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Effectiveness of Virgin Coconut Oil Application in Non-Therapeutic Pain Management of Infants by Using NPASS Pain Score as Parameter: An Integrative Review

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ABSTRACT

Background: There has been greater emphasis in recent years on the effectiveness of non-pharmacological interventions in soothing infants and reducing pain perception in preterm infants in neonatal intensive care units (NICUs). While approaches ranging from swaddling, breastfeeding, to sensory stimulation have encountered limitations in their effectiveness and practical application across different settings; Virgin Coconut Oil (VCO) has concurrently emerged as a potential non-therapeutic remedy for pain management in infants, thanks to its unique composition. Researchers are investigating its safety and effectiveness as an alternative pain management option for neonates. To answer the following questions: (i) can virgin coconut oil effectively help improve skin dryness and irritation in infants? and (ii) how does the effectiveness of virgin coconut oil compare to standard care in neonatal pain management?
Methods: A search of the existing literature was done on online databases using keywords to narrow down the articles.
Results: Based on the selection criteria, 24 articles were selected to be included in this paper. Three main points can be observed that is on: (i) the properties of VCO in skin barrier function and preventing infection; (ii) recommendations for the use of VCO in infant skin care; and (iii) in pain management of neonates.
Conclusion: There is a gap in the literature for how the pain management of infants and the success of VCO in managing skin conditions in neonates can be further studied to develop standards in managing non-therapeutic pain among infants.

Keywords: Neonates pain management; Non-therapeutic; Virgin coconut oil (VCO)

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INTRODUCTION

Virgin coconut oil (VCO) is a natural substance that has potential benefits in maintaining skin integrity, particularly in environments with low humidity (1). Used as an emollient in neonatal skin care, there is substantial research acknowledging their significance in promoting healthy skin. This framework addresses immediate health concerns and paves the way for future research in infant care and the implementation of pain management strategies. VCO has been the focus of the critical issue of pain management in infants in this literature review. An overwhelming attention here is paid to research that uses validated tools for assessing the level of discomfort before and after the application of VCO in neonates. This review considers several theoretical perspectives, namely: The Gate Control Theory of Pain, Stratum Corneum Hydration Theory, and the Humidity and Skin Integrity Model. The Gate Control Theory of Pain shows the complexity of pain mechanisms and states that pain is modulated by a gating mechanism in the central nervous system (2). External stimuli, such as the application of topical agents like virgin coconut oil, can influence this gating mechanism and potentially mitigate the perception of pain in infants (3).

Whereas Stratum Corneum Hydration Theory emphasizes the importance of stratum corneum hydration for maintaining skin integrity; virgin coconut oil, with its emollient properties, may enhance stratum corneum hydration, particularly in low-humidity environments (4). This improvement in skin hydration could indirectly contribute to pain management by preserving skin integrity and reducing discomfort caused by dry skin (5). Lastly the Humidity and Skin Integrity Model explores how environmental factors, like humidity, impact skin integrity. Low humidity can lead to skin dryness, increasing the risk of skin damage and potentially affecting pain perception (1). Virgin coconut oil's moisturizing effect might mitigate these risks, thereby playing a role in pain management (6).

METHODS

Data Collection

Data was searched using several electronic databases: Google Scholar, BioMed Central (BMC), EBSCO CINAHL, and ELSEVIER Clinical Key Nursing. Keywords used to narrow down the searches include "virgin coconut oil", "neonatal pain management", "emollients", "infant pain management", and "non-therapeutic pain management". Articles selected were initially focused on papers that have come out in the last 10 years (from the year 2014-2024), but also expanded to include others that were more appropriate to the topic and especially those papers that were highly cited by other researchers. From an initial 37 journal articles, 24 studies were selected in the end which are included in the present review. The criteria of inclusion and exclusion can be seen in **Table 1** below:

Table 1: Inclusive and Exclusive Criteria

Inclusive Criteria	Exclusive Criteria
Focus on the use of coconut oil as an emollient for skin care	Those not related to the use of virgin coconut oil, its properties, skin care management of neonates and neonatal pain management.
Study designs that include reviews	Non-English language
The use of emollients in pain management	Does not address the research questions below
English Language	

Research Questions

I. Can virgin coconut oil effectively help improve skin dryness and irritation in infants?
II. How does the effectiveness of virgin coconut oil compare to standard care in neonatal pain management?

Summary of Studies Selected for Inclusion

Table 2 shows a brief overview of the studies that have been selected. The table identifies each articles' research question/objectives, the methodology design, the setting and sample size, the results and analysis and its conclusions. Subsequently, the data gathered from the literature review will be divided and analysed according to theme, which can be seen in **Table 3,** and which is further discussed in the Methods section below.

Table 2: Studies selected for inclusion criteria

Author/ Year	Research Question(s)/ Hypotheses/ objectives	Methodology Design	Setting/ Sample Size	Analysis & Results (major)	Conclusions
Agero & Verallo-Rowell, 2004	The effectivity and safety of virgin coconut oil compared with mineral oil as a therapeutic moisturizer for mild to moderate xerosis.	Patients were randomized to apply either coconut oil or mineral oil on the legs twice a day for 2 weeks. Quantitative outcome parameters to measure skin hydration, skin lipids, transepidermal water loss (TEWL), and skin surface hydrogen ion concentration (pH).	n=34	Both oils showed effectivity through significant improvement in skin hydration and increase in skin surface lipid levels. Subjective grading of xerosis by the investigators and visual analogue scales used by the patients showed a general trend toward better (though not statistically evident) improvement with coconut oil than with mineral oil.	Extra virgin CO and mineral oil (twice weekly application for 2 weeks) similarly improved hydration and increased skin surface lipids, without significantly altering TEWL and pH. CO is just as effective a moisturizer as mineral oil and can be a safe, antimicrobial alternative in patients with AD and xerosis.
Bautista et al., 2013	To determine the efficacy of topically applied virgin coconut oil (TVCO) in the prevention of nosocomial infection in neonates born ≤ 34 weeks gestational age.	Preterm infants received TVCO 4 g/kg twice daily for 14 days or routine skin care and followed up until 28 days or discharge. Outcome measures included incidence of nosocomial infections, need for double-volume exchange transfusion (DVET) for sepsis, all-cause mortality rates and length of hospital stay	n=52; Conducted at the Neonatal Intensive Care Unit (NICU) of the Philippine General Hospital	This clinical trial was stopped before the computed sample size was reached as researchers thought that benefits of TVCO in premature infants may not outweigh possible adverse outcomes.	Insufficient evidence to conclude a difference in the incidence of nosocomial infections, mortality rates and length of hospital stay.
Clemison & McGuire, 2021	To assess the effect of topical application of emollients (ointments, creams, or oils) on the risk of invasive infection and mortality in preterm infants.	A search of literature via Cochrane Register of Studies (CRS) Web and MEDLINE via Ovid (updated 08 January 2021) and the reference lists of retrieved articles.	n= 22 trials (5578 infant participants)	Regular application of ointments or creams (also sunflower and other vegetable oils) to the skin of very preterm infants may have little or no effect on serious infection or death.	The level of certainty about the effects of emollient therapy on invasive infection or death in preterm infants is low.
Cooke et al., 2016	Can the use of specific types of defined topical oils have an effect on baby skin	Babies of women who gave consent were randomized to one of the intervention	n=115 full term neonates; study setting –	All groups displayed an increased ordering of the lipids, both on the surface and	Data generated in the study provided evidence that specific topical

	barrier function and the magnitude of that effect, and to assess the feasibility of conducting a robust definitive RCT of specific types of defined topical oils versus no oil for newborn term babies.	groups or the control group within 72 h of birth. Babies were randomized to one of 3 groups: olive oil, sunflower oil or no oil (control).	St. Mary's Hospital in Manchester, England	within the SC, over the 4 weeks following birth, but this improvement was significantly less in the groups using the tropical oils.	oils may have an adverse effect on skin barrier function, and informed the feasibility of a definitive trial with regard to recruitment, retention, protocol adherence, choice of optimal primary outcome measure and trial design.
Darmstadt et al., 2014	A study of the relationship between skin condition score as a measure of skin barrier integrity and risk for bloodstream infection, and the effect of emollients on that relationship.	Data for this study comes from a randomized controlled trial of the impact of topical emollient therapy on nosocomial infections in 491 preterm infants <33 weeks gestational.	n=491 preterm infants <33 weeks gestational age; Setting: Dhaka Shishu Hospital in Bangladesh	Rate of deterioration of skin condition was significantly lower ($P < 0.05$) in both emollient arms compared with the untreated control group. Emollients reduced the incidence of infection only when the skin had no signs of deterioration.	Emollients preserved skin integrity and thus prevented infection in preterm neonates. To optimize benefits of emollients for the prevention of bloodstream infection, use of emollients should begin immediately after birth when the skin is still intact.
Elmore, 2014	A summary of in vivo and in vitro studies of topical anti-infective properties of coconut products for dermal infections.	Search for in vitro and in vivo trials published in English using the MEDLINE, International Pharmaceutical Abstracts, Natural Standard, and Natural Medicine databases was conducted for clinical trials evaluating the anti-infective efficacy and safety of coconut oil and its components.	n=10 articles	Constituents of coconut oil, predominantly lauric acid, have in vitro and in vivo evidence for killing a wide variety of gram-positive and gram-negative bacteria and Candida species. Coconut oil can be prepared in emulsions and liposomes and retain anti-infective properties.	Given the low side effect burden, it may be a reasonable option for patients with mild to moderate dermal infections, especially acne vulgaris caused by P. acnes, polymicrobial atopic dermatis, impetigo, or wound infections. Additional randomized controlled trials are needed to solidify the place in therapy of C. nucifera as a treatment of dermal infections.

Evangelista et al., 2014	The Effects of topical virgin coconut oil (VCO) and mineral oil on SCORAD (SCORing of Atopic Dermatitis) index values, TEWL (Transepidermal water loss), and skin capacitance in pediatric patients with mild to moderate Atopic Dermatitis	Randomized controlled trial design in which participants and investigators were blinded to the treatments allocated. Patients were evaluated at baseline, and at 2, 4, and 8 weeks with the primary outcomes being the SCORAD index, TEWL and skin capacitance.	n=117	In the VCO group, 47% (28/59) of patients achieved moderate improvement and 46% (27/59) showed an excellent response. In the mineral oil group, 34% (20/58) of patients showed moderate improvement and 19% (11/58) achieved excellent improvement. The VCO group achieved a post-treatment mean TEWL of 7.09 from a baseline mean of 26.68, whereas the mineral oil group demonstrated baseline and post-treatment TEWL values of 24.12 and 13.55, respectively.	Extra virgin coconut oil and mineral oil both improved skin hydration. However, for pediatric patients with mild to moderate AD, topical application of VCO was superior to that of mineral oil based on clinical (SCORAD) and instrumental (TEWL, skin capacitance) assessments.
Hall & Anand, 2014	To study effective pain management as a desirable standard of care for preterm and term newborns.	A review of literature involving approaches for implementing an effective pain management program in the Neonatal ICU, together with practical protocols for procedural, postoperative, and mechanical ventilation-associated neonatal pain and stress.	n=257 articles	Non-opioid drugs include various sedatives and anesthetic agents, mostly used as adjunctive therapy in ventilated neonates. Acetaminophen, ibuprofen and other drugs are used for neonates, although their efficacy and safety remains unproven.	NICU patients deserve a focus on pain prevention, routine pain assessments and evidence-based strategies for pain management, using both non-pharmacologic and pharmacologic apporaches.
Inuzuka et al., 2023	To determine the effectiveness of twice- or once-daily application of Fam's Baby moisturizer (Fam's Inc.) in preventing AD compared with once-daily 2e moisturizer.	An individually randomized controlled trial. 60 newborns with at least one parent or sibling who has AD to receive Fam's Baby moisturizer twice daily (Group A) or once daily (Group B), or 2e once daily (Group C) in a 1:1:1 ratio until they were 32 weeks old.	n=60	Atopic dermatitis was observed in 11/20 (55%), 5/20 (25%) and 10/20 (50%), infants in Groups A, B and C, respectively. Cumulative incidence values for AD according to the Kaplan–Meier method showed that infants in Group B tended to maintain an intact skin for a longer period than those in Group C.	Moisturization plays a crucial role in preserving the skin integrity of neonates.

Johnston et al., 2017	To determine the effect of skin-to-skin care (SSC) alone on pain from medical or nursing procedures in neonates undergoing painful procedures compared to no intervention, sucrose or other analgesics, or additions to simple SSC such as rocking; and the effects of the amount of SSC (duration in minutes) and the method of administration (who provided the SSC, positioning of caregiver and neonate pair).	The standard methods of the Cochrane Neonatal Collaborative Review Group were used. Evidence-Based Medicine Reviews; MEDLINE (1950 onwards); PubMed (1975 onwards); EMBASE (1974 onwards); CINAHL (1982 onwards); Web of Science (1980 onwards); LILACS database (1982 onwards); SCIELO database (1982 onwards); PsycInfo (1980 onwards); AMED (1985 onwards); Dissertation-Abstracts International (1980 onwards).	19 studies involving (n=1594 infants) were included.	Although 11 studies measured heart rate during painful procedures, only data from four studies (n = 121) were combined, yielding a mean difference of 0.35 beats per minute. Five studies using the Premature Infant Pain Profile (PIPP) favored SSC at 30 seconds, but no studies provided findings on return of heart rate to baseline level, oxygen saturation, cortisol levels, duration of crying, and facial actions for combined analysis.	Purely behavioural indicators tended to favour SSC but there remains questionable bias regarding behavioural indicators. Physiological indicators were typically not different between conditions. There was more heterogeneity in the studies with behavioural or composite outcomes.
Kim et al., 2017	To analyse the expression of skin barrier molecules and collagens after applying cultured coconut extract (CCE) on human explanted skin.	Exposure to ultraviolet B (UVB) radiation. The expression of inflammatory markers was analyzed after UVB irradiation. Cell culture and cultured coconut oil extract was prepared as liquids and were added to the culture medium and serially diluted to different concentrations.	a number of skin samples for molecular analysis and testing of inflammatory markers post UVB irradiation were used.	CCE showed barrier-enhancing and anti-inflammatory effects against ex vivo UVB radiation-induced changes.	The promising anti-inflammatory activity of CCE may be attributed to increased levels of polyphenols and FAs in CCE.
Konar et al., 2020	To find out the efficacy of coconut oil application for skin maturity, prevention of sepsis, hypothermia and apnea, its effect on long-term neurodevelopment and adverse effect of it, if any.	A randomized controlled trial. Preterm born in the study period was divided into Group A (received virgin coconut oil application) and Group B (received body massage without any application). Neonatal skin condition was assessed on 7th,	2294 preterm were included in the study	Mean weight loss in first few days was less in group A but mean weight gain per day was higher in group B. Lesser incidences of hypothermia and apnea, and better skin maturity and neurodevelopmental outcome were noted in group A. No significant adverse effect was	Use of coconut oil helps in dermal maturity and better neurodevelopmental outcome

		14th, 21st and 28th day of life. Neurodevelopmental status was assessed on 3rd, 6th and 12th months		noted with coconut oil application	
Kuller, 2016	Does the existing literature provide evidence-based information to educate parents on the use of products for preterm and term infants	A search of literature including search terms such as "infant skin care," "infant products," "infant bath," "emollients," "diaper skin care," and "diaper wipes." Product searches also include consumer information, product information, and regulatory guidelines	Full text review, n=68	Research shows that cleansers formulated for infant skin do not weaken the skin barrier the way harsher soaps and detergents can. Oils with the lowest oleic acid content provides a lower risk of irritant contact dermatitis.	Not even product labels that claim things such as derm tested, balanced pH, natural or organic, guarantee the safety of the ingredients in a product. The study states that "Natural" should not be equated with safe, because herbs and plants can be just like drugs.
Madhu et al., 2021	To develop standard recommendations for skin care in neonates, infants and children to aid the pediatrician to provide quality skin care to infants and children.	A systematic review of the evidence available on skin care for babies in the various headings such as bathing, cleansing, care of the umbilical cord, nappy care, care of hair, cleansers, oils used for baby massage, atopic dermatitis and dry skin	Full text review. n=57	Appropriately selected emollients which are petrolatum-based, water miscible, and free of preservatives, dyes and perfumes could be used in pre/post term/ Intrauterine growth restriction (IUGR) babies, neonates under radiant warmers/ phototherapy and in those infants and children with atopic dermatitis, contact dermatitis, psoriasis and ichthyosis.	Application of emollient in newborns born in families with high risk of atopy tends to reduce the risk of developing atopic dermatitis. Emollients decrease the risk of invasive infection in preterm infants by prevention of access to deeper tissues and the blood stream through skin portals of entry.
Nangia et al., 2015	To study the effects of coconut oil used traditionally for infant massage in India as a way to reduce trans-epidermal water loss (TEWL) in preterm neonates.	Very low birth weight (VLBW) neonates were randomized at 12 h of age to Oil (n = 37) or Control (n = 37) groups. Oil group neonates received twice-daily coconut oil application without massage, and Control group received standard care. TEWL was measured every 12	n=37	Compared with the neonates who received no oil massage, those in the CO group had a significant decrease (14.06% decrease versus 7.99% decrease in the control group) in TEWL.	Coconut oil application reduced TEWL without increasing skin colonization in very-low-birth-weight (VLBW) neonates.

		h using an evaporimeter till Day 7 when skin swabs were obtained for bacterial growth and skin condition was assessed using a validated score.			
Riddle & Racine, 2019	To discuss the primary importance of understanding the caregiver context when assessing infant pain expression.	A study of the research on pain management in infancy and the caregiver's role.	N=29	i) Pain assessment is as subjective as the pain experience itself. ii) Assessors must be cognizant of the relationship between infant pain expression, and caregiver sensitivity and emotional displays. iii) Larger systemic factors of the infant (such as caregiver relationship styles, caregiver psychological distress or caregiver acculturative stress) directly impact on infant expression.	Caregiver behaviours and predispositions have been shown to have a significant impact on infant pain reactivity and, accordingly, should not be ignored when assessing the infant in pain.
Sakaranaray anan et al., 2005	To compare the effect of massage with coconut oil versus mineral oil and placebo (powder) on growth velocity and neuro-behavior in well term and preterm babies.	Open Randomized Controlled trial. Babies in each group were randomized to receive massage with either coconut oil, mineral oil or with placebo. Oil massage was given by a trained person from day 2 of life till discharge, and thereafter by the mother until 31 days of age, four times a day. Babies were followed up daily till discharge and every week after discharge for anthropometry. Neuro-behavioral outcome was assessed by the Brazelton Score at baseline, day 7 and on day 31.	n=36, study was conducted in the Premature unit and the postnatal wards of a major teaching hospital in a metropolit an city.	Coconut oil massage resulted in significantly greater weight gain velocity as compared to mineral oil and placebo in the preterm babies group; and in the term baby group, as compared to the placebo. Preterm infants receiving coconut oil massage also showed a greater length gain velocity compared to placebo group.	Coconut oil massage has beneficial effects on the weight gain in preterm neonates compared to mineral oil massage.

Salam et al., 2014	To assess the efficacy of topical coconut oil applications among a cohort of hospital-born preterm infants.	A prospective, individually randomised controlled clinical trial. Twice daily topical application of coconut oil by nurses from birth until discharge and continued thereafter by mothers at home until completion of the 28th day of life. The primary outcome measure would be the incidence of hospital acquired bloodstream infections while a secondary measure chosen was the weight gain, skin condition and neonatal mortality.	n=258; Setting: the nursery and neonatal intensive care unit at Aga Khan University Hospital, Pakistan	Among the enrolled neonates, 23% developed clinically suspected sepsis and 14% had blood culture-proven infections. The control group had a much higher hazard for hospital-acquired infection (6.0, 95% CI 2.3 to 16) and infection rate (219.1 per 1000 patient-days) compared to the intervention group (39.5 per 1000 patient-days). Additionally, the intervention group experienced a higher mean weight gain of 11.3 g/day (95% CI 8.1 to 14.6, p<0.0001) and significantly better skin condition.	Emollient therapy was effective in maintaining skin integrity and reducing the risk of bloodstream infection in preterm infants in a tertiary hospital setting in Pakistan.
Solanski et al., 2005	To study the transcutaneous absorption of traditionally massaged oil in newborns and to specifically compare the effects of (i) essential fatty acid (EFA) rich - safflower oil and (ii) saturated fat rich coconut oil, on fatty acid profiles of massaged babies.	Randomized neonates received topical safflower oil (SAF) or CO four times per day for 5 days or no oil	n=120. Study was conducted at the tertiary care Neonatal Intensive Care Unit (NICU) of a large teaching hospital and a large university research lab.	Post-oil triglyceride values were significantly increased in both the oil groups and the control group, but the increase was more substantial in the oil groups. The safflower oil group showed significant rises in essential fatty acids (linolenic acid and arachidonic acid), while the coconut oil group showed increases in saturated fats. These changes were more pronounced in term babies, and there were no side effects associated with the massage.	Topically applied oil can be absorbed in neonates and is probably available for nutritional purposes. The fatty acid constituents of the oil can influence the changes in the fatty acid profiles of the massaged babies.
Strunk et al., 2018	What is the feasibility, safety and effects of topical coconut oil on skin condition in very preterm infants	An open-label randomised controlled trial in preterm infants <30 weeks' gestation was conducted. Enrolled infants were randomised to receive either routine care or	A total of 72 infants born <30 weeks' gestation were enrolled (36 infants per arm), with comparabl	The NSCS was maintained in the coconut oil group throughout the intervention period but deteriorated from a median (IQR) of 3 (3-4) on day 1 to 4 (4-4) on day 21 in the control group (p = 0.01). There were	Topical coconut oil maintained a better skin condition in very preterm infants without adverse effects.

		topical coconut oil (5 mL/kg) twice daily for 21 days, starting within 24 h of birth. The neonatal skin condition was the primary outcome, and was assessed using the Neonatal Skin Condition Score (NSCS) on days 1, 7, 14, and 21.	e demographic characteristics.	no differences in common neonatal outcomes, including sepsis, necrotising enterocolitis, retinopathy of prematurity, chronic lung disease, and mortality.	
Varma et al., 2018	To study the relationship between anti-inflammatory and skin protective benefits of VCO in vitro.	The mechanistic action of VCO and its benefits on skin has not been elucidated in vitro. The cytotoxicity (CTC50) of VCO was measured.	not applicable	VCO can alter the expression of several genes concerned with inflammatory response and skin beneficiary effects. CO increased the expression of Aquaporin-3 (AQP3), involucrin (INV) and filaggrin (FLG) and showed moderate UV protection in HaCaT cells. VCO is a non-skin irritant and non-phototoxic.	VCO could be useful in treating skin disorders with permeability barrier dysfunction, especially those accompanied by reduced epidermal protein expression, such as atopic dermatitis, eczema.
Verallo-Rowell et al., 2008	To compare the moisturizing and antibacterial properties of virgin CO with virgin olive oil (OO) in adult patients with AD	A double-blind controlled trial in two outpatient dermatology clinics with adult AD patients who were diagnosed by history, pattern, evolution, and skin lesions and who were randomized to apply VCO or VOO twice daily at two noninfected sites. SA cultures, photography, and objective-SCORAD severity index (O-SSI) scoring were done at baseline and after 4 weeks.	n=26	Only 5% of subjects receiving CO remained positive for SA, while 50% in the OO group remained positive.	VCO and monolaurin's SCORAD severity index (O-SSI) reduction and in vitro broad-spectrum activity against SA, fungi, and viruses may be useful in the proactive treatment of AD colonization.
Wilborn et al., 2023	An overview of the evidence of skin care activities in neonates and infants.	Four main skin care interventions: bathing, wiping, washing, and topical application of leave-on products. The four skin care interventions	42 studies since 2010	13 skin care goals were identified by the study. "Maintaining healthy skin/skin barrier function/skin barrier integrity," "prevention of	There is substantial variability regarding outcome domains in skin care research. The paper supports the

		focused on 13 different care goals, mainly prevention of skin diseases, maintaining skin barrier function, and improving (skin) health. Mostly, laboratory or instrumental measurements were used.		atopic dermatitis," "cleansing," and "improving skin barrier function" were most often allocated to skin care interventions.	need of developing core outcome sets in the field of skin care in healthy skin, especially in the studied age-group of neonates and infants. This includes gentle cleansing appropriate moisturization, and the careful selection of skin care products.
Zidni et al., 2022	To review systematic summaries of the effectiveness of topical coconut oil in improving the skin integrity of premature infants	Searching of electronic databases: Pubmed-MEDLINE, Scopus, ProQuest, Cochrane library, ClinicalTrials.gov, and Google Scholar.	n=17	Standardized mean difference in NSCS of -0.93 [-1.28, -0.58] between the intervention and control groups ($p < 0.001$).	Data from a systematic review and meta-analysis showed that the application of VCO can provide significantly better results in improving the skin integrity of preterm infants

Themes

From the literature chosen, seven prominent themes can be identified. This includes i) the evidence of skin care activities in neonates and infants; ii) effect of coconut oil on skin barrier function and development; iii) properties of coconut oil in treating dermal infection; iv) comparative analysis with other forms of emollients; v) infant pain management; vi) recommendations of standards for skin care in neonates, infants and children; and vii) the effectiveness and safety of coconut oil. The appearance of these themes in the literature can be seen in **Table 3**.

Evidence of Skin Care Activities in Neonates and Infants

Among the main themes discussed in the literature consist of monitoring various skin care activities in neonates and infants as part of their study. Around 66.7 percent (14 studies) of the articles dissected here contain aspects of this as part of their outcome measures. previous research studied whether it was better to use emollients oar not although his study did not use coconut oil rather it used sunflower oil, olive oil or no oil (7). This was supported by other that argued the application of emollients in newborns in families with high risk of atopic dermatitis did in fact experience a reduction (8).

The prevention of nosocomial infections in neonates was done by (9) but was unfortunately nor completed due to the authors deeming it impractical and unethical to continue their work into topically applied virgin coconut oil. (10) has suggested that the use of emollients should happen immediately after birth when the skin is still intact as emollients have shown to preserve skin integrity and thus prevent infection in preterm neonate and its use can be optimized for the prevention of bloodstream infection. Meanwhile, (11), suggested four main skin care interventions in his paper (sampled from 42 studies) in order to assess the skin condition of neonates and infants i.e. bathing, wiping, washing, and topical application of leave-on products and found that skin care interventions were important factors in improving skin barrier function.

Table 3: The prevalence of themes in articles reviewed

No.	Author/ Year	Evidence of skin care activities in neonates and infants	Effect of coconut oil on skin barrier function and development	Properties of coconut oil in treating dermal infection	Comparative analysis with other forms of emollients	Infant pain management	Recommendation of standards for skin care in neonates, infants and children	Effectiveness and safety of coconut oil
1.	Agero & Verallo-Rowell, 2004		√		√			√
2.	Bautista et al., 2013	√					√	
3.	Clemisoon & McGuire, 2021	√	√		√			
4.	Cooke et al., 2016	√	√					
5.	Darmstadt et al., 2014	√	√	√				
6.	Elmore, 2014			√				
7.	Evangelista et al., 2014	√	√		√			
8.	Hall & Anand, 2014	√				√	√	
9.	Inuzuka et al., 2023	√			√			
10.	Johnston et al., 2017	√				√		
11.	Kim et al., 2017		√	√			√	
12.	Konar, et al., 2020	√	√				√	
13.	Kuller, 2016				√		√	
14.	Madhu et al., 2021	√	√		√		√	√
15.	Nangia et al., 2015	√	√	√				
16.	Riddle & Racine, 2019	√				√		
17.	Sakaranarayanan et al., 2005	√	√		√			
18.	Salam et al., 2014	√	√	√				
19.	Solanski et al., 2005			√	√			
20.	Strunk et al., 2018	√					√	√
21.	Varma et al., 2018		√	√				

No.	Author/ Year	Evidence of skin care activities in neonates and infants	Effect of coconut oil on skin barrier function and development	Properties of coconut oil in treating dermal infection	Comparative analysis with other forms of emollients	Infant pain management	Recommendation of standards for skin care in neonates, infants and children	Effectiveness and safety of coconut oil
22.	Verallo-Rowell et al., 2008			√	√			
23.	Wilborn et al., 2023	√	√	√			√	
24.	Zidni et al., 2022	√	√				√	

Effect of Coconut Oil on Skin Barrier Function and Development

While not all the studies test coconut oil specifically, those that do have looked at its ability to improve skin barrier function and development. This includes looking at the lipid on the surface of the skin with and without topical oils, the development of lamellar lipid structures of the permeability barrier of the skin (7); and risk for bloodstream infection (10). Popular tools for measurement against the rate of deterioration of skin condition were used such as the SCORAD (SCORing of Atopic Dermatitis) index values, the Neonatal Skin Condition Score (NSCS) (12,13), TEWL (Trasepidermal Water Loss) (14) and skin capacitance (15). Another study had measured nero-behavorial outcomes in their study of the effect of massaging preterm babies with coconut oil using a Brazelton Score (16).

The effect of coconut oil in particular has been a popular study in countries in South Asia and Southeast Asia. In India, (14) studied the effects of coconut oil on TEWL in preterm neonates and found that its application reduces TEWL without increasing skin colonization in very-low-birth-weight neonates. Previous study found that emollient therapy using coconut oil could also reduce the risk of bloodstream infection in preterm infants (17). The effects on skin condition is usually measure by the skin barrier integrity (10). It was found that if there are no signs of deterioration on the skin to begin with then emollients reduce the incidents of infection (10). Skin barrier function will decrease if there is reduction in the ordering of lipids throughout the skin (7).

Coconut oil application according to (18) was also additionally important not just in skin maturity but also helped long term, neurodevelopment and any adverse effect associated to it. In another study, (19), maintained that virgin coconut oil could be used to treat disorders with permeability barrier dysfunction especially those accompanied by reduced epidermal protein expression such as atopic dermatitis and eczema. (13), also presented results that conformed to the view that virgin coconut oil can provide significantly better results in improving the skin integrity of preterm infants; with their paper focusing on the meta-analysis collected from a sample size of 17 papers on the effectiveness of topical coconut oil in improving the skin integrity of premature infants.

Molecular Properties of Coconut Oil in Treating Dermal Infection

Studies such as (20) analysed the expression of skin barrier molecules and collages following the application of coconut oil in order to look at how it had barrier enhancing and anti-inflammatory effects thanks to increased levels of polyphenols and Ferulic acid, with clinical implications for coconut oil in both diseased and healthy skin. The preparation of coconut oil can be done in emulsions and liposomes and still retain its anti-infective properties (21).

The component known as lauric acid which is present in coconut oil has been found to have in vitro evidence for killing a wide variety of gram-positive bacteria and Candida species although it is important to note that it also does not have the same bacteriostatic or bactericidal potential that is present in commercially available antibiotics (21). It is particularly effective against mild to moderate dermal infections, especially acne vulgaris caused by P. acnes, polymicrobial atopic dermatis, impetigo, or wound infections (21). The antimicrobial properties of VCO, attributed to its medium-chain fatty acids like lauric acid and caprylic acid, are explored. These components are believed to disrupt the lipid membranes of pathogens, thereby offering a protective effect against various bacterial, viral, and fungal infections (22).

Comparative Analysis with Other Forms of Moisturizer

Among the popular comparisons made with coconut oil include mineral oil for therapeutic moisturizer for mild to moderate xerosis (1), who found that both oils were effective in skin hydration and increase in skin surface lipid levels. Previous study on the other hand made a comparative study on the effect of massage with coconut oil versus mineral oil to measure the growth and neuro-behaviour in well term and preterm babies (16). The study found coconut oil massage to have a positive impact on weight gain on preterm neonates compared to mineral oil massages hence agreeing with previous study (1).

It was shown that the different types of emollients have an effect on baby skin barrier function with some types of oil having a negative effect on the skin especially sunflower oil and olive oil (7). More specifically, results showed that it's use may impede the development of the lamellar lipid structures hence affecting permeability of the infant's skin (7). Previous study, on the other hand says that oils with the lowest olic acid content provides a lower risk of irritant contact dermatitis (23). Another study had made a point however that caution should be used for products labelled natural, herbal or organic due to the limited availability of reliable research on the subject (8). One of the factors influencing how well an emollient does in the fatty acid constituents of the oil as it has an influence on the changes in fatty acid profiles of massaged babies (24). Previous study was able to show in a direct comparison between virgin coconut oil and mineral oil that both were able to improve skin hydration; with virgin coconut scoring better results on the SCORAD (Scoring of Atopic Dermatitis), TEWL (Transepidermal water loss) and skin capacitance values (15).

Infant Pain Management

One of the glaring opportunities for further research in the literature comes from the lack of studies done on the relationship between the use of emollients such as coconut oil and pain management strategies to for infants. According to previous studies (25), found studies relating to skin-to-skin care being effective way for nursing procedures in neonates, especially those undergoing painful procedures compared to nonintervention, sucrose or other analgesics.

Many of the studies approached pain management in infants by using popular tools such as the Premature Infant Pain Profile (PIPP), and the Neonatal Pain Agitation and Section Scale (N-PASS). Previous study had called for a focus on pain prevention, routine assessments and evidence-based strategies or main management for NICU patients (which include both pharmacological and non-pharmacological approaches (26). Effective pain management was touted as a desirable standard for preterm and term newborns as they may potentially improve their clinical and neurodevelopmental outcomes. Previous study also agrees with this argument although not studying pain management (18). The study reported that the use of coconut oil helps with dermal maturity and as well as better neurodevelopmental outcomes in preterm infants. One notable study that differed from the rest in their approach was Pillai et al. (27), who in their study on infant pain expression highlighted the need to pay attention to caregiver behaviours and predisposition as they can have a significant impact on infant reactivity, and accordingly cannot be ignored when assessing infant in pain.

Recommendation of Standards for Skin Care in Neonates, Infants and Children

In the incomplete study by previous study, which had aimed to look at topically administered virgin coconut oil, the authors of the study instead stated how resources would be better directed at evaluating the effectiveness and safety of the emollient orally instead, suggesting their preference and recommendation for the administration to neonates (9).

Previous study has made a comparative study of trials involving infants in high-, middle- and low-income countries and found that the regular application of emollients on the skin of preterm infects have little or no effect on serious infection or death (28). As stated earlier, additionally raised the question if effective pain management was a desirable standard for preterm and term newborns as they may potentially improve their clinical and neurodevelopmental outcomes (26). Some papers did attempt to show the effectiveness and safety of the emollients under use, however concluded that more evidence was needed, or that limited data was a hindrance to making a definitive conclusion (8,12,17).

The Clinical Feasibility, Effectiveness and Safety of Coconut Oil

Several studies considered approaching the safety and effectiveness of coconut oil use on the skin into their research (1,8,12). One method of doing this was to also test out how virgin coconut oil compared to other types of oils such as mineral oil. Previous study also looked at coconut oil as a therapeutic moisturizer (1). All three studies suggested that coconut oil was indeed safe and can also be used as an antimicrobial alternative in patients especially for those with AD and xerosis.

Test for the clinical feasibility safety and effectiveness of coconut oil on skin include monitoring neonatal skin condition against the Neonatal Skin Condition Score (NSCS) as done by previous in their study that also found topical coconut oil maintained better skin conditions in preterm infants without adverse effects (12).

DISCUSSION

As stated earlier, the point of this review paper is to answer the following research questions; and more importantly to point towards a gap in the research. The research questions guiding this review of literature is as follows:

I. Can virgin coconut oil effectively help improve skin dryness and irritation in infants?
II. How does the effectiveness of virgin coconut oil compare to standard care in neonatal pain management?

From the overview of the literature here, three main points can be observed that is on: (a) the properties of VCO in skin barrier function and preventing infection; (b) recommendations for the use of VCO in infant skin care; and (c) in pain management of neonates. There is a gap in the literature for how the pain management of infants and the success of VCO in managing skin conditions in neonates can be further studied to develop standards in managing non-therapeutic pain among infants. Not many research papers point to a direct relationship between the use of VCO in pain management of neonates to standard care in neonatal pain management.

Firstly, the properties of coconut oil are an important feature of the literature as it explores its unique composition that allows it to improve skin barrier function and in preventing infection in that of neonates. Studies have engaged in this and explored the antimicrobial properties of VCO that are attributed to its medium-chain fatty acids like lauric acid and caprylic acid. The importance of this to the research questions raised is that VCO is hence found to be pertinent in infant care, allow for the maintenance of hygiene and the prevention of infection. Studies have generally agreed that VCO is both possible to be applied to the skin and its application is beneficial directly to the skin of extremely premature infants while also posing no risks.

Secondly, from the literature there was an attempt by some researchers to piece together standards that can be used to guide skin care in infants. The recommendations are important

because skincare practices in NICUs require specialized skincare due to their increased vulnerability. In the literature, this takes form in two of the highlighted themes i.e. recommendation of standards for skin care in neonates, infants and children; and in the clinical feasibility, effectiveness and safety of coconut oil. The application of emollients like VCO can be beneficial, not only for maintaining skin hydration but also for potentially modulating pain perception through improved skin health in infants. The immaturity of the skin of neonates puts that at increased risk of transpidermal water loss and skin permeability to harmful substance therefore its careful management is required to maintain adequate hydration.

Lastly, pain management in the literature review as was seen is not only confined to the role of emollient application in maintaining the skin hydration of neonates but have also involved other non-pharmacological interventions such as skin to skin care, those ranging from swaddling, breastfeeding, to sensory stimulation, and even one study that focused on the role of caregiver behavior and its impact on infant pain reactivity. A popular method tool used was to compare pre- and post-intervention pain scores using the Neonatal Pain, Agitation, and Sedation Scale (NPASS) to assess the level of discomfort in infants. This was used as empirical evidence on the effectiveness of certain interventions in pain management practices in neonatal care.

CONCLUSION

This integrative review maintains that several points can be derived from the body of literature surrounding this topic of the effectiveness of virgin coconut oil application in non-therapeutic pain management of infants. This includes that are that emollients like VCO can play a crucial role in maintaining hydration and potentially managing pain through improved skin health.

At the same time, studies have begun to unravel the unique properties of VCO, particularly its ability to enhance skin barrier function and mitigate infection risk in neonates. However, the current body of literature presents notable gaps and inconsistencies, particularly regarding the direct comparison of VCO's effectiveness in pain management against standard care protocols; while the effectiveness of pain assessment tools like the NPASS itself could be used with more frequency to validate the effectiveness of these interventions and inform clinical decision-making

Moreover, recommendations for standardised skincare practices in neonates are essential for mitigating the vulnerability of premature infant skin. It is therefore important for future research to aim at establishing better guidelines for the use of VCO and other non-pharmacological interventions in NICU settings, while also considering their integration into existing pain management protocols. The adoption of VCO as part of evidence-based pain management practices into routine neonatal care can ultimately enhance the quality of care for preterm infants.

CONFLICT OF INTEREST

We declared no conflicts of interest in this study.

AUTHOR CONTRIBUTIONS

CMN: drafted the manuscript and contributes to the concept development and design of the article through data collection, analysis and data interpretation for the article.
YBL: revised the manuscript critically with intellectual contents and approved the final version of the manuscript.

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