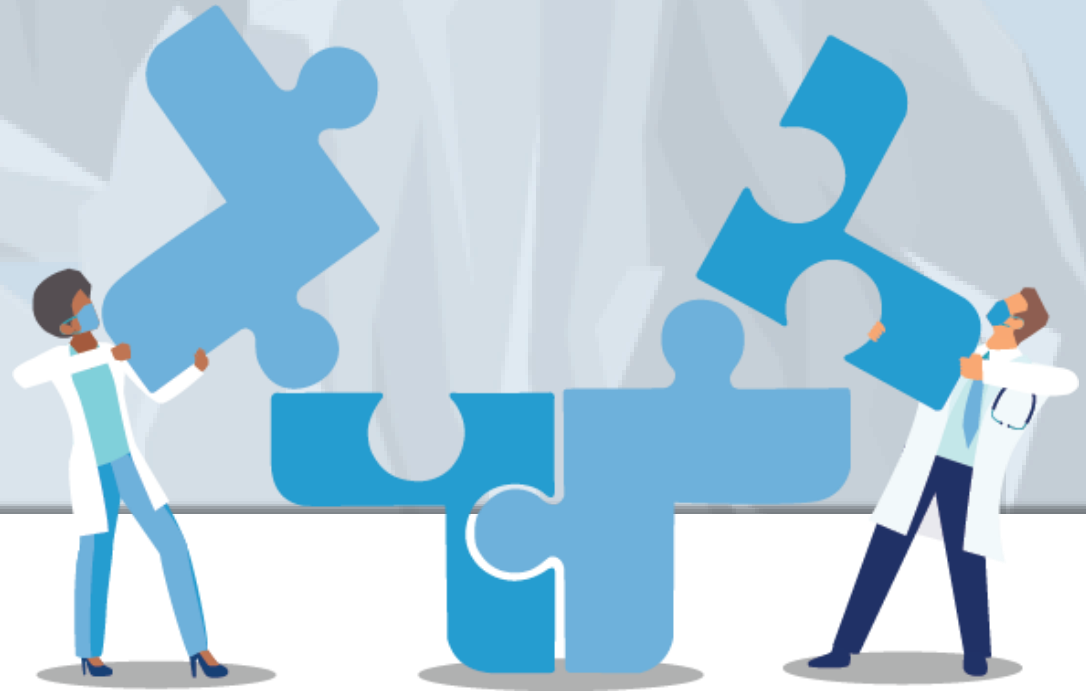
Support Surface Testing, How to Use What We Get

Evan Call, MS, CSM (NRM)



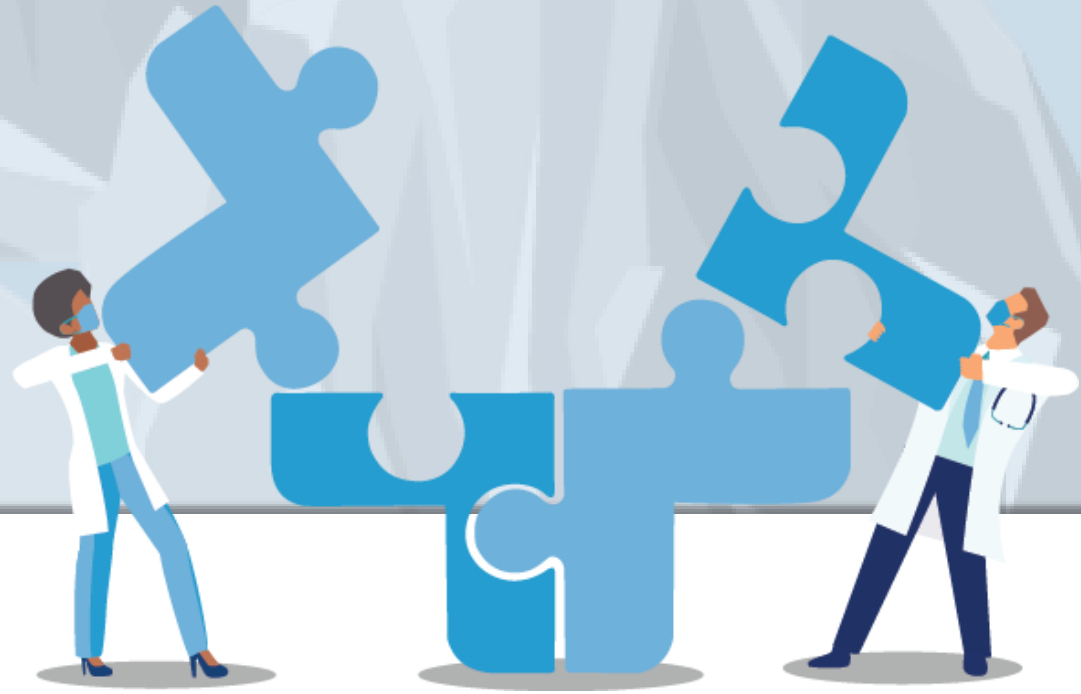
AAWC Association for the Advancement of Wound Care
2022 Annual Conference
Technology in Wound Care

Disclosures:

Operate a test lab, performing tests on Support Surfaces and other medical devices.

Advisor to Molnlycke on topics not related to today's presentation

Speaker Urgo Med on topics not related to today's presentation



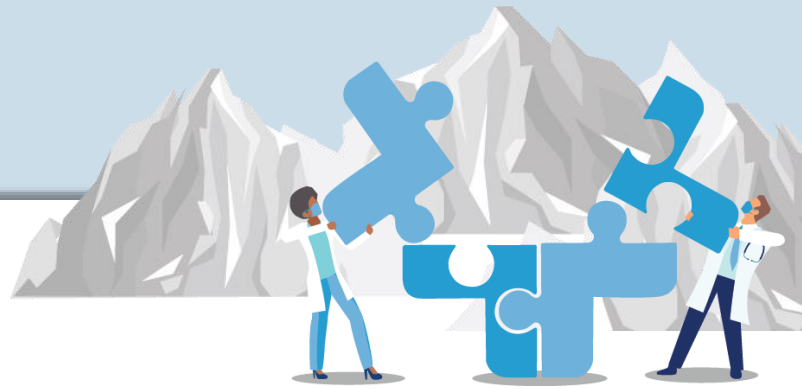
Support Surface Testing with Standardized Methods

S3I Terms and Definitions were now 9 years old

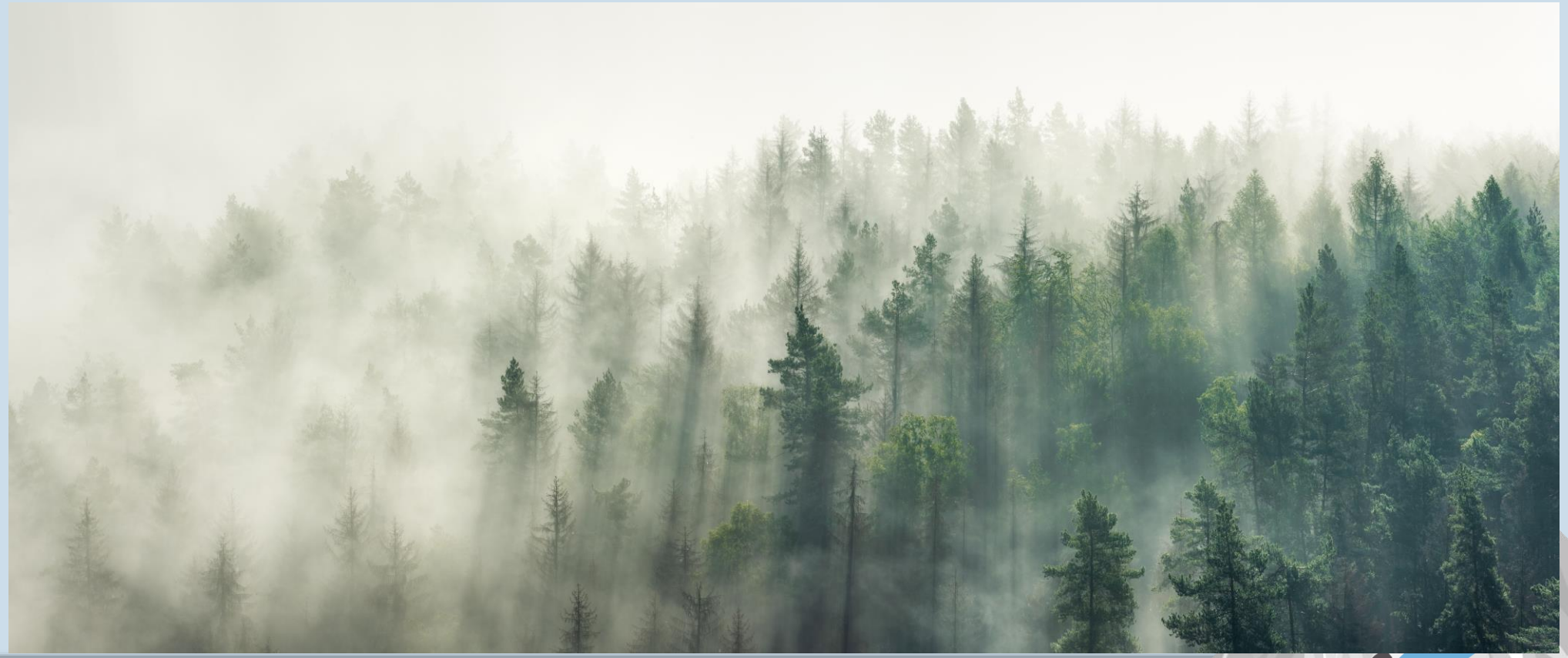
Should we find a different reference so it is ”NEW Science”

Standards are Voted on for Renewal every 3 years.

They are never more than 3 years old



What Do We Have?



Six Elements and Their Control

Pressure- Immersion and Envelopment- spread over greater area

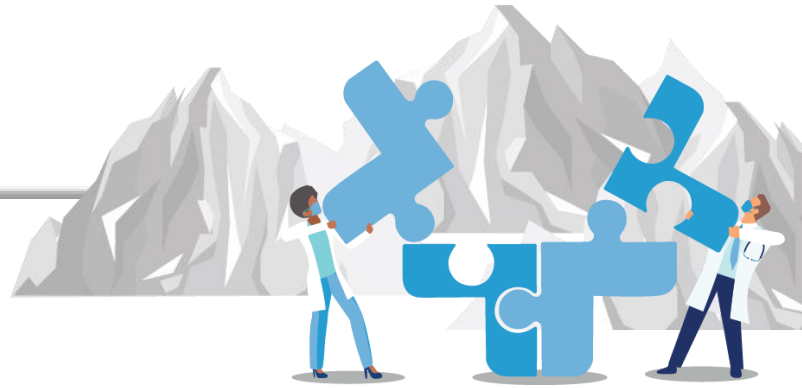
Friction- Sheet, chuck, overlay, moisture - Balance positioning with release

Shear- HOB, Type of Surface, Friction- Reduce sliding and release shear

Heat- Type of surface, turn schedule- Skin off the surface to breath

Moisture- Surface selection, power – moisture reduction, risk reduction

Nursing Practices-Interacts with all features-Provides all the interventions



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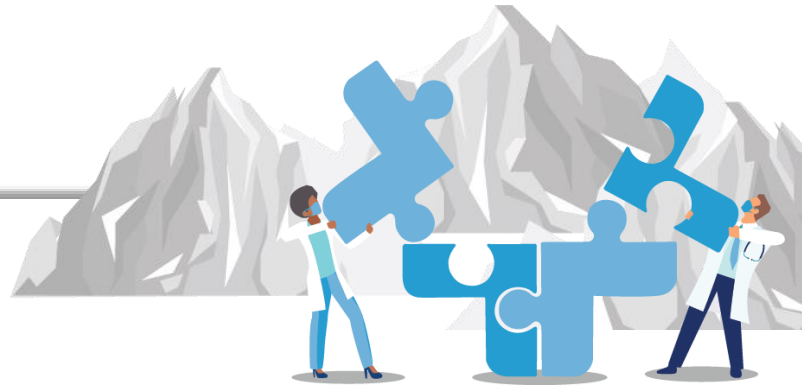
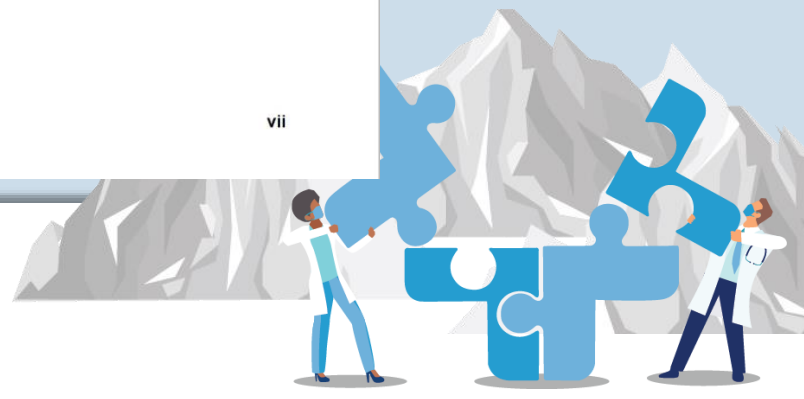
Nursing Practices- Single Greatest Impact



7 Tests to Measure the 6 Elements

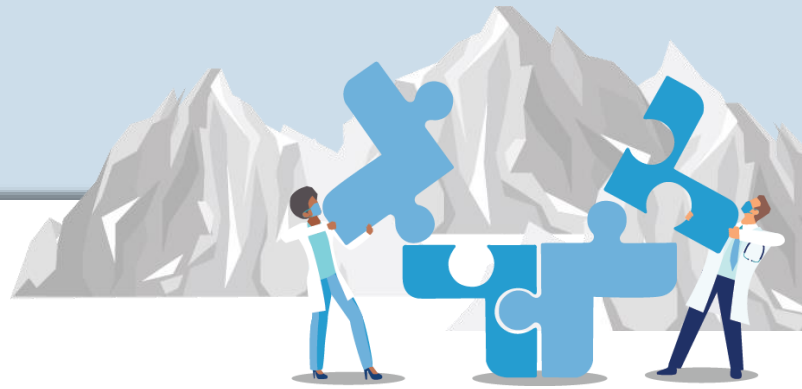
Contents



Section 1

Vocabulary

- Terms and definitions to clarify and standardize communication and specification
- Available at: https://cdn.ymaws.com/npiap.com/resource/resmgr/s3i/S3I_poster_Term_and_Defs__po.pdf
- Also available in the standard from: https://webstore.ansi.org/Search/Find?in=1&st=ANSI%2FRESNA+SS-1%3A2019



Using the Standards: Specialty Support Surface Can be Defined by

CATEGORIES

Reactive support surface

Active support surface

Integrated bed system

Non-Powered

Powered

overlay

FEATURES

Air fluidized

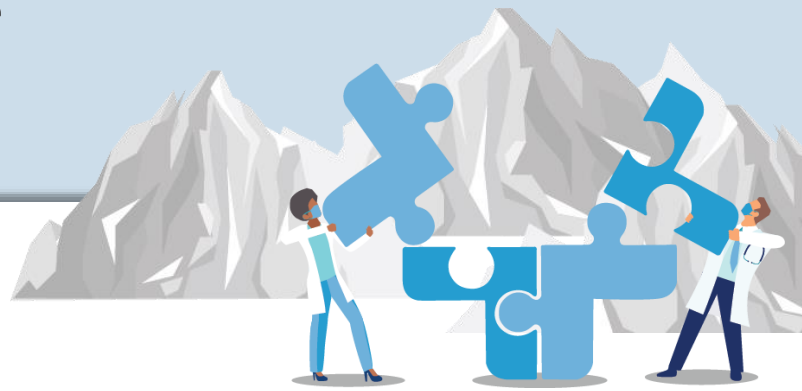
Alternating pressure

Lateral rotation

Low Air Loss

Zone

Multi-Zoned surface



Immersion and Envelopment

Section 2

- Standard Protocol for Measuring Immersion in Full Body Support Surfaces

Section 6

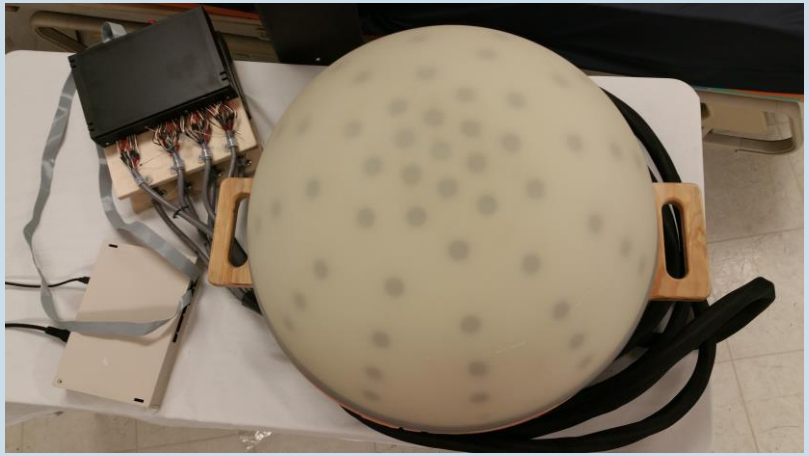
- Envelopment and Immersion – Hemispherical Indenter Test

Section 7

- Envelopment with Dual Semispherical Indenter Test

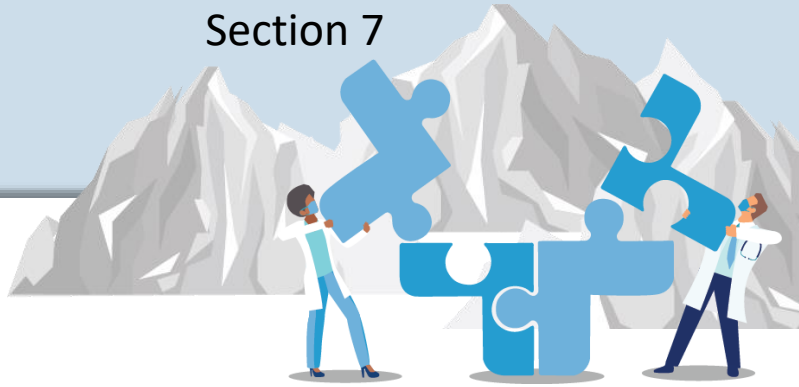
Immersion and Envelopment

Section 2



Section 6

Section 7



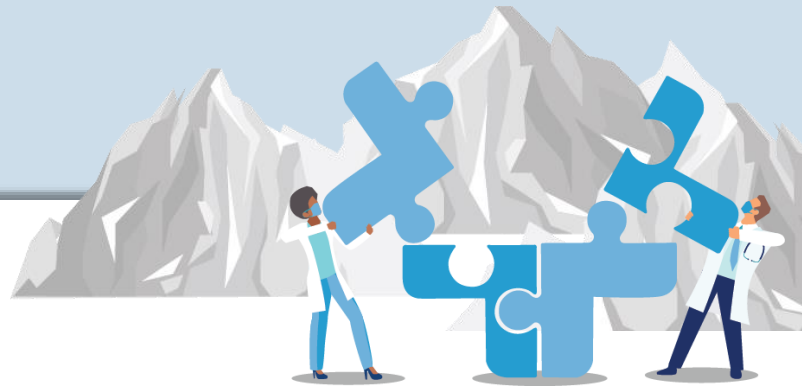
Why Three Tests??

Support Surfaces Have Different Functions and Intended Uses

No Single Test Measures all the features

Immersion and Envelopment are the Physical Characteristics that define ”PRESSURE”

- How Far the patient sinks in
  - Defines how much surface is potentially available
- How well the surface Envelopes
  - Defines how well force can be distributed to the available surface
- Only 1/3 of surfaces tested register a value in the High Challenge test



Section 2: Immersion (only immersion)

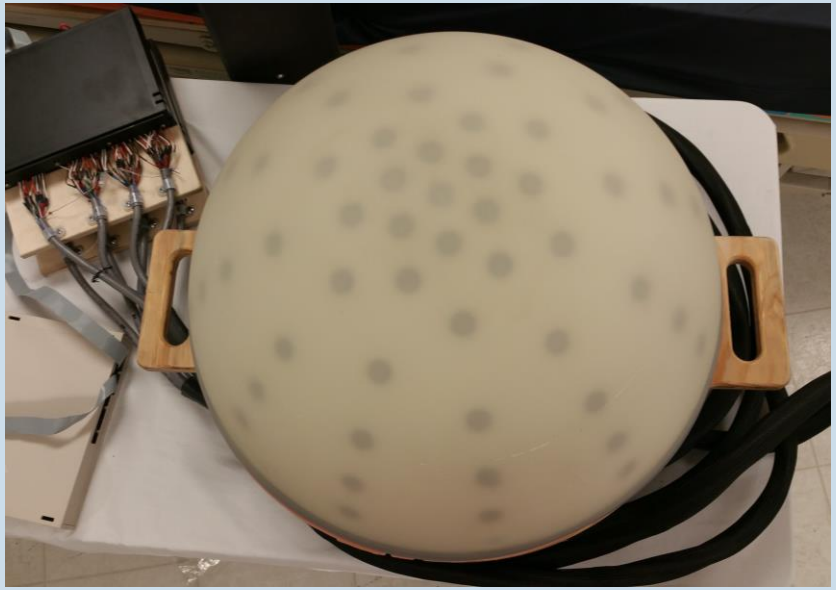
High Resolution

Mass and Height of Average Male

BOUNDRIES:

- Thickness of the surface
- Material of construction
  - Foam 50-60%
  - Air 80+%
- Friction reduces immersion
- Anything on the surface impacts immersion
- Surfaces react to chucks, sheets, overlays differently

Section 6 Immersion and Envelopment



Immersion (high resolution) and Envelopment

Sensor vertical spacing is ¾”, horizontal varies

Shows envelopment More than actual pressure

Pressure by sensor row , more rows is better

BOUNDRYS

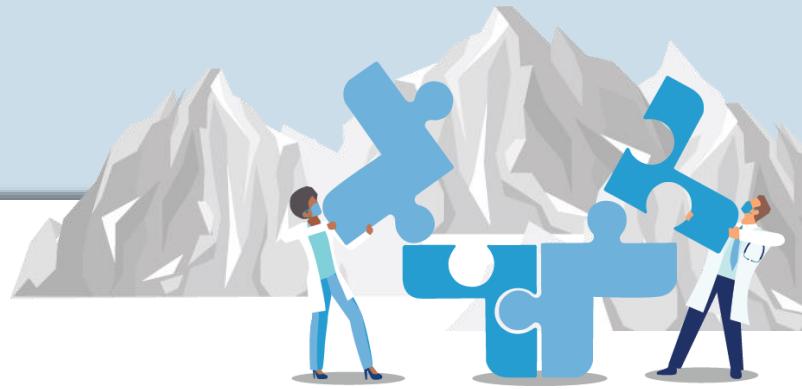
Thickness and material of construction of surface

Friction and devices placed on surface impact

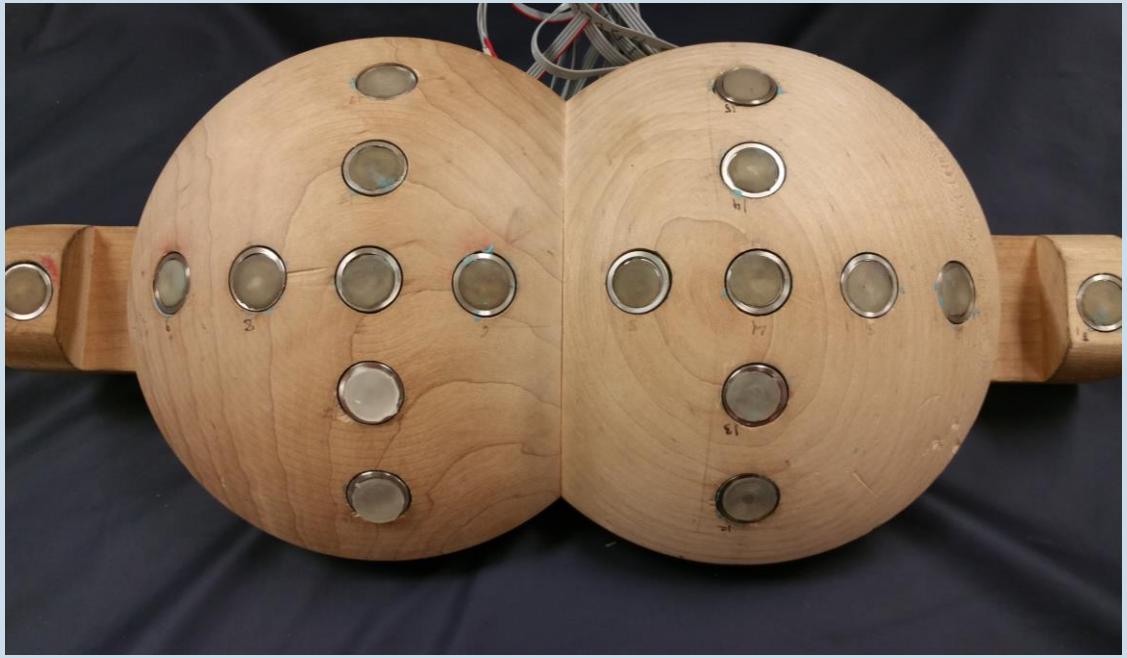
Sensor distribution

Senses to 20” depth

Pelvic region only



Section 7: Immersion and Envelopment High Challenge



Immersion (High Resolution) and Envelopment

Represents atrophied pelvic region

Highly Significant Cleft Challenge

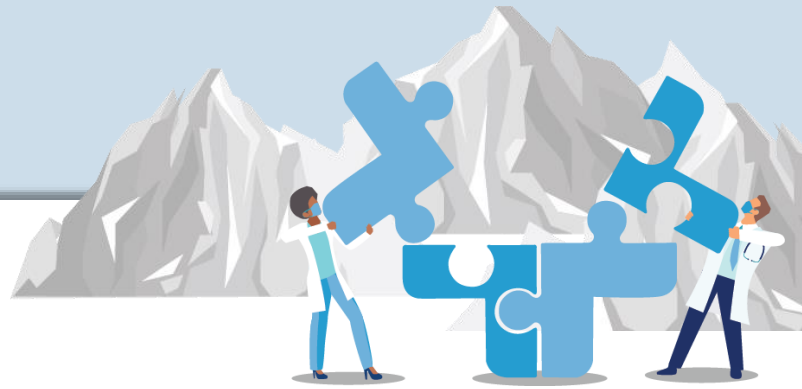
BOUNDRYS

- Thickness and material of construction of surface
- Sensor distribution
- Measures highest enveloping surfaces
- Segmented and elastic materials of construction
- Fluid like materials

How Do I use Immersion and Envelopment?

In depth support surface selection study published by Mayo Clinic

- Nursing practices had a greater impact on pressure redistribution through turning protocol than the support surface immersion and envelopment did.
  - Head of bed management
- Moisture management practices by nurses were more impactful than microclimate management by bed
  - Incontinence care
  - Sweat
- Proper positioning and repositioning protects sacrum from shear more than the accommodating surface
  - Horizontal stiffness test
  - Repositioning schedule
  - Knee gatch
  - Positioning aids



How Do I Use Immersion and Envelopment?

IMMOBILE SPINA BIFIDA CLOSURE PATIENT

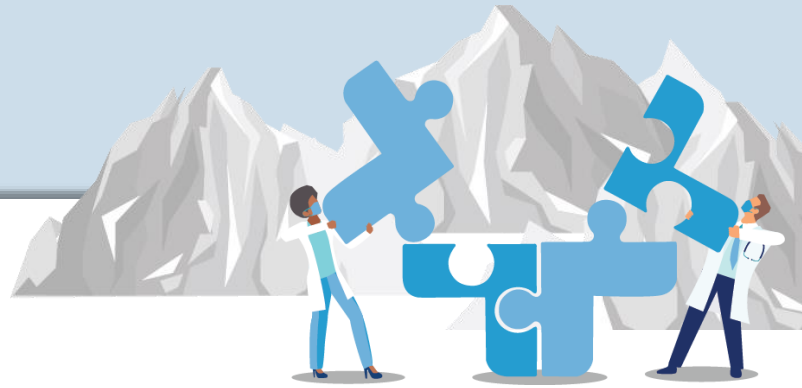
High Immersion
- Highest number from Section 2, 6 or 7

High Envelopment
- Highest number of sensors with load in Section 6
- Highest readings on sensors 5 and 6 Section 7

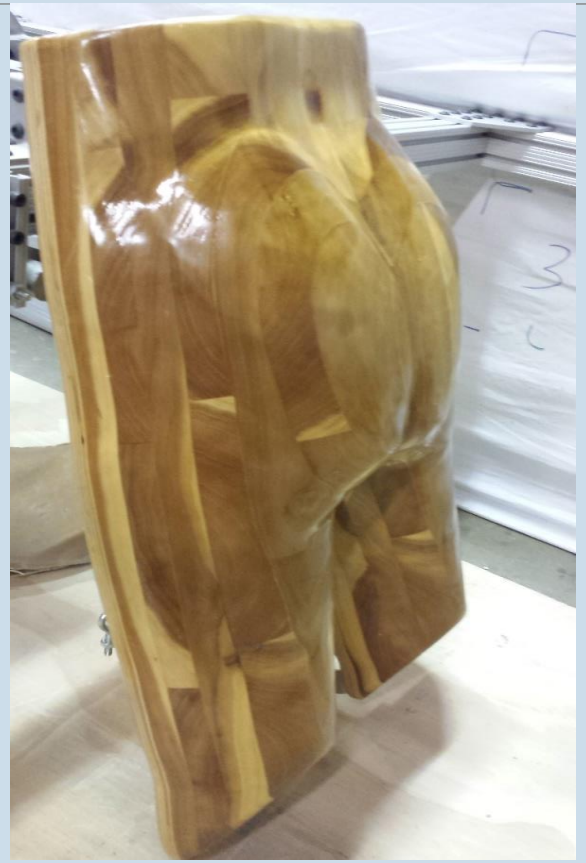
MOBILIZATION ORTHOPEDIC JOINT REPLACEMENT PATIENT

Medium to Low Immersion
- Stability for bed edge mobility
- Low immersion for in bed PT

Low to Medium Envelopment
- Low or no readings on sensors 5 and 6 Section 7



Section 5: Horizontal Stiffness



Section 5: Horizontal Stiffness

Resistance to patient sliding

Used to simulate movement after elevation of the head of bed

BOUNDRIES

- Visco foam, high resistance
- High immersion air, low resistance
- Believed to be predictive of DTI

Great Point to Consider

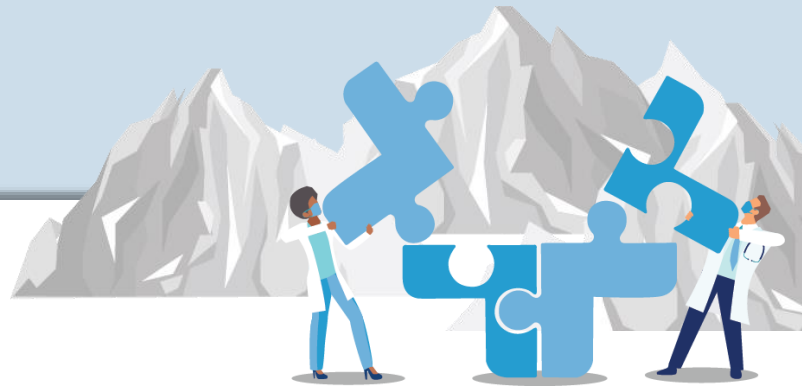
New study coming to a close at University of Pittsburg.

Dr. Dave Brienza, Associate Dean of Research and Team, Patricia Karg etc.

Clinical study looking at pressure injury rates between different support surfaces in a 3 year study

We are watching with great anticipation and interest

High quality of care hospitals, mask the potential of measuring surface impact on injury rates



How Do I use Horizontal Stiffness

CATAPLEXY

High horizontal stiffness

- May assist in preventing sliding or bunching in bed.

Low horizontal stiffness

- May assist in distribution of forces
- Consider Lower HOB
- Consider higher envelopment

Body type may change considerations

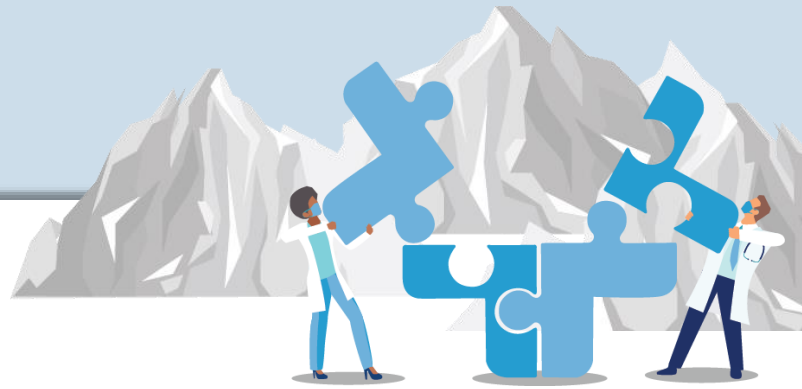
POTENTIAL SHEAR ENVIRONMENTS

Continuous lateral rotation

Rotational Beds

Reverse Trendelenburg

High Head of Bed



Microclimate

Why Three Tests

Body Analog

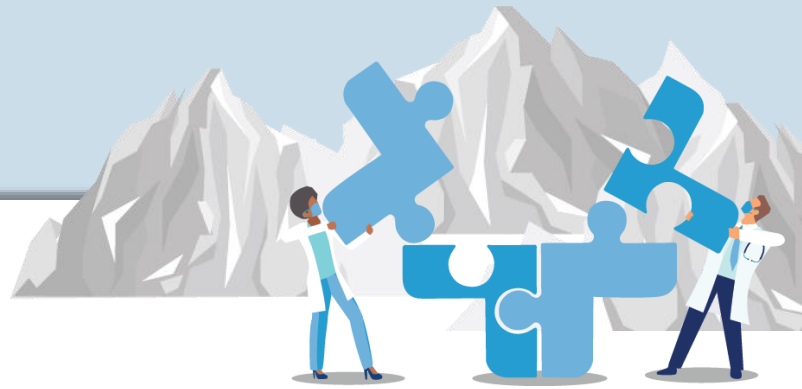
- Measures the accumulation of heat and humidity
- Reports Temperature in °C
- Reports Humidity in relative humidity
- These two values are highly cognitive to the typical user.
  - We all know what high humidity and high temperature feel like
- We report gm moisture removed per trial (pelvic region)

Sweating Guarded Hot Plate

- Measures the heat movement through flux sensors when dry and when wet
- Uses this to calculate the potential removal of moisture in normal operation
- Reports calculated gm/m^2/hr of potential moisture removal
- Reports measured heat removal when both wet and dry J/m^2/hr

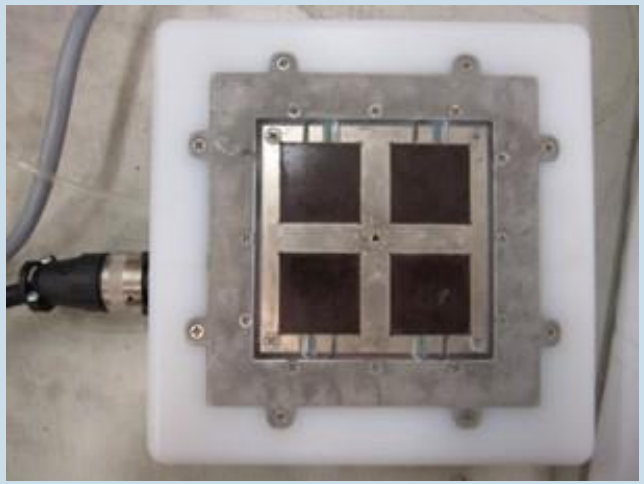
Heated Bladder Method

- Measures the actual moisture removed in Grams, gm/m^2/hr
- Measures continuous removal over 3 hours
- We add heat accumulation as temperature in C°
- Only actual water removal in gm of the 3



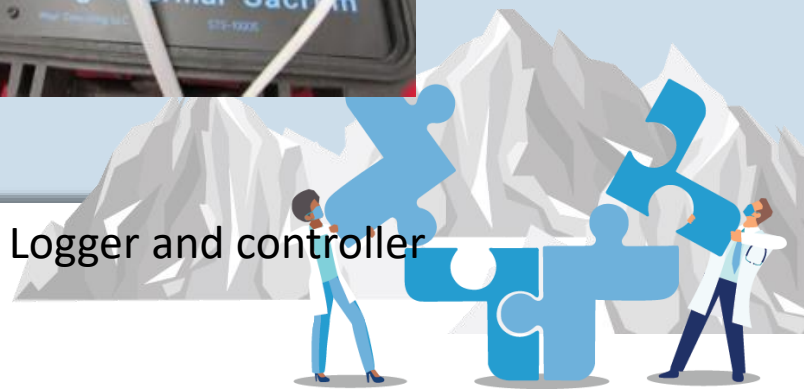
Sweating Guarded Hot Plate Microclimate Test

In use



Surface contact side

Data Logger and controller



Sweating Guarded Hot Plate Boundaries

Environment where surface is used

Moisture absorption of the cover fabric

Moisture wicking of the cover fabric

- Wool sock effect, still warm when wet

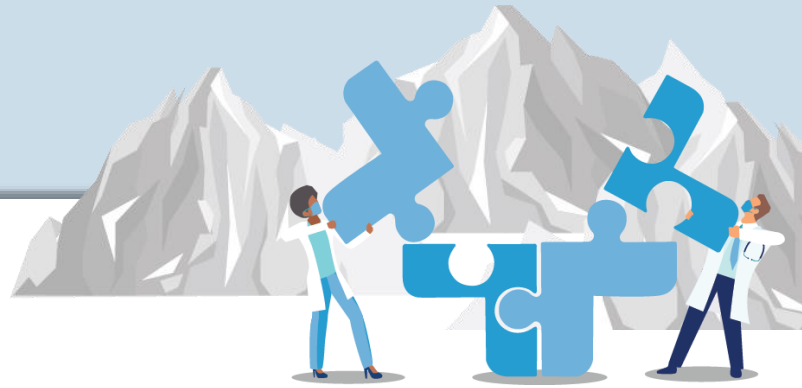
Sensitive to the insulation R value of the bed

Sensitive to the heat conduction Q value

Appears be skewed by the Dyne value

ALL THIS JUST MEANS THE WOOL SOCK EFFECT

Body Analog Microclimate Test



Body Analog Boundries

Temperature and humidity in the room where support surface is in use

Support surface can not drop humidity below ambient

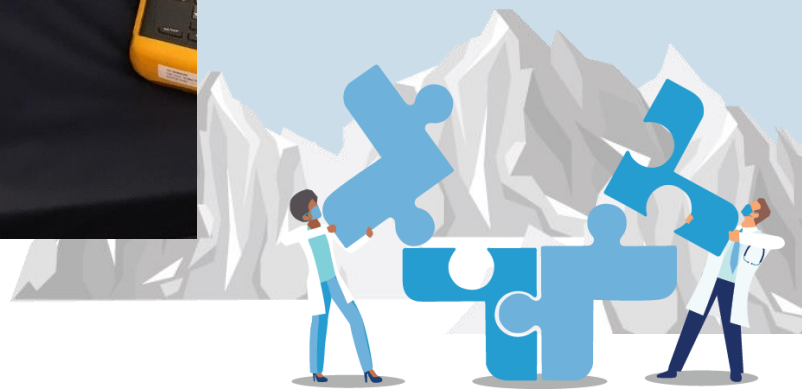
Temperature in the presence of moisture can be lowered slightly below due to evaporation, but effect is minimal

Exposed skin in air is approximately 28°C (22°C to 34°c in our study)

Electronic Controls of surface and number of blankets and absorbent pads govern performance

Some surfaces heat, I have only seen prototypes of cooling surfaces

Heated Water Bladder Test



Heated Water Bladder Boundaries

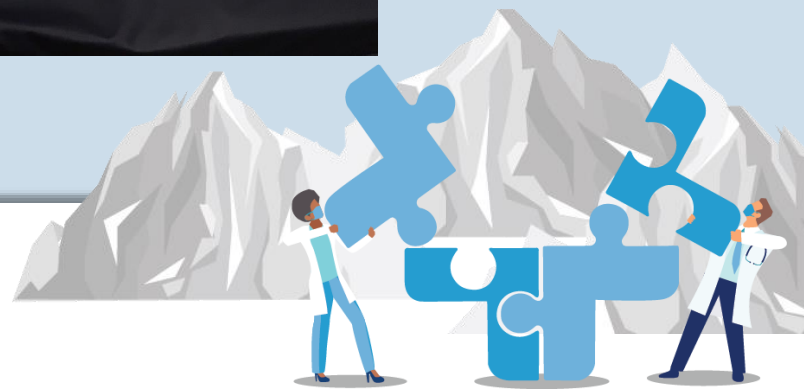
Hydrophilic nature of fabric

Water Delivery rate of the fixture

Measures and reports amount of water removed from fixture.

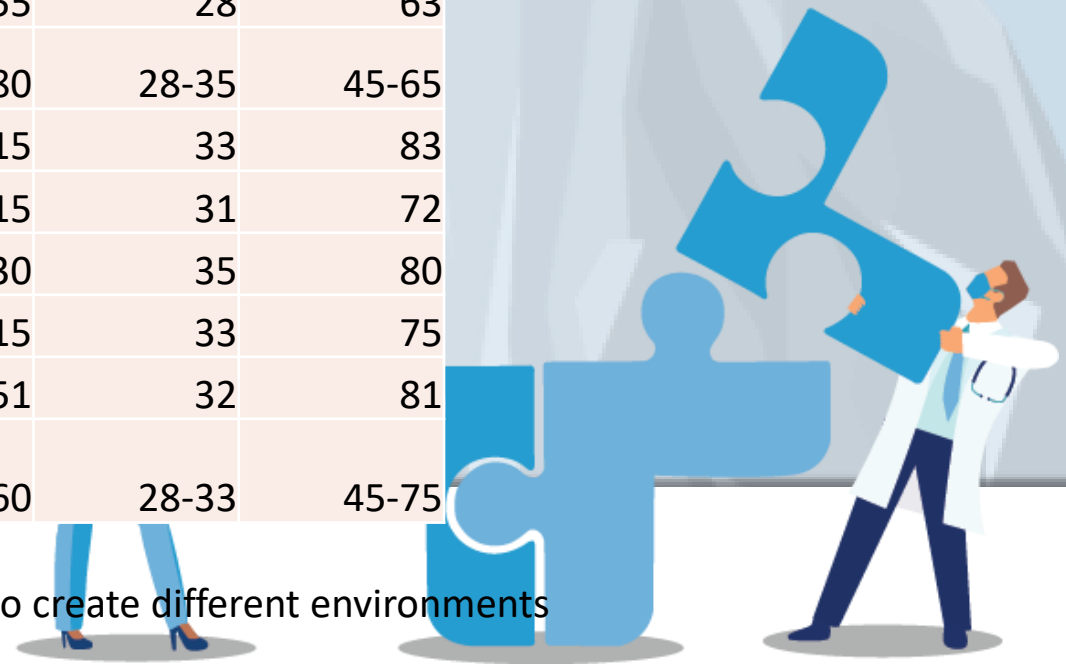
Direct measure is desirable

Simple measurement



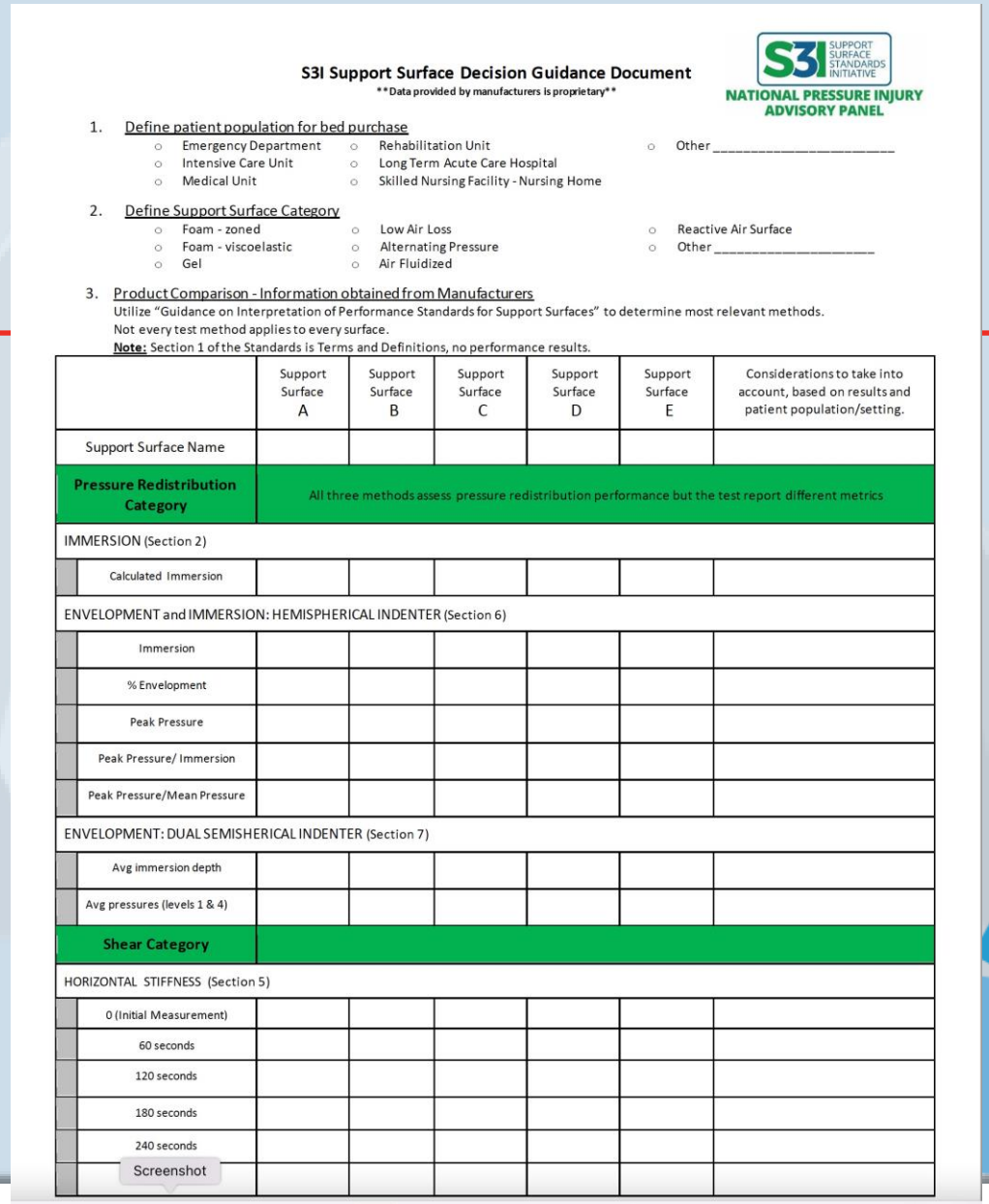
Examples of the Numbers

Description	Immersion Distance (mm)	Moisture Removal (gm^2/hr)	Heat Removal W/m^2	Peak Temp (°C)	Peak RH (%)
	High is Good	High is Good	High may be good	Low may be Good	Low is good
LAL 1	87	93	55	28	63
Air Fluidized*	80-120	400+	40-80	28-35	45-65
LAL and AP	57	5	15	33	83
AP	55	9	15	31	72
Air	55	17	30	35	80
Foam	50	14	15	33	75
Visco Foam 1	61	44	51	32	81
Neg Pressure Overlay	50-70	320+	15-60	28-33	45-75



* Powered surfaces may have adjustable controls to create different environments

Selection Guidance 1 Available at NPIAP.com



S3I Support Surface Decision Guidance Document

****Data provided by manufacturers is proprietary****

S3I SUPPORT SURFACE STANDARDS INITIATIVE
NATIONAL PRESSURE INJURY ADVISORY PANEL

1. Define patient population for bed purchase
   - ○ Emergency Department
   - ○ Intensive Care Unit
   - ○ Medical Unit
   - ○ Rehabilitation Unit
   - ○ Long Term Acute Care Hospital
   - ○ Skilled Nursing Facility - Nursing Home
   - ○ Other _____

2. Define Support Surface Category
   - ○ Foam - zoned
   - ○ Foam - viscoelastic
   - ○ Gel
   - ○ Low Air Loss
   - ○ Alternating Pressure
   - ○ Air Fluidized
   - ○ Reactive Air Surface
   - ○ Other _____

3. Product Comparison - Information obtained from Manufacturers

Utilize "Guidance on Interpretation of Performance Standards for Support Surfaces" to determine most relevant methods.
Not every test method applies to every surface.
Note: Section 1 of the Standards is Terms and Definitions, no performance results.

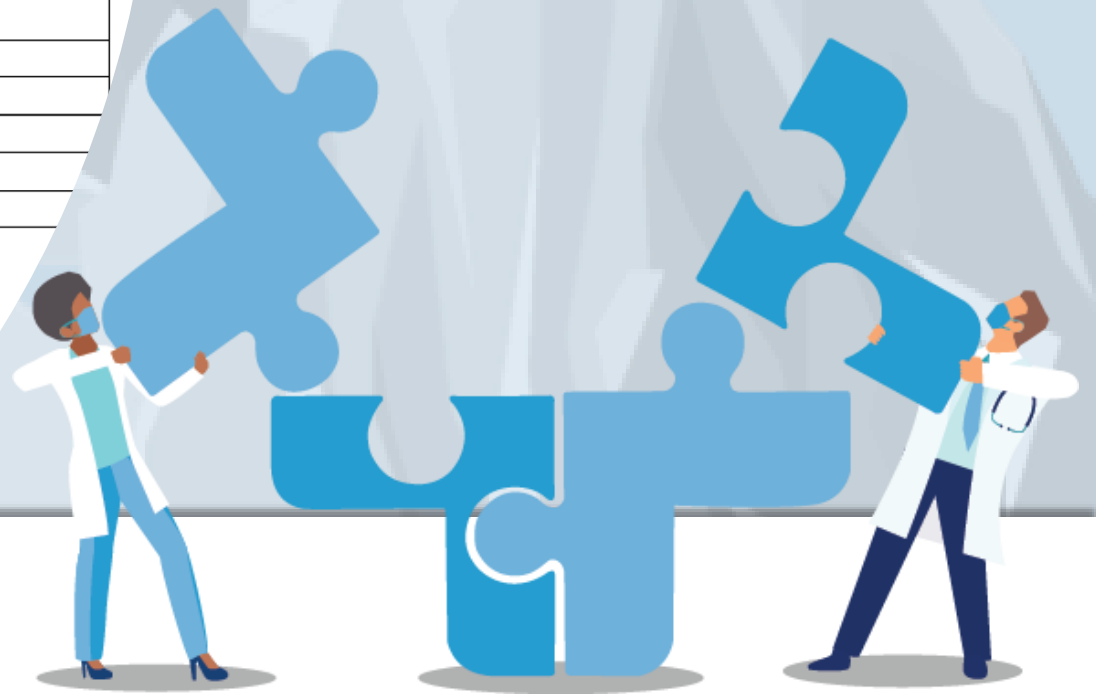
	Support Surface A	Support Surface B	Support Surface C	Support Surface D	Support Surface E	Considerations to take into account, based on results and patient population/setting.
Support Surface Name						
Pressure Redistribution Category	All three methods assess pressure redistribution performance but the test report different metrics					
IMMERSION (Section 2)						
Calculated Immersion						
ENVELOPMENT and IMMERSION: HEMISPHERICAL INDENTER (Section 6)						
Immersion						
% Envelopment						
Peak Pressure						
Peak Pressure/ Immersion						
Peak Pressure/Mean Pressure						
ENVELOPMENT: DUAL SEMISHERICAL INDENTER (Section 7)						
Avg immersion depth						
Avg pressures (levels 1 & 4)						
Shear Category						
HORIZONTAL STIFFNESS (Section 5)						
0 (Initial Measurement)						
60 seconds						
120 seconds						
180 seconds						
240 seconds						

Screenshot

Selection Guidance 2

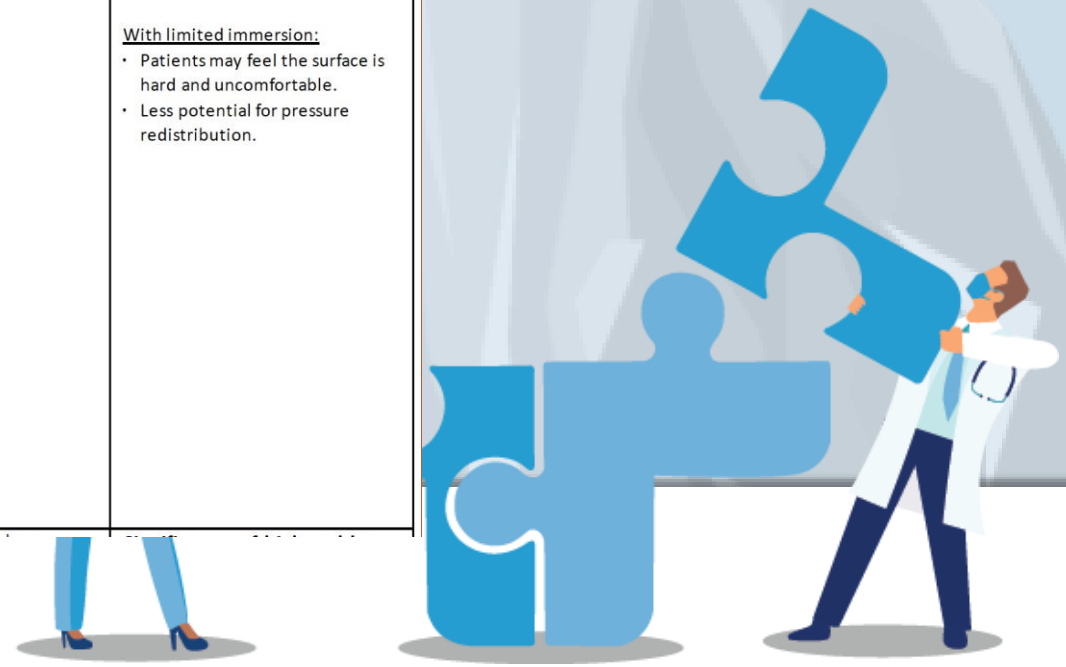
			Support Surface A	Support Surface B	Support Surface C	Support Surface D	Support Surface E	Considerations to take into account, based on results and patient population/setting.
Microclimate Management			All three methods assess microclimate performance but the test report different metrics					
BODY ANALOG (Section 3)								
	Relative Humidity	60min						
		120min						
		180min						
	Temperature	60min						
		120min						
		180min						
SWEATING GUARDED HOT PLATE (Section 4)								
	Dry Heat Flux							
	Wet Heat Flux							
	Evaporative Capacity							
HEATED WATER BLADDER METHOD (Section 8)								
	30 minutes							
	60 minutes							
	90 minutes							
	120 minutes							
	150 minutes							
	180 minutes							
Overall Facility Ranking								

4. Compare results and determine which support surface is the most appropriate for
   Ranking)
5. Collaborate with Purchasing and Administration regarding procurement of re



Interpretation Aids Available at NPIAP.com

Performance Test	Test Overview	Performance Measures	Interpretation of Results	Guidance
Immersion **Intent of method:** This test provides one measure of pressure redistribution through immersion into the support surface. Increased contact area (evaluated by immersion and envelopment) disperses the individual's weight and redistributes the pressure over a broader area.	The Immersion method measures the depth of penetration of a rigid test mannequin into a support surface. The resolution of the test system is very high and provides a continuous linear measure of immersion not provided by the other indenters. The measurement is made using a rigid body like indenter so the results show immersion for the entire surface, where the sphere-based measures of immersion can report results by regions of the surface (the pelvic region for example). Limitation: Only can be used in flat or 0-degree head of bead articulation.	**Validated Output** Calculated Immersion (depth) (mm)	Products that are less stiff/firm will typically have higher immersion. Conversely, products that are more stiff/firm will typically have lower immersion values. This value is limited to the thickness of the support surface.	**Significance of high and low measurements:** Higher levels of immersion provide opportunities for increased pressure redistribution. With excessive immersion: • Patients may feel like they are in a hole. • Bottoming out may occur. • Clinicians may find it difficult to reposition patient. With limited immersion: • Patients may feel the surface is hard and uncomfortable. • Less potential for pressure redistribution.



Summarize Results in Decision Making tool

(4) Compile a chart with the data for Evaluation

Low Air Loss Mattress Comparisons For an ICU

**These are simulated results and are not from specific products*

Mattress Type	A	B	C	D
Surface Height	7”	7”	12”	6”
Performance Characteristics				
Immersion	52%	47%	50%	20%
Envelopment *(Peak Pressure)*	127 mmHg	140 mmHg	138 mmHg	102 mmHg
Horizontal Stiffness	30N	50N	40N	40N
Sweaty Guarded Hotplate *(Evaporative Capacity)*	20 g/m2/hr	20 g/m2/hr	30 g/m2/hr	N/A
Body Analog	70%	75%	80%	50%
Heated Water Bladder Method	35 g/m2/hr	35 g/m2/hr	38 g/m2/hr	N/A
Cost & Overall Ranking				
Cost	$2,500	$1,500	$7,000	$1,000
Overall Ranking	*Based upon MICROCLIMATE as a priority*			
	3	2	1	4
Overall Ranking	*Based upon IMMERSION & ENVELOPMENT as a priority*			
	1	3	2	**4**

Mattress Replacement Project: Putting the S3I Testing Protocols into Practice

Beth Sievers, APRN, CNS, CWCN, Evan Call, MS, CSM, Therese M. Jacobson, DNP, APRN, CNS, CWOCN, Julie Moenck, MBA, PMP, Gina Rohlik, APRN, CNS and Ann N. Tescher, PhD, APRN, CNS, CCRN, CWCN, FCCM

Mayo Clinic, Rochester, MN

Introduction

In 2015, a large Midwestern Academic Medical Center needed to replace aging mattresses and bedframes. The Clinical Nurse Specialist (CNS), tasked with leading the institution's mattress replacement project, proposed using the Support Surface Standards Initiative (S3I) and British testing protocol results to inform the decision making process.

Literature Review

S3I was founded by the National Pressure Ulcer Advisory Panel and is now the official testing standards body for therapeutic support surfaces. In 2014, S3I for the first time published mattress testing protocols making it possible for hospitals to request testing results from manufacturers that would allow accurate comparison of similar surfaces. The protocols were designed to measure immersion and microclimate (Stone et al., 2015). A British standard protocol for measuring sliding resistance was also published and available for testing.

Aim

The purpose of the project was to use the best available evidence to objectively evaluate support surfaces as part of pressure injury prevention efforts.

Methods

The following information was shared with an independent testing lab (EC Service, Corp.) to help determine which surfaces would benefit the patient populations cared for at our tertiary medical center. The types of information included:

- ICU and General Care patient characteristics
- Patient care skin protection related products
- Nursing care guidelines, procedures, & algorithms
- Mattress testing results

Multidisciplinary team members also evaluated and rated the importance of select features of the mattresses and bed frames (i.e. weight accommodation, safety features, etc.).

Results

The results from the mattress testing protocols were presented in a table and the surfaces were ranked against each other. The lower the ranking, the better able the surface would meet the patient population needs. See table for an example.

Table

Mattress	A	B	C
Hospital Area	General Care	General Care	General Care
Max Temp (°C)	2	2	4
Temp Diff (°C)	1	2	4
Max RH (%)	3	1	4
Relative Humidity Diff (%)	2	3	4
Evaporative Capacity (gm^2/hr)	3	1	4
Moisture Removal (W/m^2)	2	3	1
Immersion (mm)	4	1	3
Peak Temp (°C)	3	2	4
Temperature Population Microclimate Risk Factor	2	4	3
Peak Relative Humidity (%)	3	1	4
Humidity Population Microclimate Risk Factor	4	2	3
Total	29	22	38

Note: Mattress B outperformed the other mattresses as demonstrated by the lowest cumulative score.

Testing Apparatus for Measuring Immersion

Call, 2017

Testing Apparatus for Measuring Heat and Water Vapor

Call, 2017

Conclusions

The results of standardized support surface testing were highly influential in selecting mattresses for general care and ICU; however, they were not used in isolation. Though the process seemed arduous at times, the team members gained knowledge and insight in surface selection which can be incorporated into future purchase and rental options.

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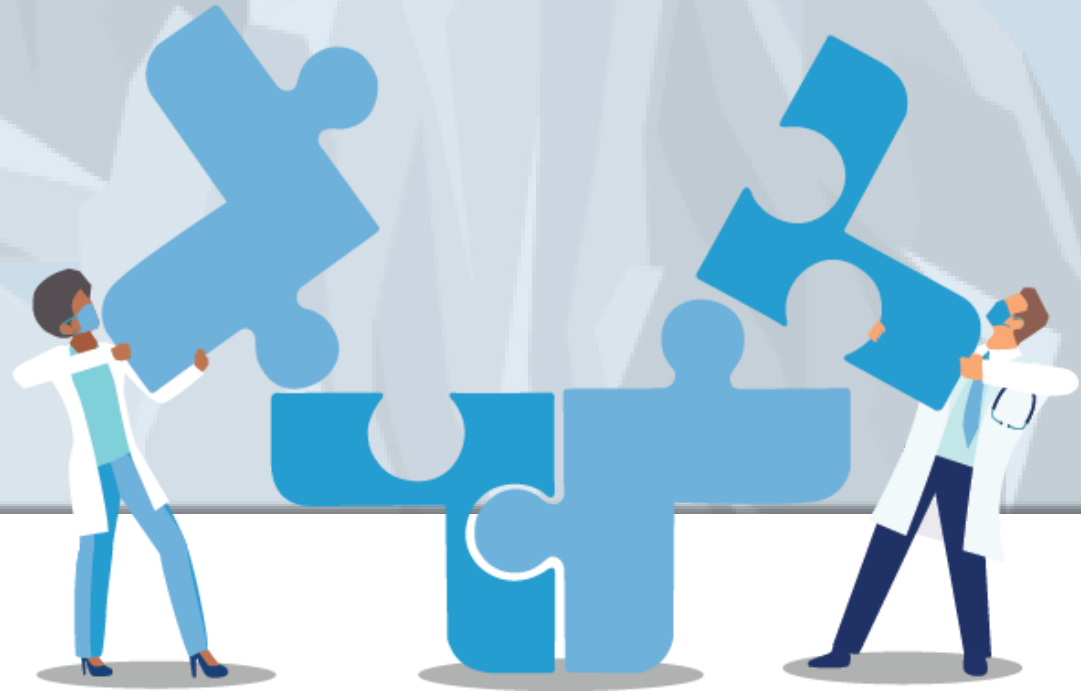
Model the Effect of Care on Elements of Risk

Using Test Results, Literature and Expert Opinion

- Determine the positive or negative impact of Devices and Practices -Direction-
- Measure where possible – Magnitude-
- Estimate where not possible – Magnitude-

Construct a Mathematical Model

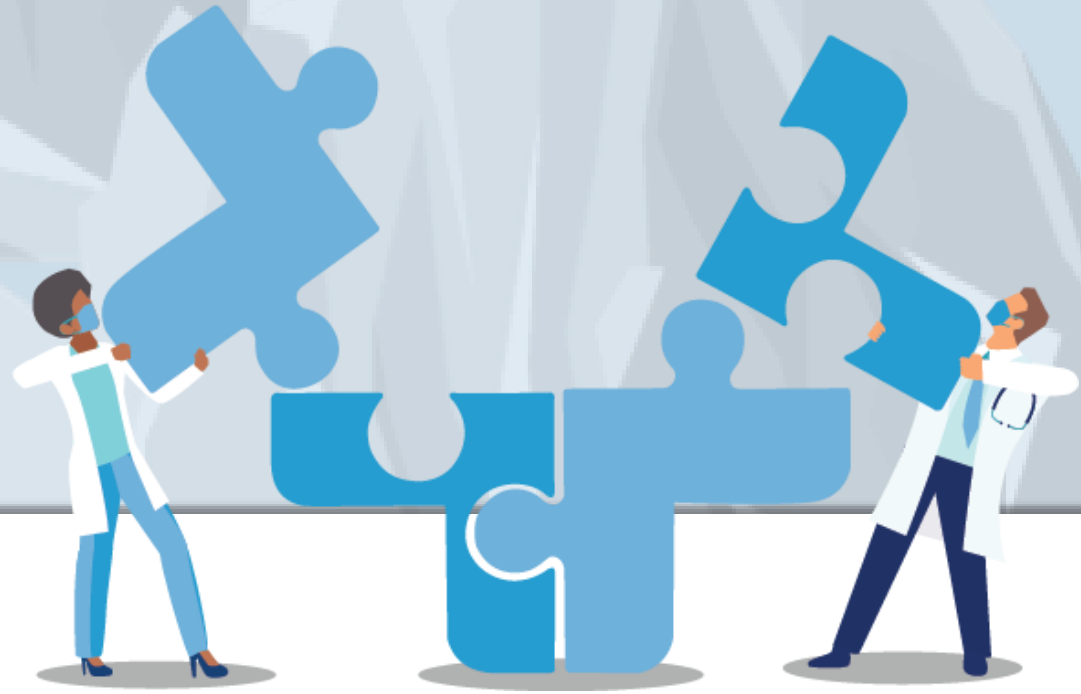
- Predict impact of devices and practices
- Test Predictions



Include Influence of Care Practices

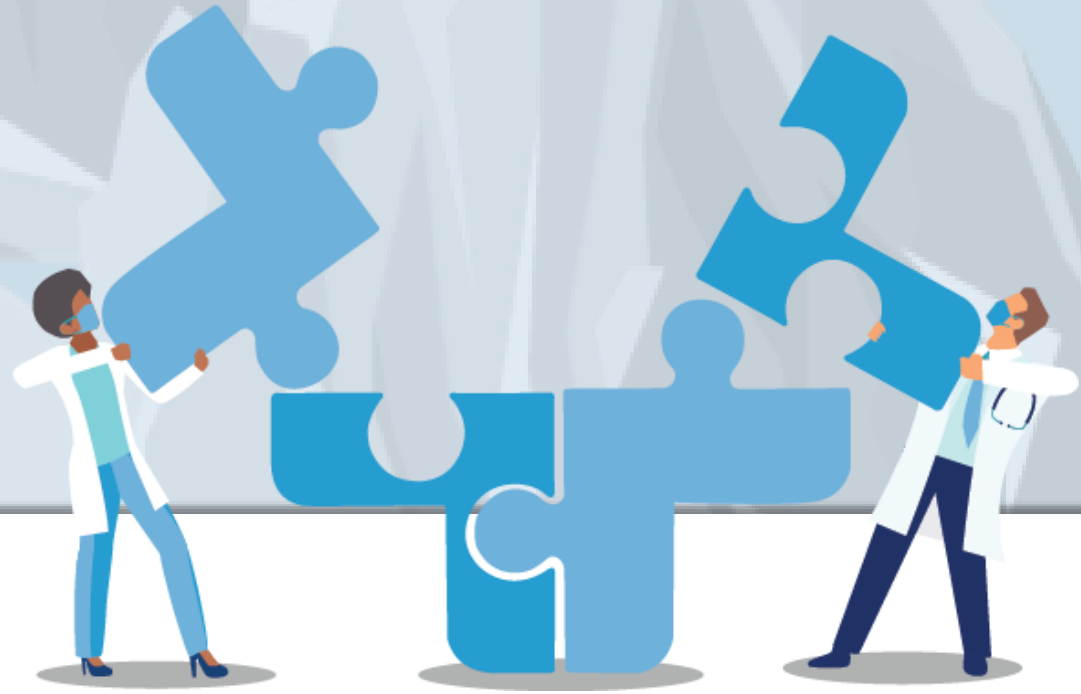
In depth interview with 5 nurses from 5 Care settings

- Boosting
- Turning Program,
- Use of draw sheets and positioners
- Positioning
- Early Mobility
- Micro turns



Include Influence of Care Practices

- Heel Elevation
- HOB Restrictions
- Skin Care Products
- Protectants
- Moisturizers
- Prophylactic Dressings



Literature as Input

Element	Reference
Impact of Temperature	Oberg T, Domek M, Call E. Effect of Heat on Epithelial Cell Viability. Abstracts, Intermountain Branch Meeting, ASM 2010, Brigham Young University, Provo, Utah.
	Lachenbruch C. Skin Cooling Surfaces: Estimating the Importance of Limiting Skin Temperature. Ostomy/Wound Management 2005:51(2):70-79.
	Kokate J, Leland K, Held A, Hansen G, Kveen G, Johnson B, Wilke M, Sparrow E. Iaizzo S. Temperature-Modulated Pressure Ulcers: A Porcine Model. Archives of Physical Medicine and Rehabilitation. 1995 Vol. 76, pgs 666-673.
Sheets and layers on the Surface	Williamson, R, Lachenbruch, C, VanGilder, C, Sauser, F. The effect of Multiple layers of Linens on Surface Interface Pressure: Results of a Laboratory Study Ostomy Wound Management. Jue 2013 pgs 38-47
Tissue Deformation	Brienza, D, Karg, P, Lin, JW, Xue, Y. Task: S-2 Distortion Measureemnt and Biomechanical Analysis of In Vivo Loae Bearing Soft Tissues RERC on Wheelchair Technology Final Report: 1993-1998
	Gawlitta, D, Li, W, Oomens, C, Baaijens, F, Bader,D. The Relative Contributions of Compression and Hypoxia to Development of Muscle Tissue Damage: an Invitro Study Annals of Biomedical Engineering, Vol 35, No. 2, Feb 2007, pp 273-284
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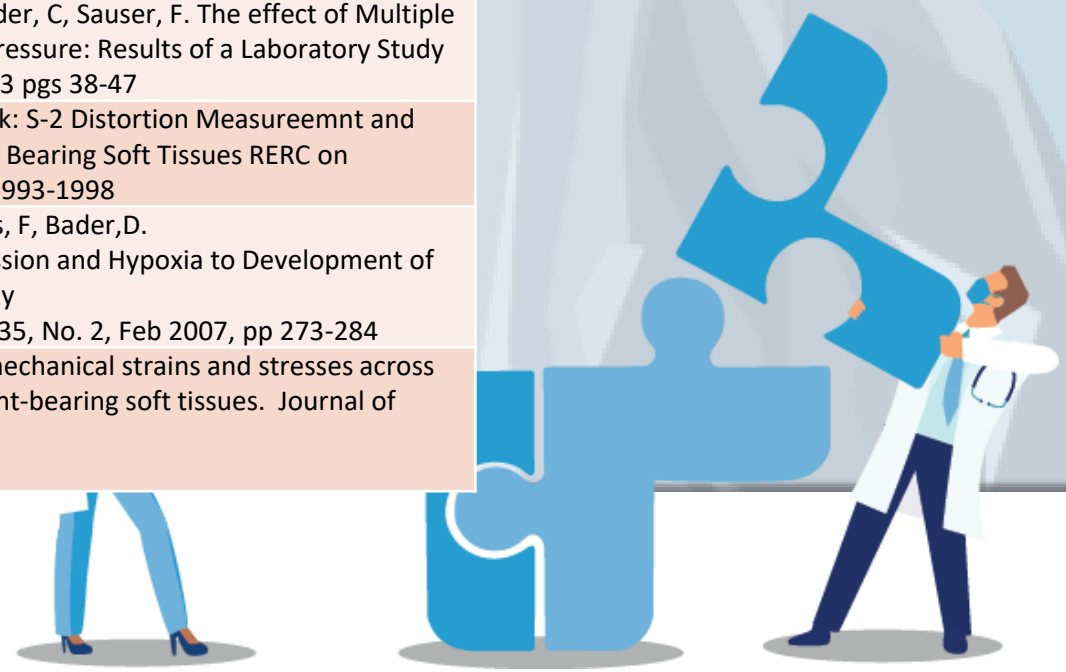
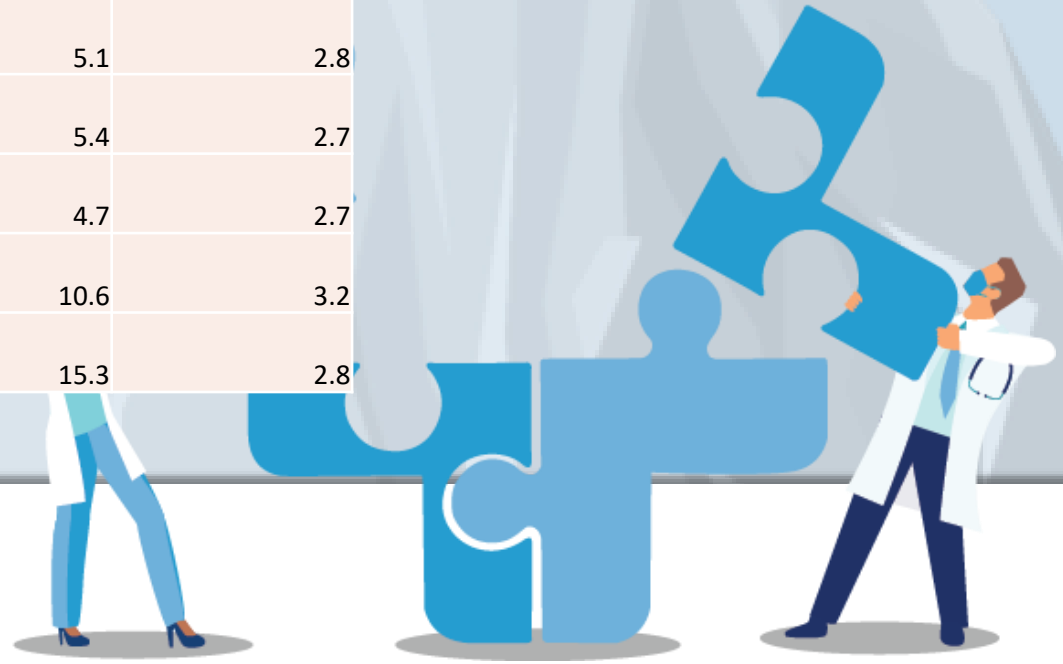


Support Surface Population Risk Factor

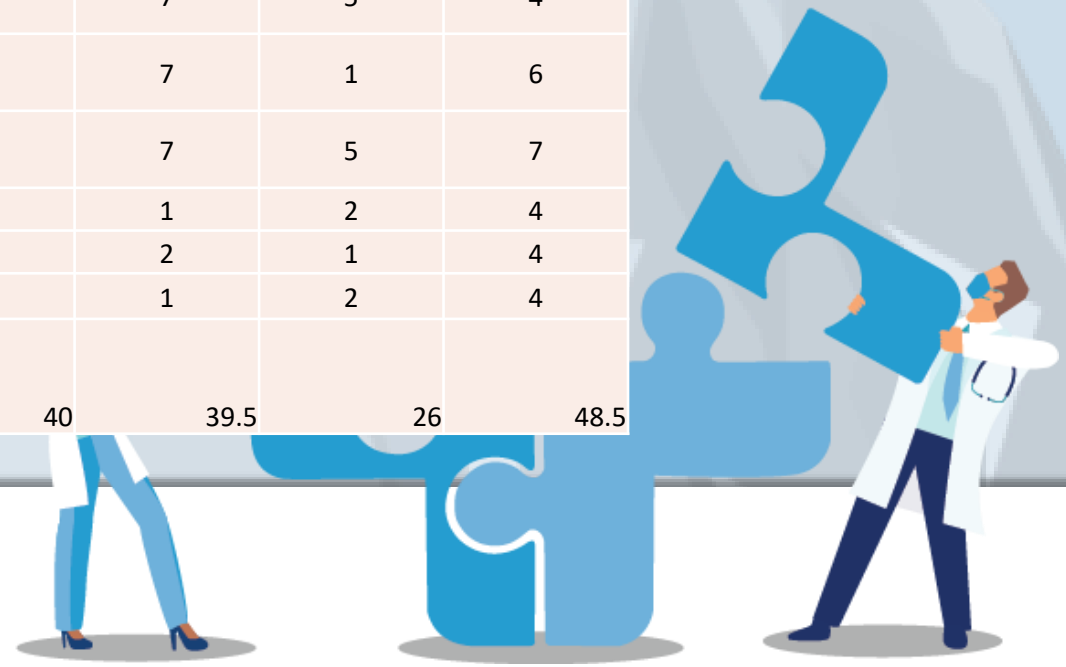
- For a given set of care practices and patient conditions
- A score is generated.
- Low is better

Description	HPMRF	TPMRF
LAL 1	5.0	2.7
LAL 2	12.5	2.7
LAL and AP	7.7	2.9
AP	5.1	2.8
Air	5.4	2.7
Foam	4.7	2.7
Visco Foam 1	10.6	3.2
Visco Foam 2	15.3	2.8



Final Ranking Considering all Test Results and Care Practices

Mattress	Foam	Foam and Air	AP	LAL	LAL	Foam	LAL	Powered Air
Max Temp (°C)	7.5	7.5	5	6	1	3.5	2	3.5
Temp Diff (°C)	8	7	5	6	1	2	3	4
Max RH (%)	8	7	3	5	6	2	1	4
RH Diff (%)	5	6	7	8	1	2	3	4
EvapCap (gm^2/hr)	8	2	6	7	3	5	1	4
Q dry (W/m^2)	3	1	6	8	2	7	5	4
Immersion (mm)	8	3	5	4	2	7	1	6
Peak Temp (°C)	3	2	1	4	7	7	5	7
TPMRF	6	8	5	7	3	1	2	4
Peak RH (%)	8	6	3	5	7	2	1	4
HPMRF	8	6	3	5	7	1	2	4
Over all Rank, Low score is best	72.5	55.5	49	65	40	39.5	26	48.5



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