3.

Neonatal Skin Condition Score		
Dryness	**Erythema**	**Breakdown**
1 = Normal, no signs of dry skin	1 = No evidence of erythema	1 = None evident
2 = Dry skin with visible scaling	2 = Visible erythema (<50% body surface)	2 = Small and/or localized areas
3 = Very dry skin with cracking and/or fissures present	3 = Visible erythema (>50% body surface)	3 = Extensive

Adapted from AWHONN guideline[20,21]
Interpretation of the results:
Perfect score = 3; Worst score = 9.
The relevant medical team must be notified if a neonate scores a single score of 3 in one area or a combined score of 6 and above. A dermatology referral may also be appropriate.

TABLE 4.

Types of Skin Cleansers		
Type of cleanser	**Description**	**pH**
Soap	Contains fat and alkali-treated salts of fatty acids	9.0–12.0
Syndet bar	Contains synthetic detergents	4.0–6.0
Combar	Contains equal parts of soap-based detergent mixed with a synthetic detergent	10.0–12.0
Liquid cleanser	Contains synthetic detergents, can be ionic or anionic in lotion, cream, oil, or gel form	6.0–7.0
Cleansers containing lipids that mimic physiological lipids	Non-soap-based cleaners containing synthetic detergents and lipids such as CERs	5.0–6.0

Adapted from Schachner et al[14]

Xerosis and Scaling in Neonates and Infants

The epidermal barrier is composed of corneocytes, held together with corneodesmosomes.[26,27] SC barrier function depends on the complex interplay among SC pH, desquamation rate, and the appropriate ratio of skin lipids.[16] The intercellular lamellar lipid membrane is primarily composed of CERs, cholesterol, and fatty acids, which play a vital role in SC hydration's physiological maintenance.[28,29] The SC lipids are composed of CERs (40–50%), cholesterols (20–33%), and free fatty acids (7–13%).[28,29] Other SC lipids include cholesterol-3-sulfate (0–7 %) and cholesteryl esters (0–20 %).[28,29] The SC contains numerous different CERs. The number of hydroxyl groups in the head group of the CERs appears to be playing a critical role in the SC barrier function.[28,29]

The importance of the individual structural features of CERs is not fully understood.[16,29,30] In neonatal and infant skin, the ratio of free fatty acids/cholesterol/CERs is not static.[14] Without the proper CERs ratio, the SC barrier function can become incompetent impairing barrier homeostasis, leading to dryness, irritation, erythema, and itching.[16]

Premature infants SC is deficient in essential fatty acids due to less fat-storing capacity.[21,31] SC lipid deficiency can present as superficial scaling of the skin and desquamation and irritation in the neck, groin, and perianal areas.[21,31]
Xerosis in infants may be indicative of a predisposition to AD. An impaired skin barrier function (measured as increased TEWL) assessed at birth and two months of age may precede clinical AD.[25,32]

The panel members agreed that prevention of AD is a broad topic that requires discussion of key studies and evidence beyond this algorithm's scope, which focuses on skin barrier function and the role of skincare in healthy neonates and infants.

Skincare

Skincare, including a gentle cleanser and moisturizer, is important in all neonates and infants and should begin immediately after birth, but must be safe and products must be appropriate for a newborn's skin based on its unique characteristics (Box 1).

Newborns and infants have a high surface-to-weight ratio, immature epidermis, and a compromised skin barrier, making them particularly vulnerable to transcutaneous toxin exposure.[12] Topical agents, which are harmless for adults, may cause respiratory distress, neurological toxicity, and even death in infants depending upon systemic absorption.[12] Topical agents that may cause toxic reactions include isopropanol, benzocaine, pyrethrin, hexachlorophene, and salicylic acid, among others.[12]

Skincare for neonates and infants should be safe, effective, fragrance and sensitizing agent-free. Skincare with CERs may benefit the stratum corneum's lipid and water content.[14]

Skin Hygiene and Cleansers

Bathing details are provided in Box 2. The frequency of bathing and time of day should be based on individual preference.[14]

Soaps, surfactants, and detergents, especially those with an alkaline pH, may excessively remove skin lipids, which is explicitly damaging to neonatal and infant skin.[14] Skin cleansers with a near physiologic skin surface pH (4.0–6.0) containing CERs and no soap are less irritating than alkaline soaps and may reduce skin irritation (Table 4).[9,14,15,21-23] When the skin is dried, corneocytes' rapid dehydration can lead to their release from the lipid matrix, creating cracks and facilitating penetration of

the surfactant to deeper layers.[15]

Box 1: Skincare tips

- Bathing (QD or QOD)
- Gentle cleanser with physiological pH
- Apply head-to-toe moisturizer after bath once daily for all infants
- Apply moisturizer more frequently for dryness, fissures, or flaking
- Maintain good hygiene by using one baby-specific container and a single-use applicator
- Provide a cool environment
- Use soft cotton clothing
- Clip nails regularly to avoid injury

A synthetic cleanser of non-ionic and amphoteric surfactants (pH around 5.5) was compared to water for skin cleansing of infants.[33] Biophysical and clinical measurements (TEWL, pH, SC hydration, dryness, erythema) revealed that both did not compromise SC integrity.[33] Various papers recommend that a pH-neutral, mild liquid cleanser is the preferred infant cleansing choice.[9,14,15,21-23]

Synthetic cleansers that do not contain soap may avoid adverse effects; however, robust evidence and clinical consensus on their use in neonates and infants are lacking.[33-38]

The inconsistent outcome measures hamper the available evidence on bathing, cleanser use versus water alone, and diaper care.[34]

The choice of cleanser and moisturizer is dependent on individual preference as long as the products used are free of fragrance and common sensitizers.[14]

The panel agreed that the advice that may be given to parents includes synthetic cleansers or liquid cleansers containing a mixture of fatty acids, cholesterol, and CERs.[14]

Box 2: Bathing

- Frequency of bathing and time of day should be based on individual preference
- Appropriate safety measures should be implemented
- Cleanse the bath with water before and after each use
- Water should be deep enough to allow the neonates shoulders to be well covered
- Cleansers should be free of potential irritants such as fragrance, alcohol, essential oils, botanicals (eg, lavender), and harsh detergents (eg, sodium lauryl sulfate)
- A neutral or mildly acidic (pH 4–6.0) cleanser may be used
- Maintain an adequately heated external environment, with an ideal room temperature of 21 – 24°C (close the doors to the room to minimise convective heat loss)
- Neonates and infants should be immediately covered with a towel and patted almost dry
- Ensure all skin folds are dried thoroughly (armpits, groin, neck, and behind the ears)
- A moisturizer is to be applied head to toe for skin dryness prevention and management

humectants, or emollients.[14] Moisturizers with occlusives, such as petrolatum, mineral oil, lanolin, olive oil, jojoba oil, etc, coat the SC and decrease TEWL.[14] Moisturizers with humectants can improve hydration of the SC, but in dry weather conditions can dry the skin further.[14] For that reason, these agents should be used together with occlusives.[14] Examples include glycerin, urea, hyaluronic acid alpha, beta hydroxy acids, propylene glycol, etc.

Emollients may include SC type lipids, such as CER, fatty acids, cetyl stearate, cholesterol, etc., which soften and smooth the skin by filling spaces between skin cells and creating a smooth skin surface.[14]

A systematic review and meta-analysis of evidence suggest that daily use of full-body emollient therapy may reduce the risk of AD in infants with a genetic predisposition to AD; however, the use of olive oil or sunflower oil for infant xerosis may adversely affect skin barrier function.[34]

Formulations that contain ceramides mimic physiological lipids supporting homeostasis and improving skin condition.[14,39-46] Those with dry and sensitive skin and particularly neonates and infants at risk for AD or having AD, greatly benefit from frequent moisturizer use (Box 3).[14] Moisturizer use decreases pruritus, symptoms, and the severity of AD, while also improving quality of life.[14,42,43,46] Moreover, the number of AD flares and the time to flaring is reduced when ceramide-containing skincare is frequently applied.[14,42,43,46]

Box 3: Moisturizer Use

- Apply a moisturizer head to toe daily once daily, for all infants
- Apply moisturizer more frequently for dryness, fissures or flaking of the skin
- Maintain good hygiene by using one baby-specific container and a single-use applicator
- Products should contain well- tolerated preservatives and be free of common sensitizers
- Moisturizers containing skin lipids such as CER may offer additional benefits

Erythema

Neonatal skin differs in structure and function from adult skin, and hence the dermatoses seen during this period differ in their clinical presentation. Depending on the etiology, various groups of dermatoses may be distinguished. For example, inherited or congenital disorders [Netherton syndrome, congenital ichthyosis, etc.], infectious diseases (herpes simplex, bullous impetigo, etc), and other skin fragility conditions may present uniquely in newborns.[21]

Most hereditary disorders with increased skin fragility may occur first during the neonatal period before four months of age, at an average of 7–9 weeks of life.[46] Congenital erythroderma is less common but is strongly suggestive of ichthyosis, Netherton syndrome, or immunodeficiency syndromes.[46]

Infectious disorders in neonates are rare.[46] Congenital cutaneous candidiasis arises from intrauterine exposure and presents as a inflammatory eruption with scattered pustules and rarely vesicles.[21,46-48] Lesions develop within the first six days of life, spreading from the trunk to acral sites, and can include the palms and soles. The lesions may rarely lead to life-threatening systemic infection and exfoliative erythroderma.[21,46-48]

Common types of erythema include erythema toxic neonatorum [ETN], miliaria, neonatal cephalic pustulosis [NCP], and transient neonatal pustular melanosis [TNPM] (Figure 2B).[21,22]

ETN is uncommon in premature neonates but affects about 30–50% of full-term babies. This condition arises in the first few days after birth and presents with scattered transient pink or red papules and wheals scattered over the face and the rest of the body, sparing the palms and soles. ETN does not cause discomfort and resolves spontaneously over one to two days.[21,22]

Transient neonatal pustular melanosis is a disorder in which macules and papules are present at birth.[21,22] The pustules show a mixture of neutrophils and some eosinophils and resolve with hyperpigmented macules that fade with time.[21] As in ETN the babies are otherwise well.

Miliaria affects about 15% of newborn babies in warm climates due to occlusion of the sweat duct. If the occlusion is superficial, sweat collects just below the SC forming clear, thin-walled blisters (miliaria crystallina). Slightly deeper occlusion results in red papules and pustules (miliaria rubra or 'prickly heat').[21,22] Miliaria most often affects the forehead, neck, and upper trunk and occluded skin areas of neonates in the first few weeks of life. The skin changes resolve within a few days on cooling and removing occlusive clothing.[21,22]

Neonatal cephalic pustulosis or Pityrosoprum folliculitis are none pruritic, erythematous papules, and superficial pustules presenting in crops commonly on the cheeks, nose, and forehead.[21,22] The condition results from an inflammatory reaction to Malessezia species on the skin and within the hair follicles which can be seen after birth and may relate to increased activity of the sebaceous glands.[21,22] It affects newborn infants in the first weeks of life and will resolve within weeks without treatment, but may resolve more quickly with topical antifungal agents.[21,22]

Erosion and Bullae

Severe conditions such as staphylococcus scalded skin syndrome, epidermolysis bullosa, eczema herpeticum, herpes simplex, and erosions are outside the scope of this algorithm.[46-48]

Newborns are more likely to develop bullae and erosions in response to heat, chemical irritants, and mechanical trauma and are at an increased risk for cutaneous infections.[9,14,21-23,48] As the SC barrier is maturing, neonates and infants are especially vulnerable.[14] Exposure to common irritants, including saliva, nasal secretions, urine, feces, fecal enzymes, dirt, and microbial pathogens for long periods can lead to discomfort, irritation, infection, and skin barrier disruption.[14] Furthermore, the unsaturated fatty acids are easily extracted during cleansing, compromising SC barrier function.[14,15,29]

Diaper rash is the most common skin condition in infants presenting as erythema or, in more severe cases, skin erosion.[21] The most common type of diaper rash is irritant dermatitis due to stool, urine, or mechanical irritation.[21] The groin folds are usually protected from urine and stool and therefore not affected.[21] If the rash is continuous despite appropriate care, rule out a *candida* infection.[21,48] If a *candida* infection is present, also check for oral candidiasis.[21,48] Details on diaper care are given in Box 4.

Box 4: Diaper Care

- Evaluation of the perineal area is required at each diaper change to ensure early identification of perineal dermatitis and infections
- Disposable diapers are preferred[8,21]
- In case of diarrhea increased frequency of diaper changes are required depending on the condition to every 1–4 hours
- Cotton balls or soft disposable towels with warm water are the preferred cleansing method
- A physiological pH (4-7) cleanser may be used if stools are dry and difficult to remove[8,21]
- Wipes should be avoided (if required they should be free from alcohol and fragrance)
- Barrier creams should be used on all neonates at every diaper change at the first sign of erythema or skin breakdown[8,21]
- The removal of barrier creams between diaper changes is not necessary, rather apply another layer. Barrier creams containing plant extracts and/or fragrance should be avoided[8,21]
- Risk factors for perineal dermatitis include: Frequent stooling; antibiotic use; malabsorption; opiate withdrawal; abnormal rectal sphincter tone[8,21]
- Avoid use of powders in diaper area

Umbilical cord care until its detachment remains controversial.[47,49,50] The World Health Organization advocates for dry cord care; however, the use of chlorhexidine on the stump is recommended when hygienic conditions are poor, and the risk for omphalitis is higher (Box 5).[47,49,50]

Box 5: Umbilical Cord Care

- Keep the cord area clean with water[47,49,50]
- Use chloorhexidine on the cord to avoid infection when hygienic conditions are insufficient[47,49,50]
- Fold the diaper down below the umbilicus
- Cord clamp may remain in place until separation
- Where possible the umbilical stump should be kept exposed to air or loosely covered with clean clothing to avoid irritation and promote healing
- Avoid exposing the periumbilical skin to chemicals in order to prevent periumbilical burns[47,49,50]
- Regular assessment is necessary to ensure normal umbilical cord healing and to identify potential problems including infection

heat, chemical irritants, and mechanical trauma that are small and or localized.[9,14,21-23,44,48]

Due to mechanical trauma such as caused by repeated friction, bullae develop just below the stratum granulosum.[48] Burns and scalds can be accidental or intentional in the case of child abuse. A careful history and physical examination with attention to the child and caregiver interactions is needed.[48] In inflicted burns, there is often a delay in seeking care from healthcare professionals, therefore look for lesions in various stages of healing and also with unusual patterns or locations.[48]

Neonates and infants with skin erosions are particularly at risk for infection, especially as their skin is immature.[3-6,21] For closed bullae, cleanse the skin using a gentle cleanser and lukewarm water followed by the application of a moisturizer while leaving the bullae intact. A wound dressing may be required for open bullae. Select a dressing depending on the wound bed condition and exudate levels. Various dressings may be used, such as a foam dressing, a hydrofiber dressing, or a non-adherent wound contact layer, including silicone-coated dressings. The frequency of dressing changes depends on exudate level and are typically twice/week (Figure 2C). For infants at risk for infection, use an antiseptic cleanser, such as chlorhexidine aqueous solution. Avoid the use of prophylactic topical antibiotics to comply with antimicrobial stewardship preventing antibiotic resistance.[51]

LIMITATIONS

Although limited evidence was available to guide the development of the algorithm, the project will hopefully spur more skincare studies in neonates and infants. Until then, we kno wit is important to maintain a healthy skin barrier, which is accomplished by using skincare products that are sensitizer and fragrance free and also containing lipids, such as ceramides.

CONCLUSONS

The algorithm focuses on neonatal and infant healthy skin that can benefit from skincare. A growing body of evidence recognizes the benefits of ongoing daily use of non-alkaline cleansers and ceramides containing moisturizers. When applied from birth onwards, gentle cleansers and moisturizers containing barrier lipids help maintain the protective skin barrier.

DISCLOSURES

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