Hygiene in healthcare settings.
A contribution from microbial-based systems for infection and antimicrobial resistance (AMR) control

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BE can be considered as **SUPER-ORGANISMS**, with their own microbiome, similarly to what recognized for the human body.

**BE-µBIOME** (built-environments microbiome)

More confined environments have more «anthropic» microbiomes.

More confined environments have less biodiversity and more drug-resistance (critical value >3)
Healthcare associated infection (HAI) are a global concern (5-15% patients): 
~ 4 millions patients in EU per year, > 33,000 deaths per year, > 1.1 billions € sanitary costs.

Major causes:
- **Persistent microbial contamination** on hospital surfaces
- **Drug resistance (AMR):** most of HAI-associated pathogens are MDR or even panDR

**WHO «dirty dozen»**

<table>
<thead>
<tr>
<th>Priority 1: CRITICAL</th>
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<tbody>
<tr>
<td>Acinetobacter baumannii, carbapenem-resistant</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa, carbapenem-resistant</td>
</tr>
<tr>
<td>Enterococcus faecalis, carbapenem-resistant, 3rd generation oxazolidinone-resistant</td>
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<table>
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<tr>
<th>Priority 2: HIGH</th>
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<tbody>
<tr>
<td>Klebsiella pneumoniae, carbapenem-resistant</td>
</tr>
<tr>
<td>Staphylococcus aureus, methicillin-resistant, vancomycin intermediate and resistant</td>
</tr>
<tr>
<td>Haemophilus influenzae, extended-spectrum cephalosporin-resistant</td>
</tr>
<tr>
<td>Carbenapenemase, fluoroquinolone-resistant</td>
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<tr>
<td>Stenotrophomonas maltophilia, 3rd generation cephalosporin-resistant, fluoroquinolone-resistant</td>
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<tr>
<th>Priority 3: MEDIUM</th>
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<tbody>
<tr>
<td>Staphylococcus pneumoniae, penicillin-resistant</td>
</tr>
<tr>
<td>Haemophilus influenzae, amoxicillin-resistant</td>
</tr>
<tr>
<td>Staphylococcus epidermidis, fluoroquinolone-resistant</td>
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</tbody>
</table>

**<ESKAPE> group**

- **ESBL**
- **MRSA**
- **KPC**
- **MDR**
- **VRE**
- **Carbapenemase producer**

World Health Organization

HOSPITAL MICROBIOME & HAI/AMR CONCERN
CONTROL OF CONTAMINATION

PCHS® (Probiotic Cleaning Hygiene System)

So far, addressed by conventional chemical-based sanitation (chlorine, disinfectants):

- cannot prevent recontamination
- high environmental impact
- can favour selection of resistance (several «cross-resistances» reported: chlorexidin induction of ColR in KPC; triclosan and chinolones; etc...)

- the current high use of disinfectants/antibiotics due to the COVID-19 pandemics might induce a further worsening of AMR concern

New methods:

- Effective in STABLE abatement of contamination
- Devoid of «side effects» (AMR, environmental impact)

Biological sanitation-MICROBIOMA BALANCE
rather than eliminating ALL microbes, it can be more effective to REPLACE bad microbes with good ones: COMPETITIVE EXCLUSION
1. **STABLE ABATEMENT** of pathogens on surfaces (in vitro and on field)

**PCHS RESULTS**

2. **NO AMR selection**

3. **SAFETY of use**

**Genetic stability**: no genetic modifications in ~10 years (molecular analysis)

**No infectious risk**: no infections in hospitalized patients in ~10 years analysis; no *Bacillus* presence in biological samples from patients
HAIs

- Multicentre
- Pre-post
- 18 months
- Internal Medicine

**Simultaneous and continuous analysis of:**
1. Surface bioburden (>32,000 environmental samples)
2. HAI incidence (>12,000 patients)

**GLOBAL REDUCTION:** -52.1%

- n° HAI/tot patients: 314/5930 vs 141/5531

**HAI incidence**/1000 patients days:

- 5.4 vs 2.4

**OR = 0.44** (95% CI 0.35-0.54; p<0.0001) halved risk
Table 3 Drug consumption and therapy days during pre-PCHS and PCHS phases of the survey

<table>
<thead>
<tr>
<th>Drug types</th>
<th>Molecules (n)</th>
<th>Therapy days (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-PCHS</td>
<td>PCHS</td>
</tr>
<tr>
<td>Lactams</td>
<td>126</td>
<td>75 (-40.5%)</td>
</tr>
<tr>
<td>Fluoroquinolones</td>
<td>111</td>
<td>20 (-62.2%)</td>
</tr>
<tr>
<td>Glycopeptides</td>
<td>43</td>
<td>18 (-58.1%)</td>
</tr>
<tr>
<td>Cephalosporins</td>
<td>43</td>
<td>22 (-40.9%)</td>
</tr>
<tr>
<td>Antifungals</td>
<td>31</td>
<td>6 (-80.9%)</td>
</tr>
<tr>
<td>Acid antibiotics</td>
<td>13</td>
<td>1 (-90.9%)</td>
</tr>
<tr>
<td>Polymyxins</td>
<td>7</td>
<td>3 (-57.1%)</td>
</tr>
<tr>
<td>Sulfamidines</td>
<td>6</td>
<td>1 (-83.3%)</td>
</tr>
<tr>
<td>Aminoglycosides</td>
<td>5</td>
<td>2 (-60.0%)</td>
</tr>
<tr>
<td>Others</td>
<td>16</td>
<td>9 (-43.7%)</td>
</tr>
<tr>
<td>Total</td>
<td>403</td>
<td>160 (-60.1%)</td>
</tr>
</tbody>
</table>

Notes: *With or without β-lactamase inhibitors.

- **60%** HAI-associated antimicrobial drug consumption
- **75%** global reduction of HAI therapy costs

Impact of a probiotic-based hospital sanitation on antimicrobial resistance and HAI-associated antimicrobial consumption and costs: a multicenter study

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

**COST-CUTTING PERSPECTIVE**
CONCLUSIONS

It’s important to recognize hospital hygiene as part of the solution, with low costs and low/no environmental impact (fully ecolabelled)

STABLE REMODULATION of hospital microbiome is possible and can counteract AMR and decrease HAI incidence.

This could be especially important now, while we are managing the current pandemics, to avoid the possible risk of eventual future pandemics due to secondary bacterial AMR infections in patients.
...electric light did not come from the continuous improvement of candles

(Oren Harari)