

On the use of ionizing radiation for the development and production of low cost advanced wound dressings for the Brazilian Universal Health System (SUS)

Ademar Benévolo Lugao

Instituto de Pesquisas Energéticas e Nucleares/Comissão Nacional de Energia Nuclear - IPEN/CNEN

outlook

- **Motivation:**

 - urgent Need to decrease the medical care costs

- **Wounds**

 - Pressure ulcer; neglected diseases; burns

- **Wound Dressings**

 - Challenges
 - Technological platform

- **Radiation processing and new dressings from IPEN**

- **Low cost dressings for the SUS**

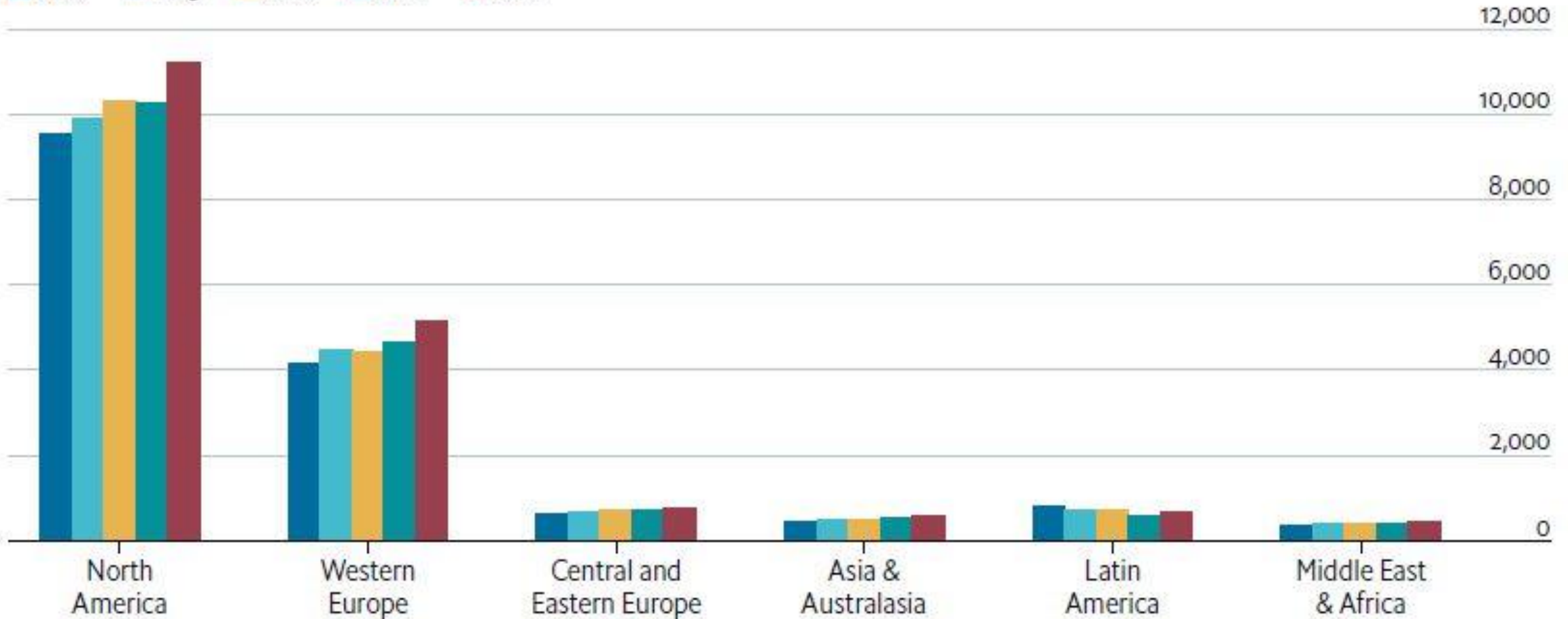
Motivation : urgent need to lower the cost of medical care



Healthcare spending per head

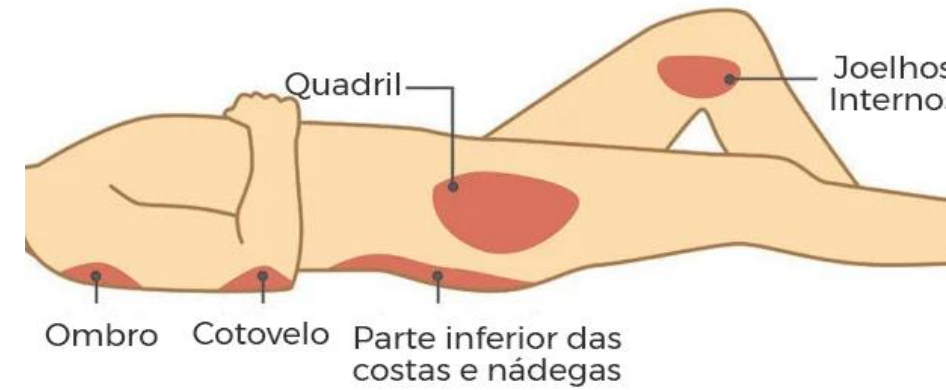
(Projections for 2022; US\$)

2018 2019 2020 2021 2022

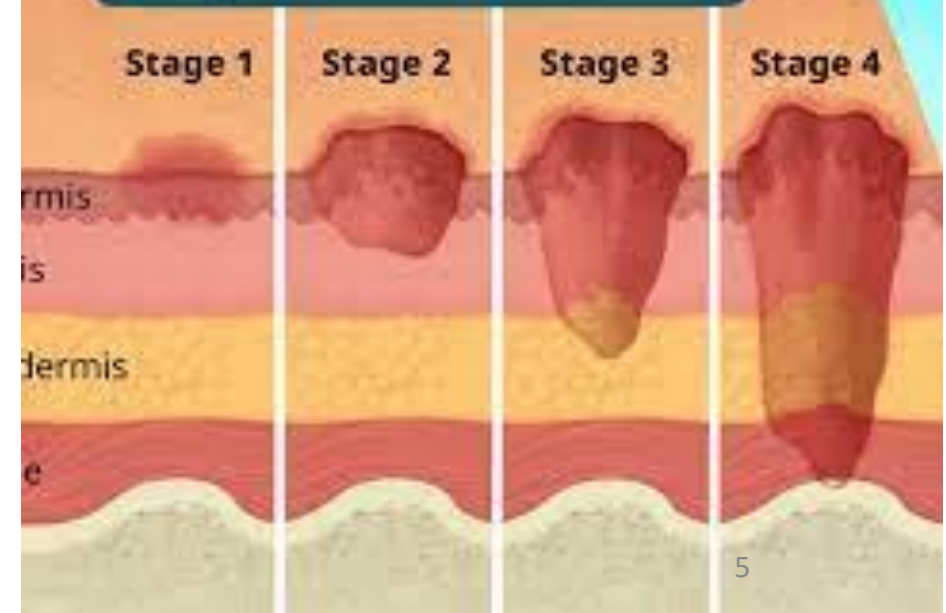


Source: EIU.

Locais de apoio



Stages of a Pressure Ulcer



- Pressure wounds

Need to tackle orphan*
and neglected diseases

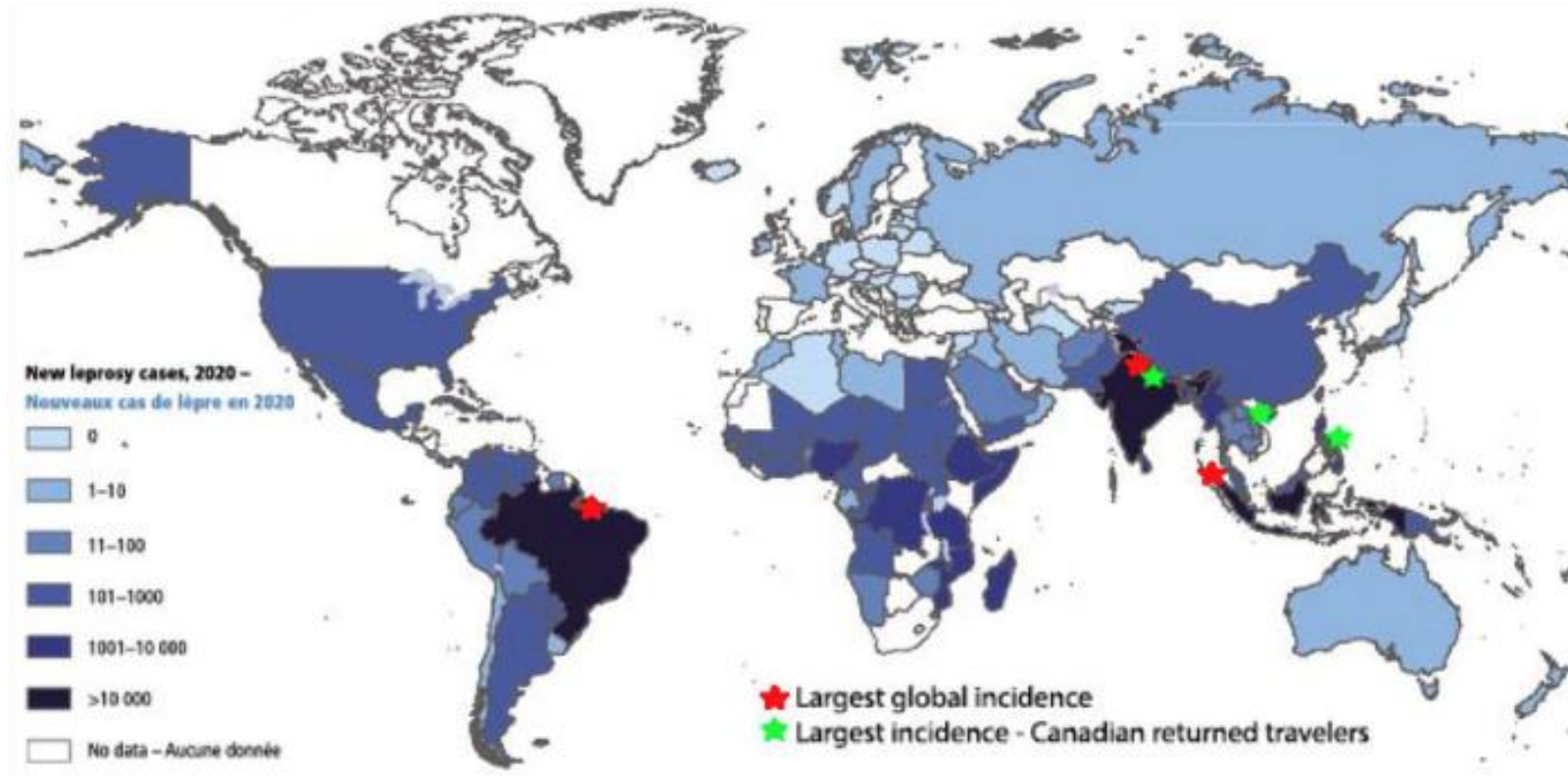
- Neglected

ORPHAN diseases

Epidermolysis bullosa (EB) is a group of rare medical conditions that result in easy [blistering](#) of the [skin](#) and [mucous membranes](#). Its severity can range from mild to fatal.

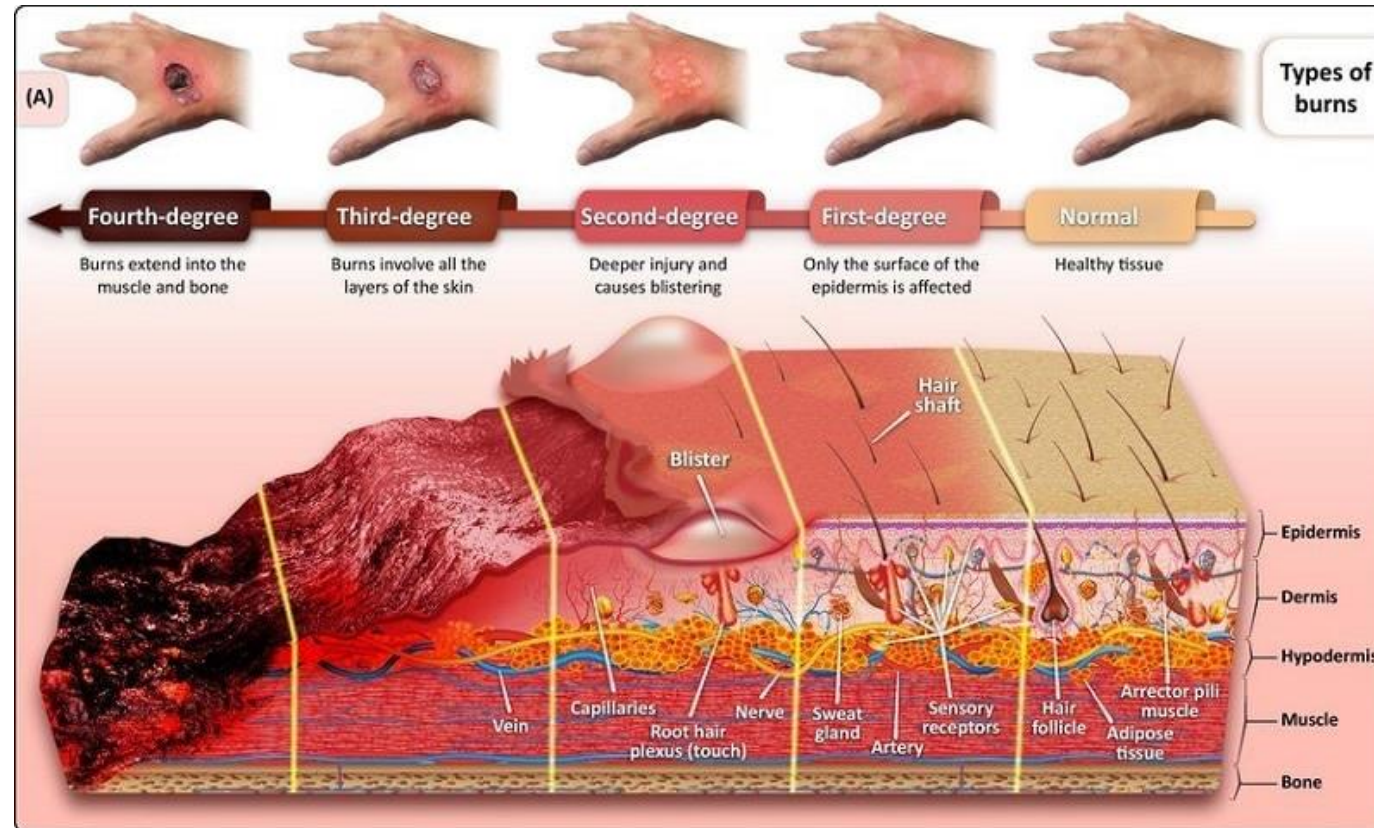


World distribution of leprosy, June 2022



World Health Organization geographic distribution of new leprosy cases, 2020. Red star: India, Brazil and Indonesia. Green star: India, Vietnam and the Philippines. Source: Adapted from World Health Organization. 61

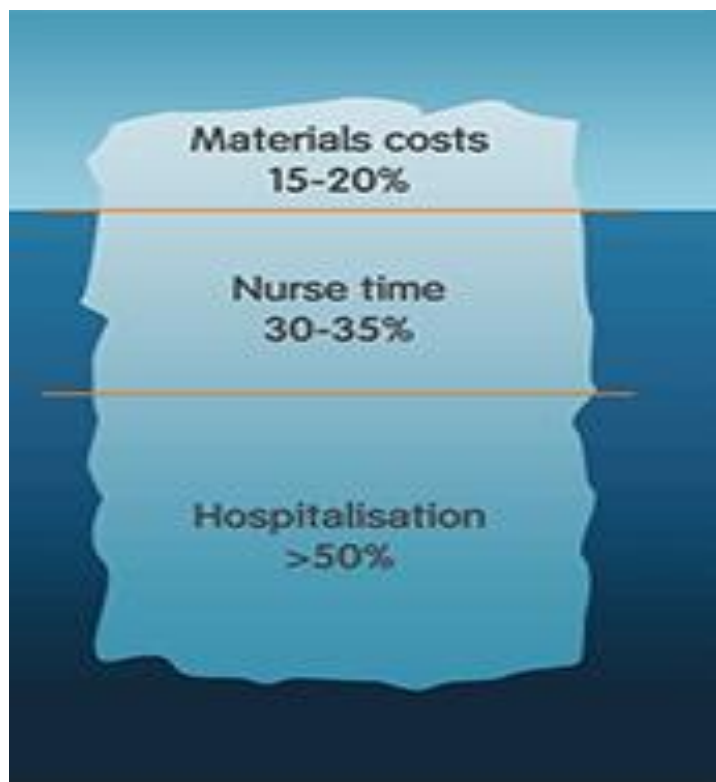
Burns



Mo, Fayin & Zhang, Minjun & Duan, Xuwei & Lin, Chuyan & You, Tianhui. (2022). Recent Advances in Nanozymes for Bacteria-Infected Wound Therapy. International Journal of Nanomedicine. Volume 17. 5947-5990. 10.2147/IJN.S382796.

Dimension of the Challenge

The economic cost of wounds is measured in literally billions of A lot of it is “hidden”, in that it’s not apparent in the cost of materials.



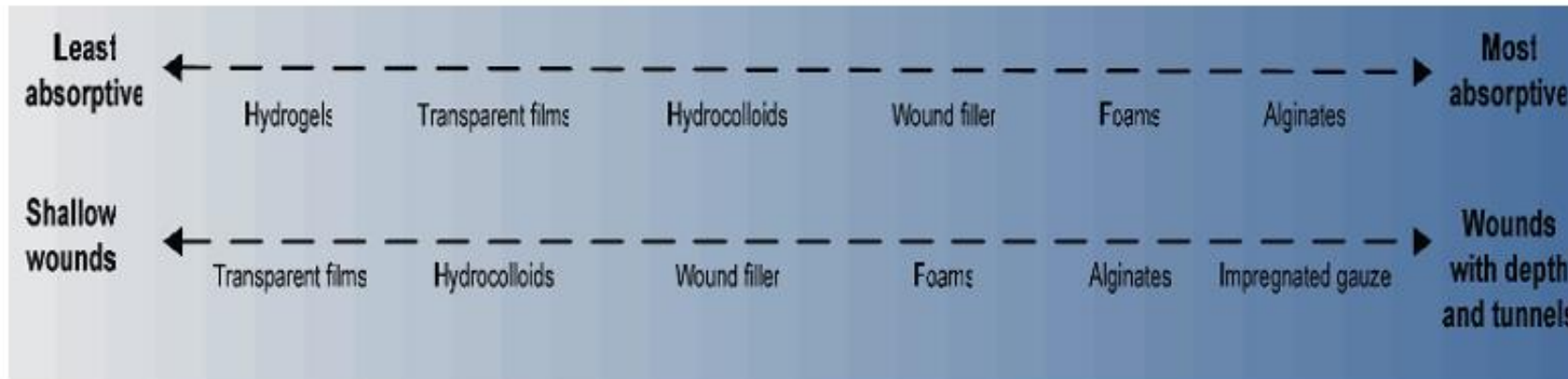
Hospitalisation itself is the main cost driver for wound care for the system.

Nursing time is another factor that far outweighs the cost of materials.

Wounds account for almost 4% of total health system costs, and that this proportion is increasing¹.

Dressing festival

Dressing types



Industrial processing by ionizing radiation

Sterilization is usually mandatory for Biomaterials;

achieved usually with 10 to 25 kGy of minimum dose

Polymer modification (mainly Hydrogels) can be achieved in the same range

Therefore is possible to crosslink and sterilize hydrogels in simultaneous way

Excellent route to develop LOW COST advanced hydrogels for wound dressing

Laboratório de Biomateriais Poliméricos CURATIVOS AVANÇADOS



Less than US\$ 0.50 / 100 cm²



- A good advanced dressing :
- Cannot stick to the wound
- Stickness to skin
- **Transparent**
- Macio, flexível e suficientemente resistente;
- manage exsudation;
- Barrier to bacteria;
- PAIN CONTROL OR ELIMINATION
- **Lowest cost and sterile**

Hydrogels with silver nanoparticles by one pot process

One pot
processing for
developing
dressings with
silver
nanoparticles

• Simultaneous

- **Crosslinking**
- Silver ions (Ag^+)
reduction
- Nanoparticle
stabilization
- sterilization

Curativo de hidrogel com NPAG reticulado por radiação gama



Custos do curativo de hidrogel/NPAG produzido pelo IPEN

Composição	Referência	Custo / curativo – 20g
Matéria prima	membrana de 10 x 10 cm	~ US\$ 0.100
Embalagem	~ US\$ 48.00/1000 un	~ US\$ 0.048
Irradiação (CBE)	US\$ 300.00/m ³	US\$ 0.025
2 trabalhadores + 1 supervisor	US\$ 800,00/trabalhador + custo de supervisão + benefícios	~ US\$ 0.100
CUSTO TOTAL GERAL /un		~ US\$ 0,237

Razões para baixo custo do curativo:

- Cerca de 90% do curativo é composto por água
- O processo é extremamente simples
- Numa única etapa é possível reticular o hidrogel, sintetizar as NPAG e esterilizar



Teste clínico com feridas crônicas realizado no CREDESH (Centro de Referência Nacional em Hanseníase e Dermatologia Sanitária)

Tabela 2 – Média da taxa de cicatrização $\Delta A_{(0-n)}$ entre as semanas por cada tratamento

Taxa de Cicatrização em Semanas	Tratamentos			Total geral (Média)
	Alginato	Espuma	HNPAg	
Semanas 0-1	0.64	2.30	10.10	4.29
Semanas 0-2	6.81	5.36	16.78	9.84
Semanas 0-3	13.40	14.61	25.23	17.73
Semanas 0-4	26.61	24.12	32.37	27.70

Cost of wound dressings for the wound healing (USD)

weeks	Silver alginate (market reference)	Silver foam (market reference)	IPEN Silver Hydrogel
1	198,2	278,5	9,8
2	198,2	278,5	9,8
3	198,2	278,5	9,8
4	198,2	278,5	9,8
total	792,8	1114	39,2



ARAUJO, J. GONÇALVES. Dissertação (mestrado). Eficácia do curativo de hidrogel com nanopartículas de prata na cicatrização de feridas crônicas: estudo clínico randomizado. Univ. Federal de Uberlândia - MG.

Dimension of the Challenge....The case of chronical wounds and wounds from neglected diseases in Brazil



wounds from
Leishmaniose
Tegumentar



Neuropathic ulcers from Hanseniasse

Eventually useful for Radiation Burn???



Curativo para cavidades profundas



Wound

<http://www.enluxtrawoundcare.com/faq.html>

Thank you

Funding

CNEN

CNPq

AIEA

(Kattesh Katti)

(M. Grasselli)

(Janusz Rosiak)

FINEP

FAPESP

CAPES

Clinical Trials

ITPAC

Talita R. Cardoso

Albeliggia Vicentine

CREDESH-UFU

Isabela Goulart

Juliano Araujo

UESB

Roberta Azoubel

Marcelo Sá (UFPb)

Development Team

2000-2022

Mara T. Alcântara - PhD

Sizue Rogero - PhD

Maria José A. de Oliveira - PhD

Justine Paula Ramos de Oliveira – PhD

Gustavo Varca

2022 - Present

Mara T. Alcantara

Lucas F. de Freitas

Tatiana Balogh

POSDOCS

Aryel Heitor Ferreira

Murilo Vigilato – PhD

Caroline AS de Lima

STUDENTS

Adriana S Rodrigues

Cassia PC da Cruz

Gabriel A. Sasdelli

Isadora Spadrezano

Larissa Sabino dos Santos

Especial
agradecimento ao
CETR pela
cooperação ao
longo dos anos

ablugao@ipen.br
ablugao@gmail.com

IRaP2024

The Ionizing Radiation and Polymers Symposium

October 28th to November 01st
Rafain Palace Hotel
Foz do Iguaçu | PR | Brazil

Welcome ▾ Information ▾ Program ▾ Venue ▾ Registration Abstract Sponsors Important Contact
Submission Dates



Organized by CNEA- Argentina and CNEN-Brazil



www.irap2024.org