

# Innovation for infection prevention & control Learning from Pasteur's vision

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**THE LANCET**

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# Who was Louis Pasteur?

- 1822: Born in Dole, only son of a poorly educated tanner
  - Rather **mediocre student** during his years of elementary education
- 1840-1842: BA degree Royal College in Besancon, and BSc
- 1843: Ecole Normale Superieure in Paris to study chemistry
- 1845-1849: Licencie es sciences, and docteur es sciences (PhD), Professor of **physics** and **Chemistry**
- 1854: Dean & Professor of Chemistry, Faculty of Sciences Lille
- **1875: Turn his attention to medicine**
- 1881: Académie Nationale des Sciences



# Louis Pasteur's discoveries

- Crystallography sediments fermenting wine: → **Alcoholic fermentation**
- Fermentation and Pasteurization
  - **Yeast responsible for forming alcohol** from sugar
  - Contaminating microorganisms → turned the fermentations sour
  - **High temperatures** kill the living microorganism → sterilize
- End of the Spontaneous Generation theory:
  - Skin of grapes source of the yeast, contamination with microorganisms from the air
- Silk Worms → awareness of **environmental factors** on contagion
  - **Germ Theory of Disease** and Vaccination
- Immunology and vaccinology:
  - Chicken Cholera, Anthrax, Rabies (vaccine)

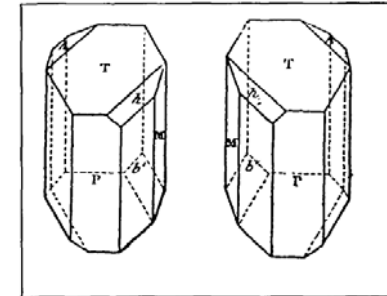


Figure 2. Pasteur's early work concentrated on optical properties of crystals

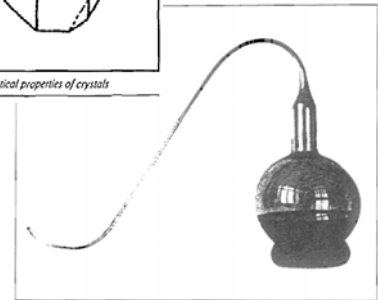
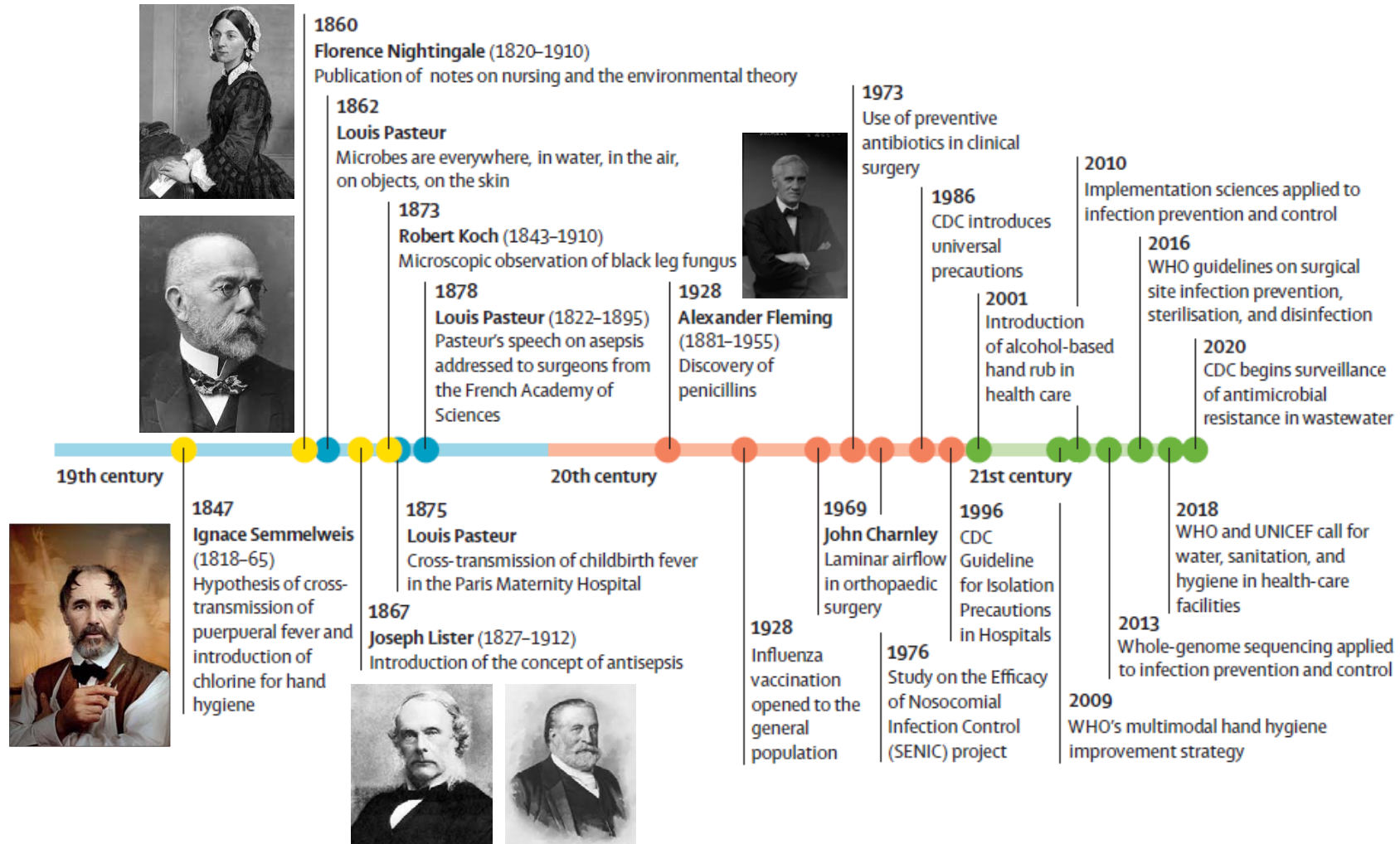


Figure 4. Pasteur used Swan-necked flasks to disprove the theory of spontaneous generation of bacteria



# From 1852, the essor of hygiene



# Pasteur's vision of the hospital as a reservoir of microorganisms

Microbes are **everywhere, in water, in the air, on objects**, and on the skin,  
and some of them are responsible for illnesses

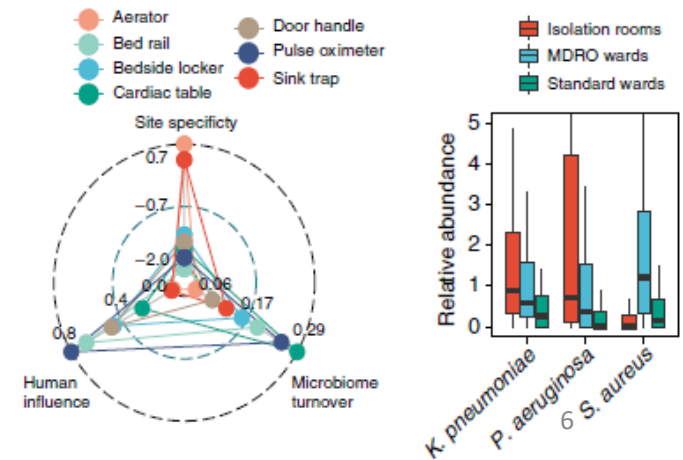
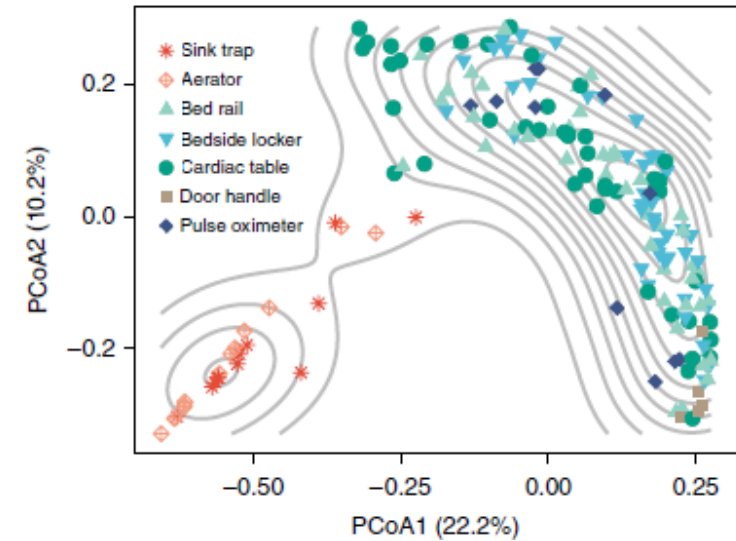
*“les poussières de l'atmosphère  
renferment des micro-  
organismes qui se développent  
et se multiplient”*



*“les liquides les plus putrescibles  
restent inaltérés, si après les avoir  
chauffés, on les laisse à l'abri de  
l'air, donc de ces micro  
organismes”*

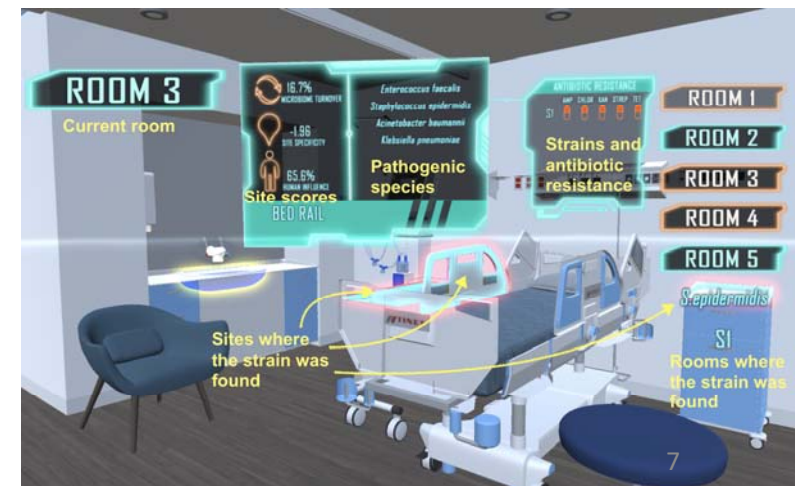
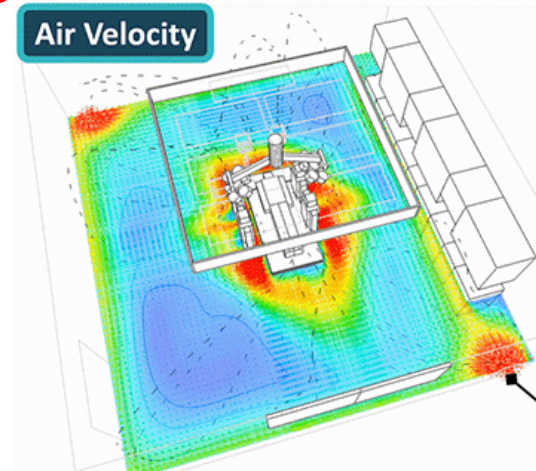
Germ transmission could result from a contaminated environment

- Hospital's infrastructure/architecture influence HAI
  - Single room designs, sink, ergonomics, temperature, humidity, and the indoor ventilation system
- Distinct ecological niches for opportunistic, nosocomial pathogens and ARGs
  - Microbes persist in hospitals for extended periods (>8 years), to opportunistically infect patients
  - Significant **uncharacterized diversity of microbes** and ARG combinations
  - Fertile ground for the **evolution of ARG** combinations
  - High prevalence of ARGs plasmids enabling gene transfer across species



## Some perspectives

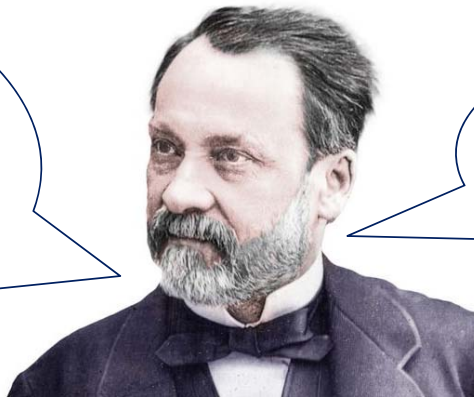
- Raise attention to hospital environments
  - Systematic metagenomics surveys → SMART-IPC
  - Simulation approaches to model efficacy of design and engineering solutions
- Overcome issues on environmental disinfection
  - Implementation science
    - Methods/strategies that facilitate uptake of best practices at organisational level
  - Innovative technologies as alternative strategy for environmental hygiene
    - Disinfectants, steam, automated dispersal systems, and antimicrobial surfaces



# Pasteur's vision of the hospital as an amplifier of transmission

- 1875: 64 fatalities caused by childbirth fever in the Paris Maternity Hospital

*“Il me vient cette idée **que le corps étranger** quand il amène le pus, ce qui n'est pas constant, **doit apporter un germe**, lequel germe serait cause de la formation de pus. »*



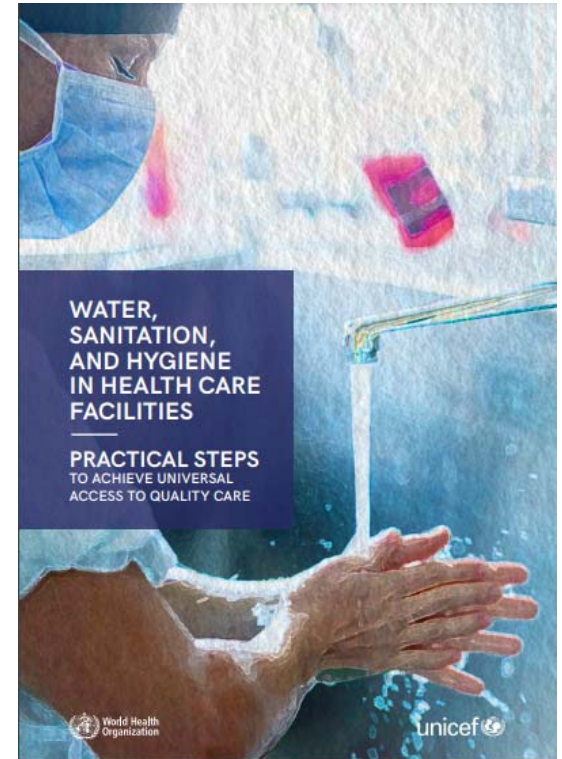
*“Au lieu de s'ingénier à tuer les microbes dans les plaies, ne serait-il pas **plus raisonnable de ne pas en introduire?**”*

- Strongly proposed infection being spread by physicians/attendants
  - Never mentioned that the hands could transmit the disease
  - Fanatic of hand hygiene, obsessive with hand-to-hand/hand-to-environment contact
- 1<sup>st</sup> shift on Hand hygiene: Semmelweis and Nightingale; 2<sup>nd</sup> shift: AHR

# Hospital as an amplifier of transmission

## Some perspectives

- Still few data regarding types of care resulting in transmission of patient flora to HCW' hands
- Adequate infrastructure: water, sanitation, hygiene (WASH)
  - Africa: 58% of health facilities with protected source of water, 22% with no sanitation services
- Enhance coordination of control measures across network of hospitals sharing patients
- Challenging global spread of emerging pathogens, ie MDR-E
  - Surveillance screening → Microbiological analysis of wastewater
  - Real-time WGS in hospitals → Smart IPC
  - Better predict risk through massive data analysis (AI)



# Aseptic technique and the origins of modern surgery

In 1878, Pasteur's speech addressed to surgeons from the French Academy of Sciences



# Aseptic technique and the origins of modern surgery

- At the same period in England, Joseph Lister
  - Putrefaction = same principles as fermentation
  - Concept of antiseptis: spray of carbolic acid
    - ↳ in-hospital death rate from 40% to 15%
- Concept of asepsis by Pasteur:
  - Prevent pathogens from entering the wound
- 1883: Octave Terrillon, French surgeon
  - Sterilised instruments and dressings by boiling or by dry heat autoclave

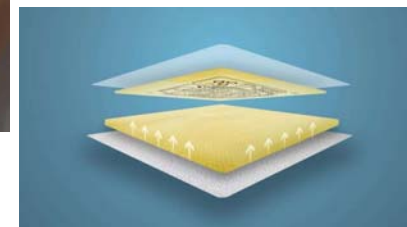
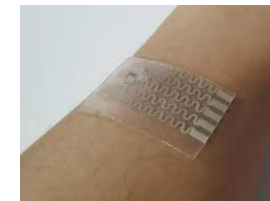
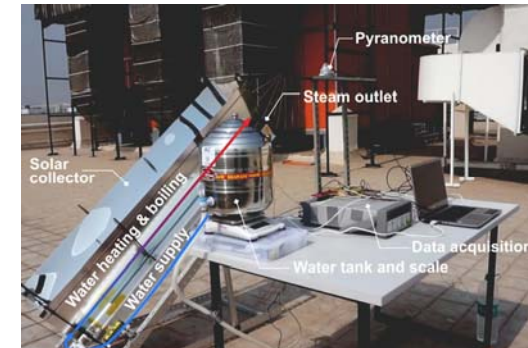


# Aseptic technique

## Some perspectives

- Remaining debates/controversies
  - Role of intraoperative environment (ventilations, devices, behaviours)
  - Skin prep/decolonization: effectiveness & collateral damages
  - Alternative concepts (ie, vaccination or immunotherapy)
- Innovative sterilisation methods
  - Sunlight heat: widespread solutions, sustainable
- Innovations in dressing types
  - Negative pressure wound therapy, silver/antiseptic dressings
  - Practical tools: ideal cost-effective dressing /type of wound
  - Smart wound dressings with sensors assessing the healing process

Sunlight sterilisation, MIT

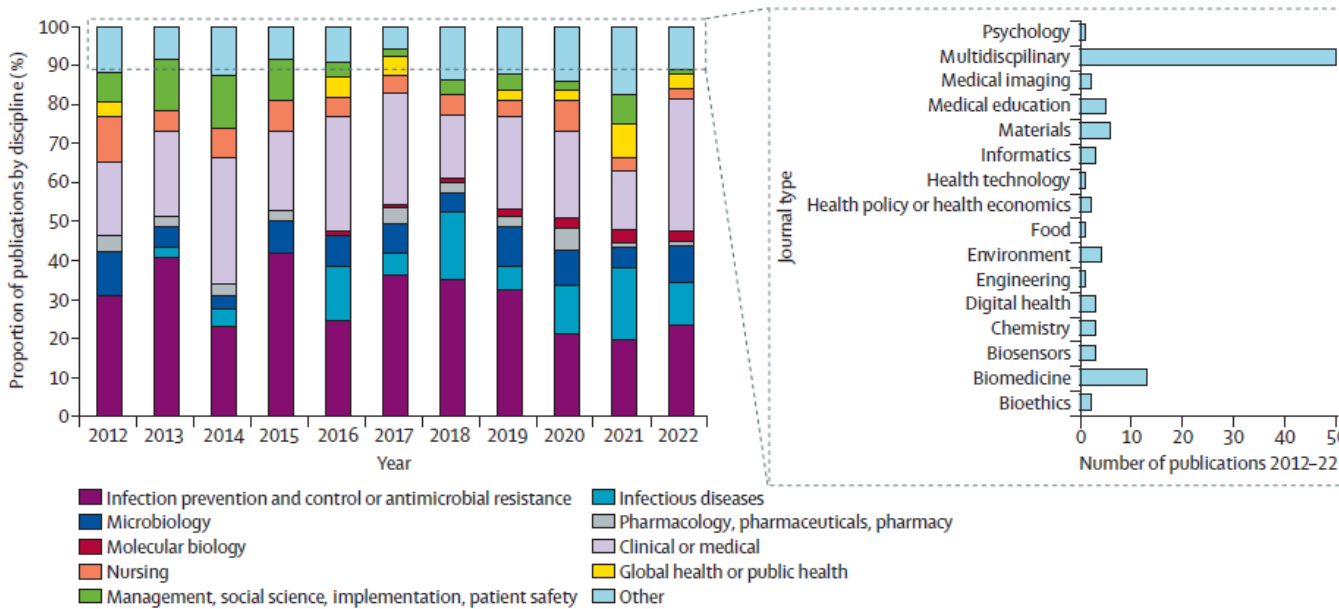


Smart dressings

Collaborative work, clinicians, scientists from physics, materials science, nanoengineering, stem cell biology to manufacture dressings that serve as physical, chemical, and antimicrobial barriers, and devices for growth-factor and cell delivery

# Multidisciplinary and cross-boundary working and leadership

Pasteur brought together engineering, chemistry, and medicine



- Cross-boundary translation of innovations to medicine
- Human factors in safety cultures of institutions and systems
  - Multimodal strategies, social sciences & roles of social norms behaviours in good IPC practices
  - Spread of Implementation sciences

- Learning between HIC and LMICs is still skewed towards high-income settings
- System level innovations for new technologies and processes
- Innovation for embedding and scaling up interventions that have a well-established evidence base

# Pasteur's vision of health-care settings as a platform to spread public health education

*“L’hôpital doit être le lieu de la formation publique sur l’hygiène, aidé en cela par les assistantes sociales et les infirmières visiteuses des dispensaires qui vont au-devant de l’humanité souffrante”*



- Pedagogical innovations
  - Virtual reality, simulation, arts-based approaches
- Education and self-efficacy of patients and citizens
  - Needs to explore cultural/contextual sensitivities to participation
- Determinants of suboptimal health literacy
  - Addressing misinformation/disinformation
- Integrative models
  - Hospitals + primary/secondary providers, local authorities
  - Holistic policy responses to complex causes/consequences of infections
- Interventions to arrest the emergence of infectious threats
  - Prosocial behaviours encouraged by social cohesion, greater equity in access, reduced inequalities in outcomes

# Vaccines as armoury to protect health services and patients

Indirect positive effect of Pasteur's discovery of vaccines

Vaccination to prevent risk to HCW/patients, keeps health-care functioning

- COVID-19: up to 77%  $\searrow$  emergency department visits among >75 years
- Influenza vaccination: cost-effective vs absenteeism, presenteeism, medical care
- Barriers: Vaccine hesitancy, resources of occupational health services

Vaccines, passive immunisation, monoclonal therapies to  $\searrow$  burden of HAIs

- Effective vaccines for *S aureus* or gram-negative bacteria challenging (endogenous)
- *C difficile* infections, seems to be near
- Antibody-based therapy: pathogen-specific antibacterial alternative to antibiotics

# Vaccines as armoury to protect health services and patients

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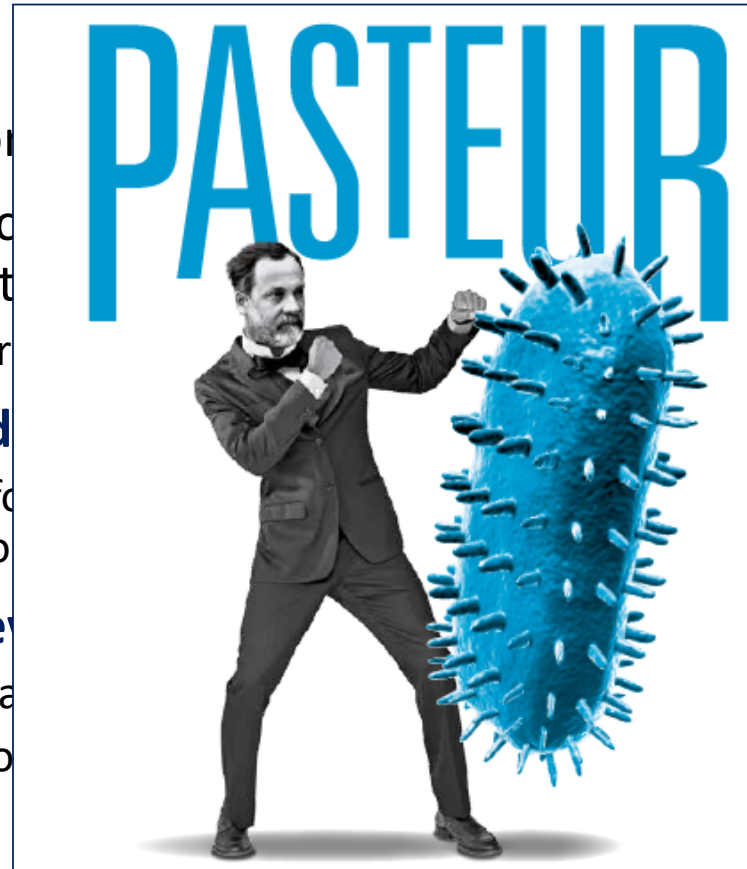


# Future challenges to infection control

- Current IPC probably prevents only **up to 55–70%** of all HAI
- Ageing populations, increasingly sicker, multiple comorbidities, therapies modifying immune system and personal microbiota
  - Outpatient and day-care procedures grow increasingly complex and invasive
- Requirement for **broad, collaborative, multidisciplinary efforts**, creative thinking
  - Informatics, engineer for electronic medical records, sensor badges, PPE, antisepsis, disinfection, sterilisation, and cleaning, microbiome
- **Precision infection prevention** might offer opportunities to tailor IPC measures
  - ML assessing multiple available data to prioritise IPC interventions
  - Virtual IPC platforms to assist rural / low resource settings → Real-time, expert consultation
  - One Health approach

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ons  
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“Permettez-moi de vous révéler le secret qui m’a conduit à atteindre mon but. Ma force repose uniquement sur ma ténacité



**EUCIC** EUROPEAN COMMITTEE ON  
INFECTION CONTROL

European Society of Clinical Microbiology and Infectious Diseases



**@EUCIC1**

Edit profile

**Thank you**

## **European Committee on Infection Control @ESCMID**

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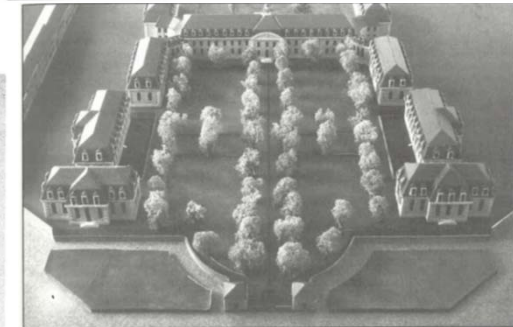
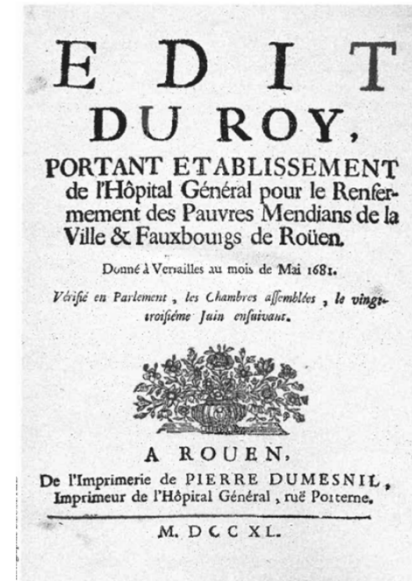
EUCIC @escmid aims to strengthen infection control and preventive measures in European countries to reduce the burden of healthcare-associated infections

# Evolution of Hygiene and IPC

- Middle age: Exemplar Hygiene of hospital
- 17-18th century: the decline of Hygiene
  - Large dormitories, poor and sick people with older people, children, and healthy alike
- From 1786: Start of modern hygiene
  - Architectural measures to improve air quality, but infections persisted and continued to kill
- 1852 - early 20<sup>th</sup> century: the essor of hygiene
  - Ignaz Semmelweis on hand hygiene,
  - 1850 to 1975: triumph of the laboratory medicine



VUE ACTUELLE DE L'HÔTEL-DIEU DE BEAUNE  
CONSTRUIT ENTRE 1443 ET 1451.



Plan en relief de l'hôpital maritime de Rochefort (1785).

