VENTILATION SYSTEMS AND THERMAL CONDITIONS IN OPERATING ROOMS
Rising trends in surgical activities:

- Control of the asepsis level

- Control of the concentration of any form of pollutants:
  - chemical (anaesthetic gas and volatile substances)
  - physical (particulate and aerosol)
  - micro-biological (pathogenic agents related to the human presence, to the surgical interventions themselves and to the spores carried on by the airborne particulate).

The needs:

- to assure values of the air quality not dangerous for the health of the operators;
- to contain the infection risks.
Hospital infections in Italy:

- Over 500,000 cases a year (30,000 deaths) on 9.5 million patients (30-35% related to the operating site);
- Over 1.5 million €/year for medical treatments;
- An expected loss of 3 million of working days.

The cost of a sepsis of small entity, caught in the operating room, is about €3,500 ÷ €7,000 at expense of the hospital structure. The cost of a deep sepsis is up to €20,000 ÷ €25,000.

In some countries the insurance companies don't cover the deep sepsis as imputed to a bad hospital management.
The Aim of the Research is to assess:

- the genesis of the pollution phenomena in operating rooms;
- the correlations among the boundary conditions (room’s technological state, type of surgical operation, people in the room, clothing, clinical frame of the patient, etc.).

The research is carried out both within four surgical rooms at the Cento Hospital (Ferrara, Italy) (general surgery, urology/gynecology, emergency and orthopedics) and within the CERTECA (Air Technologies Researches Centre) Laboratory of the Ferrara University.
Operating Rooms at Cento Hospital: HVAC Plants

[Diagram of operating rooms and HVAC plants]
CERTECA
(Air Technologies Researches Centre)
The CERTECA Test Facility reproduces a real operating room, with all the equipments, HVAC plant and control systems able to reproduce different conditions of ventilation and pollution.
CERTECA CENTRE: HVAC Plants
Data are collected on three databases:

1. Containing in-field sensitive data (implemented on a server at the hospital and not directly accessible to the researchers)
2. Containing all the data of scientific interest (implemented on a server at the University of Ferrara)
3. Containing the experimental data of contamination, decontamination, efficiency and effectiveness of ventilation tests carried out in the same room under the different conditions of operation.
The Automatic Data Acquisition Systems performs the followings functions:

- identification of the patient going into the operating room (RFID)
- identification of the personnel present in the room (RFID)
- time schedule of the surgical operation (RFID)
- identification of the surgical irons set (RFID)
- assessment of the successful sterilization of the irons set (RFID)
- identification of the of anaesthetic infusion (Palm-PC)
- identification of the surgical intervention (Palm-PC)
- identification of the used prostheses (Palm-PC + bar code)

The final aim is to build a computerized clinical report
Microbiological and Environmental Monitoring

Measuring campaigns have been performed either with the operating room “at rest” or “in operating”

- **Microbiological pollution**  
  (Petri Plates, S.A.S.)

- **Physical Pollution**  
  (Kanomax)

- **Environmental Comfort**  
  (Babuc A)

- **Air Flow Control**  
  (Balometer, Ultrasonic Anemometer)
Orthopaedics Room

Surface: 36 m²

Ventilation Plant: turbulent flow (22 air changes/hour) absolute double filtering.

Instrumentation Layout

- Petri Plates
- S.A.S
- Babuc A
- Kanomax
Microbiological Monitoring

Microbiological Measurements:

1. Passive instruments (Petri plates)
2. Active equipment (SAS instrument).
Passive Air Sampling

- Data collected in Orthopaedic Room *at rest* and *in operating*
- Plates incubated at 37°C for 48 hours
- Number of CFU verified
Active Air Sampling

✓ Surface air sampler (SAS-PBI International)

✓ A known volume (6000 l/h) of air is blown onto Agar Clean Room Contact FDA (55 mm) plate

✓ SAS was positioned on to harm-shelf (1m away from the operating bed)

✓ Plates were incubated at 37°C for 48 hours

✓ Data collected in Orthopaedic Room at rest and in operating
Physical and Environmental Monitoring

1. Babuc A data acquisition system
2. Kanomax Geo-α particulate meter

- BABUC A
- PSYCHROMETRIC PROBE
- GLOBOOTHERMOMETRIC PROBE
- ANEMOMETRIC PROBE
Physical Pollution

Following the ISO 14644 Rules for the white rooms and other sterile environments, the measurements of the airborne particulate (0.3 µm, 0.5 µm, 1 µm, 3 µm e 5 µm) have been performed in correspondence at 6 points.
10 min, 20 min, and 30 min tests have been performed for setting up the optimal sampling time allowing the ventilation plant to effect a sufficient number of air exchanges without intervention by the operators.

- Operating room at rest
- Kanomax Geo-α with sampling flow of 2.8 l/min.
The result of tests show that the minimum sampling time for attaining the asymptotic value is 30 min.
The distribution of the concentration (ten minutes averaged values) depends on the position of the sampling point:
- A = 400.000 part/m³
- B = 50.000 part/m³
- C, D, E, F = near to the asymptotic value since the beginning.

The doors operation influences the concentration level at the nearest points (A and B). Door opens from left to right, the left part of the room (A) remains exposed for more time.
The results of the measurements allow us to classify the orthopaedic room as ISO 5 class (ISO 14644 Rules) at rest.

<table>
<thead>
<tr>
<th>point</th>
<th>Concentration (particle/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.3 µm</td>
</tr>
<tr>
<td>A</td>
<td>3.43E+03</td>
</tr>
<tr>
<td>B</td>
<td>1.66E+03</td>
</tr>
<tr>
<td>C</td>
<td>9.55E+02</td>
</tr>
<tr>
<td>D</td>
<td>2.09E+03</td>
</tr>
<tr>
<td>E</td>
<td>1.73E+03</td>
</tr>
<tr>
<td>F</td>
<td>9.91E+02</td>
</tr>
</tbody>
</table>

Classification ISO orthopaedics theatre

<table>
<thead>
<tr>
<th>C_n</th>
<th>number of particle / m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>Particle diameter considerer</td>
</tr>
<tr>
<td>N</td>
<td>N = log (C_n) / 2.08·log (0.1/D)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>diameter</th>
<th>CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3 µm</td>
<td>4.2</td>
</tr>
<tr>
<td>0.5 µm</td>
<td>3.9</td>
</tr>
<tr>
<td>1 µm</td>
<td>4.1</td>
</tr>
<tr>
<td>5 µm</td>
<td>5.0</td>
</tr>
</tbody>
</table>
The time course of the concentration is similar for all the particles, the difference among the values is sensible to the diameter of the particles.

Notable differences arise among the various intervention typologies or among episodes occurring in the same operation.
notably higher values during the reconstruction of the extensor apparatus than those referring to the arthroscopy

remarkable peak of concentration corresponding to the realization of a plaster knee-guard.
ENIRONMENTAL COMFORT

Thermal comfort conditions in the operating room: a very complex problem.

It is necessary to conciliate several requirements:

- homothermic conditions of the patient, avoiding the risk of Hypothermia
- comfort conditions of the components of the surgical team

Incorrect micro-climatic conditions can also affect the airborne microbiological components promoting the development and the growth of bacterial colonies.
The aim of the study is to verify the correlation among the two different techniques of investigation:

- the first (objective): the acquisition of the most important parameters related to the environment, the medical operators and the patient

- the second (subjective): the gathering of the judgments expressed by all the presents towards the environment

The latter objective can be reached by means of a questionnaire regarding the feelings of comfort or uneasiness, the clothing, the weight, the age, the activity level, etc.
The microclimatics parameters, the clothing characteristics and the activity level, allow to elaborate the Fanger’s indices of thermal comfort:

- Predicted Mean Vote (PMV)
- Predicted Percentage of Dissatisfied (PPD).

The measures have been performed placing the equipment in the center of the room at a height of 1,5 meters, with the scialytic lamp both turned on and off, with the room both “at rest” and “in operating”

The results of this investigation conducted either in field or in simulated environment will allow us to set an investigation methodology and a measuring protocol aimed to the identification of new indices of thermal stress specific for the environment that is the object of our study.
Ospedale "S.S. Annunziata" di Cento (FE)
Sala di Ortopedia - 12 Marzo 2005

- $T_{globo}$
- $T_{b.s.}$
- Vel. aria media
- $T_{b.u.}$
- RH %

At rest

Lampada scialitica spenta
Lampada scialitica accesa

Temperature [°C]
Velocity [cm/sec]

9:30 10:00 10:30 11:00 11:30 12:00 12:30 13:00
Orario
Ospedale "S.S. Annunziata" di Cento (FE)
Sala di Ortopedia - 10 Maggio 2005

Protesi ginocchio sx
Lesione cuffia spalla
Frattura femore dx

In operating
Control of ventilation rates

Periodically the flow rates at the air intakes are checked using an AIRDATA Shortridge-ADM-850L balometer.
The air flow distribution is also verified by using a Thies Bi-axial Ultrasonic Gonioanemometer.
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