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Maintaining skin integrity in the aged: a systematic review

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Summary

Ageing is associated with structural and functional changes of the skin that result in increased vulnerability. The aim of this systematic review is to synthesize empirical evidence about the efficacy and effectiveness of basic skin care interventions for maintaining skin integrity in the aged. The databases Medline, EMBASE, CINAHL (1990–2012), Scopus, SCI (February 2013) and reference lists were searched. Inclusion criteria were primary intervention studies using skin care products in physiologically aged skin (lower age limit 50 years). Study and sample characteristics, interventions and outcomes were extracted. The methodological quality was assessed and a level of evidence was assigned. From 1535 screened articles 188 were read in full text. From these, 33 articles were included reporting results on treating dry skin conditions, and preventing incontinence-associated dermatitis and superficial ulcerations. Most studies had lower levels of evidence of 3 or 4. Skin-cleansing products containing syndets or amphoteric surfactants compared with standard soap and water washing improved skin dryness and demonstrated skin-protecting effects. Moisturizers containing humectants consistently showed statistically significant improvements in skin dryness. Skin barrier products containing occlusives reduced the occurrence of skin injuries compared with standard or no treatment. Owing to methodological limitations the current evidence base for basic skin care in the aged is weak. Using low-irritating cleansing products and humectant- or occlusive-containing moisturizers seems to be the best strategy for maintaining the skin barrier function and integrity. We know little about the effects of cleansing regimens and about the benefits of moisturizers when compared with each other.

What's already known about this topic?

- Ageing is associated with structural and functional changes of the skin.
- Xerosis cutis is the most common disorder in aged skin.
- Increased vulnerability of aged skin may result in superficial injuries and ulcerations.

What does this study add?

- Available evidence supporting basic skin care interventions in the aged is weak.
- Humectant-containing moisturizers are effective in reducing dry skin symptoms.
- The advantages of occlusives vs. emollients for incontinence dermatitis and superficial injury prevention in the aged are unclear.

The world's population is growing and ageing. Today there are more than 7 billion people, of whom more than 17 million are aged ≥ 80 years.[1] Longevity is a worldwide phenomenon.[2] For instance in Europe, the median population age has increased steadily over the past decades and is now > 40 years.[3] The ageing process is associated with inevitable anatomical, morphological, physical and psychosocial changes. These changes also compromise the skin. In ageing skin, cell replacement is continuously declining, the barrier function and mechanical protection are compromised, wound

healing and immune responses are delayed, thermoregulation is compromised and sweat and sebum production are decreased. On the cellular level, the content of natural moisturizing factors and lipids in the stratum corneum is reduced leading to decreased lamellar bilayers and poorer water-holding capacity. Chronic diseases, drugs and environmental factors including detrimental skin care habits damage the skin barrier integrity in the elderly.[4–6]

The age-related skin changes often result in dermatological disorders and skin injuries.[7,8] One of the most common dermatological diagnoses in the elderly is xerosis cutis with prevalences ranging from 30% to 85%.[9,10] The prevalence of dry skin-related pruritus also increases with increasing age;[11] this severely affects quality of life and worsens the skin status. Because of the flattening of the dermoepidermal junction and increasing skin stiffness, elderly patients are at increased risk of shear-type injuries such as skin tears or other partial to full-thickness wounds such as superficial pressure ulcers (SPUs).[12–14] Depending on the setting, skin tear and SPU prevalence varies between 2% and 40%.[15–17] In geriatric care, incontinence-associated dermatitis (IAD) is a common problem. Excessive moisture from urine and/or stools leads to overhydration and chemical irritation of the epidermis. Physical irritation (e.g. cleansing) contributes to the destruction of the epidermis and dermis.[18] Across all healthcare settings IAD affects up to 50% of all incontinent patients, and geriatric patients are most often affected.[19,20]

Adequate skin care is regarded as a major strategy for maintaining the skin barrier, skin integrity and health.[21–23] This is especially true for high-risk populations such as geriatric patients. Special bathing products and cleansing procedures, moisturizers, barrier creams or other leave-on products are widely recommended for preventing and treating xerosis,[8,24] for preventing skin injuries such as skin tears,[15] IAD[18] or other vulnerable skin conditions.[25,26] However, there is no up to date systematic synthesis and appraisal about the evidence base supporting these basic skin care treatments in the aged population. Therefore, the aim of this systematic review was to evaluate the empirical evidence about the effectiveness of nondrug topical skin care interventions for promoting and maintaining skin integrity and skin barrier function in the aged.

Methods

Eligibility criteria

In order to identify evidence about the efficacy and effectiveness of interventions, primary empirical studies were included describing, analysing and reporting treatment effects. These included experimental and observational designs. Further inclusion criteria were: intervention included a bathing/cleansing procedure and/or applications of leave-on and/or rinse-off products; use of cosmetic products according to the EU cosmetics directive including moisturizers, soaps, syndets (synthetic detergents), lotions; human studies; *in vivo* studies; physiologically aged skin including xerosis; publication date 1990–2012; in English, German, Russian, Spanish or Dutch language; and lower limit of age range 50 years. Exclusion criteria were: nonresearch papers, e.g. narrative reviews, editorials, letters to the editor; tool development and/or validation studies; observational studies without interventions; studies focusing on the treatment of diseased skin such as rosacea, atopic dermatitis and IAD (studies including diseased and nondiseased subjects were included when the proportion of diseased patients was ≤ 25%); medicinal product or drug studies; antiageing treatments to improve skin appearance at photodamaged skin areas; and *in vitro* studies.

Information sources and search

The databases Medline and EMBASE via OvidSP (1990 to August 2012) were searched (Table 1). The database CINAHL was searched using EBSCOhost (1990 to August 2012) using a comparable search strategy. Reference lists of included and possible eligible articles were screened for additional studies. After inclusion of studies from the databases and reference lists a forward search was conducted in the Science Citation Index (January 2013) and Scopus (February 2013) to identify other potentially relevant sources citing the already included studies. The last update of the database searches was completed in February 2013.

Study selection and data collection process

The results of the database searches were screened independently by two reviewers (J.K., A.L.) based on title and abstract. Possible eligible articles were read in full text independently by the same two reviewers. Reasons were given for all excluded full-text articles. A structured summary of every included study was prepared. The following study characteristics were extracted: research question/aim; design; study duration; sample characteristics – number, setting, gender, ethnic origin/skin phototype, further characteristics; intervention – short description of intervention, procedures, durations and products; outcomes – standardized lists of outcomes including

Table 1 Search strategy in Medline and EMBASE using OvidSP (16 August 2012)

	Searches	Results
1	'Aged'/ OR 'aged, 80 and over'/	4 234 597
2	'Humans'/	26 293 275
3	1 AND 2	4 147 203
4	Moisturi*.ti. OR moisturi*.ab.	2848
5	Emollien*.ti. OR emollien*.ab. OR 'emollients'/	5666
6	Skin care product*.ti. OR skin care product*.ab.	828
7	4 OR 5 OR 6	8662
8	3 AND 7	1008
9	Remove duplicates from 8	732
10	Limit 9 to year = '1990 –current'	690

applied instruments and/or operational definitions; results; and losses of follow-up. Data extraction was performed by two reviewers independently (J.K., A.L.).

Risk of bias in individual studies

The methodological quality of included randomized controlled trials (RCTs) was judged based on the Cochrane Collaboration's tool for assessing risk of bias.[27] The six possible bias categories – sequence generation, allocation concealment, blinding, incomplete outcome data, selective outcome reporting, other potential threats to validity (e.g. industry funding) – were judged as 'low risk of bias', 'high risk of bias' or 'unclear'. Taking the overall methodological study quality into account, a level of evidence (LoE) was assigned based on the Oxford Centre for Evidence-Based Medicine framework.[28] A LoE of 1 indicates evidence based on systematic reviews of RCTs, LoE 2 is based on an RCT or an observational study with a dramatic effect, LoE 3 is based on nonrandomized controlled cohort/follow-up studies, LoE 4 is based on case series or case–control studies, and LoE 5 indicates mechanism-based reasoning.[28] Based on methodological limitations or other risks of bias, the LoE was graded down.[28] In this review, RCTs were downgraded if more than four quality criteria were not met. Therefore, the LoE can be interpreted as an overall indicator for study design and quality, and thus the validity of the findings.

Summary measures and synthesis of results

Results of individual studies were extracted from the text or recalculated if necessary. Because of the large heterogeneity of investigated treatments and reported study outcomes, calculation of comparable summary measures across studies was not possible. Based on the structured data extraction sheets including the methodological appraisal, abbreviated summary tables were created and results compared narratively.

Results

Study selection

The flow diagram of study identification, screening and eligibility is shown in Figure 1. The Medline, EMBASE and CINAHL searches resulted in 1387 records. Forward searches in the Web of Science and Scopus based on the included studies resulted in an additional 321 records. Through reference lists and the last update, 145 additional references were identified. A total of 188 articles were read in full text from which 155 were excluded. Thirty-three articles reporting 33 studies were finally included in the data synthesis.

Study characteristics and risk of bias

Summaries of study characteristics, interventions, main outcomes, methodological appraisals and LoE are given in Tables 2 and 3. Based on the primary objectives and applied interventions, included studies were inductively classified into two broad categories: prevention and treatment of dry skin conditions and prevention of skin injuries such as superficial ulcerations, skin tears and IAD.

We included 14 articles[29–42] and two poster abstracts[43,44] reporting the results of 17 studies aiming at preventing or treating xerotic skin. In total, 690 subjects participated in these studies. From these there were eight RCTs with an LoE of 2 and 3. The remaining studies applied other experimental designs with an LoE of 3. Based on unclear reporting and design limitations one study was assigned an LoE of 4.[42] Due to incomplete information, the poster abstracts were ignored in the subsequent synthesis and no LoE were assigned.

Sixteen studies (from 17 articles) were included on IAD prevention,[20,45–53] SPU prevention,[54–57] and skin tear prevention[58–60] including approximately 2500 subjects. The LoE was 4 for nine studies and 3 for six studies applying quasiexperimental or observational designs or secondary data analyses. One placebo-controlled RCT comparing two skin protectants for PU prevention had the highest LoE of 2.[57]

Preventing and treating dry skin

Washing and bathing

Hardy, in 1990 and 1996, demonstrated in two before–after studies[29,31] that using a syndet soap and subsequent application of a mineral oil reduced the skin dryness in nursing home residents (LoE 3). This effect was observed irrespective of the frequency of bathing or showering.[31] Replacing traditional bathing practices with water by a no-rinse-off bag bath also reduced skin dryness in nursing home residents[34] (LoE 3). Sloane *et al.*[39] compared four different bathing modes in whirlpool and ultrasound tubs but found no differences between groups (LoE 3).

Applying leave-on skin care products

The efficacy of creams and lotions containing the humectants urea, lactic acid and glycerin was investigated in eight studies. Applications of urea with concentrations up to 10% and lactic acid 5% reduced skin dryness,[30] increased stratum corneum hydration,[32,33,41] and decreased transepidermal water loss (TEWL)[35] compared with lotions containing no humectant or no treatment (LoE 3). In a high-quality RCT, Pham *et al.*[36] demonstrated a significant reduction in xerosis of the feet in patients with diabetes when using an emulsion containing 10% urea and 4% lactic acid compared with the vehicle (LoE 2). On the other hand there were no differences when comparing humectant-containing products with each other. For instance the effects of a cream containing 10% urea compared with a cream containing 10% urea and panthenol and bisabolol were similar[33] (LoE 3). The same seems to be true for glycerol-containing products. Compared with no treatment, the application of a glycerol-containing

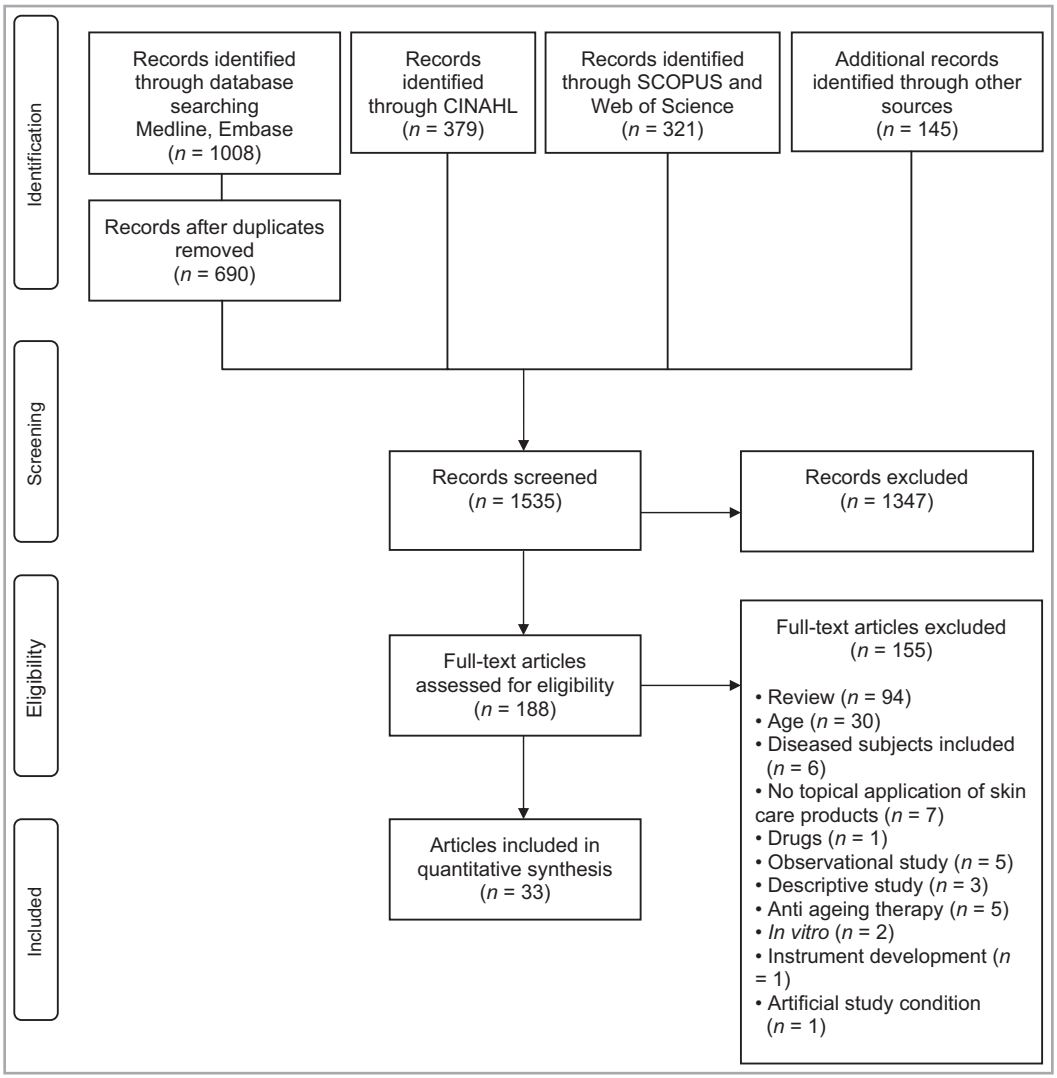

Fig 1. Literature search and study selection.

lotion seems to protect against subsequent experimental irritation[42] (LoE 4), but when comparing the effects of two glycerin-containing creams on xerosis on the feet of women with diabetes in a high-quality RCT no differences were observed[40] (LoE 2). A clinical reduction of skin dryness was also demonstrated after the application of the occlusive dimethicone 6%[37] (LoE 3). In a prospective cohort study, an ointment containing *Hamamelis* led to increased sebum content, stratum corneum hydration and reduced dryness[38] (LoE 3) and the application of a newly developed chitin–glucan cream also increased stratum corneum hydration compared with placebo treatment[40] (LoE 2).

Preventing skin injuries

Washing and bathing

Six studies reported the effects of using special soaps, cleansers or impregnated washcloths for skin injury prevention. Using an emollient soap or a nondetergent non-rinse-off cleanser compared with standard soap and water, cleansing reduced skin-tear incidence[58,59] (LoE 4). Cleansers and washcloths containing low-irritating surfactants (e.g. amphoteric), dimethicone and emollients consistently showed skin-protecting effects when compared with standard care[47,52–54] (LoE 3 and 4), but when comparing these products with each other no differences were observed[52] (LoE 3).

Applying leave-on skin care products

The effect of barrier creams for IAD and SPU prevention was investigated in four studies.[20,49–51,57] In a small cohort study, the application of a skin barrier lotion after incontinence episodes reduced erythema and pain[49] (LoE 3). The application of a product containing a mixture of oils compared with a stearin-based placebo product reduced SPU incidence[57] (LoE 2). When comparing the performance of different barrier products containing petrolatum and/or zinc oxide and/or

Table 2 Summary of included studies for prevention and treatment of dry skin

Source	Design	Setting, sample	Intervention[a]	Study duration (weeks)	n	Mean age (years)	Outcomes	Main results[a]	Risk of bias						LoE
									Sequence	Allocation	Blinding	Completeness	Selection	Other	
Hardy 1990[29]	Quasi -experimental	Nursing home	Twice-weekly standardized bathing regimen using superfatted soap (Dove) and mineral oil	18	15	70	(1) Skin dryness (2) Redness (3) Flaking (4) Scaling (5) Cracking	Reduction of skin dryness ($P = 0{\cdot}031$)	na						3
Wehr *et al.* 1991[30]	RCT	Outpatients	Twice-daily application of Lac-Hydrin Five (5% lactic acid) vs. Eucerin lotion	12	56	52	(1) Skin dryness	Reduction of skin dryness in both groups over time ($P < 0{\cdot}001$); lower skin dryness scores in Lac-Hydrin Five group ($P < 0{\cdot}001$)	Unclear	Unclear	Unclear	Yes	Yes	Yes	3
Hardy 1996[31]	Quasi -experimental	Nursing homes and outpatients	Standardized bathing regimen using superfatted soap (Dove) and mineral oil using various bathing frequencies	18	143	75	(1) Skin dryness	Reduction of skin dryness irrespective of bathing frequency	na						3
Schölermann *et al.* 1998[32]	RCT	Outpatients	Twice-daily application of Eucerin 10% urea lotion vs. urea-free vehicle lotion	6	60	64	(1) SCH (2) Skin dryness	Increase of SCH in both groups; higher SCH in Eucerin 10% urea group compared with placebo ($P < 0{\cdot}05$)	Unclear	Unclear	Yes	No	No	Yes	3

Table 2 (continued)

Source	Design	Setting, sample	Intervention[a]	Study duration (weeks)	n	Mean age (years)	Outcomes	Main results[a]	Risk of bias						LoE
									Sequence	Allocation	Blinding	Completeness	Selection	Other	
Schölermann et al. 1999[33]	RCT	Outpatients	Twice-daily application of Eucerin cream 10% urea vs. Eucerin cream 10% urea with 1% panthenol and 0·07% bisabolol vs. placebo	4	72	70	(1) SCH (2) Skin dryness	Increase of SCH in Eucerin 10% urea and Eucerin urea 10% with panthenol and bisabolol compared with placebo ($P < 0·01$); no difference between Eucerin 10% urea and Eucerin urea 10% with panthenol and bisabolol	Unclear	Unclear	Unclear	No	No	Yes	3
Sheppard and Brenner 2000[34]	Quasi -experimental	Nursing home	Bag Bath/Travel Bath vs. traditional bathing	6	32	85	(1) Skin dryness (2) Redness (3) Flaking (4) Scaling (5) Cracking	Reduction of skin dryness in Bag Bath/Travel Bath compared with traditional bathing group ($P < 0·001$)	na						3
Kuzmina et al. 2002[35]	RCT	Outpatients	Twice-daily application of oil-in-water emulsion (40 mg g^{-1} urea) vs. oil-in-water emulsion (40 mg g^{-1} urea and 40 mg g^{-1} sodium chloride)	2	23	73	(1) TEWL (2) SCH (3) Electrical impedance	Decrease of TEWL in both groups; difference between groups $P = 0·24$	Unclear	Unclear	Unclear	Yes	Yes	Yes	3
Pham et al. 2002[36]	RCT	Diabetic outpatients	Atrac-Tain cream (10% urea, 4% lactic acid) vs. vehicle	8	40	62	(1) Skin dryness (2) Development of new foot ulcers	Larger reduction of xerosis of feet in Atrac-Tain cream group compared with vehicle ($P < 0·05$)	Yes	Yes	Yes	Yes	Yes	No	2

Table 2 (continued)

Source	Design	Setting, sample	Intervention[a]	Study duration (weeks)	n	Mean age (years)	Outcomes	Main results[a]	Risk of bias						LoE
									Sequence	Allocation	Blinding	Completeness	Selection	Other	
Wilson and Nix 2005[37]	Quasi -experimental	Nursing home	Once-daily application of Sween 24 cream (6% dimethicone)	1	16	76	(1) Erythema (2) Dry scaly skin (3) Presence of scratching	Reduction of skin dryness ($P < 0{\cdot}001$)	na						3
Okada et al. 2006[43] (abstract)	Quasi -experimental	Nursing home	Two-weekly application of bathing detergent using pseudoceramide	3	21	82	(1) SCH (2) pH (3) Ceramide content (4) Sebum content (5) Bacterial flora	Increase in SCH	na						na
Welzel et al. 2006[38]	Quasi -experimental	Outpatients	Twice-daily application of *Hamamelis* ointment	6	89	63	(1) Sebum content (2) SCH (3) Skin dryness (4) Degree of fissures (5) Itching (6) Adverse events	Increase in sebum content and SCH ($P < 0{\cdot}001$)	na						3
Sloane et al. 2007[39]	RCT	Nursing home	Effects of four bathing procedures on skin condition	12 and 16	31	86	(1) Skin condition	No differences of skin condition between the four bathing regimens ($P = 0{\cdot}81$)	Unclear	No	No/Yes	Yes	Yes	Yes	3
Quatresooz et al. 2009[40] (study 1)	RCT	Diabetic menopausal women	Once-daily application of 1·5% chitin–glucan cream vs. placebo	5	30	59	(1) Moisture accumulation	Increase of SCH in chitin–glucan group compared with placebo ($P < 0{\cdot}01$)	Yes	Yes	Unclear	Yes	Yes	Yes	2
Quatresooz et al. 2009[40] (study 2)	RCT	Diabetic menopausal women	Once-daily application of two different glycerol formulations	5	30	59	(1) Moisture accumulation	Increase of SCH in both groups; differences between groups $P = 0{\cdot}061$	Yes	Yes	Unclear	Yes	Yes	Yes	2

Table 2 (continued)

Source	Design	Setting, sample	Intervention[a]	Study duration (weeks)	n	Mean age (years)	Outcomes	Main results[a]	Risk of bias						LoE
									Sequence	Allocation	Blinding	Completeness	Selection	Other	
Papanas et al. 2011[41]	Quasi -experimental	Diabetic outpatients	Twice-daily application of urea 10%, α-hydroxy acid, panthenol -containing foam vs. no treatment	2	20	61	(1) SCH	SCH higher in Neuropad repair foam compared with no treatment ($P < 0{\cdot}001$)	na						3
Elewa et al. 2012[44] (abstract)	Quasi -experimental	Healthy subjects	Induction of skin barrier disruption and subsequent treatment	1	No data	> 65	(1) SCH (2) TEWL (3) pH (4) Erythema	No data	na						na
Roure et al. 2012[42]	Quasi -experimental	Healthy subjects	Application of lotion containing glycerin and subsequent simulated exposure of dry and cold wind	1 day	12	62	(1) SCH	Application of lotion before wind exposure increased SCH, decrease of SCH after wind exposure without lotion	na						4

LoE, level of evidence according to the Oxford Centre for Evidence-Based Medicine 2011; na, not applicable; RCT, randomized controlled trial; SCH, stratum corneum hydration; TEWL, transepidermal water loss. [a]Manufacturers: Dove®, Unilever, London, U.K.; Lac-Hydrin®, Bristol-Myers Squibb, New York, NY, U.S.A.; Eucerin®, Beiersdorf AG, Hamburg, Germany; Bag Bath®/Travel Bath®, Incline Technologies, Carson City, NV, U.S.A.; Atrac-Tain®/Sween 24, Coloplast, Peterborough, U.K.; Neuropad®, Crawford Healthcare, Knutsford, U.K.

Table 3 Summary of included studies for skin injury prevention

Source	Design	Setting, sample	Intervention[a]	Study duration (weeks)	n	Mean age (years)	Outcomes	Main results	Risk of bias						LoE
									Sequence	Allocation	Blinding	Completeness	Selection	Other	
Lyder *et al.* 1992[45]	Quasi -experimental	Geriatric	Structured skin care regimen including application of cleansers and moisturizers for IAD prevention	10	15	75	(1) IAD incidence	No reduction of IAD incidence	na						4
Byers *et al.* 1995[46]	Quasi -experimental	Nursing home	No-rinse cleanser vs. soap and water and moisture barrier vs. no-rinse cleanser and moisture barrier for IAD prevention	15	12	87	(1) TEWL (2) pH (3) Erythema	No differences in TEWL, pH, and erythema between treatment groups	na						4
Mason 1997[58]	Quasi -experimental	Nursing home	Nonemollient soap vs. emollient soap for skin-tear prevention	20	43	86	(1) Incidence of skin tears (2) Skin quality	Lower skin-tear incidence in emollient soap group ($P = 0{\cdot}082$)	na						4
Cooper and Gray 2001[47]	RCT	Nursing home	Soap vs. foam cleanser (amphoteric surfactants, triclosan, dimethicone) for IAD prevention	2	93	82	(1) Skin condition	Larger proportion of residents in foam cleanser group with intact skin (66%) than in soap group (37%)	Unclear	No	No/Yes	Yes	Yes	No	3
Clever *et al.* 2002[54]	Retrospective	Nursing home	All-in-one disposable washcloth (dimethicone) vs. standard care for PU prevention	26	64	83	(1) PU incidence	Lower PU incidence in intervention group compared with standard care group ($P = 0{\cdot}015$)	na						4

Table 3 (continued)

Source	Design	Setting, sample	Intervention[a]	Study duration (weeks)	n	Mean age (years)	Outcomes	Main results	Risk of bias						LoE
									Sequence	Allocation	Blinding	Completeness	Selection	Other	
Lewis-Byers and Thayer 2002[48]	RCT	Nursing home	Soap and water and moisturizer vs. no-rinse liquid cleanser and barrier cream for IAD prevention	3	32	70	(1) Perineal skin condition (2) Pain	Better skin condition in no-rinse cleanser and barrier cream group compared with water and soap (not statistically significant)	No	No	No	Yes	Yes	No	4
Warshaw *et al.* 2002[49]	Quasi -experimental	Nursing home	Cleanser barrier lotion for IAD prevention	1	19	73	(1) Erythema score (2) Pain score	Reduction of erythema and pain ($P < 0{\cdot}01$)	na						3
Birch and Coggins 2003[59]	Retrospective	Nursing home	One-step no-rinse cleanser for skin-tear prevention	16	29	80 to 82	(1) Skin tears	Reduction of skin-tear incidence	na						4
Hunter *et al.* 2003[55]	Quasi -experimental	Nursing home	Skin protectant (50% lanolin, beeswax, petrolatum) and body wash for skin breakdown and PU prevention	26	83	81	(1) Incidence of 'skin breakdown' (2) PU incidence	Reduction of 'skin breakdown' incidence after implementation of skin protectant and body wash ($P = 0{\cdot}007$); no reduction of PU incidence ($P = 0{\cdot}437$)	na						3
Zehrer *et al.* 2004[50]	Descriptive	Nursing home	Protective ointment as needed vs. barrier film once daily vs. barrier film three times per week for IAD prevention	26	250	83	(1) IAD incidence	No difference in IAD incidence between groups ($P = 0{\cdot}445$)	na						4

Table 3 (continued)

Source	Design	Setting, sample	Intervention[a]	Study duration (weeks)	n	Mean age (years)	Outcomes	Main results	Risk of bias						LoE
									Sequence	Allocation	Blinding	Completeness	Selection	Other	
Thompson et al. 2005[56]	Quasi -experimental	Nursing home	Skin care protocol including application of a cleanser and skin protectant (50% lanolin, beeswax, petrolatum) for PU prevention	26	136	81	(1) Prevalence of category I and II PU (2) Incidence of category I and II PU (3) Number of category I and II PU	No difference between PU prevalence before and after intervention ($P = 0.244$); reduction of PU incidence after intervention ($P = 0.01$); reduction of number of PU after intervention ($P = 0.05$)	na						3
Torra i Bou et al. 2005[57]	RCT	Nursing home/ hospital	Mepentol (various oils) vs. placebo for PU prevention	4	380	84	(1) Incidence of PU	Lower PU incidence in Mepentol group ($P < 0{\cdot}006$)	Yes	Yes	Yes	Yes	Yes	No	2
Bliss et al. 2006, 2007[20,51]	Quasi -experimental	Nursing home	Barrier film (spray acrylate) vs. ointment (43% petrolatum) vs. ointment (98% petrolatum) vs. barrier cream (12% zinc oxide, 1% dimethicone) for IAD prevention	6	981	65+	(1) IAD incidence	No differences between groups ($P = 0{\cdot}55$)	na						4
Cooper et al. 2008[52]	RCT	Nursing home/ reha -bilitation centre	Tena Wash mousse (emollients) vs. Clinisan foam cleanser (amphoteric surfactants, triclosan, dimethicone) for IAD prevention	2	30	81	(1) Skin integrity	Slight increase of patients with intact skin in both groups, no difference between groups	Unclear	Unclear	No/Yes	Yes	Yes	No	3

Table 3 (continued)

Source	Design	Setting, sample	Intervention[a]	Study duration (weeks)	n	Mean age (years)	Outcomes	Main results	Risk of bias						LoE
									Sequence	Allocation	Blinding	Completeness	Selection	Other	
Groom *et al.* 2010[60]	Retrospective	Nursing home	Surfactant-based cleanser and moisturizer/barrier cream (dimethicone) vs. phospholipid-based cleanser and moisturizer/barrier cream (dimethicone) for skin-tear prevention	52	200	65+	(1) Skin-tear incidence (2) Number of skin tears	Higher skin-tear incidence in surfactant-based cleanser and moisturizer/ barrier cream group compared with phospholipid-based cleanser ($P < 0{\cdot}001$)	na						4
Beeckman *et al.* 2011[53]	RCT	Nursing home	3-in-1 perineal care washcloth (3% dimethicone) vs. water and soap for IAD prevention and treatment	17	141	86	(1) Prevalence of IAD (2) Severity of IAD	Decrease of IAD prevalence ($P = 0{\cdot}003$) and severity ($P = 0{\cdot}06$) in intervention group; larger decrease of IAD prevalence in intervention group compared with control group ($P = 0{\cdot}003$)	Yes	No	No	Yes	Yes	No	3

IAD, incontinence-associated dermatitis; LoE, level of evidence according to the Oxford Centre for Evidence-Based Medicine 2011; PU, pressure ulcer; RCT, randomized controlled trial; TEWL, transepidermal water loss. [a]Manufacturers: Mepentol®, Bama-Geves, Barcelona, Spain; Tena® Wash Mousse, SCA Hygiene Products UK Ltd, Dunstable, U.K.; Clinisan™, Synergy Health, Swindon, U.K.

dimethicone no clinical differences in terms of IAD incidence were observed[20,50,51] (LoE 4).

The remaining six studies investigated the efficacy of combined skin care regimens consisting of standardized cleansing procedures and the application of leave-on products. Three methodologically limited studies found no or only minor differences in IAD incidence or skin barrier function when comparing special cleansing and caring procedures with soap and water cleansing alone[45,46,48] (LoE 4). Using cohort study designs, Hunter *et al.* and Thompson *et al.* demonstrated reductions of dry, scaly and cracked skin and/or SPU incidence after application of a body wash and a leave-on product containing lanolin and petrolatum (LoE 3).[55,56] Based on a retrospective analysis of skin-tear incidence in a nursing home Groom *et al.*[60] reported a statistically significant reduction after implementing a phospholipid-based cleanser combined with a dimethicone-containing moisturizer compared with a surfactant-based cleanser and two dimethicone- and/or zinc-containing skin protectants (LoE 4).

Discussion

Using a comprehensive and systematic approach we identified 33 studies published during the past 20 years providing evidence about the efficacy and effectiveness of basic skin care interventions in the aged. Based on the focus and on the primary outcomes of the included research articles the evidence was classified into dry skin prevention/treatment and skin injury prevention. The overall study quality and thus the validity of results were higher for the dry skin-prevention studies than for the skin injury-prevention studies.

For preventing and treating dry skin in the aged, findings suggest that replacing traditional soaps with syndet (liquid) soaps or alternatively using bag baths instead of traditional baths reduces skin dryness. This effect seems to be independent of bathing and washing frequency or the way of bathing. Application of moisturizers containing humectants such as lactic acid, urea, glycerin and α-hydroxy acids is clearly effective in reducing dry skin conditions and enhancing the skin barrier function. An additional benefit of panthenol, bisabolol or sodium chloride in combination with humectant-containing moisturizers could not be shown suggesting that the moisturizer in combination with the humectant itself causes the hydrating effects. Furthermore there is no evidence that one humectant-containing moisturizer is superior to another.

Decreasing the clinical signs of skin dryness and increasing stratum corneum hydration might also be achieved by the application of dimethicone-containing skin care products that primarily retard the TEWL. Whether this should be the preferred way for hydrating dry skin in clinical practice is unclear, but because occlusives are largely used for IAD prevention (Table 3) this strategy might have an overall value in skin protection especially in aged incontinent patients. Although skin dryness was also reduced by a *Hamamelis* ointment, due to the study design it is unclear whether the active and/or other ingredients of the cream were responsible for the observed effect.

The findings of this systematic review support the recently proposed pathway to dry skin prevention and treatment[24] and expert recommendations.[10,61] Based on empirical evidence using emollients combined with humectants seems to be the best strategy for treating xerosis in the aged.

For preventing skin injuries the use of special soaps, and nondetergent cleansers with or without moisturizing substances reduced the incidence of skin tears, IAD and SPUs. The skin-protecting effects might be enhanced when emollients or barrier products are additionally applied. Because ingredients were often not reported the modes of action are difficult to interpret. The occlusive dimethicone was most often reported for IAD and skin-tear prevention but the effect seemed to be comparable to petrolatum-containing products. Combinations of petrolatum, waxes and lanolin, and/or combinations of unsaturated fatty acids seem to be effective in preventing SPUs.

In a strict sense, skin tears, IAD and SPUs are distinct pathological concepts and medical diagnoses but they have a lot in common. In all cases, external mechanical loads and chemical or biological irritants disrupt the skin barrier, which may lead to the destruction of the epidermis and dermis.[62–64] Therefore, preventive skin care interventions can be expected to increase the stratum corneum integrity and skin health in many of these conditions. Interestingly, authors of IAD-prevention studies used, for instance, PU classification systems to grade the skin condition as an outcome in their clinical trials.[47,52] Hunter *et al.* used the concept of 'skin breakdown' to summarize clinical symptoms like dryness, redness and superficial wounds in one concept.[55] Also, from a clinical practice point of view, there is an overlap between skin care interventions for preventing superficial ulcers, skin tears and IAD.

The findings of this systematic review are limited due to the design and reporting weaknesses of the original studies. In total we identified only three high-quality RCTs that can be regarded as the reference standard design for investigating treatment effects.[65] Insufficient sequence generation, allocation concealment and blinding were the most often observed design limitations. One can argue whether blinding is always possible and feasible when investigating skin care regimens, but at least outcome assessors should be blinded to prevent detection bias.[27] To gain detailed insight into the topic we also included lower-level evidence of nonrandomized cohort studies and historically controlled studies. Because cofounders are not controlled, such designs provide only weak evidence about treatment effects. However, external validity is supported because comparable effects could be identified across studies (e.g. moisturizers to treat dry skin).

A further limitation might be the presence of indirectness[66] because in many included studies skin care treatments were compared with no or 'standard' treatment. Therefore, we have only limited evidence about the specific advantages of certain care strategies. Varying reported primary and secondary study outcomes also make a synthesis difficult. Prevalence, incidence, and different clinical scores and/or skin barrier

function parameters were measured and one might argue whether it is appropriate to compare them with each other. Finally, although we focused on the aged population, the lower limit of the age range of 50 years might limit the comparability between study samples.

Although three databases, two citation indexes and numerous reference lists were searched, there might be reports that were not identified. We did not explicitly search other sources for grey literature and we did not screen journals.

In conclusion, skin care in the aged is a challenge especially in geriatric and long-term care settings and it will become more important in the future. Keeping the skin in a healthy condition and preventing skin barrier damage and injuries are commonly agreed upon goals. Available health service research studies show large variations of basic skin care practices and product use in clinical settings.[67–69] Unexplained variation in healthcare usually indicates room for quality improvement.[70] The current state of the evidence suggests that the skin barrier and integrity in the aged can be improved by using low-irritating cleansing products and humectant-containing moisturizers. In cases of increased risk of IAD or SPU development, occlusive leave-on products should be used. Compared with the application of leave-on products we know little about the effects of washing and cleansing regimens, their frequencies and durations on aged skin. There is an urgent need for high-quality clinical trials investigating the specific effects of skin care regimens including head-to-head comparisons of common applied skin care products.

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