Evaluarea, filtrarea si decontaminarea aerului intraspitalicesc are impact semnificativ in scaderea infectiilor transmise prin aer

dr. Andi Radu AGROSOAIE

Introduction

A nosocomial infection — also called “hospital acquired infection” can be defined as:

An infection acquired in hospital by a patient who was admitted for a reason other than that infection.

Frequency :

- At any time, over 1.4 million people worldwide suffer from infectious complications acquired in hospital.
- Around 8.7% of hospital patients had nosocomial infections. (1/20 patients in USA)
- The highest frequencies of nosocomial infections were reported from hospitals in the **Eastern Mediterranean** and **South-East Asia Regions** (11.8 and 10.0% respectively) (1)

(1)Sources: WHO Report 2016

I. Nosocomial infections: Impacts

- **Direct economic costs:**
  - Hospital admissions,
  - Increased length of stay,
  - Patient mortality: one of the leading causes of death
  - Infection transmission to discharged patients, staff, and visitors.

- **Indirect economic costs** :
  - Lost work,
  - The increased use of drugs,
  - The need for isolation,
  - The use of additional laboratory & diagnostic studies,
  - Penalties and bad reputation.

*Direct medical cost of HAIs is around **$10 billion annually**.*
*Including cost-shifting, HAIs may cost closer to **between $35 billion and $45 billion** annually.*

The total direct, indirect and nonmedical social costs of HAIs
$96 billion to $147 billion annually
(including loss of work, legal costs and other patient factors)

*The duration of hospitalization for patients is **8.2 days**, ranging from:*

-3 days for gynaecology
-9.9 for general surgery
-19.8 for orthopaedic surgery.

In 2015, HAI costs a 300-bed hospital $1.3 million annually.
($ 3 560 per day)*

Sources: The Direct Medical costs of Healthcare-Associated Infections in U.S. Hospitals and the Benefits of Prevention R.Douglas Scott – Economist
WHO Report ;

2. Microorganisms in cause

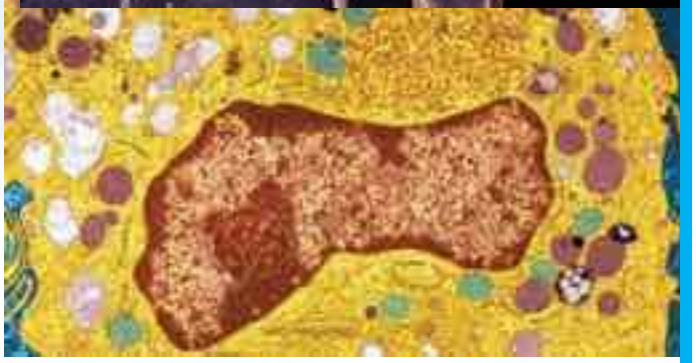
- ***Commensal bacteria*** found in normal flora of healthy humans

- ***Pathogenic bacteria*** have greater virulence, and cause infections (sporadic or epidemic) regardless of host status. For example:
  - Gram-positive bacteria: ***Staphylococcus aureus***
  - Gram-negative bacteria: Enterobacteriacae (***Escherichia coli, Proteus, Klebsiella, Enterobacter, Serratia marcescens)***
  - Anaerobic Gram-positive rods cause gangrene.
  - Gram-negative organisms such as ***Pseudomonas spp.*** are often isolated in water and damp areas.
  - Selected other bacteria are a unique risk in hospitals. For instance, ***Legionella*** species may cause pneumonia...

- ***Viruses-*** SARS CoV2

- ***Parasites and fungus Aspergillus fumigatus, Candida albicans, Candida auris***

Sistemul imunitar si geneza inflamatiei



TIBTEC 1638 No. of Pages 15 ARTICLE IN PRESS

Trends in Biotechnology

CellPress REVIEWS

Review

Inflammation-on-a-Chip: Probing the Immune System *Ex Vivo*

Daniel Irimia[1,*,@] and Xiao Wang[1,*]

Inflammation is the typical result of activating the host immune system against pathogens, and it helps to clear microbes from tissues. However, inflammation can occur in the absence of pathogens, contributing to tissue damage and leading to disease. Understanding how immune cells coordinate their activities to initiate, modulate, and terminate inflammation is key to developing effective interventions to preserve health and combat diseases. Towards this goal, inflammation-on-a-chip tools provide unique features that greatly benefit the study of inflammation. They reconstitute tissue environments in microfabricated devices and enable real-time, high-resolution observations and quantification of cellular activities relevant to inflammation. We review here recent advances in inflammation-on-a-chip technologies and highlight the biological insights and clinical applications enabled by these emerging tools.

Highlights

Inflammation is a cascade of immune responses that is marked in host defense against invading pathogens, as well as in the pathogenesis of a variety of chronic diseases such as heart diseases, cancer, Alzheimer's disease, and diabetes.

Understanding the initiation, modulation, and termination of inflammation could help to uncover new treatments and early interventions to prevent complications.

The cellular components involved in inflammation play a significant role in

Asher Claire, The Scientist, 2017

3. Infection factors & routes of transmission

Factors influencing the development of nosocomial infections

- The microbial agent : bacteria, viruses, fungi and parasites.

Infections may be caused by/from:

- a microorganism acquired from another person in the hospital (**cross-infection**)
- the patient's own flora (**endogenous infection**).
- an inanimate object or substances contaminated from another human source (**environmental infection**).

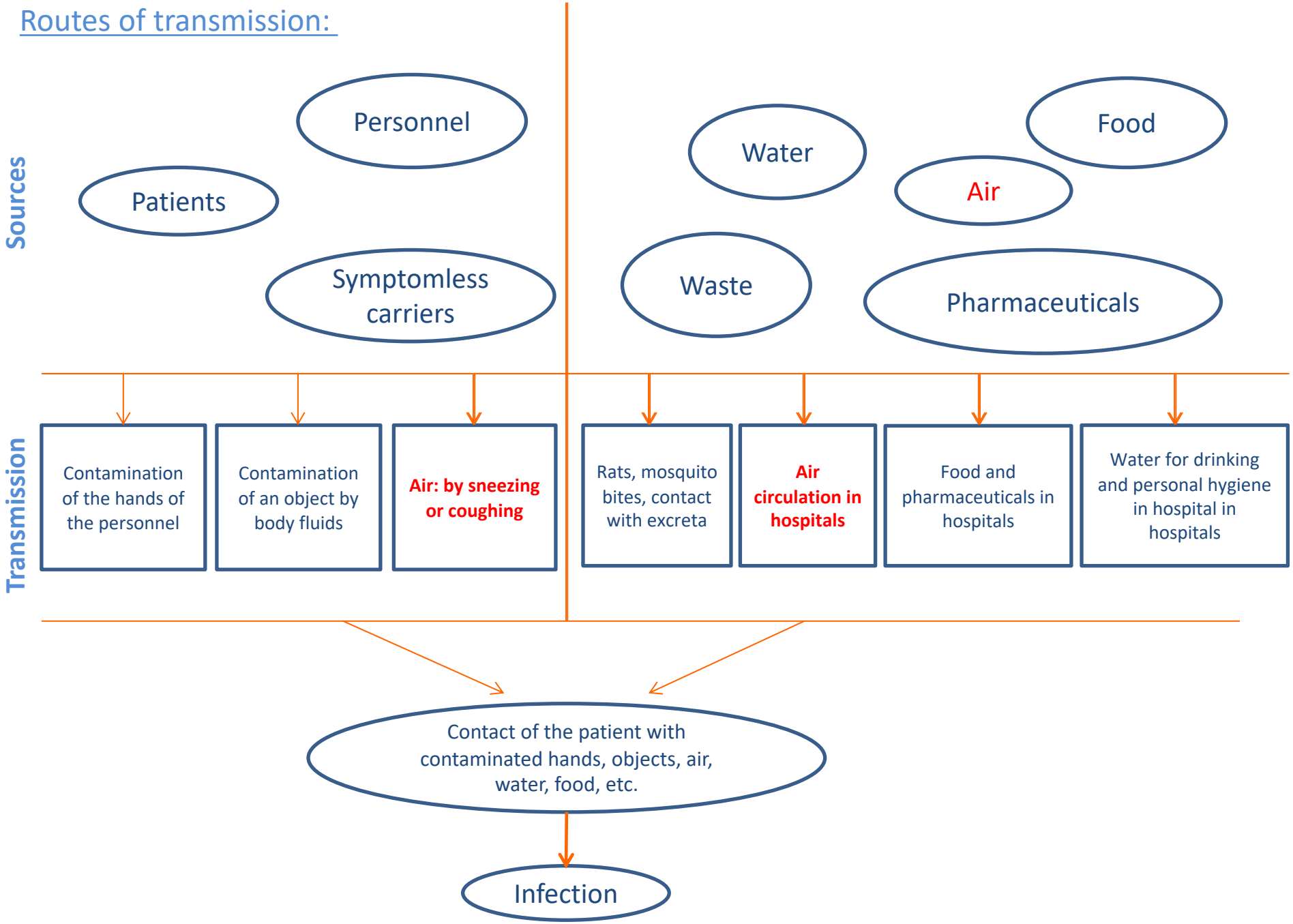
Exemples: Staphylococcus aureus, coagulase-negative Staphylococci, Enterococci, Enterobacteriaceae.

- Patient susceptibility : age, immune status, underlying disease, and diagnostic and therapeutic interventions..

- Environmental factors *Infections are typically spread to and from hospital personnel, patients, and visitors and microbial flora may contaminate objects, devices, and materials..*

- Bacterial resistance to antibiotics: *Klebsiella and Pseudomonas aeruginosa.*

Routes of transmission:



II. Surveillance of the infections

1. Implementation

The nosocomial infection rate in patients in a facility is an indicator of quality and safety of care.

1st STEP

SURVEILLANCE PROCESS

First step to identify local problems and priorities,
and evaluate the success
of infection control activity.

Adevar sau provocare?

2. Risk stratification

PATIENT FACTORS AND INTERVENTIONS FACTOR

→ DIFFERENT RISKS

TABLE I. **Differential nosocomial infection risk by patient and interventions**

Risk of infection	Type of patients	Type of procedures
1 Minimal	Not immunocompromised; no significant underlying disease	Non-invasive No exposure to biological fluids *
2 Medium	Infected patients, or patients with some risk factors (age, neoplasm)	Exposure to biological fluids or Invasive non-surgical procedure (e.g. peripheral venous catheter, introduction of urinary catheter)
3 High	Severely immunocompromised patients, (<500 WBC per ml); multiple trauma, severe burns, organ transplant	Surgery or High-risk invasive procedures (e.g. central venous catheter, endotracheal intubation)

* Biological fluids include blood, urine, faeces, CSF, fluid from body cavities.

3. Risk stratification for airborne transmission

NORM : ISO 90 351 / ISO 14644-1 (2003)

NFS 90-351 is a useful tool for the design, construction, operation and maintenance of air handling of "clean zones" in health facilities.

This standard defines **objectives** and the **methods** to **achieve depending on the risk areas**.

Objectives

The standard defines levels of performance to be achieved within the protected area:

- Particule classification
- Kinetics target level Classification of particle decontamination
- Bacteriological classification
- The standart also gives : Air temperature , Air humidity and maximum sound pressure.

Methods

The standard prescribes ways to achieve the goals set.

- Type of air flow in area
- Room air renewal rate :

Example : CP20 = less than 20 mn are needed for decontamination (90 %)

Example : B10 = the presence of less than10 cfu/m3 of air
CFUs (colony-forming units).

3. Risk stratification for airborne transmission

Risk areas

Risk area is a **defined and delimited place** in which **subjects and / or products** are **particularly vulnerable to contamination.**

For **each project in design** (building or rehabilitation), it belongs to the **responsible in the fight against HAI** to **carry out a risk assessment** in order to define **the level of requirements** for **each area or room to treat.**

NORM : ISO 90 351 / ISO 14644-1

Risk assessments for health facilities

3. Risk stratification for airborne transmission

NORM : ISO 90 351 / ISO 14644-1

Examples of risk areas:

Risk 4 (VERY HIGH INFECTIOUS RISK)
Orthopedics, ophthalmology, immunodeficient, transplant, major burns, neurology, cardiology.

Risk 3 (HIGH INFECTIOUS RISK)
Obstetrics, intensive care, vascular, digestive endoscopy.

Risk 2 (MODERATE HIGH INFECTIOUS RISK)
Endoscopy, recovery room, conditioning room, sterilization, emergency,

III. Prevention

1. Reducing person-to-person transmission

A. Hand decontamination :

- Hand washing: running water, soap, facilities for drying ..
- Hand disinfection:

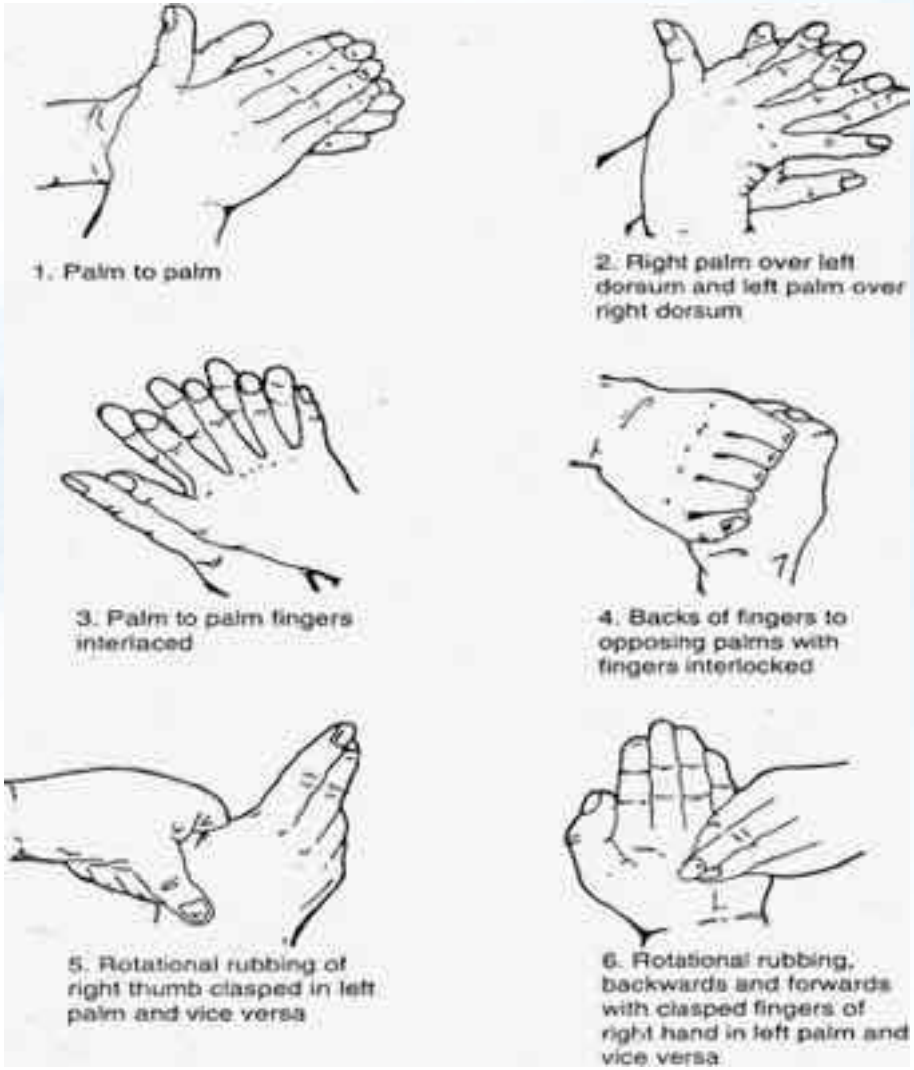
Personnal hygiene: nails, beard, moustaches, hair.

B. Clothing

- Working clothes
- Shoes
- Caps

C. Mask for patient and staff protection.

D. Safe injection practices



2. Prevent transmission from surfaces

- Cleaning of the hospital environment

Ninety per cent of microorganisms are present within “visible dirt”

Methods must be appropriate for the likelihood of contamination, and necessary level of asepsis.

This may be achieved by classifying areas into one of different hospital zones.

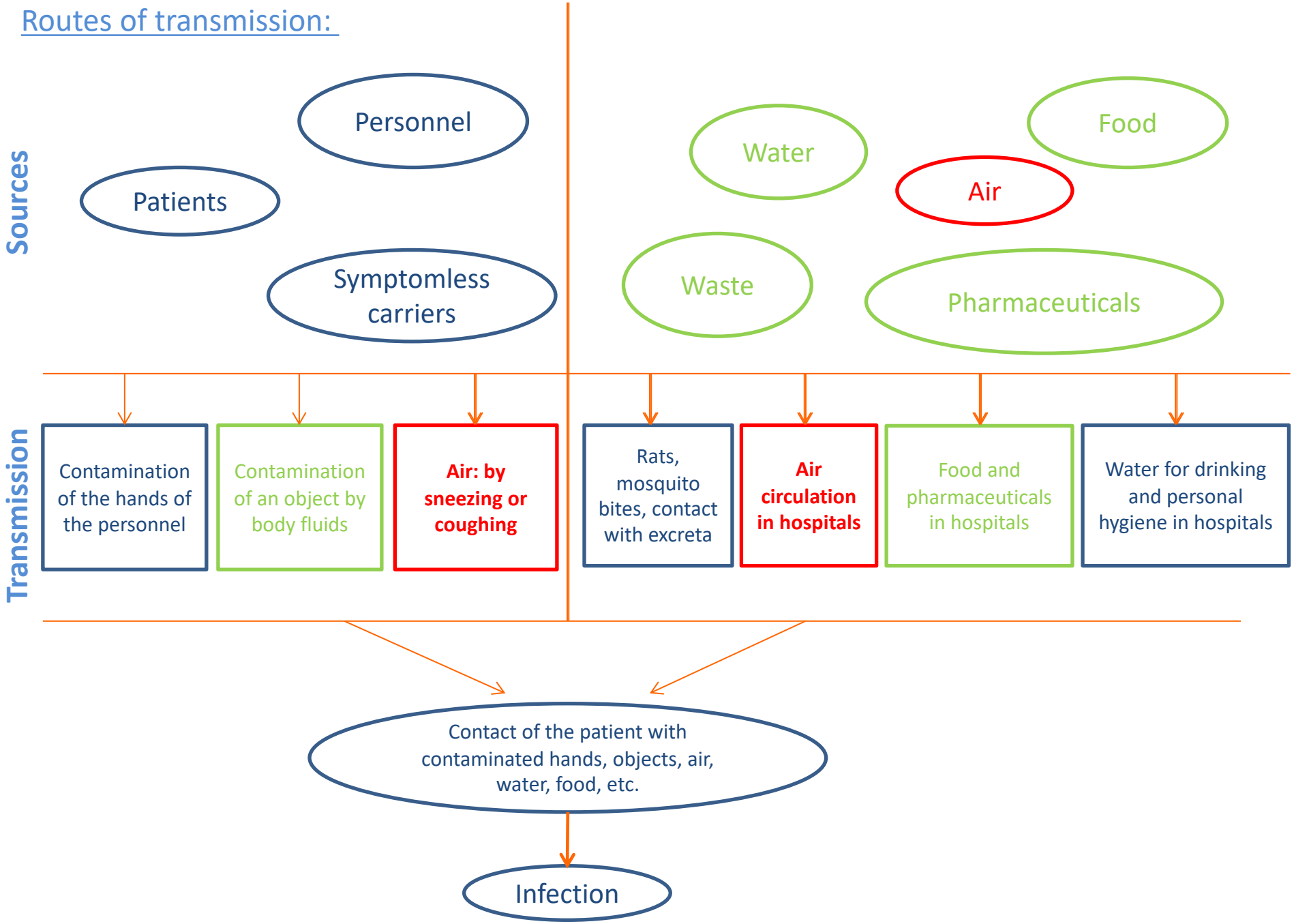
- Disinfection of patient equipment

Disinfection removes microorganisms without complete sterilization to prevent transmission of organisms between patients. Different products or processes achieve different levels of disinfection.

- Sterilization

- Thermal or Chemical Sterilization
- The object must be wrapped for sterilization. Only a wrapped sterilized object should be described as sterile:

Routes of transmission:



3. Reduce transmission from the air

HUMANS : MAIN SOURCE OF CONTAMINATION

AIR PARTICLE CONTAMINATION (particle emission by minute)

Air is one vector for nosocomial infection transmission.

Microorganisms responsible for HAI are moving around on airborne particles of different sizes.

No activity
Standing or sitting

100.000
particles/min

Important movements
Standing or sitting

1.000.000
particles /min

Walking

5.000.000
particles /min

Walking up the stairs

10.000.000
particules /min

Physical exercise

15 - 30.000.000
particles /min

3. Reduce transmission from the air

High-risk hospital areas should have air with minimal bacterial contamination.

Air quality at hospitals needs special precautions during design and maintenance stage to prevent infections from spreading

Fresh filtered air, appropriately circulated, will dilute and remove airborne bacterial contamination.

3. International standards

International standards give instructions about air quality and quantity of particles accepted:

CP 10 means that the maximum time to reduce the 90% initial pollution peak level is around 10 minutes.
B100 means a concentration of 100 viable particles per cubic meter of air.

Target							Means	
No human presence but furniture				During activity				
Designation of area	Particle classification of area to protect	Kinetics target level Classification of particle decontamination at 0,5 micron/m	Target level of bacteriological classification of the area to protect	Air temperature (except for specific needs)	Air humidity (approximate)	Maximum sound pressure	Type of air flow in area to protect	Room air renewal rate
AREA 4	ISO 5 Class 100	CP5	M1	19°C to 26°C	45% 65%	48 dBA	Unidirectional flow	Zone under the air flow Air speed 0,25m/s à 0,35m/s Fresh air rate 6vol/H
AREA 3	ISO 7 Class 10 000	CP10	M10	19°C to 26°C	45% 65%	45 dBA	Unidirectional flow or not	15 volumes/ hour
AREA 2	ISO 8 Class 100 000	CP20	M100	19°C to 26°C	45% 65%	40 dBA	Non unidirectional flow	10 volumes/ hour
AREA 1	Non-specific areas (1)					35 dBA		

3. International standards

International standards give instructions about air quality and quantity of particles accepted:

ISO Classification N°	Maximum concentration of particles allowed (particles/m3) of sizes equivalent or higher than those shown below					
	0,1 micron/m³	0,2 micron/m³	0,3 micron/m³	0,5 micron/m³	1 micron/m³	5 micron/m³
ISO 1	10	2				
ISO 2	100	24	10	4		
ISO 3	1.000	237	10	35	8	
ISO 4	10 .000	2.370	1.020	352	83	
ISO 5	100.000	23.700	10.200	3.520	832	29
ISO 6	1.000.000	237.000	102.000	35.200	8.320	293
ISO 7				352.000	83.200	2.930
ISO 8				3.520.000	832.000	29.300
ISO 9				35.200.000	8.320.000	293.000

IV. Our solutions

RISK ZONE 2	MODERATE HIGH INFECTIOUS RISK

ASEPTIC

OPERATING ROOMS
Endoscopy
Pre-operative care
Post-surgery care
Circulation in the operating rooms, Storage of sterile medical devices

RESUSCITATION
Multi-purpose room
Neonatal resuscitation room
Infectious patient room
Circulation resuscitation

STERILIZATION
Packaging and storage unit

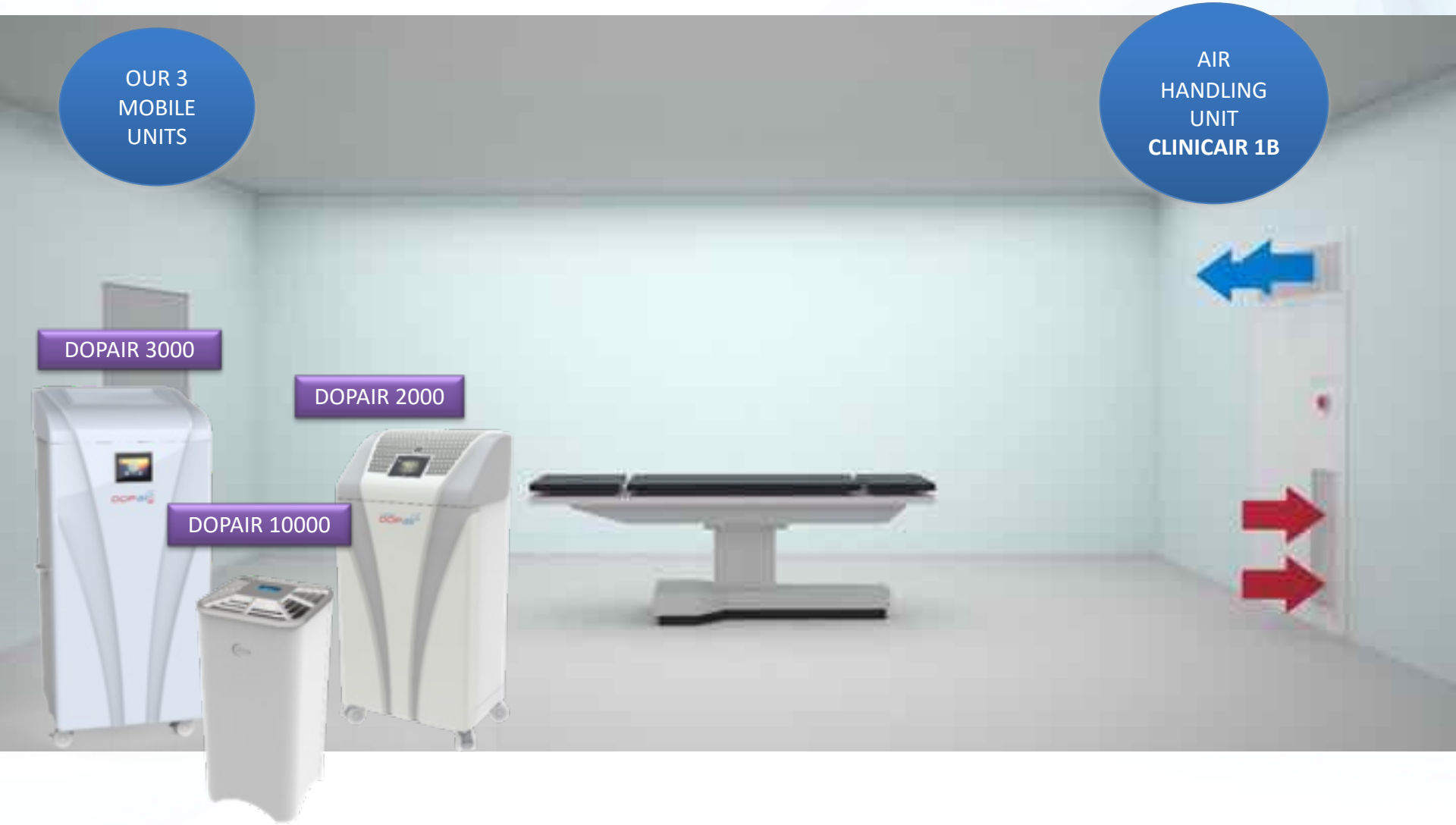
HOSPITALIZATION
Intensive care room
Continued monitoring room

PHARMACEUTICAL AND PHARMACEUTICAL TECHNOLOGY
Radio Pharmaceuticals

Particulate cleanliness Class:
ISO8
Decontamination kinetics class
CP20
Bacteriological cleanliness class
M100
Fresh air rate: 6 vol/h

Air change rate: superior or equal to 10 volume/h
Differential pressure (+/-) : 15 Pa +or- 5 Pa
Type of air flow in the protected area : Non unidirectional flow
Noise level EN 15726 :
Operating room 48 dba/ hospitalization 48 dba/ Hospitalization 40 dba/ Radiology 48 dba/ Laboratories 48 dba

IV. Our solutions



Air flow	160-1000 m3/h
Noise level at 2 m	160 m³/h - 34 dBA 350 m³/h - 39 dBA 500 m³/h - 44 dBA 780 m³/h - 49 dBA 1000 m³/h - 58 dBA
Application ATA CONTROL	The application allows you to remotely control one or more devices and monitor the values.
Air diffusion	Suction from below and diffusion from the top thanks to the Blowing plenum
System of filtration	G4 + activated carbon filter + H14
Decontamination system	Bioxigen
Size	L 450 x W 450 x H 1000 mm
Weight	30 Kg
Supply	230 V / 50 - 60 Hz
Control	4 Inch Touch Screen
Interface languages	French, English

To whom it may concern,

The Dopair (500, 1000, 2000, 3000) Mobile Air Purifiers manufactured by ATA MEDICAL have been tested by the independent laboratory VIRNEXT in Lyon (France) in order to measure their decontamination efficiency in a confined environment.

Tests conditions:

- Chamber size: 2,5m³
- Dopair CADR: 160m³/h
- Dopair terminal filter: HEPA H14 *EN1822 certified*
- Number of samples: 14 for each microorganism

Tests Results:

Microorganism	Functioning Time – Vol/h	Decontamination Efficiency
Influenza H1N1	5 minutes – 5 vol/h	99,9929%
Adenovirus Type 5	5 minutes – 5 vol/h	99,905%
Bacillus Subtilis spores	5 minutes – 5 vol/h	95,234%
Pseudomonas Aeruginosa	5 minutes – 5 vol/h	99,965%
Escherichia Coli	5 minutes – 5 vol/h	99,925%
Staphylococcus Aureus	5 minutes – 5 vol/h	99,842%
Enterococcus Faecium	5 minutes – 5 vol/h	99,800%
Candida Albicans	5 minutes – 5 vol/h	99,973%
Aspergillus Fumigatus	5 minutes – 5 vol/h	99,467%

Eficacitatea pe Gram+

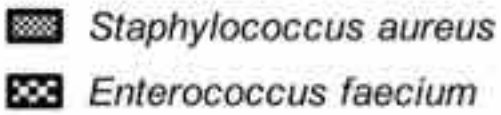


Figure 1: Evaluation of « Dopair 500/1000/2000/3000 » filter system on Gram positive bacteria: *Staphylococcus aureus* and *Enterococcus faecium*.

The collecting data allow to define the efficiency of the « Dopair 500/1000/2000/3000 » system on decontamination of confined space with Gram positive bacteria.

- Reduction Log CFU/mL *Staphylococcus aureus* :
  - 2,8 ± 0,1 Log in 5 minutes
  - 2,9 ± 0,2 Log in 10 minutes
  - 3,5 ± 0,4 Log in 20 minutes

- Reduction Log CFU/mL *Enterococcus faecium*:
  - 2,7 ± 0,1 Log in 5 minutes
  - 3,0 ± 0,1 Log in 10 minutes
  - 3,0 ± 0,2 Log in 20 minutes

IV. Our solutions

RISK ZONE 3	HIGH INFECTIOUS RISK

ASEPTIC

OPERATING ROOMS

Multi-purpose operating room, ENT, Other orthopedics,
Gastro-enterological surgery,
Urology,
Cardio-vascular surgery,
Neurosurgery,
Obstetrics, Gynecology…

Arthroscopy,
Hemodynamics
Plastic reconstructive & Aesthetic surgery,

LABORATORY

In vitro fertilization (IVF)

HOSPITALIZATION

Hematology room
Organ transplant room
Post-transplant unit room

RADIOLOGY

Interventional Imaging room

Particulate cleanliness Class: ISO7
Decontamination kinetics class : CP10
Bacteriological cleanliness class : M10
Fresh air rate: 6 vol/h

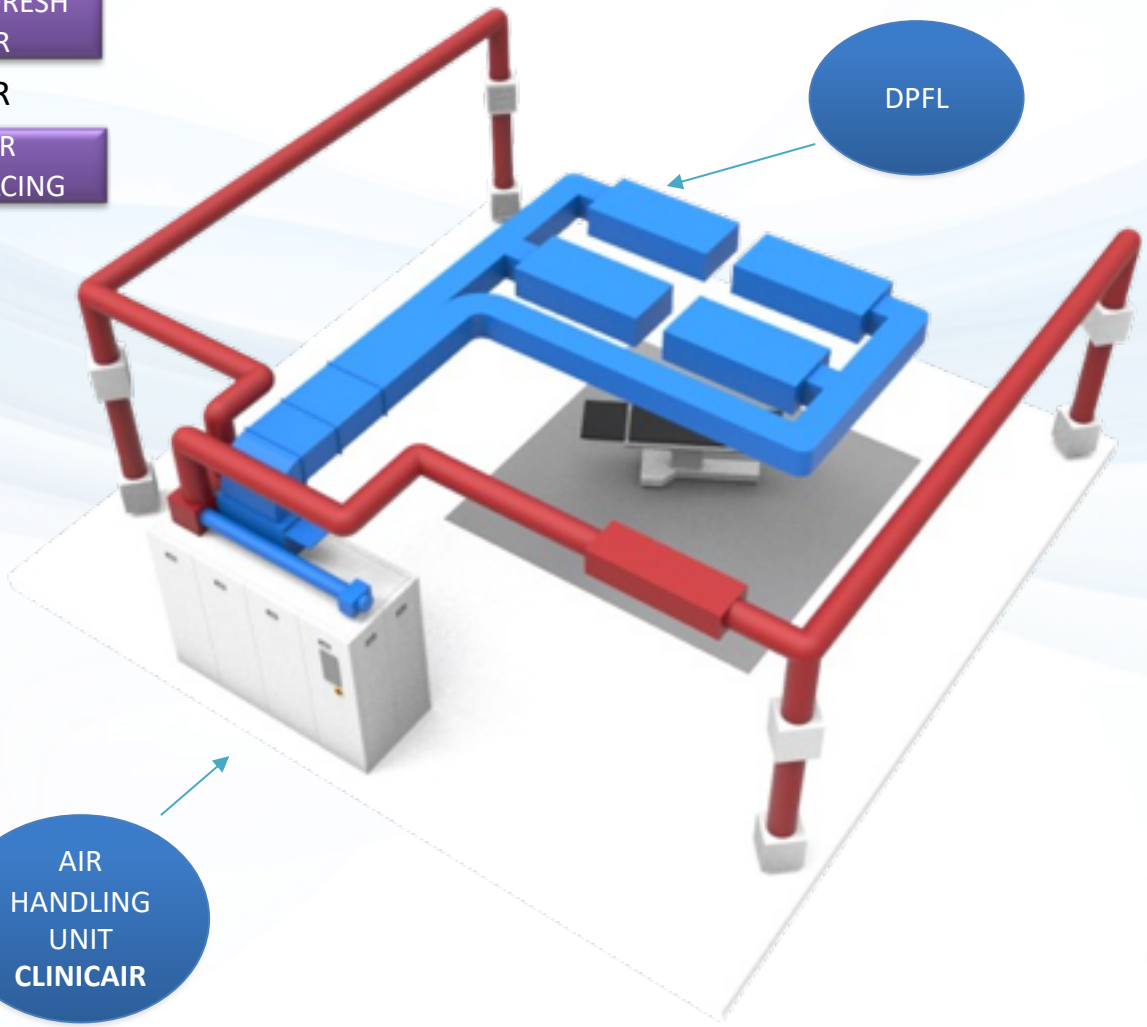
Air change rate: superior or equal to 15 volume/h
Differential pressure (+/-) : 15 Pa +or- 5 Pa
Type of air flow in the protected area : Unidirectional or non unidirectional flow
Noise level EN 15726 :
Operating room 48 dba/ hospitalization 40 dba/ Radiology 48 dba/ Laboratories 48 dba

IV. Our solutions

100% FRESH AIR

OR

AIR RECYLCING



DPFL

MOBILE UNITS

AIR HANDLING UNIT **CLINICAIR**

DOPAIR

ROOM DOPAIR

IV. Our solutions

RISK ZONE 4	VERY HIGH INFECTIOUS RISK

HYPERASEPTIC

OPERATING ROOM
Prosthetics othopedics
Organ transplant
Burn wards
Cardiac (open heart)

HOSPITALIZATION
Burn patients rooms
Protected units rooms (hematology)

PHARMACEUTICAL
Preparation of cytotoxics (bpf)
Manufacturing of parenteral solution (bpf)

Particulate cleanliness Class: ISO5
Decontamination kinetics class : CP5
Bacteriological cleanliness class : M1
Fresh air rate: 6 vol/h

Differential pressure (+/-):15 Pa +or- 5 Pa
Air change rate: Depending on the dimensions of the laminar air flow ceiling
Type of air flow in the protected area : Unidirectional flow
Noise level EN 15726 : Operating room 48 dba / hospitalization 40 dba / Pharmaceuticals 45 dba

IV. Our solutions

LAMINAR AIR FLOW CEILING ATA

100% FRESH AIR

OR

AIR RECYLCING

AIR HANDLING UNIT **CLINICAIR**

pital Robert Debre (75) - bone marrow transplant center

In private MCO clinics, private hospitals and Public hospitals, CLINICAIR® air handling unit equips 100% of departments classified as "risk areas":

- Operating Theaters,
- Risk 4/3/2 operating rooms,
- resuscitation services,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