Health economic benefits of cyanoacrylate skin protectants in the management of superficial skin lesions

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Key words
Cost analysis; Skin barrier; Skin tears; Superficial skin lesions

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Abstract
Superficial skin damages, including stage II pressure ulcer, skin tears and moisture-associated skin damages (MASDs) are common and constitute a significant disease burden to the health care system. A cost analysis was conducted by comparing a cyanoacrylate barrier film with routine care in the treatment of superficial skin damages in a chronic care facility. The analysis included 12 patients: four patients with stage II pressure ulcers, six with MASD and two with skin tears. Cost analysis was conducted comparing the cost of care 7 days before and 7 days after the acrylate barrier was used. The total cost took into consideration the time, products and supplies required to manage the skin problem.

Introduction
Skin breakdown is common across the entire spectrum of health settings. Based on the depth of tissue damage and differences in aetiologies, skin breakdown can generally be described as superficial or deep (Table 1). While deep skin damages are predominantly related to pressure and shear, superficial skin lesions are frequently related to: (i) friction, (ii) skin tears and related trauma, and (iii) moisture-associated skin damage (MASD). With the growing concerns in patient safety, quality of care and health care resources, there is a need to reduce the incidence of skin breakdown and early treatment to prevent progression of superficial to deep skin damages within a cost-effective framework. The purpose of this article is to provide a preliminary cost analysis of a skin barrier for three main types of superficial skin conditions including partial thickness pressure ulcers, skin tears and MASD.

Pressure ulcers
A pressure ulcer is a localised injury to the skin and/or underlying tissue usually over a bony prominence, involving an intricate interplay of multiple external forces such as pressure, shear and friction according to the definition of the National Pressure Ulcer Advisory Panel (NPUAP) (1). Pressure ulcers are common across the continuum of health settings. According to the results of nine international pressure ulcer prevalence surveys from 1989 to 2005 including a total of 447,930 patients (2), pressure ulcer prevalence rates ranged from 9.2% in 1989 to 10% in 2004. The highest prevalence was estimated at 27.3% in long-term care. The majority of pressure ulcers were superficial, classified as stages I and II. A stage I pressure ulcer is characterised by non-blanchable erythema of intact skin that may be coupled with alterations in skin temperature and tissue consistency (3). A stage II pressure ulcer is a superficial lesion involving the erosion of epidermis, exposing the dermal base (3). Skin breakdown can lead to serious complications such as infection, cellulitis, osteomyelitis and sepsis. The burden of pressure ulcers as a chronic disease is far-reaching and onerous. In a recent economic analysis of annual expenditures for pressure ulcer care in Dutch hospitals (4), the calculated costs were staggering (ranging between €206·3 million and €238·1 million). The United States Centers for Medicare and Medicaid Services (CMS) stipulates federal guidelines for the prevention and early treatment of pressure ulcers (5).

Key Messages
• superficial skin lesions due to skin tears, moisture damage and friction are common in long-term care environments
• use of cyanoacrylate barrier is cost-effective for the management of superficial skin lesions
Deep pressure ulcers are associated with periwound areas that have not been protected skin. MASD is also seen in the maceration typically as a barrier to keep excess moisture and irritants away from the skin. Management of MASD should involve the use of a synthetic barrier to keep excess moisture and irritants away from the skin. A retrospective study using Minimum Data Set (MDS) data consisting of 29,040 observations of 13,457 nursing home residents at 108 nursing homes validated that incontinent residents were 1.4 times more likely to develop pressure ulcers (95% CI = 1.1–1.6) (13). Effective management of MASD should involve the use of a synthetic barrier to keep excess moisture and irritants away from the skin. MASD is also seen in the maceration typically associated with periwound areas that have not been protected by protective agents or absorptive and moisture retentive wound dressings. Skin changes associated with superficial moisture damage include erythema, maceration, erosion and skin weeping.

To minimise trauma and irritation from the above general classes of external insult to the skin, a number of sealants, barriers and protectants such as wipes, sprays, gels and liquid roll-on have been developed. Several studies have investigated the cost and efficacy of the components and/or procedures of skin care regimens for incontinence. Zehrer et al. (14) compared the cost-effectiveness of three incontinence skin barrier products including a polymer-based barrier film and two petrolatum-based ointments. They followed up 250 nursing home residents from four facilities in the USA for 6 months. The polymer-based barrier film studied was used either once daily or three times weekly as opposed to petrolatum ointments that were used after each episode of incontinence. Taking into account the cost of barrier product and labour to apply the barrier products, the economic analysis indicated an average cost of $0.26/day for the barrier film and to $1.40/day for the petrolatum ointments. Petrolatum, often thickened with zinc oxide, is a common external barrier that is occlusive to water. However, these preparations have a greasy consistency that can affect the adhesion of an external appliance, such as a wound dressing, to the skin. In addition, pastes containing zinc oxide tend to be exceedingly adherent to skin, difficult to remove and may affect the performance of absorbent incontinence briefs by clogging the fabric when partly deposited on such external surfaces. Baatenburg de Jong and Admiral (15) evaluated the cost of treating moderate to severe incontinence-associated dermatitis by comparing nursing home patients who were randomly assigned to treatment with an acrylate polymer-based barrier film or zinc oxide oil (n = 39). The acrylate barrier film was applied every 24–72 hours depending on the severity as compared with the zinc oxide oil that was applied twice per day and after each episode of incontinence. The total cost (including products, labour and supplies) per day of the regimen using the barrier film was less than the regimen using the zinc oxide oil.

In a large study involving 771 individuals from 16 nursing homes, Bliss et al. (16) compared cost associated with the prevention of incontinence-associated dermatitis using four different barriers: polymer-based barrier film, an ointment with 43% petrolatum, an ointment with 98% petrolatum and a cream with 12% zinc oxide and 1% dimethicone. The polymer film barrier was applied thrice weekly whereas other barriers were applied after each episode of incontinence. At the end of 6 weeks, incontinence dermatitis developed in 3.4% of enrolled residents. The median cost of the polymer barrier film was $0.04/episode of incontinence compared to $0.22–$0.25 for the other three barrier ointments. Estimating a median of six episodes of incontinence per resident per day, the potential cost savings for the barrier over 1 year would be $372.30 to $459.90/resident. The total cost including products and labour cost was lowest for the polymer-based barrier film. The investigators estimated that the total cost savings ranged from $0.40 to $0.85/episode of incontinence.

### Table 1: Superficial and deep skin damages

<table>
<thead>
<tr>
<th>Superficial skin changes</th>
<th>Partial thickness</th>
<th>Full-thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primarily because of moisture and friction</td>
<td>– Grade/stage II</td>
<td>– Grade/stage III, IV</td>
</tr>
<tr>
<td>– Skin tears</td>
<td>– Incontinence-associated dermatitis (IAD)</td>
<td>– Suspected deep tissue injury (sDTI)</td>
</tr>
<tr>
<td>– Contact dermatitis</td>
<td>– Friction-associated blisters</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Deep pressure ulcers</th>
<th>Partial thickness</th>
<th>Full-thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primarily because of tissue deformation (compression, shear and tension)</td>
<td>– Grade/stage III, IV</td>
<td>– Suspected deep tissue injury (sDTI)</td>
</tr>
</tbody>
</table>

Modified from Ref. 6.

### Trauma-related skin damage

Repeated application and removal of adhesive tapes and dressings pull the cornified layer of the skin surface from the living epithelial cells and this can precipitate skin damage by stripping away the stratum corneum, leaving the damaged skin susceptible to injury and inflammation (dermatitis) (7). In severe cases, erythema, oedema and blistering have been observed (8). In a study of 4200 wounds in 1891 nursing home residents, trauma associated with dressing removal and pain were the major concerns according to individuals receiving wound care (9). Use of ‘atraumatic’ dressings and a protective barrier was considered the most important strategy to avoid skin damage and minimise pain.

### Moisture-associated skin damage

Superficial skin damages in the periwound area, skin folds and perineum are common as a result of prolonged exposure to moisture, often related to heavy wound exudate, incontinence and excessive perspiration. Skin becomes susceptible to breakdown because of erosion from proteolytic enzymes, injuries caused by inflammatory mediators and weakening of the cell-to-cell junctions of the connective fibres of the epidermis (10). Moisture-related skin damage is linked to contact irritant or allergic dermatitis, cutaneous fungal/bacterial infection, pain and exacerbation of existing ulcers (10,11). In addition, moisture increases the friction coefficient of skin (the ratio of friction between the skin and a surface and the force that presses them together) putting individuals at a high risk of stage II pressure ulcers (6). Guihan et al. (12) demonstrated that increased subepidermal moisture heralds early stage of pressure ulcer development. A retrospective study using Minimum Data Set (MDS) data consisting of 29,040 observations in 13,457 nursing home residents at 108 nursing homes validated that incontinent residents were 1.4 times more likely to develop pressure ulcers (95% CI = 1.1–1.6) (13). Effective management of MASD should involve the use of a synthetic barrier to keep excess moisture and irritants away from the skin. MASD is also seen in the maceration typically associated with periwound areas that have not been protected skin.
Film-forming liquid acrylates and other spray-on barriers, which sometimes contain plasticising agents to augment flexibility and varying amounts of alcohol to form an impermeable solid film on the skin, are well known in clinical practice. In comparison with a placebo or with no treatment, the liquid acrylates have been deemed superior in preventing maceration at the periwound surface \( P < 0.0001 \) (17).

**Cyanoacrylates**

A special class of acrylate polymer derivatives is now available. These are known generically as cyanoacrylates or, in common parlance, superglue. Cyanoacrylates, or more accurately alkyl esters of cyanoacrylates, are compounds that have an extra cyano group attached to the acrylate portion of a molecule. This addition of the cyano(−CN) chemical group to the acrylate moiety in the film-forming monomer renders these compounds to be very sensitive to moisture on skin, resulting in the quick formation of a flexible yet tough film, within minutes, on the skin. The film is a polymeric form of the monomeric cyanoacrylate that is liquid until it comes into contact with the skin, when it begins rapid polymerisation. The liquid is provided ‘neat’, without solvents, which eliminates problems generally associated with organic solvents such as inhalation hazards and fire risks. In addition, they bond chemically to the skin surface as opposed to being deposited as a polymer film. Cyanoacrylates have been used in medicine for several years, for example, as wound closure products with microbial barrier properties on surgical incisions after closure of such sites with subcuticular sutures. These materials appear to have a unique degree of robustness, based on experience from clinicians who have reported on the skin protective aspect of these materials. A case series by Milne et al. (18), for example, has discussed the successful use of a cyanoacrylate protectant in the management of peristomal irritant dermatitis and superficial skin lesions in residents in acute care and outpatient settings. The cyanoacrylate protectant is supplied in unit dose ampoules. It has a purple tint that allows clinicians to identify the area where the liquid barrier is applied in order to avoid excessive application. It is lost naturally from the skin surface as the stratum corneum sloughs off and this sloughing off is easily monitored by the gradual removal of the purple tint from the skin where the product was applied. A product belonging to this category, Marathon® Liquid Skin Protectant (Medline Industries Inc., Mundelein, IL), which is described in this research article, recommends a change frequency of 1–3 days following application on skin. Experience shows that once bonded to skin, washing or soaping with water will not eliminate the product from the skin for 24–72 hours, which is consistent with the product label, and demonstrates the ability of the chemical bond of the product to the underlying skin to resist external insult from environmental agents. Being sensitive to moisture, the products are usually supplied in single-use unit doses. The study product was presented in a plastic-sleeved glass ampoule with a foam tip designed to ease dispensation as a thin layer on the affected skin. The product label claims that it is suitable for the protection of intact skin and management of damaged skin from the effects of moisture, friction (rubbing) or shear (tearing). The product should not be applied directly to deep, open, bleeding or chronic wounds, second or third degree burns or infected areas. In this study, the stage II pressure ulcers, MASD areas and partial thickness skin tears assessed were classified as damaged skin.

**Objectives**

The primary objective of this study is to evaluate the potential cost effectiveness of a cyanoacrylate barrier skin protectant in the treatment and management of superficial skin damage, most importantly in the area of pressure ulcers, moisture associated skin damage, and skin tears. Such conditions are major impacting factors to public health economy.

The secondary aim of this study is to evaluate if the use of a cyanoacrylate barrier skin protectant is effective in the treatment and management of moisture associated skin damage in terms of erythema, maceration, erosion, and skin weeping.

**Method**

Setting and sample: Data from a convenience sample of 12 patients in a chronic care facility was analysed. In this interim analysis group, four patients had stage II pressure ulcers, six patients developed MASD and two patients suffered from skin tears.

Inclusion criteria:

1. Individuals with superficial skin lesions categorised as stage II pressure ulcers, skin tears or MASD.
2. Individuals who were able to provide consent to the study.

Exclusion criterion:

1. Individuals who had known allergies to the ingredients in the cyanoacrylate barrier.

All participants were assessed for 7 days following usual care for the treatment of superficial skin lesions. All participants were assessed for another 7 days using cyanoacrylate film barrier. Cost analysis was conducted comparing the cost of care 7 days before and 7 days after the cyanoacrylate barrier was used. The total cost analysis took into consideration the time, products and supplies to manage the skin problem. Clinical improvements, if any, were noted but the economic impacts of these improvements are not monetised in this study.

**Data analysis**

Descriptive statistics are presented as frequencies for categorical data, and means with standard deviations or medians and ranges for interval data depending on the distribution of the measure. Various costs used in the economic analysis were estimated as follows.

Labour cost: Time to apply the barrier products and perform dressing changes was estimated in minutes by the registered nurses (RNs) and personal support workers (PSWs). Labour cost was calculated by multiplying the time...
in minutes to apply the barrier and complete related care (e.g. dressing change) by the estimated cost of salary by minute. The estimated hourly wage for a RN was $36.22 (http://www.livingincanada.com/salaries-for-registered-nurses.html) and for a PSW, also called nursing assistants, was $13.50 (http://personalsupportworker.ca/articles/wage-related/psw-hourly-wage-rate/).

Where applicable, the cost was computed by summing the following items:

1. Multiplying the cost of barrier by the number of applications per week.
2. Multiplying the cost of supplies (e.g. dressing, briefs) by the number of treatments per week.
3. Multiplying minutes of labour to provide treatment by hourly wage/60 per week.

Cost of barrier:

- A clear petrolatum-based moisture barrier ointment containing dimethicone (Critic Aid Clear, Coloplast, Humlebaek, Denmark) was used by the facility. The pricing for a 71 g tube of ointment was $12.54. It was estimated that approximately 2 g of barrier ointment ($0.35) was used with each episode of incontinence.
- The cost of the cyanoacrylate barrier was estimated to be $4.95/ampoule.

### Table 2 Cost of supplies

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost/unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium alginate dressing with silver</td>
<td>$16.99</td>
</tr>
<tr>
<td>Silicone dressing: (10 × 10 cm²)</td>
<td>$2.79</td>
</tr>
<tr>
<td>ABD pad (5 × 9 in.²)</td>
<td>$0.18</td>
</tr>
<tr>
<td>A pair of disposable gloves</td>
<td>$0.17</td>
</tr>
<tr>
<td>Gauze for wound cleansing</td>
<td>$0.06</td>
</tr>
</tbody>
</table>

Cost comparisons between foam and cyanoacrylate barrier in the management of stage II pressure ulcers.

Costs of supplies: The costs of individual supplies were obtained from hospital contract, published distributor’s lists and catalogues (Table 2). Clinical evaluation of MASD: MASD is evident by increased erythema, maceration, erosion and skin weeping. Each of the parameters was evaluated at baseline and on day 7 on scales of 0–10, where 0 represents none and 10 represents most severe.

### Results

#### Stage II pressure ulcers

Four patients with stage II pressure ulcers were included in the study (Tables 3 and 4; Figure 1).

The average cost for the care of stage II pressure ulcers was 18.04 using foam dressings in comparison with $8.18 using cyanoacrylate barrier. The use of cyanoacrylate barrier

### Table 3 Costs associated with the management of stage II pressure ulcers using foam dressings

<table>
<thead>
<tr>
<th>Patient ID</th>
<th>Previous dressing regimen for 7 days</th>
<th>Estimated product cost</th>
<th>Labour cost (performed by registered nurse) $0.60/minute</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>PU1: sacral</td>
<td>Soft silicone dressing × 3 because of rolling of dressing</td>
<td>(2.79 + 0.17 + 0.06) × 3 = 9.06</td>
<td>15 minutes for each dressing change: (15 × 0.60) × 3 = 27.00</td>
<td>36.06</td>
</tr>
<tr>
<td>PU2: sacral</td>
<td>Silicone dressing × 1</td>
<td>2.79 + 0.17 + 0.06 = 3.02</td>
<td>10 minutes for each dressing change: 10 × 0.6 = 6.00</td>
<td>9.02</td>
</tr>
<tr>
<td>PU3: knee</td>
<td>Silicone dressing × 1</td>
<td>2.79 + 0.17 + 0.06 = 3.02</td>
<td>10 minutes for each dressing change: 10 × 0.6 = 6.00</td>
<td>9.02</td>
</tr>
<tr>
<td>PU4: elbow</td>
<td>Silicone dressing × 2</td>
<td>(2.79 + 0.17 + 0.06) × 2 = 6.04</td>
<td>10 minutes for each dressing change: (10 × 0.6) × 2 = 12.00</td>
<td>18.04</td>
</tr>
</tbody>
</table>

### Table 4 Costs associated with the management of stage II pressure ulcers using cyanoacrylate barrier

<table>
<thead>
<tr>
<th>Patient ID</th>
<th>Cyanoacrylate barrier applied once every 7 days</th>
<th>Estimated product cost</th>
<th>Labour cost (performed by registered nurse) $0.60/minute</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>PU1: sacral</td>
<td>Cyanoacrylate barrier</td>
<td>4.95 + 0.17 + 0.06 = 5.18</td>
<td>5 minutes for each dressing change: 5 × 0.60 = 3</td>
<td>8.18</td>
</tr>
<tr>
<td>PU2: sacral</td>
<td>Cyanoacrylate barrier</td>
<td>4.95 + 0.17 + 0.06 = 5.18</td>
<td>5 minutes for each dressing change: 5 × 0.6 = 3</td>
<td>8.18</td>
</tr>
<tr>
<td>PU3: knee</td>
<td>Cyanoacrylate barrier</td>
<td>4.95 + 0.17 + 0.06 = 5.18</td>
<td>5 minutes for each dressing change: 5 × 0.6 = 3</td>
<td>8.18</td>
</tr>
<tr>
<td>PU4: elbow</td>
<td>Cyanoacrylate barrier</td>
<td>4.95 + 0.17 + 0.06 = 5.18</td>
<td>5 minutes for each dressing change: 5 × 0.6 = 3</td>
<td>8.18</td>
</tr>
</tbody>
</table>
achieved cost savings between 9% and 77% when the comparison involved two or more foam dressings. The amount of savings was dependent on the frequency of treatment and time required to provide the treatment. A sensitivity analysis was conducted by increasing the application of cyanoacrylate to three times per week. The average cost per treated lesion would increase to $38.69 if cyanoacrylate barrier were applied three times per week. The potential cost savings would be reduced to 51%, in favour of cyanoacrylate barrier (Figure 2).

### Moisture-associated skin damage

Six patients were treated for MASD (Tables 5 and 6).

Except one case where the cost difference between the two regimes was negligible, the cost savings could be as high as 95% in a patient with frequent faecal and urinary incontinence.

Sensitivity analysis indicates that the average cost could increase to $38.69 if cyanoacrylate barrier were applied three times per week. The potential cost savings would be reduced to 51%, in favour of cyanoacrylate barrier (Figure 2).

### Skin tears

Two patients were treated for skin tears (Tables 7 and 8).

For skin tear management, there is an increase in cost associated with the use of cyanoacrylate barrier. However,
both skin tears were healed after a 2-week treatment of cyanoacrylate barrier indicating potential cost-effectiveness over time.

**Clinical evaluation**

All MASDs were evaluated on four dimensions including erythema, maceration, erosion/denudement and exudation on scales of 0–10 by the investigator. After a 7-day use of cyanoacrylate barrier, significant improvement was noticed in erythema \( (P = 0.003) \), erosion \( (P = 0.006) \) and exudate \( (P = 0.017) \). This improvement is noted but not valued in monetary terms in this study.

**Discussion and conclusion**

Because epidemiological data is more easily available in the area of pressure ulcers, this analysis is restricted to the cost analysis on pressure ulcers alone when a cyanoacrylate barrier is used.

According to an analysis of data collected for a large administrative health database at the Institute for Clinical Evaluative Sciences (ICES) in Toronto \( [Health Outcomes for Better Information and Care (HOBIC), http://www.ices.on.ca/webpage.cfm?org_id = 26&morg_id = 0&gsec_id = 7129 &item_id = 7129] \), there were 1099 cases of pressure ulcers from 2010–2012 in long-term care facilities across Ontario. Of all the pressure ulcers, 34.7% were categorised as stage II. Considering a long-term care facility of 100 residents and a pressure ulcer prevalence rate of 20%, it is estimated that there are seven stage II pressure ulcers at any given time. According to this analysis, the average cost per pressure ulcer using foam dressing is approximately $18-04/week, $72-16 for a month and $938-08/year. The total cost for seven stage II pressure ulcers per year amounts to $6566-56.

Alternatively, the cost of using the cyanoacrylate barrier is $8-18/ulcer per week according to the current analysis. The monthly cost for each stage II pressure ulcer is estimated to be $32-72 and an annual cost of $392-64. The total cost for seven stage II pressure ulcers per year amounts to $2748-48. This is equivalent to a total cost savings of 55% in favour of the cyanoacrylate barrier (Figure 3).

In the case of MASD, an analysis of the average (excluding the outlier) shows that the traditional treatment, per patient, per week, averaged at $46-20. The cost for management with the cyanoacrylate, with at least similar results was $12-26. The project cost savings monthly and yearly are summarised in Figure 4. This represents an even greater saving of 73.5% with a cyanoacrylate as compared with traditional methods. Because epidemiological data on MASD is not reliably available, we report this 73.5% saving as a remarkable economic benefit on a per patient basis.

The cost drivers in this study are clearly the frequency with which dressings and barriers need to be changed. It appears that the traditional methods of skin protection in general require much higher rates of staff intervention because of their shorter usage life on patients. The robustness of the skin barrier over time made the difference we report in this study. Conclusions will be confirmed further when the study is completed.

**Limitations**

While the preliminary analysis indicates significant cost savings from the use of cyanoacrylate barrier, the sample size is too small to draw a definitive conclusion. Potential cost savings were related to reduction in labour cost or staff time incurred by the frequency of dressing change or application of topical treatment, both of which are variable. For
example, in this study, the cyanoacrylate barrier was reapplied every 7 days based on clinical need, rather than every 1–3 days/product instructions for use. This study evaluated a variety of superficial skin damage including stage II pressure ulcers, MASD and skin tears. The impact on cost varies from as high as 95% savings for MASD to minimal or a deficit for skin tears and pressure ulcers, depending on the frequency of the dressing change. It is plausible that the wound types may influence the final outcome of this study. The other limitation of the study is the relatively short monitoring periods. Participants were only monitored for a duration of 14 days; the long-term cost impact of the cyanoacrylate barrier may be more significant. All superficial lesions improved over time with the treatment of cyanoacrylate barrier. Taking into account the healing outcomes, the cyanoacrylate barrier may be more cost-effective than the alternative treatment approaches. The use of foam dressing in the perianal area has been problematic because of soiling of the dressing by urine or faecal material and the lack of adherence surface. This leads to more frequent dressing and suboptimal barrier to protect the skin lesion. The cyanoacrylate barrier may be a viable option for superficial skin damages and a different study model should be used to analyse the comparative health economics in this particular context.

Acknowledgement

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References