# Linen Usage
# Impact on Pressure and Microclimate Management

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## Introduction

Underpads and layers of linens are positioned under patients for numerous reasons from incontinence, drainage, patient transfer and repositioning to patient comfort. The management of bed linens is not only important for the financial impact to the facility but also patient care.

Caregivers often ask the question, "What type of bed linens should I use under my patient?" It is a misconception that multiple layers of linens will be more effective in containing moisture and potentially increasing patient comfort. When in fact, adding layers of linens under the patient may inhibit the surface's ability to redistribute pressure and maintain an optimal skin microclimate.

## Effect of pressure and microclimate on the skin

Pressure and skin microclimate are important factors that contribute to skin breakdown. Pressure is a perpendicular force that is applied to the body from contact with the support surface.[1] Pressure is higher over bony prominences where wounds most commonly develop. The physiological effect of excessive pressure over time is: compression of the tissue, restriction in blood flow which eventually leads to ischemia, necrosis, ruptured cells and vessels.[2,3,4] Measuring the pressure between the patient and support surface (defined as interface pressure) is useful in understanding the perpendicular force on the skin.

Controlling the heat and moisture levels of the skin surface, known as skin microclimate management, also plays a significant role in the prevention and control of pressure ulcers.

If the free flow of heat from the body is not removed, the skin becomes warm. Warm skin requires a greater supply of blood-borne nutrients. Warm skin in combination with unrelieved external pressure or shear forces reduces blood flow.[5,6] If the skin is deprived of oxygen and nutrients for too long, the tissue dies and a pressure ulcer forms.

The accumulation of heat leads to perspiration. Prolonged, high levels of moisture weaken the skin, making it more susceptible to the damaging effects of pressure and shear forces.

## Effect of various linen layers on pressure

Support surfaces should be designed to provide pressure redistribution. Decreasing interface pressure is accomplished by maximizing both immersion and envelopment. Immersion is defined as the depth of penetration into a surface.[1] Envelopment is the contact area for a level of immersion.[1] The type of underpad or linen layers may inhibit the surface's ability to conform around the patient and redistribute pressure.[7]

A 50$^{th}$ percentile male sensored pelvic indentor was used to measure the peak sacral and overall average pressure in mmHg with five linen configurations on an air and foam surface. Ten trials were performed at 0°, 30° and 45° head of bed elevations by adjusting the loads appropriately. ANOVA was performed followed by the Fisher-Hayter test to determine statistical differences at a 95% confidence level.

Chart 1 below shows the peak sacral pressure for a low air loss surface with the five different linen configurations. Each data point represents an average of 30 trials (10 trials x 3 head of bed elevations). The 95% confidence interval for each configuration tested is shown by the bars on the chart below. Overlapping bars represent statistical equivalence and bars that do not overlap represent a statistical difference between two configurations.

The low air loss surface with a fitted sheet produces the lowest peak sacral pressure. All other linen configurations produced statistically higher peak sacral pressures at a 95% confidence level.

**Chart 1.** Low Air Loss Surface Peak Sacral Pressure with Various Linen Layers, Average Data for 0, 30 and 45 Degrees Head of Bed Elevation

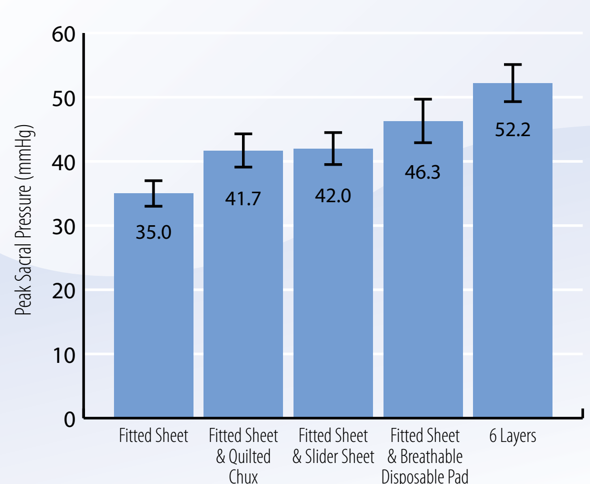
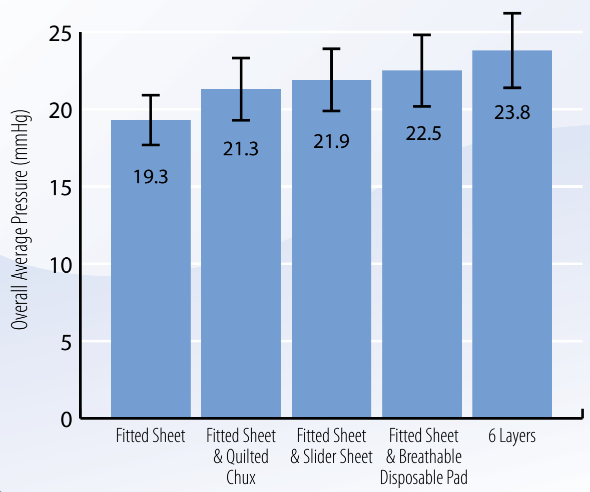


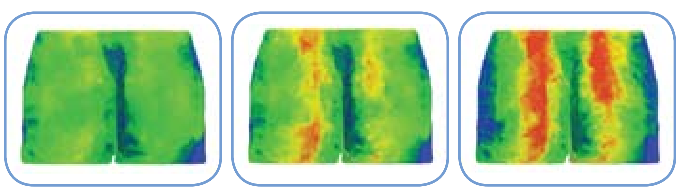
Chart 2 below shows the overall average pressure over the entire pelvic indentor for the low air loss surface with the linen layer configurations. Again, each data point represents an average of 30 trials (10 trials x 3 head of bed elevations). The 95% confidence interval for each configuration tested is shown by the bars on the chart below. Overlapping bars represent statistical equivalence and bars that do not overlap represent a statistical difference between two configurations.

The low air loss surface with only a fitted sheet produced the lowest overall average pressure. All configurations tested were statistically equivalent at a 95% confidence level.

**Chart 2.** Low Air Loss Surface Overall Average Pressure with Various Linen Layers, Average Data for 0, 30 and 45 Degrees Head of Bed Elevation




The 50th percentile male sensored pelvic indentor images below show the increase in interface pressure with the additional linen layers on a low air loss surface at 30° head of bed elevation.



***Low air loss surface with fitted sheet***

***Low air loss surface with fitted sheet and breathable disposable pad***

***Low air loss surface with 6 linen layers***

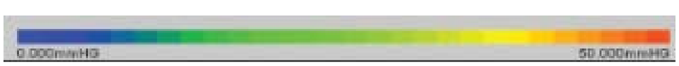



Chart 3 shows the peak sacral pressure on a standard foam surface with the five different linen configurations. Each data point represents an average of 30 trials (10 trials x 3 head of bed elevations). The 95% confidence interval for each configuration tested is shown by the bars on the chart below. Overlapping bars represent statistical equivalence and bars that do not overlap represent a statistical difference between two configurations.

A standard foam surface with only a fitted sheet produced the lowest peak sacral pressure, which was 42.1mmHg. All other linen configurations produced statistically higher peak sacral pressures at a 95% confidence level. A low air loss surface with a fitted and slider sheet also produced a peak sacral pressure of 42.0mmHg. Therefore, by adding an additional layer to the low air loss surface, the peak sacral pressures become equivalent to a foam surface with a fitted sheet.

**Chart 3.** Standard Foam Surface Peak Sacral Pressure with Various Linen Layers, Average Data for 0, 30 and 45 Degrees Head of Bed Elevation

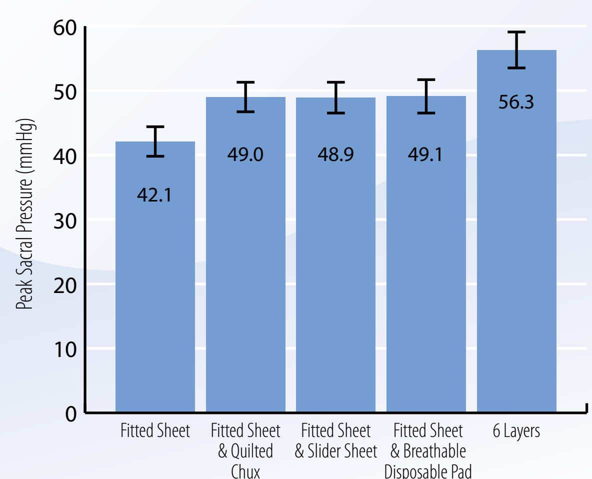


Chart 4 below shows the overall average pressure on a standard foam surface with five different linen configurations. Each data point represents an average of 30 trials (10 trials x 3 head of bed elevations). The 95% confidence interval for each configuration tested is shown by the bars on the chart below. Overlapping bars represent statistical equivalence and bars that do not overlap represent a statistical difference between two configurations.

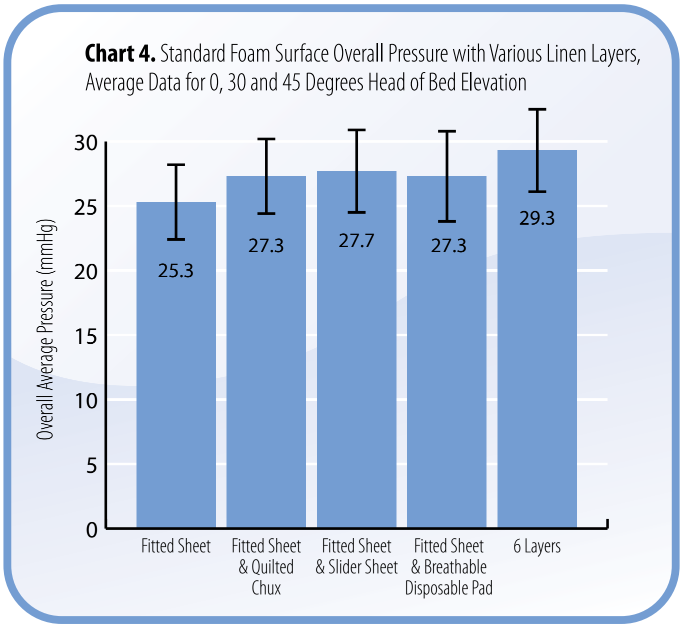
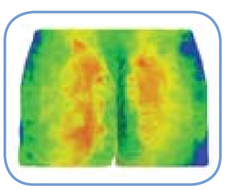
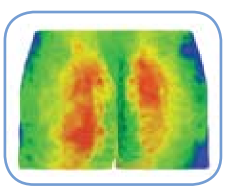


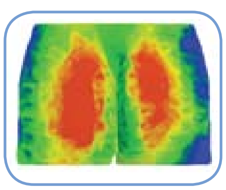
**Chart 4.** Standard Foam Surface Overall Pressure with Various Linen Layers, Average Data for 0, 30 and 45 Degrees Head of Bed Elevation

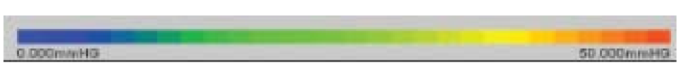
The standard foam surface with only a fitted sheet produced the lowest overall average pressure. All configurations tested were statistically equivalent at a 95% confidence level.

The 50th percentile male sensored pelvic indentor images below show the increase in interface pressure with the additional linen layers on a standard foam surface at 30° head of bed elevation.


***Standard foam surface with fitted sheet***


***Standard foam surface with fitted sheet and breathable disposable pad***


***Standard foam surface with 6 linen layers***




## Effect of various linen layers on microclimate management

Low air loss surfaces should be designed to maintain the skin temperature and humidity within a target range to keep the skin cool and dry.[8] Low air loss surfaces are defined as "a feature of a support surface that provides a flow of air to assist in managing the heat and humidity (microclimate) of the skin."[1] This is achieved by effectively removing excess heat and moisture from the patient's skin. The type of underpad or linen layers may impede the air flow to the patient's skin, restrict the flow of heat from the body into the surface or reduce the ability to evaporate moisture.

The support surface's ability to withdraw heat and moisture was measured using an Advanced Thermal Mannequin, which is a technique adapted from the outdoor garment industry known as the sweating guarded hot plate method. The device was positioned in the seat section and weighted appropriately for a 50th percentile male. Six dry and six wet trials were performed at 0° head of bed elevation with six linen configurations.[9]

The dry condition represents the surface's ability to dissipate heat when no moisture is present. The wet condition, in which the environment under the test plate is at 100% relative humidity, represents additional heat loss due to evaporation. The sum of the dry and wet flux equals the total heat withdrawal capacity of the surface. The evaporative capacity is calculated from the wet flux, which is in units of watts per square meter, and reported as grams per square meter hour. The evaporative capacity quantifies the surface's ability to remove moisture.

Chart 5 below shows the total heat withdrawal and evaporative capacity of a low air loss surface with various linen configurations. The higher the total heat withdrawal and evaporative capacity value, the better the surface's ability to withdraw heat and moisture from the patient.

The quilted chux and multiple layers greatly reduce the surface's ability to remove heat and moisture, which may lead to an increase in skin temperature and humidity. The total heat withdrawal of a standard foam surface is 12.9 W/sqm and 1.0 g/sqmhr for evaporative capacity.

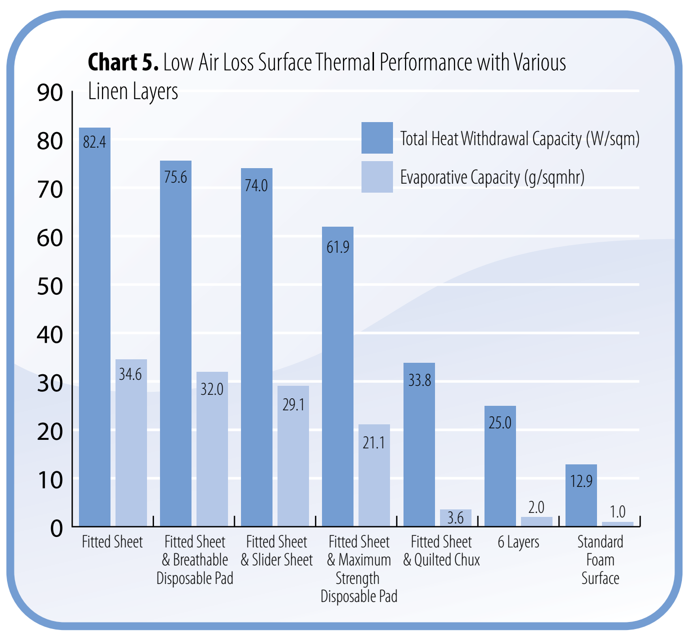
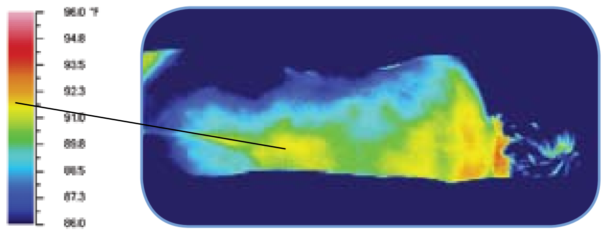
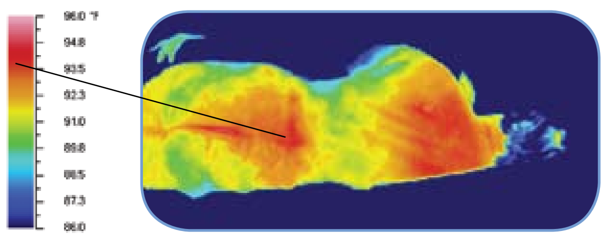


**Chart 5.** Low Air Loss Surface Thermal Performance with Various Linen Layers

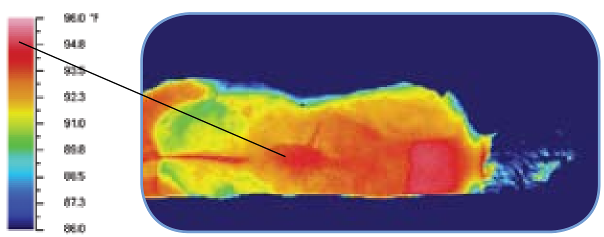
Below are infrared images that show the skin temperature distribution of a 5'2" 135 lb female after 3 hours lying supine at 30° head of bed elevation on a low air loss surface with a fitted sheet and 6 linen layers. The additional linen layers impede the surface's ability to withdraw heat away from the body. An infrared image of the same test subject on a standard foam surface is also shown for comparison.




***Low air loss surface with fitted sheet***




***Low air loss surface with 6 linen layers***




***Standard foam surface with fitted sheet***

## Conclusion

Pressure and skin microclimate are critical factors that contribute to skin breakdown. Depending upon the linen used, peak sacral interface pressure can increase from 7-17 mmHg. This difference in interface pressure can decrease a dynamic multi-zoned air product performance to the same level as a foam surface. In terms of heat and moisture withdrawal, the slider sheet and breathable disposable pads did not significantly impact performance. By adding a quilted chux or various layers of linens, the heat and moisture withdrawal performance of the product decreased to the same level as a non low air loss surface with a topper foam.

It is important to understand the function of the linen and impact to the patient's skin to minimize the risk of breakdown.

## References

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| **6 Layers of Linen:** |
| --- |
| Fitted Sheet |
| Bath Blanket |
| Flat Sheet in Quarters |
| Quilted Chux |
| Bath Blanket |
| Quilted Chux |



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