

Pressure Ulcer Risk Assessment and Prevention

A Systematic Comparative Effectiveness Review

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Background: Pressure ulcers are associated with substantial health burdens but may be preventable.

Purpose: To review the clinical utility of pressure ulcer risk assessment instruments and the comparative effectiveness of preventive interventions in persons at higher risk.

Data Sources: MEDLINE (1946 through November 2012), CINAHL, the Cochrane Library, grant databases, clinical trial registries, and reference lists.

Study Selection: Randomized trials and observational studies on effects of using risk assessment on clinical outcomes and randomized trials of preventive interventions on clinical outcomes.

Data Extraction: Multiple investigators abstracted and checked study details and quality using predefined criteria.

Data Synthesis: One good-quality trial found no evidence that use of a pressure ulcer risk assessment instrument, with or without a protocolized intervention strategy based on assessed risk, reduces risk for incident pressure ulcers compared with less standardized risk assessment based on nurses' clinical judgment. In higher-risk populations, 1 good-quality and 4 fair-quality randomized trials found that more advanced static support surfaces were associated with lower risk for pressure ulcers compared with standard mattresses

(relative risk range, 0.20 to 0.60). Evidence on the effectiveness of low-air-loss and alternating-air mattresses was limited, with some trials showing no clear differences from advanced static support surfaces. Evidence on the effectiveness of nutritional supplementation, repositioning, and skin care interventions versus usual care was limited and had methodological shortcomings, precluding strong conclusions.

Limitation: Only English-language articles were included, publication bias could not be formally assessed, and most studies had methodological shortcomings.

Conclusion: More advanced static support surfaces are more effective than standard mattresses for preventing ulcers in higher-risk populations. The effectiveness of formal risk assessment instruments and associated intervention protocols compared with less standardized assessment methods and the effectiveness of other preventive interventions compared with usual care have not been clearly established.

Primary Funding Source: Agency for Healthcare Research and Quality.

Ann Intern Med. 2013;159:28-38.

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Pressure ulcers are defined as “localized injury to the skin and/or underlying tissue usually over a bony prominence, as a result of pressure, or pressure in combination with shear” (1). Risk factors include older age, cognitive impairment, physical impairments, and comorbid conditions that affect soft tissue integrity and healing (such as urinary incontinence, edema, impaired microcirculation, hypoalbuminemia, and malnutrition) (2, 3). Pressure ulcers affect 1.3 million to 3 million adults in the United States and are associated with decreased quality of life; impaired function; complications, such as infection; poorer prognosis; and increased costs of care (3–6).

Interventions to prevent the occurrence or reduce the severity of pressure ulcers could have important health effects and may be more efficient than treating ulcers after they have developed (7). Recommended prevention strategies generally involve the use of risk assessment tools to identify persons at higher risk for ulcers in conjunction with preventive interventions, with higher-risk patients receiving more intensive interventions (1, 8, 9). Commonly used risk assessment instruments include the Braden, Norton, and Waterlow scales (3, 10–12).

Various preventive interventions are available, including various support surfaces, repositioning, skin care (including creams, dressings, and management of incontinence), and nutritional supplementation (8, 9). Each of

these categories encompasses various interventions. The use of preventive interventions may vary according to patient characteristics or the care setting. For example, nutritional supplementation may be of greater benefit in patients who are undernourished, and skin care needs may be greater for persons with incontinence. Some interventions that require substantial nursing resources or specialized equipment may be less feasible for community settings.

The purpose of this report is to review the comparative clinical utility of pressure ulcer risk assessment instruments and the benefits and harms of preventive interventions. This topic was nominated to the Agency for Healthcare Research and Quality (AHRQ) by the American College of Physicians, which intends to develop a guideline on prevention and management of pressure ulcers. Treatment of established pressure ulcers is addressed in a separate report (13).

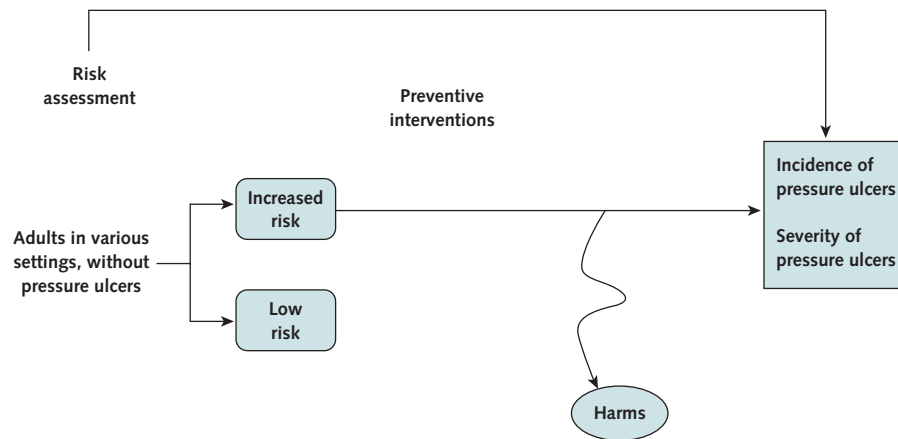
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Figure 1. Analytic framework.

METHODS

Scope of the Review

We followed a standardized protocol and developed an analytic framework (Figure 1) that included the following key questions:

Is the use of risk assessment tools effective in reducing the incidence or severity of pressure ulcers, and how does effectiveness vary according to setting and patient characteristics?

In patients at increased risk for pressure ulcers, what is the effectiveness and comparative effectiveness of preventive interventions in reducing the incidence or severity of pressure ulcers and how does effectiveness vary according to assessed risk level, setting, or patient characteristics?

What are the harms of interventions for preventing pressure ulcers?

The protocol was developed using a standardized process (14), with input from experts and the public. Detailed methods and data for the review, including search strategies, detailed inclusion criteria, data abstraction tables, and tables with quality ratings of individual studies, are available in the full report (15). The first key question focused on direct evidence of effects of using a risk assessment instrument on pressure ulcer incidence or severity. An underlying assumption was that the risk assessment instrument will inform the use of preventive interventions. The other key questions evaluated the benefits and harms of various preventive interventions. Settings of interest included acute care hospitals, long-term care facilities, rehabilitation facilities, operative and postoperative settings, and community settings (for example, home care and wheelchair users in the community). Patient characteristics of interest included age; race or skin tone; physical impairment; body weight; and medical comorbid conditions, such as urinary incontinence, diabetes, and peripheral vascular disease. A key question on the diagnostic accuracy of

risk assessment instruments; outcomes related to resource utilization (such as duration of hospital stay); studies of low-risk surgical populations; and other treatments, including drugs, intraoperative warming therapy, and polarized light, are included in the full report (15).

Data Sources and Searches

We searched Ovid MEDLINE from 1946 to November 2012, CINAHL (EBSCOhost) from 1988 through November 2012, the Cochrane Library through the fourth quarter of 2012, grant databases, clinical trial registries, and reference lists.

Study Selection

At least 2 reviewers independently evaluated each study to determine inclusion eligibility. English-language articles were selected for full review if they were relevant to a key question and met predefined inclusion criteria.

We included controlled clinical trials and cohort studies that compared pressure ulcer incidence or severity after use of a risk assessment instrument versus clinical judgment or another risk assessment instrument, as well as randomized trials of preventive interventions that reported pressure ulcer incidence or severity or harms. We excluded trials in which more than 20% of patients had stage 2 or higher ulcers at baseline. Figure 2 shows the results of the search and study selection process.

Data Extraction

One investigator abstracted details about the study design, population, setting, interventions, analysis, follow-up, and results. A second investigator reviewed data for accuracy. Two investigators independently applied predefined criteria (16–18) to assess the quality of each study as good, fair, or poor. Discrepancies were resolved through consensus.

For studies of interventions, we abstracted relative risks (RRs) and associated 95% CIs or calculated them on

the basis of the pressure ulcer incidence in each intervention group.

Data Synthesis and Analysis

We did not conduct meta-analysis because of methodological limitations in the studies and clinical heterogeneity. We assessed the overall strength of each body of evidence as high, moderate, low, or insufficient in accordance with the AHRQ Methods Guide for Effectiveness and Comparative Effectiveness Reviews (14, 19), on the basis of the quality of studies, consistency among studies, precision of estimates, and directness of evidence.

Role of the Funding Source

This research was funded by AHRQ’s Effective Health Care Program. Investigators worked with AHRQ staff to develop and refine the scope, analytic framework, and key questions. AHRQ staff had no role in study selection, quality assessment, synthesis, or development of conclusions. AHRQ staff provided project oversight, distributed the

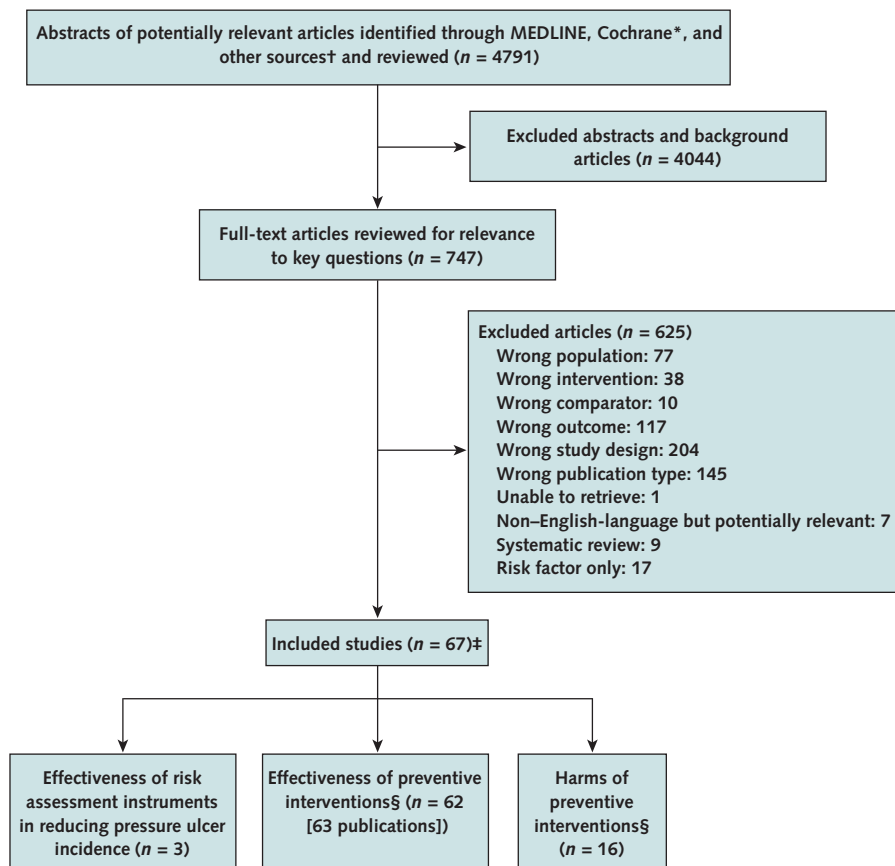
draft report for peer review, and reviewed the draft report and manuscript. The investigators are solely responsible for the content of the manuscript and the decision to submit it for publication.

RESULTS

Effectiveness of Risk Assessment Instruments

One good-quality trial ($n = 1231$) randomly assigned patients newly admitted to internal medicine or oncology wards to the Waterlow scale, the Ramstadius tool, or nurses’ judgment and followed patients through discharge (20). Six percent of patients had ulcers at baseline, and the mean discharge period was 9 days. The Ramstadius tool is a combination risk assessment and intervention protocol that specifies the use of an alternating-air mattress and frequent repositioning in patients assessed as being at high risk. In the other 2 groups, nurses used the Waterlow scale or clinical judgment to assess risk, but subsequent interven-

Figure 2. Summary of evidence search and selection.



* Includes the Cochrane Central Register of Controlled Trials and the Cochrane Database of Systematic Reviews.

† Includes reference lists, grant databases, clinical trial registries, and suggestions from peer reviewers.

‡ A key question on the diagnostic accuracy of risk assessment instruments; outcomes related to resource utilization; studies of low-risk surgical populations; and studies of drugs, intraoperative warming therapy, and polarized light are included in the full Agency for Healthcare Research and Quality report (15).

§ Some studies are included for >1 key question.

tions were not specified. Incidence of pressure ulcers did not differ among the groups (8%, 5%, and 7%, respectively), and no patients were lost to follow-up. Similar proportions of patients received more intensive preventive interventions (for example, more advanced support surfaces, documented pressure ulcer care plan, skin integrity referral, or dietitian referral) in the 3 groups.

Two other trials reported conflicting results of the effects of using risk assessment instruments on the likelihood of subsequent ulcers, but both were rated poor-quality (21, 22). One trial (21) used a nonrandomized design with nonconcurrent controls and did not adjust for confounders, and the other (22) used unclear methods of randomization, reported important baseline differences between groups, and did not blind outcome assessors to risk assessment scores.

Effectiveness of Preventive Interventions in Patients at Increased Risk

Support Surfaces

Support surfaces are various devices designed to redistribute pressure (23) and include mattresses and related equipment (such as mattress overlays or bed systems), heel supports, and wheelchair or chair cushions. Criteria for classifying support surfaces have historically included the material used (for example, foam, air, gel, beads, or water), whether the support surface is static or dynamic (for example, alternating-air or low-air-loss systems), and whether it requires power (24). More recent proposals recommend classification of support surfaces as “reactive” (one with the capacity to change load distribution in response to applied loads) or “active” (one that can alter load distribution independent of applied loads) (24, 25). However, most published trials used older and often poorly standardized classification methods. In this report, we broadly classified mattresses and related support surfaces as static, alternating-air, or low-air-loss. These are reviewed separately from heel supports and wheelchair cushions.

Forty-one randomized trials (in 42 publications) evaluated support surfaces in patients at increased risk for pressure ulcers (26–67) (Table 1 of the Supplement, available at www.annals.org). Sample sizes ranged from 32 to 1972 patients, and follow-up ranged from 6 days to 6 months or until time of discharge. When reported, mean Braden scores ranged from 9.4 to 16 (27, 28, 35, 36, 38, 47–49, 53, 58, 64, 66, 67), Norton scores ranged from 12 to 13 (30–32, 34, 40, 52, 60), and Waterlow scores ranged from 13 to 19 (33, 41, 42, 44, 57, 62). Trial settings included acute care hospitals and long-term care nursing facilities.

Three trials were rated as good-quality (56, 57, 66), 20 fair-quality (27, 30–32, 35–38, 41, 42, 46, 48–50, 52, 54, 62, 63, 65, 67), and 18 poor-quality (26–29, 33, 34, 39, 40, 43–45, 47, 51, 53, 58–61, 64). Methodological shortcomings included unclear methods of randomization and allocation concealment and failure to report blinding of outcomes assessors. In some studies, patients who devel-

oped pressure ulcers received additional preventive interventions, but no trial reported results adjusted for such differences. “Standard hospital mattress” comparators varied and were frequently not well-described in the studies but have changed over time from spring to foam mattresses. No study directly evaluated how effectiveness of preventive interventions varied according to care setting or in subgroups defined by patient characteristics.

Static Mattresses, Overlays, and Bed Systems

One good-quality ($n = 1166$) (57) and 4 fair-quality ($n = 83$ to 543) trials (41, 48, 54, 65) found that a more advanced static mattress or overlay was associated with lower risk for incident pressure ulcers than a standard hospital mattress (RR range, 0.16 to 0.82). The difference was not statistically significant in 2 trials (57, 65), including the largest good-quality trial, which found no difference between a viscoelastic and polyurethane foam mattress versus a standard mattress in risk for pressure ulcers after 11 to 12 days (15% vs. 22%; RR, 0.78 [95% CI, 0.55 to 1.1]) (57). The static support surfaces evaluated in the fair-quality trials were the Softform (Medical Support Systems, Cardiff, United Kingdom) mattress (41), a sheepskin overlay (48, 54), and an air overlay (65). Six poor-quality trials reported results generally consistent with these findings (26, 40, 43, 45, 53, 61). The variability across trials in the support surfaces evaluated made it difficult to reach conclusions about the effectiveness of specific static support surfaces versus standard hospital mattresses, although 3 trials found that an Australian medical sheepskin overlay was associated with lower risk for incident ulcers than a standard mattress (RRs, 0.30, 0.58, and 0.58) (48, 53, 54).

Three fair-quality ($n = 52$ to 100) (42, 49, 52) and 6 poor-quality ($n = 37$ to 407) trials (29, 33, 44, 51, 59, 60) found no differences among different advanced static support mattresses or overlays in incidence of pressure ulcers. One fair-quality trial ($n = 40$) of nursing home residents found that a foam replaceable-parts mattress was associated with lower risk for incident ulcers than a 10.2-cm (4-in)-thick dimpled foam overlay (25% vs. 60%; RR, 0.42 [CI, 0.18 to 0.96]) (67).

Low-Air-Loss Mattresses, Overlays, and Bed Systems

Low-air-loss support surfaces provide a flow of air to assist in managing the skin microclimate (23). One fair-quality trial of intensive care unit patients ($n = 98$) found that a low-air-loss bed was associated with a lower likelihood of 1 or more pressure ulcers than a standard hospital bed (12% vs. 51%; RR, 0.23 [CI, 0.10 to 0.51]) (46), but a small, poor-quality trial ($n = 36$) found no difference between a low-air-loss mattress and a standard hospital bed after cardiovascular surgery (47).

One fair-quality trial ($n = 62$) found that a low-air-loss mattress was associated with a lower incidence of pressure ulcers than the Hill-Rom Duo mattress (Hill-Rom,

Auburn, Australia), which has options for constant low pressure and alternating air, but the difference was not statistically significant (10% vs. 19%; RR, 0.53 [CI, 0.15 to 1.9]) (63).

Alternating-Air Mattresses, Overlays, and Bed Systems

Alternating-air support surfaces inflate and deflate sequentially, resulting in pressure at different parts of the surface for short periods (23). One good-quality, 1 fair-quality, and 4 poor-quality trials ($n = 32$ to 487) found no difference among various alternating-air mattresses or overlays versus various advanced static mattresses or overlays in pressure ulcer incidence or severity (26, 28, 30, 34, 59, 66). The good-quality trial ($n = 447$) (66) found no difference between an alternating-air mattress and a viscoelastic foam mattress plus repositioning every 4 hours in incidence of stage 2 to 4 pressure ulcers after 20 weeks in patients with a high prevalence (33%) of baseline stage 1 pressure ulcers (15% vs. 16%; RR, 0.98 [CI, 0.64 to 1.5]). The fair-quality trial ($n = 148$) found no difference between an alternating-air overlay and a silicone overlay in risk for incident ulcers after 3 months in patients without pressure ulcers at baseline (54% vs. 59%; RR, 0.91 [CI, 0.69 to 1.2]) (30). A fair-quality trial ($n = 43$) of intensive care patients found that stepped care (defined as initial use of less advanced and less expensive support surfaces followed by more advanced and more expensive support surfaces if ulcers developed, according to a predefined algorithm) starting with alternating-air mattresses was associated with decreased risk for incident pressure ulcers after 11 to 12 days versus stepped care starting primarily with static support surfaces (0% vs. 35% for stage 2 or higher ulcers; RR, 0.06 [CI, 0.00 to 0.96]) (37). Three poor-quality trials ($n = 108$ to 487) found that various alternating-air mattresses or overlays were associated with lower risk for incident pressure ulcers than standard hospital mattresses (26, 28, 58).

Four trials (1 good-quality, 2 fair-quality, and 1 poor-quality) ($n = 44$ to 1972) found no clear differences among different alternating-air mattresses or overlays (35, 55, 56, 58, 62).

Heel Supports or Boots

One fair-quality trial of patients with fracture ($n = 239$) found that the Heelift Suspension Boot (DM Systems, Evanston, Illinois) was associated with lower risk for heel, foot, or ankle ulcers than usual care without leg elevation (3.3% vs. 13% for stage 2 ulcers; RR, 0.25 [CI, 0.09 to 0.72]) (36). Two poor-quality trials ($n = 52$ and 240) found no clear differences between a boot and usual care (64) or among types of boots (39) in risk for ulcers.

Wheelchair Cushions

Four fair-quality trials of older nursing home residents ($n = 32$ to 248) compared sophisticated and standard

wheelchair cushions (27, 31, 32, 38). None focused on patients with spinal cord injuries. Results were inconsistent and are difficult to interpret because of differences across trials in the types of cushions evaluated. One trial ($n = 248$) found no difference in ulcer risk between a contoured, individually customized foam cushion and a slab cushion (31), and another trial ($n = 32$) found no difference between a specialized wheelchair cushion with an incontinence cover versus a generic foam cushion (38). A third trial ($n = 141$) found that the JAY cushion (contoured urethane foam with a gel pad topper) (Sunrise Medical, Fresno, California) was associated with decreased risk for incident pressure ulcers versus a standard foam cushion (8.8% vs. 26% for stage 2 or 3 ulcers; RR, 0.36 [CI, 0.15 to 0.85]) (32). Another trial ($n = 232$) found that various skin-protection wheelchair cushions were associated with lower risk for ischial tuberosity ulcers than a standard segmented foam cushion when used with a fitted wheelchair (9.9% vs. 6.7%; RR, 0.13 [CI, 0.02 to 1.0]) (27).

Other Preventive Interventions

Nutritional Supplementation

Six trials evaluated nutritional interventions to prevent pressure ulcers, but 5 were rated as poor quality (68–73). Methodological limitations in all trials included inadequate description of randomization and allocation concealment methods and failure to blind outcome assessors. Some trials also reported baseline differences in pressure ulcer risk (68), high attrition (69, 70), or failure to blind patients and caregivers (68–70, 72, 73). One trial reported that 28% of patients were malnourished at baseline (70). Although the other trials enrolled patients at higher risk for pressure ulcers, baseline nutritional status was not specifically reported.

The trials found little evidence to support the effectiveness of enteral or oral nutritional supplementation for preventing pressure ulcers. The only fair-quality trial ($n = 95$) compared high-fat, low-carbohydrate enteral nutrition with and without additional vitamins and antioxidants and found no difference in risk for any incident ulcer in critically ill patients with acute lung injury (33% vs. 49%; RR, 0.67 [CI, 0.40 to 1.10]) (73). One poor-quality trial ($n = 129$) of enteral supplementation (72) and 3 poor-quality trials ($n = 59$ to 495) of oral supplementation (69–71) found no statistically significant effects on risk for subsequent ulcers versus placebo or a standard hospital diet, although trends favored supplementation. One poor-quality trial ($n = 672$) found that high-calorie liquid nutritional supplements plus standard hospital diet were associated with lower risk for pressure ulcers at 15 days than standard hospital diet alone in critically ill older patients (68).

Repositioning

The goal of repositioning is to decrease risk for pressure ulcers by reducing periods of sustained pressure. The

frequency of repositioning and the positions used vary (1). One fair-quality cluster randomized trial ($n = 213$) found that repositioning at a 30-degree tilt every 3 hours was associated with lower risk for incident pressure ulcers than usual care (90-degree lateral repositioning every 6 hours during the night) after 28 days (3.0% vs. 11%; RR, 0.27 [CI, 0.08 to 0.93]) (74). Another fair-quality trial ($n = 235$) found no difference in risk for incident pressure ulcers between different repositioning intervals (alternating between the semi-Fowler 30-degree and lateral positions) (75). Two other repositioning trials ($n = 46$ and 838) followed patients for only 1 night (76) or were susceptible to confounding due to differential use of support surfaces (77).

Two small, poor-quality trials ($n = 15$ and 19) found that the addition of small, unscheduled shifts in body position to standard repositioning every 2 hours had no effect on ulcer risk, but each reported only 1 or 2 ulcers (78, 79).

Dressings and Pads

Dressings and pads may prevent pressure ulcers by reducing the risk for skin surface breakdown. A fair-quality trial of cardiac surgery patients ($n = 85$) found that a silicone border foam sacral dressing applied at admission to the intensive care unit was associated with a lower likelihood of pressure ulcers than standard care (including use of a low-air-loss bed), but the difference was not statistically significant (2.0% vs. 12%; RR, 0.18 [CI, 0.02 to 1.5]) (80). A poor-quality trial of patients in long-term care ($n = 37$) found that use of the REMOIS Pad (consisting of a hydrocolloid skin adhesive layer, a support layer of urethane film, and an outer layer of multifilament nylon) (ALCARE, Tokyo, Japan) on the greater trochanter was associated with decreased risk for stage 1 ulcers versus no pad after 4 weeks (81). A fair-quality crossover trial of incontinent female nursing home residents ($n = 81$) found no statistically significant difference between changing incontinence pads 3 versus 2 times each night in risk for incident stage 2 pressure ulcers after 4 weeks (82).

Creams, Lotions, and Cleansers

As with dressings and pads, various creams, lotions, and cleansers may be useful for preventing skin breakdown. One fair-quality trial ($n = 331$) (83) found that fatty acid creams were associated with decreased risk for incident pressure ulcers versus placebo (RR, 0.42 [CI, 0.22 to 0.80]). A poor-quality trial ($n = 86$) reported consistent results (84). Evidence from 3 poor-quality trials ($n = 79$ to 258) was insufficient to determine effectiveness of other creams or lotions (85–87). Methodological shortcomings included failure to report adequate methods for randomization or allocation concealment, failure to blind care providers or patients, and unclear attrition.

One fair-quality trial ($n = 93$) found that the Clinisan cleanser (Synergy Health, Swindon, United Kingdom) was associated with lower risk for incident ulcers (three quarters

of which were stage 1) than standard soap and water in patients with incontinence (18% vs. 42%; RR, 0.43 [CI, 0.19 to 0.98]) (88).

The trials of nutritional supplementation, repositioning, and skin care are summarized in Table 2 of the Supplement.

Harms of Preventive Interventions

Harms were reported in 16 trials (32, 35, 36, 48, 53, 54, 56, 72, 76, 77, 81, 86–90) of preventive interventions. Of the trials reporting harms, few provided detailed information on specific harms, although none reported serious treatment-related harms. The only harms reported in trials of creams and dressings were single cases of rashes or blisters (81, 87, 88).

Three trials reported cases of heat-related discomfort with a sheepskin overlay, leading to some withdrawals (48, 53, 54). One trial found that a urethane and gel wheelchair pad (JAY cushion) was associated with increased risk for withdrawal due to discomfort versus a standard foam wheelchair pad (8% vs. 1%; RR, 6.2 [CI, 0.77 to 51]) (32).

One trial of nutritional supplementation with tube feeding found that 54% (29 of 54) of patients removed the tube within 1 week and 67% (32 of 48) removed it within 2 weeks (72). One trial found that a 30-degree tilt repositioning was more difficult to tolerate than a standard 90-degree position (87% vs. 24%; RR, 0.17 [CI, 0.06 to 0.51]) (76).

DISCUSSION

The Table summarizes the findings of this review. One good-quality trial found no evidence that use of a pressure ulcer risk assessment instrument, with or without a protocolized intervention strategy based on assessed risk, reduces risk for incident pressure ulcers compared with less standardized risk assessment based on nurses' clinical judgment (20). As detailed in our full report (15), commonly used instruments (such as the Braden, Norton, and Waterlow scales) seem to be relatively weak predictors of which patients are more likely to develop ulcers (91–96). However, data on predictive accuracy are difficult to interpret because higher-risk patients may have preferentially received more intensive interventions. In addition, the usefulness of risk assessment instruments depends on the availability of effective subsequent interventions. We found that more advanced static support surfaces are more effective than standard hospital mattresses for preventing pressure ulcers in higher-risk patients (41, 48, 54, 57, 65). Evidence was inadequate to reliably determine the effectiveness of other preventive interventions, such as repositioning, nutritional supplementation, creams, and dressings or pads, versus usual care. Although evidence on harms of preventive interventions was sparse, serious harms seemed to be rare. As detailed in our full report (15), data on resource utilization were primarily limited to a small number of

Table. Summary of Findings*

Assessment	Overall Strength of Evidence	Randomized Trials, <i>n</i>	Patients, <i>n</i>	Overall Quality	Consistency†	Directness‡
Effectiveness of risk assessment instruments in reducing incidence of pressure ulcers (Waterlow, Norton, and Braden scales)	Low (Waterlow); insufficient (Norton and Braden)	3§	1992	Good (Waterlow); poor (Norton and Braden)	Not applicable (1 study for each instrument)	Direct
Effectiveness of preventive interventions						
Advanced static mattress or overlay vs. hospital mattress	Moderate	12	2533	Fair	High	Direct
Advanced static mattress or overlay vs. advanced static mattress or overlay	Moderate	11	1170	Fair	Moderate	Direct
Low-air-loss bed vs. standard hospital mattress	Low	2	134	Fair	Low	Direct
Alternating-air overlay or mattress vs. standard hospital mattress	Low	3	768	Poor	High	Direct
Alternating-air overlay or mattress vs. advanced static overlay or mattress	Moderate	6	1339	Fair	Moderate	Direct
Heel ulcer support or boots vs. usual care	Low	2	291	Fair	Low	Direct
Sophisticated wheelchair cushions vs. standard wheelchair cushions	Low	4	653	Fair	Low	Direct
Nutritional supplementation vs. standard hospital diet	Low	6	1553	Poor	Moderate	Direct
Repositioning interventions vs. usual care	Low	4	1332	Fair	Moderate	Direct
Small unscheduled shifts in body position vs. usual care	Low	2	34	Poor	High	Direct
Fatty acid cream vs. placebo	Low	2	417	Fair	Moderate	Direct
Harms of preventive interventions						
Support surfaces vs. usual care	Low	9	4524	Fair	Moderate	Direct
Nutritional supplementation	Low	1	129	Fair	Not applicable (1 study)	Direct
Repositioning	Low	2	884	Fair	Moderate	Direct
Lotions, creams, and cleansers	Low	3	424	Fair	Moderate	Direct

RR = relative risk.
 * Not all studies are presented in this table.
 † High, moderate, or low.
 ‡ Direct or indirect.
 § Includes 1 nonrandomized study.
 || Most trials did not report harms.
 ¶ Sunrise Medical, Fresno, California.

trials that found no effects of various support surfaces on length of hospital stay (45, 48, 57). The applicability of trial findings to clinical practice could be limited by delays in use of preventive interventions or differences in the quality of care between research and typical clinical settings.

Our findings on the effectiveness of preventive interventions are generally consistent with those of other systematic reviews that found some evidence that more advanced static support surfaces are associated with decreased risk for pressure ulcers compared with standard hospital mattresses (97, 98), limited evidence on the effectiveness

Table—Continued

Precision†	Summary of Findings
Low	One good-quality trial ($n = 1231$) found no difference in pressure ulcer incidence between the Waterlow scale or Ramstadius tool vs. clinical judgment alone. One poor-quality nonrandomized study ($n = 240$) found that a modified Norton scale was associated with lower risk for pressure ulcers vs. nurses' clinical judgment (RR, 0.11 [95% CI, 0.03 to 0.46]). One poor-quality cluster randomized trial ($n = 521$) found no difference between use of the Braden scale vs. nurses' clinical judgment in risk for ulcers.
Moderate	More advanced static mattress or overlay associated with lower risk for pressure ulcers (RRs of 0.16 to 0.82 in 1 good-quality and 4 fair-quality trials); no difference in duration of hospital stay in 3 trials
Moderate	No differences between different advanced static support mattress or overlay in risk for pressure ulcers
Low	One fair-quality trial ($n = 98$) found that a low-air-loss bed was associated with lower risk for pressure ulcers, but a small, poor-quality trial ($n = 36$) found no difference.
Moderate	Alternating-air mattress or overlay associated with lower risk for ulcers
Moderate	No difference in risk for pressure ulcers
Low	One fair-quality trial ($n = 239$) found that a boot was associated with decreased risk for heel, foot, or ankle ulcers, but a poor-quality trial ($n = 52$) found no difference in risk for ulcers between a boot and usual care.
Moderate	Inconsistent results, but the largest trial found no difference in risk for pressure ulcers
Low	No difference in risk for pressure ulcers
Low	More intense repositioning intervention associated with lower risk for ulcers in 1 good-quality trial ($n = 213$) but no difference in 1 fair-quality trial ($n = 235$)
Low	No difference in risk for ulcers
Moderate	Decreased risk for pressure ulcers (RRs, 0.42 [CI, 0.22 to 0.80] and 0.17 [CI, 0.04 to 0.70])
Low	Three trials reported heat-related discomfort with sheepskin overlays resulting in some withdrawals in 2 trials. One trial reported that a urethane and gel wheelchair pad (JAY cushion®) was associated with increased risk for withdrawal due to discomfort (8% vs. 1%; RR, 6.2 [CI, 0.77 to 51]).
Low	One trial of nutritional supplementation by tube feeding found that 54% of patients had the tube removed within 1 wk and 67% had it removed before the second week.
Low	Nonadherence due to intolerability reported with a 30-degree tilt position compared with standard positioning
Low	Single cases of wet sores or rashes reported

and comparative effectiveness of dynamic support surfaces (97, 98), and limited evidence on other preventive interventions (98, 99). These reviews differed from ours in that they included trials that enrolled patients with higher-stage, preexisting ulcers and trials published only as abstracts. Although 1 other prior review found that nutritional supplementation was associated with decreased risk for incident pressure ulcers (odds ratio, 0.74 [CI, 0.62 to 0.88]), conclusions were based on pooling of poor-quality

trials, none of which individually found a statistically significant effect (100).

Our review has limitations. We excluded non-English-language articles; however, some studies have found no evidence of bias due to language restrictions in systematic reviews of noncomplementary medicine interventions (101, 102). In addition, we did not exclude poor-quality studies a priori. Rather, we described the limitations of the studies, emphasized higher-quality studies, and performed sensitivity analyses that excluded poor-quality studies. We also found that results of poor-quality and higher-quality trials were generally consistent. We did not formally assess publication bias due to small numbers of studies and clinical heterogeneity of the available studies (103). Most included studies had important methodological shortcomings, with nearly half of the studies of preventive interventions rated as poor-quality. Some preventive interventions evaluated in older trials may no longer be available, and many trials of support surfaces evaluated specific brand-name products that have since changed, both of which could affect generalizability to currently available interventions. Smaller trials with negative findings may have been underpowered to detect clinically relevant effects.

Prevention of pressure ulcers is an important health priority. Given the limitations of the evidence, current decisions about whether to use pressure ulcer risk assessment instruments may depend, in part, on such considerations as preferences for standardized assessments, ease of use, and nursing preferences. Limited evidence indicates no clear differences between alternating-air and low-air-loss mattresses and overlays versus advanced static support surfaces, yet such interventions are commonly used and can be more costly. One trial found that a stepped care approach that used less expensive dynamic support surfaces before switching to more expensive alternatives in patients with early ulcers was effective and may be more efficient than using more expensive support surfaces initially in all patients (37). More research is needed to determine whether more intensive repositioning, nutritional, or skin care interventions are more effective than usual preventive care (including standard repositioning, nutrition, and skin care). It is critical that future studies of preventive interventions adhere to methodological standards, including appropriate use of blinding (such as blinding of outcome assessors even when blinding of patients and caregivers is not feasible), and clearly describe usual care and other comparison treatments. Studies should routinely report baseline risk for pressure ulcers in enrolled patients and consider predefined subgroup analyses to help better understand how preventive interventions might be optimally targeted.

From Oregon Health & Science University, Portland, Oregon.

Financial Support: By AHRQ (contract 290-2007-10057-1).

Potential Conflicts of Interest: Disclosures can be viewed at www.acponline.org/authors/icmje/ConflictOfInterestForms.do?msNum=M12-2540.

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