SANIFICAZIONE: POTENZIALI INNOVAZIONI PER IL CONTROLLO DELLE INFEZIONI

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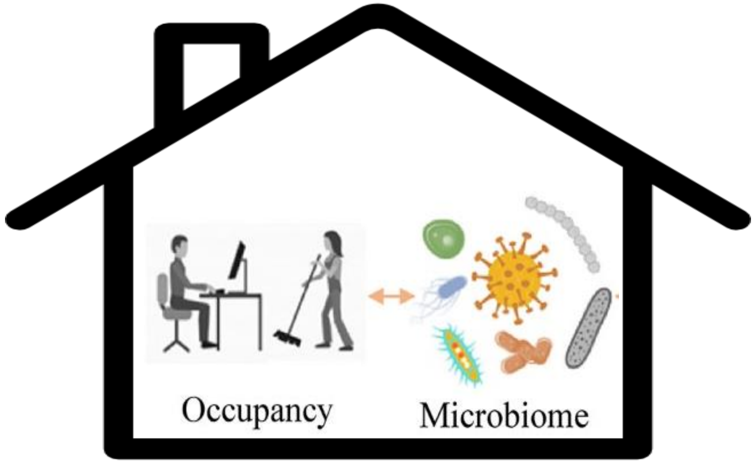
The «BE» microbiome

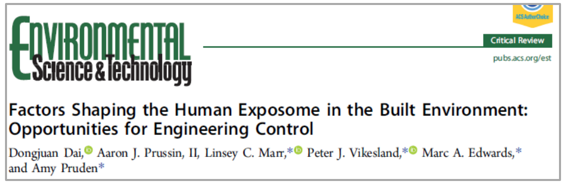
Built Environments (BE) are considered **SUPER-ORGANISMS** similar to living organisms, since they acquire a specific MICROBIOME mostly derived from human occupants.

Most confined and controlled BEs microbiomes have:

↓ **BIODIVERSITY** (anthropic contamination)

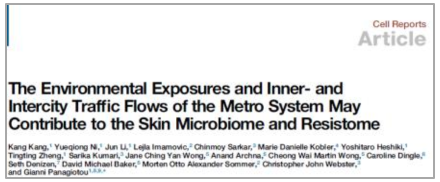
↑ **RESISTANCE-AMR** (critical value >3).




Environmental Science & Technology
Critical Review
pubs.acs.org/est

Factors Shaping the Human Exposome in the Built Environment: Opportunities for Engineering Control

Dongjuan Dai, Aaron J. Prussin, II, Linsey C. Marr,* Peter J. Vikesland,* Marc A. Edwards,* and Amy Pruden*


Cell Reports
Article

The Environmental Exposures and Inner- and Intercity Traffic Flows of the Metro System May Contribute to the Skin Microbiome and Resistome

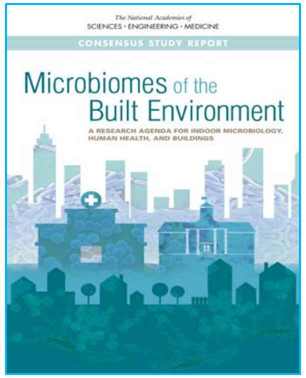
Kang Kang,[1] Yueqiong Ni,[1] Jun Li,[1] Lejla Imamovic,[2] Chinmoy Sarkar,[3] Marie Danielle Kobler,[4] Yoshitaro Heshiki,[1] Tingting Zheng,[1] Sarika Kumari,[3] Jane Ching Yan Wong,[5] Anand Archna,[5] Cheong Wai Martin Wong,[5] Caroline Dingle,[6] Seth Denizen,[7] David Michael Baker,[5] Morten Otto Alexander Sommer,[2] Christopher John Webster,[3] and Gianni Panagiotou[1,8,9,*]

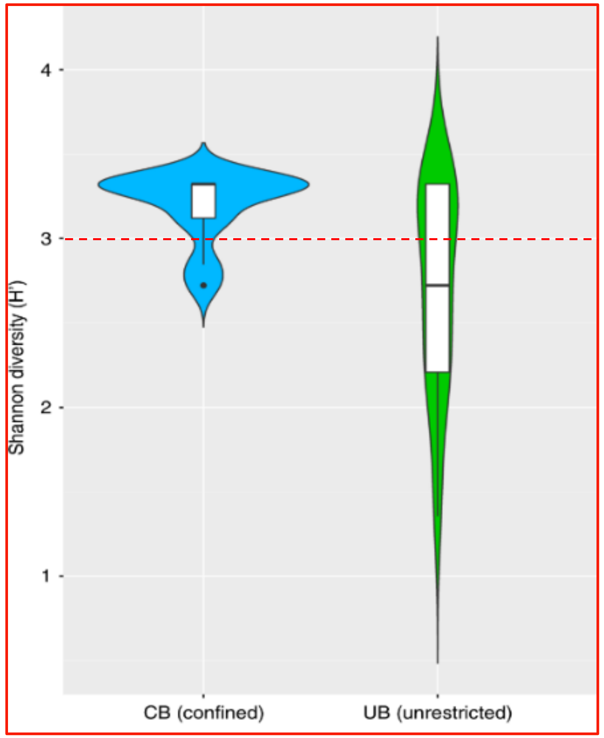

nature COMMUNICATIONS

ARTICLE
https://doi.org/10.1038/s41467-019-08864-0 OPEN

Man-made microbial resistances in built environments

Alexander Mahnert[1], Christine Moissl-Eichinger[2,3], Markus Zojer[4], David Bogumil[5], Itzhak Mizrahi[5], Thomas Rattei[4], José Luis Martinez[6] & Gabriele Berg[1,3]

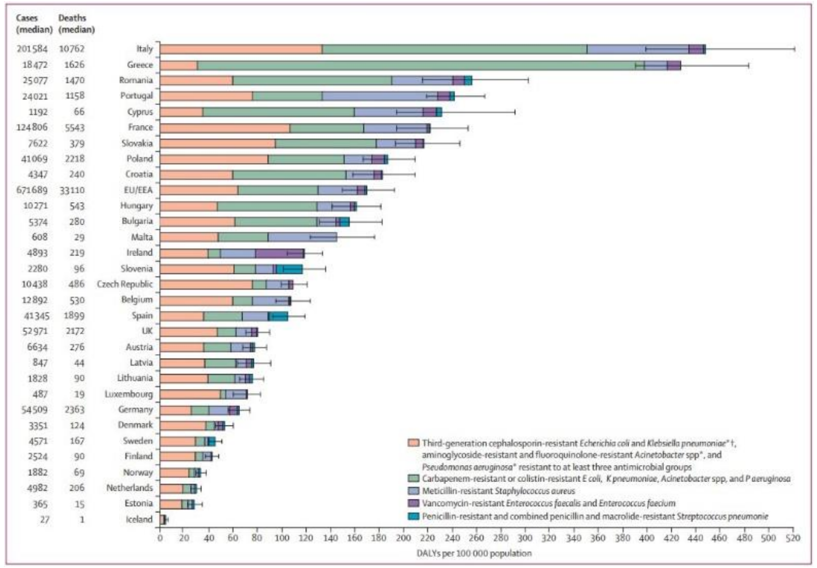


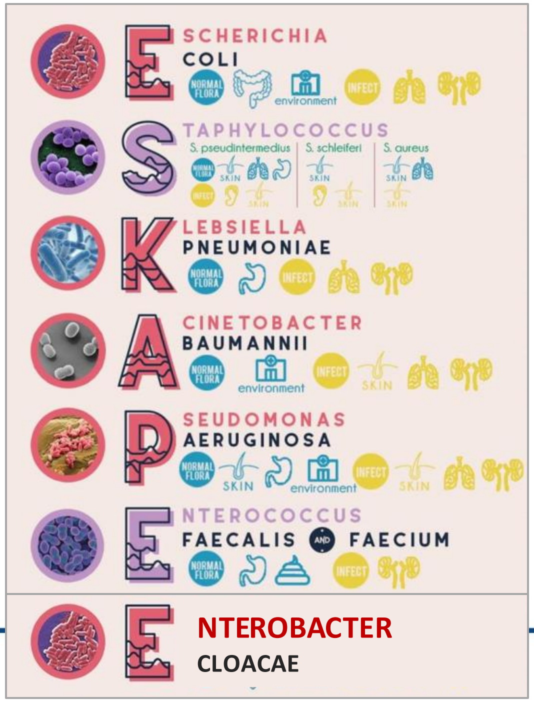


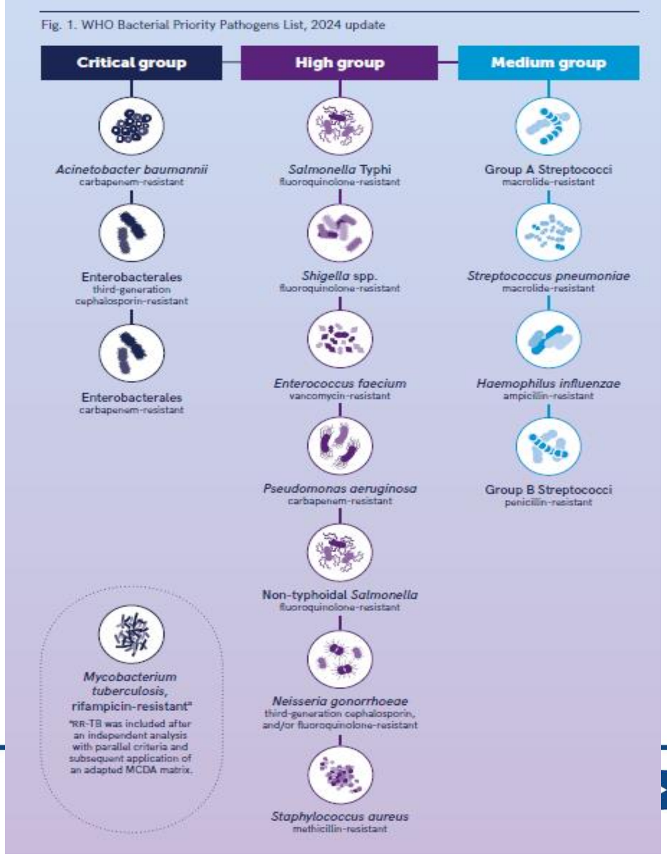
World Health Organization

HOSPITAL microbiome

H-microbiome = **RESERVOIR of human pathogens with AMR**, responsible for **HAI onset**: global concern (5-15% patients), >4 millions patients/year in EU, ≈37,000 deaths/year (10,000 in Italy), >1.1 billions € costs (ECDC)

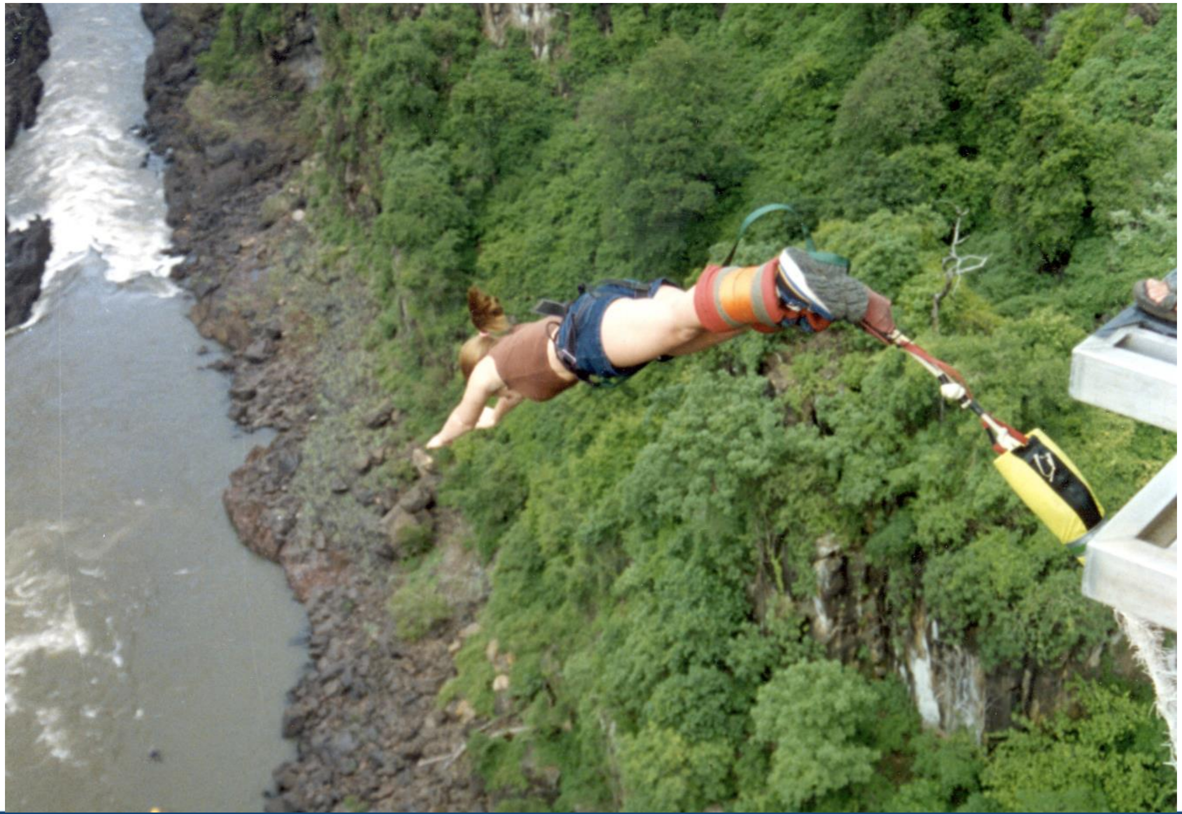




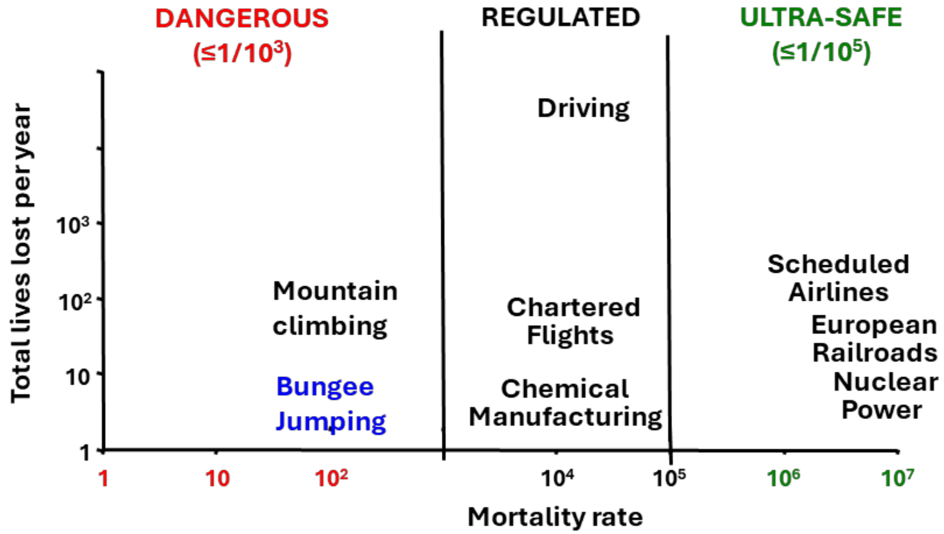


HAI-associated pathogens are MDR (**WHO**):
→ **ESKAPE**(E)
→ **PPL**
(ex DIRTY DOZEN)

HAI in EU = 70% of all infections caused by MDR bacteria



ACTIVITY	MORTALITY RATE
Bungee jumping	**1/100**
Mountain climbing	1/300
Healthcare (hospital)	**1/500**
Car driving	1/20.000
Scheduled airlines	1/8.000.000
EU railways	1/10.000.000



Harvey Murff, 2003

How to control bioburden? CONVENTIONAL DISINFECTION

1. **Temporary action**: inactive within 0.5-2 h
2. **Environmental impact**: increase hearth and water pollution
3. **AMR selection**: AMR increased during COVID19 → risk for future AMR pandemics (WHO)?

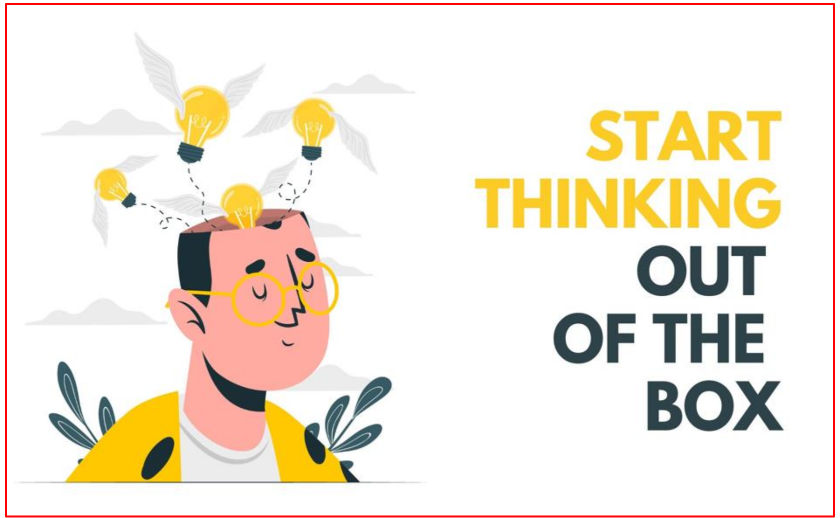
International Journal of Antimicrobial Agents 57 (2021) 106324
Contents lists available at ScienceDirect
International Journal of Antimicrobial Agents
journal homepage: www.elsevier.com/locate/ijantimicag
Increased antimicrobial resistance during the COVID-19 pandemic
Chih-Cheng Lai[a], Shey-Ying Chen[b,c], Wen-Chien Ko[d], Po-Ren Hsueh[e,f,*]

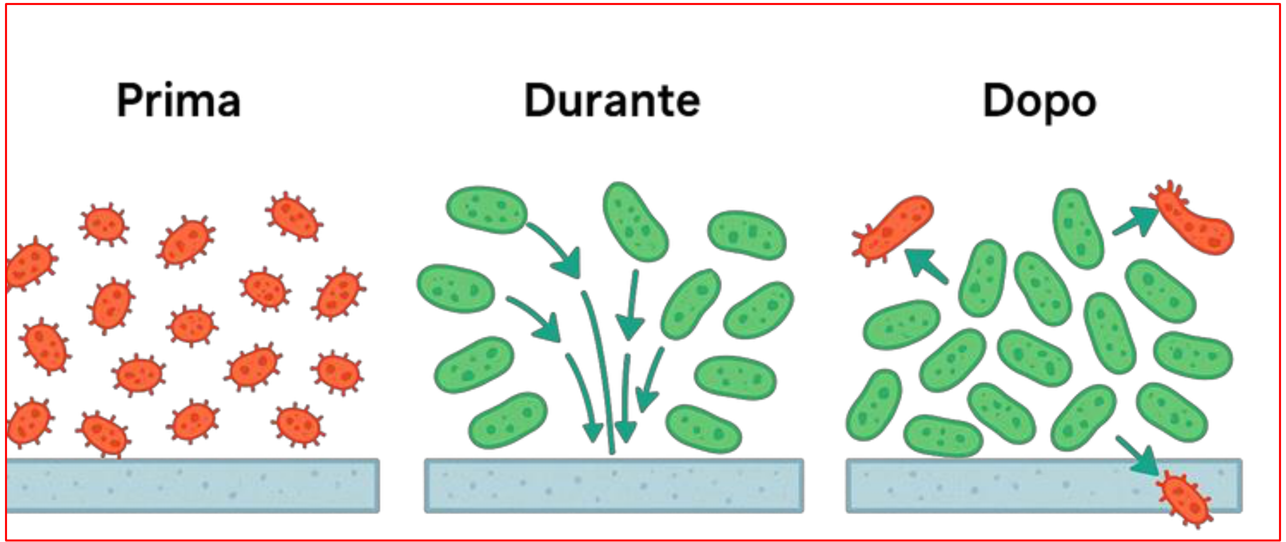
Editorials
Tackling antimicrobial resistance in the COVID-19 pandemic
Haileyesus Getahun,[a] Ingrid Smith,[a] Kavita Trivedi,[a] Sarah Paulin[a] & Hanan H Balkhy[b]

ANTIMICROBIAL RESISTANCE, FUELED BY THE COVID-19 PANDEMIC
Policy Brief
November 2021
PAHO · Food and Agriculture Organization of the United Nations · OIE World Organisation for Animal Health · European Union

JAC Antimicrob Resist
doi:10.1093/jacamr/dlaa049
JAC-Antimicrobial Resistance
PRO: The COVID-19 pandemic will result in increased antimicrobial resistance rates
Cornelius J. Clancy[1,2*], Deanna J. Buehrle[2] and M. Hong Nguyen[1]

Need to control bioburden without impacting on environment and AMR





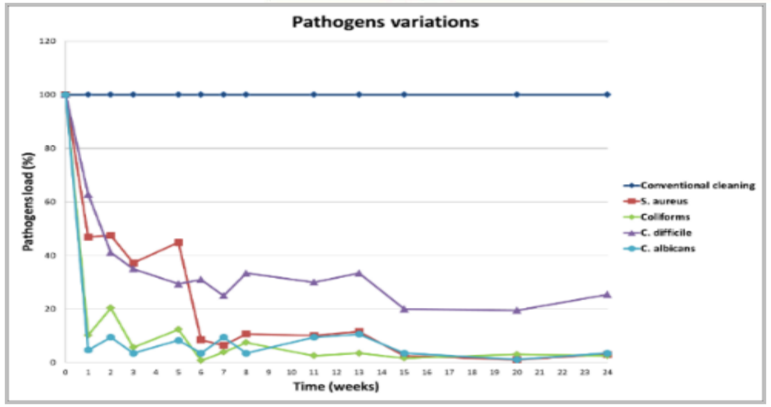
In a MICROBIOME perspective:
SUPER-SANITATION is detrimental in living organisms: decreasing microbiome biodiversity increases the risk of infection. What if we use GOOD MICROBES to REPLACE bad ones? (*COMPETITIVE EXCLUSION*)

PCHS ® *(Probiotic Cleaning Hygiene System)*

Eco-labeled DETERGENT containing SPORES of selected *Bacillus* probiotics: non pathogenic (EFSA-1), ubiquitous, used safely for decades; capable to remove dirt and replace pathogens.

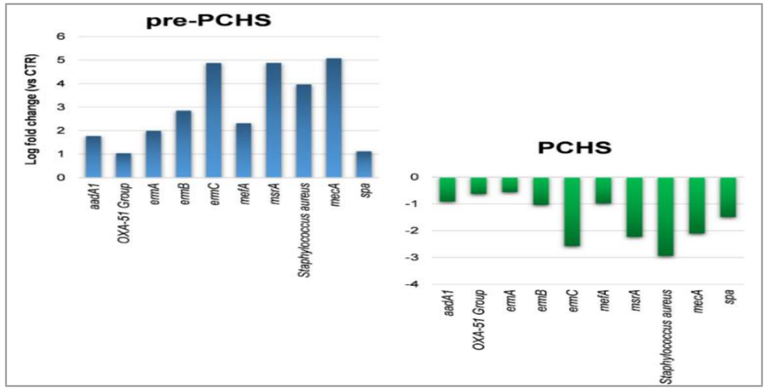
RESULTS

BIOBURDEN



STABLE decrease of ESKAPE pathogens >80% more than disinfectants (sampling after 7 h)

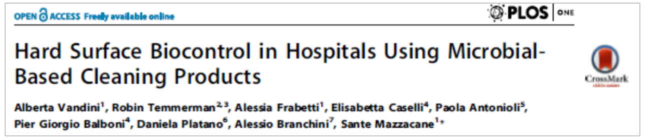
AMR



No AMR selection
-99.9% ARGs

SAFETY

NO infectious risk (>90,000 patients in 15 years)
NO changes resistome/virulome (>15 years; WGS, in collaboration with Oxford University)


OPEN ACCESS Freely available online PLOS ONE

Hard Surface Biocontrol in Hospitals Using Microbial-Based Cleaning Products

Alberta Vandini[1], Robin Temmerman[2,3], Alessia Frabetti[1], Elisabetta Caselli[4], Paola Antonioli[5], Pier Giorgio Balboni[4], Daniela Platano[6], Alessio Branchini[7], Sante Mazzacane[1]*


microbial biotechnology Open Access

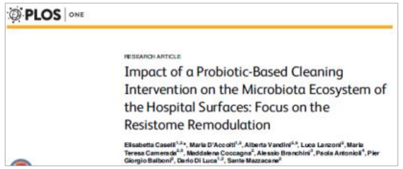
Hygiene: microbial strategies to reduce pathogens and drug resistance in clinical settings

Elisabetta Caselli*


Adv Exp Med Biol - Advances in Microbiology, Infectious Diseases and Public Health
https://doi.org/10.1007/5584_2019_399
© Springer Nature Switzerland AG 2019

An Innovative Strategy for the Effective Reduction of MDR Pathogens from the Nosocomial Environment

Elisabetta Caselli, Maria D'Accolti, Irene Soffritti, Luca Lanzoni, Matteo Bisi, Antonella Volta, Filippo Berloco, and Sante Mazzacane


PLOS ONE

RESEARCH ARTICLE

Impact of a Probiotic-Based Cleaning Intervention on the Microbiota Ecosystem of the Hospital Surfaces: Focus on the Resistome Remodulation

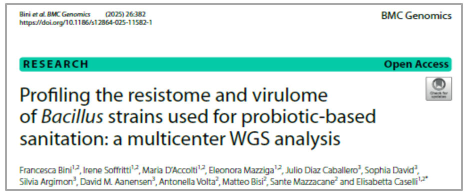

Journal of Hospital Infection 94 (2016) 193–208

Journal of Hospital Infection

Letters to the Editor

Safety of probiotics used for hospital environmental sanitation

E. Caselli, P. Antonioli, S. Mazzacane


BMC Genomics

RESEARCH Open Access

Profiling the resistome and virulome of *Bacillus* strains used for probiotic-based sanitation: a multicenter WGS analysis

HAIs

-52% HAI incidence (11461 patients):
- Pre-PCHS 4.8% (284/5930)
- PCHS 2.3% (128/5531); OR 0.47

- 55.5 % Incidence per 1000 hospital days:
- Pre-PCHS 5.4% (314/57742)
- PCHS 2.4% (141/48201); OR 0.45

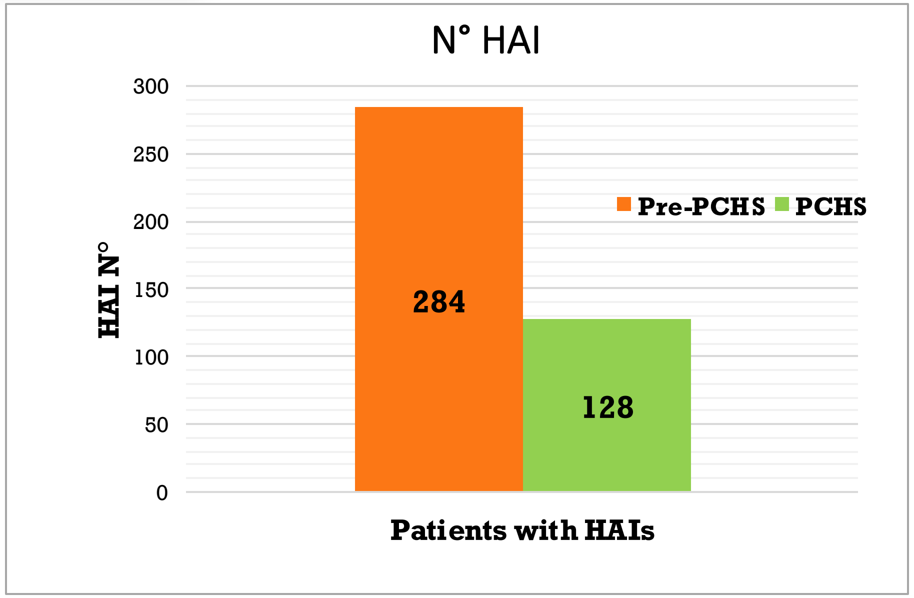


Table 5. Risk factors associated with HAI onset in patients of I_1-I_2 hospitals: Multivariable model*.

Population characteristics	P	OR	95% CI
Male	0.01812	0.78	0.63–0.96
Age 65–74 *vs* Age <65	0.0047	1.71	1.18–2.48
Age 75–84 *vs* Age <65	0.0004	1.88	1.33–2.67
Age 85 or more *vs* Age <65	0.0026	1.78	1.22–2.58
Length of stay	p<0.0001	1.08	1.07–1.09
Incontinence	0.2253	0.85	0.66–1.10
Disorientation	0.0226	1.37	1.05–1.76
Self-sufficiency	0.5600	0.92	0.69–1.43
Pressure sores	0.9757	0.99	0.69–1.44
Ventilation	0.7702	1.07	0.68–1.67
ATB 2 week before	0.8479	0.97	0.68–1.37
MDRO at admission	0.6230	0.86	0.47–1.57
Urinary catheter (any type)	p<0.0001	2.68	2.10–3.41
CVC	0.0001	1.99	1.40–2.82
PCHS	p<0.0001	0.44	0.35–0.54

Table 3 Drug consumption and therapy days during pre-PCHS and PCHS phases of the survey

Drug types	Molecules (n)		Therapy days (n)	
	Pre-PCHS	PCHS	Pre-PCHS	PCHS
β-Lactams*	126	75 (−40.5%)	1,140	711 (−37.6%)
Fluoroquinolones	111	20 (−82%)	723	102 (−85.9%)
Glycopeptides	43	18 (−58.1%)	442	178 (−59.7%)
Cephalosporins	43	22 (−48.8%)	354	136 (−61.6%)
Antifungals	31	6 (−80.6%)	287	41 (−85.7%)
Acid antibiotics	11	1 (−90.9%)	68	2 (−97.1%)
Polymixins	7	3 (−57.1%)	85	56 (−34.1%)
Sulfamides	6	1 (−83.3%)	43	9 (−79.1%)
Aminoglycosides	5	2 (−60.0%)	39	27 (−30.8%)
Others	16	9 (−43.7%)	112	98 (−12.5%)
Total	403	160 (−60.3%)	3,339	1,382 (−58.6%)

Note: *With or without β-lactamase inhibitors.

-60% antibiotic consumption
-75% HAI costs

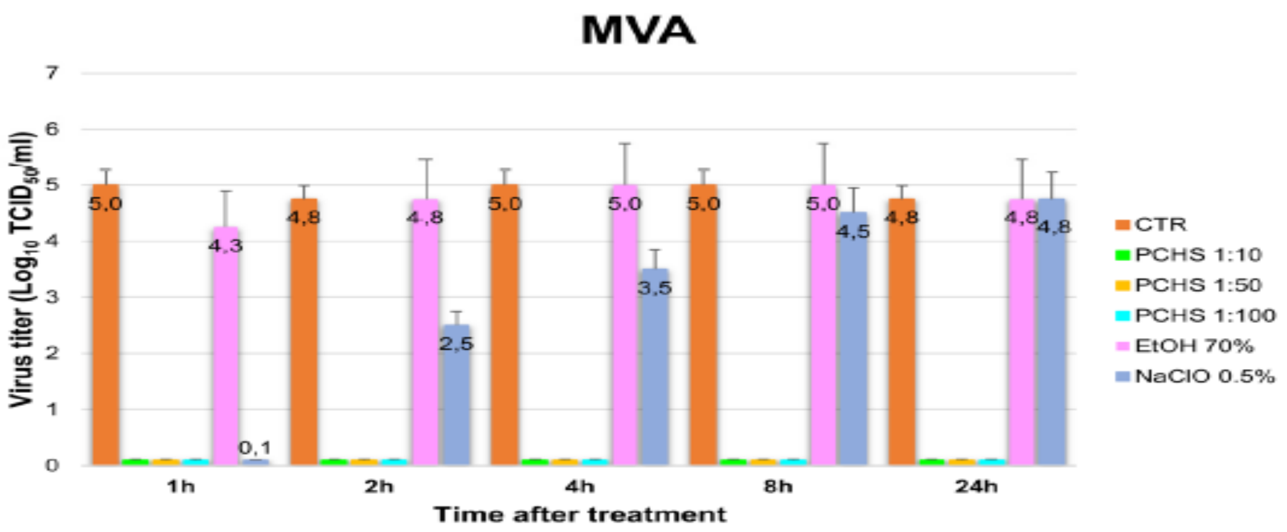
COST-CUTTING PERSPECTIVE
(model by Bocconi University)
Use of PCHS in 5 years may prevent about 31,000 HAIs and save at least 14 million €, of which 11.6 for treatment of resistant HAIs.

pathogens MDPI

Article
A Probiotic-Based Sanitation System for the Reduction of Healthcare Associated Infections and Antimicrobial Resistances: A Budget Impact Analysis

Rosanna Tarricone [1,2], Carla Rognoni [1,*], Luca Arnoldo [3], Sante Mazzacane [4] and Elisabetta Caselli [4,5]

VIRUS



ALL enveloped viruses
INACTIVATED >-90% in 1h
PREVENTION TILL 24h
ETHANOL inactive in 30'
CHLORINE inactive in 2h

viruses MDPI

Article

Potential of an Eco-Sustainable Probiotic-Cleaning Formulation in Reducing Infectivity of Enveloped Viruses

Maria D'Accolti [1,2], Irene Soffritti [1,2], Francesco Bonfante [3], Walter Ricciardi [4], Sante Mazzacane[2] and Elisabetta Caselli [1,2,*]

NO SARS-CoV-2
During COVID19 pandemics in treated ERs

Infection and Drug Resistance — Dovepress

RAPID COMMUNICATION

Introduction of Probiotic-Based Sanitation in the Emergency Ward of a Children's Hospital During the COVID-19 Pandemic

Irene Soffritti[1,2], Maria D'Accolti[1,2], Carolina Cason[3], Luca Lanzoni[2], Matteo Bisi[2], Antonella Volta[2], Giuseppina Campisciano[3], Sante Mazzacane[2], Francesca Bini[1,2], Eleonora Mazziga[1], Paola Toscani[4], Elisabetta Caselli[1,2,*], Manola Comar[3,5,*]

PBS *vs.* disinfection: other main ou...

Product/ Strain	Study type	Setting/target	Prima...	References
PCHS	In vitro and in situ	Non-ICU ward; monocenter (Italy)	- In vitro: up to ... ...ction ... ...athogens	La Fauci et al, 2015
PBS[1]	In situ	Non-ICU ward; monocenter (R...	..., Enterobacteriaceae, and ...ococcus spp.	Afinogenova et al, 2017
PBS[2]	In situ	Non-ICU w...	...se of Staphylococcus spp. (**73.5%**), Gram-negative rods (**57.4%**)	Al-Marzooq et al, 2018
PBS[3]	In situ		- **Modulation of hospital microbiome** - **Significant reduction of ARGs**	Klassert et al, 2022
PBS[4]		...; ...outh Africa)	- **Significant reduction of HAIs -55.89%**	Kleintjes et al, 2020
		...on-ICU wards; monocenter (Germany)	- **No significant** differences of HAI prevalence (≈2% incidence)	Leistner et al, 2023

... (*B. subtilis, pumilus, megaterium*); **PBS[1]** (*B. subtilis, pumilus, licheniformis*); **PBS[2]** (*B. subtilis*); **PBS[3]** (*B. subtilis, pumilus, megaterium, licheniformis, amyloliquefaciens*); **PBS[4]** (*B. subtilis, pumilus, megaterium*)

Based on these data, the **commission for Infection Prevention** of **R. Koch Institute** (Charite H, Berlin) **included PBS in the guidelines** for hospital sanitation, for its **stable effect** and **absence of AMR induction** (*DOI*: 10.1007/s00103-023-03770-9; Paragraph 6.3)

AT A GLANCE
Scientific Foresight: What if?

European Parliament

What if we could fight antibiotic resistance with probiotics?

Recent research suggests that the future combat against antimicrobial resistance (AMR) may involve probiotic-based approaches. Their use in our microbial ecosystems, including humans, animals and the healthcare environment, may provide a novel approach which deserves exploration.

EPRS | European Parliamentary Research Service
Author: Gianluca Quaglio with Sophie Millar, Scientific Foresight Unit (STOA)
PE 641.545 – April 2020

J PREV MED HYG 2022; 63 (SUPPL. 1): E1-E121 OPEN ACCESS

Valutazione di Health Technology Assessment del sistema di sanificazione biologico a base di probiotici del genere *Bacillus* (PCHS)

Health Technology Assessment of the Probiotic Cleaning Hygiene System (PCHS)

GIOVANNA ELISA CALABRÒ[1,2], ELISABETTA CASELLI[3], CARLA ROGNONI[4], PATRIZIA LAURENTI[1,5], UMBERTO MOSCATO[5,6], MARIA LUISA DI PIETRO[1], MARIA ROSARIA GUALANO[7], FIDELIA CASCINI[1], FLORIANA D'AMBROSIO[1], FABIO PATTAVINA[5], SARA VINCENTI[5], ADA MAIDA[1], ROSSELLA MANCINI[1], SILVIA MARTINELLI[1], CARLOTTA AMANTEA[6], VALERIO FLAVIO CORONA[1], ALESSANDRA DANIELE[6], ANDREA PALADINI[1], MARIA FRANCESCA ROSSI[6], EMANUELE LA GATTA[1], LUIGI PETRELLA[1], VALERIA PULEO[1], ROSANNA TARRICONE[4,8], WALTER RICCIARDI[1]
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Gebrayel *et al.*
Journal of Translational Medicine (2022) 20:111
https://doi.org/10.1186/s12967-022-03296-9
Journal of Translational Medicine

REVIEW Open Access

Microbiota medicine: towards clinical revolution

Prisca Gebrayel[1], Carole Nicco[2,3], Souhaila Al Khodor[4], Jaroslaw Bilinski[5], Elisabetta Caselli[6], Elena M. Comelli[7], Markus Egert[8], Cristina Giaroni[9], Tomasz M. Karpinski[10], Igor Loniewski[11], Agata Mulak[12], Julie Reygner[13], Paulina Samczuk[14], Matteo Serino[15], Mariusz Sikora[16], Annalisa Terranegra[4], Marcin Ufnal[5], Romain Villeger[17], Chantal Pichon[18], Peter Konturek[19] and Marvin Edeas[2,3*]

Denkel *et al. Antimicrobial Resistance & Infection Control* (2024) 13:119
https://doi.org/10.1186/s13756-024-01474-6
Antimicrobial Resistance & Infection Control

REVIEW Open Access

Can probiotics trigger a paradigm shift for cleaning healthcare environments? A narrative review

Luisa A. Denkel[1,2*], Andreas Voss[3], Elisabetta Caselli[4], Stephanie J. Dancer[5], Rasmus Leistner[1,2,6], Petra Gastmeier[1,2] and Andreas F. Widmer[7,8]

Microbial Biotechnology
WILEY
MICROBIAL BIOTECHNOLOGY

EDITORIAL OPEN ACCESS

Microbes Saving Lives and Reducing Suffering

Kenneth Timmis[1] | Zeynep Ceren Karahan[2] | Juan Luis Ramos[3] | Omry Koren[4] | Ana Elena Pérez-Cobas[5,6] | Karen Steward[7] | Victor de Lorenzo[8] | Elisabetta Caselli[9] | Margaret Douglas[10] | Clarissa Schwab[11] | Virginia Rivero[12] | Rafael Giraldo[13] | Junkal Garmendia[14,15] | Raymond J. Turner[16] | Jessamyn Perlmutter[17] | José M. Borrero de Acuña[18] | Pablo Ivan Nikel[19] | Jerome Bonnet[20] | Angela Sessitsch[21] | James K. Timmis[22,23] | Carla Pruzzo[24] | M. Auxiliadora Prieto[12] | Siavash Isazadeh[25] | Wei E. Huang[26] | Gerard Clarke[27,28] | Danilo Ercolini[29] | Max Häggblom[30]

Correspondence: Kenneth Timmis (kntimmis@gmail.com)

Received: 18 November 2024 | **Accepted:** 25 November 2024

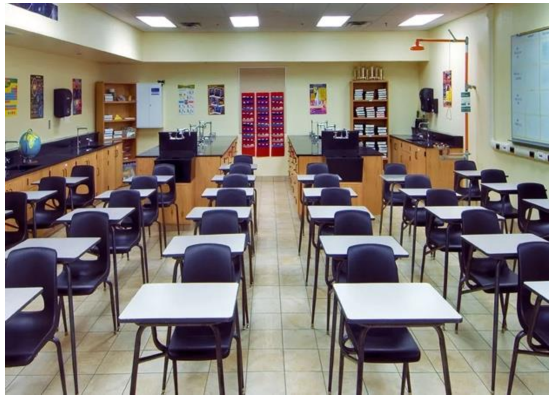
Further uses in a "One Health" perspective

-100% pathogens surface/air
-99% AMR
-70% SARS-CoV-2
ATM Milano (COVID19)

D'Accolti et al. Microbiome (2023) 11:64
https://doi.org/10.1186/s40168-023-01512-2
Microbiome
RESEARCH Open Access

Shaping the subway microbiome through probiotic-based sanitation during the COVID-19 emergency: a pre–post case–control study

Maria D'Accolti[1,2], Irene Soffritti[1,2], Francesca Bini[1,2], Eleonora Mazziga[1,2], Carolina Cason[3], Manola Comar[3,4], Antonella Volta[2], Matteo Bisi[2], Daniele Fumagalli[5], Sante Mazzacane[2] and Elisabetta Caselli[1,2*]



-90% pathogens surface/air
SCHOOLS (Ferrara)

microorganisms
MDPI
Article

A Sustainable Combined Approach to Control the Microbial Bioburden in the School Environment

Maria D'Accolti[1,2,*,†], Irene Soffritti[1,2,†], Eleonora Mazziga[1,2], Francesca Bini[1,2], Matteo Bisi[2], Antonella Volta[2], Sante Mazzacane[2] and Elisabetta Caselli[1,2,*]

-90% target bacteria in chicken farms (MDR *Salmonella spp.*)
(PCHS + phages)

Poultry Science
Volume 98, Issue 9, 1 September 2019, Pages 3602-3610
Management and Production

Impact of a probiotic-based cleaning product on the microbiological profile of broiler litters and chicken caeca microbiota

Alessandra De Cesare *, Elisabetta Caselli †, Alex Lucchi *, Claudia Sala ‡, Antonio Parisi §, Gerardo Manfreda *, Santo Mazzacane #

104 (2025) 105595
Contents lists available at ScienceDirect
Poultry Science
journal homepage: www.elsevier.com/locate/psj
ELSEVIER

Harnessing probiotics and bacteriophages to fight *Salmonella* and limit the use of antibiotics in broilers: a study in commercial conditions☆

Irene Soffritti[a,1], Maria D'Accolti[a,1], Francesca Bini[a], Eleonora Mazziga[a], Antonella Volta[b], Matteo Bisi[b], Sante Mazzacane[b], Alessandra De Cesare[c], Valentina Indio[c], Gerardo Manfreda[d], Elisabetta Caselli[a,b,*]

-90% decrease of fungal phytopathogens (in vitro)

Manuscript in preparation

- **PCHS = versatile system** potentially able to establish **microbiome balance, stable decrease** of pathogens, **AMR**, and associated **infections**.
- Being **sustainable** both economically and ecololgically, PCHS may significantly contribute achieving **«One Health» PNCAR goals**.

Gemelli – Fondazione Policlinico Universitario A. Gemelli, Università Cattolica del Sacro Cuore
ULSS 2 Feltre
ATM – Azienda Trasporti Milanesi S.p.A.
Università di Messina
Quisisana – Ospedale Privato Accreditato
IMPRS for Infectious Diseases and Immunology – International Max Planck Research School
Università degli Studi di Udine – hic sunt futura
Regione Puglia – Ospedali Riuniti – Azienda Ospedaliero-Universitaria Foggia
Azienda per l'assistenza sanitaria n.3 Regione Friuli Venezia Giulia – Ospedale di Tolmezzo
Università di Pavia
Servizio Sanitario Regionale Emilia-Romagna – Azienda Ospedaliero-Universitaria di Ferrara
University of Oxford
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Regione Autonoma Friuli Venezia Giulia – Istituto di ricovero e cura a carattere scientifico Burlo Garofolo di Trieste
Wellcome Sanger Institute

"The electric light did not come from the continuous improvement of candles"
(Oren Harari)