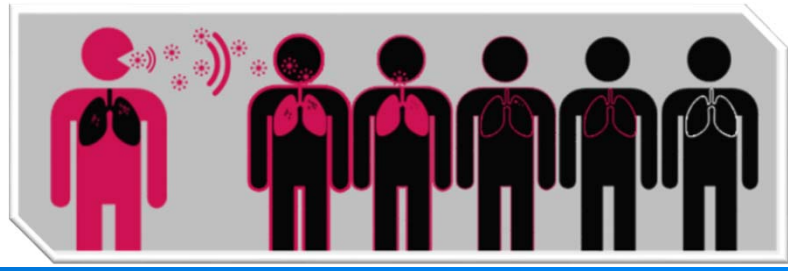
Air Infiltration and Ventilation Centre

AIVC 2017 Workshop on IAQ metrics

Brussels, 14-15 March 2017



# Can contaminant air quality indices be used to analyze the risk of airborne cross infections in hospital environments?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**Research Proyect: DPI2014-55357-C2-2-R**

TRACER **Ventilation system influence on airborne transmission of human exhaled bioaerosols. Cross infection risk evaluation**. This project is cofinanced by the European Regional Development Fund (ERDF).

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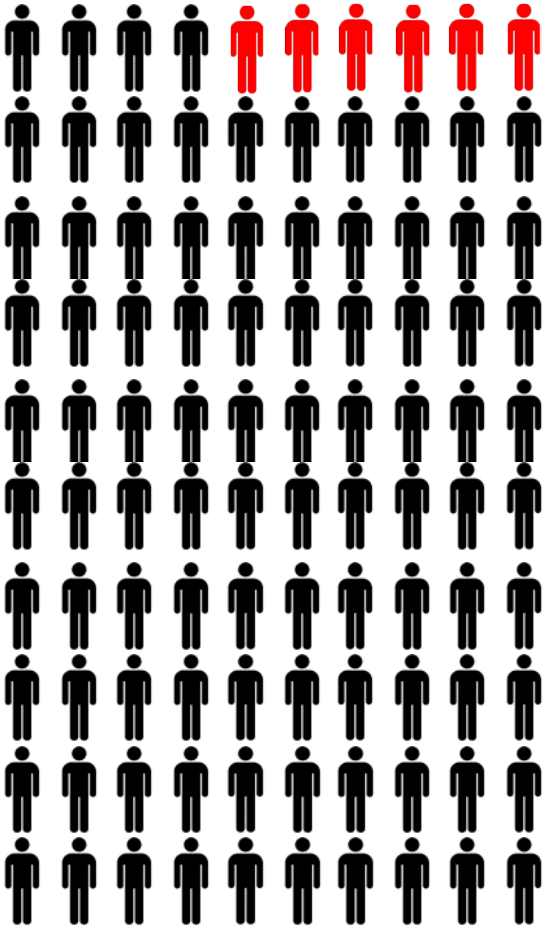
# Introduction

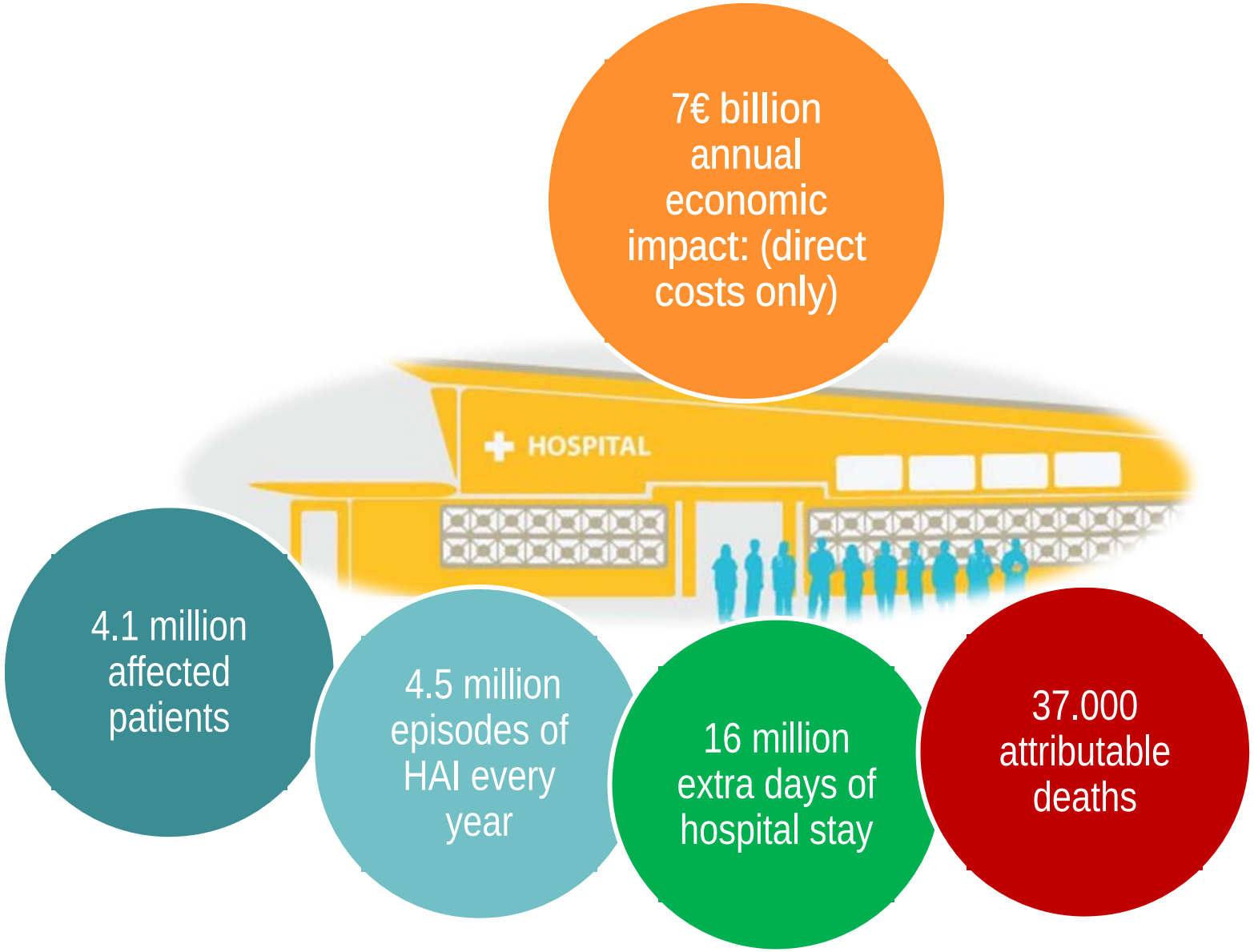
# Healthcare-associated infections (HAIs) in European hospitals



Of all patients, 6% are infected with at least one HAI

*Source:* http://ecdc.europa.eu/en/healthtopics/Healthcare-associated_infections/point-prevalence-survey/Pages/point-prevalence-survey-infographics.aspx

# Economic impact of HAIs in European hospitals




*Source: Annual epidemiological report on communicable disease en Europe, 2008, ECDC*
*http://ecdc.europa.eu/en/publications/Publications/healthcare-associated-infections-antimicrobial-use-PPS.pdf*

# Routes of pathogen transmission

## Airborne

Infection caused by airborne transmission

## Direct contact

Infection caused by contact and faeces

## Waterborne

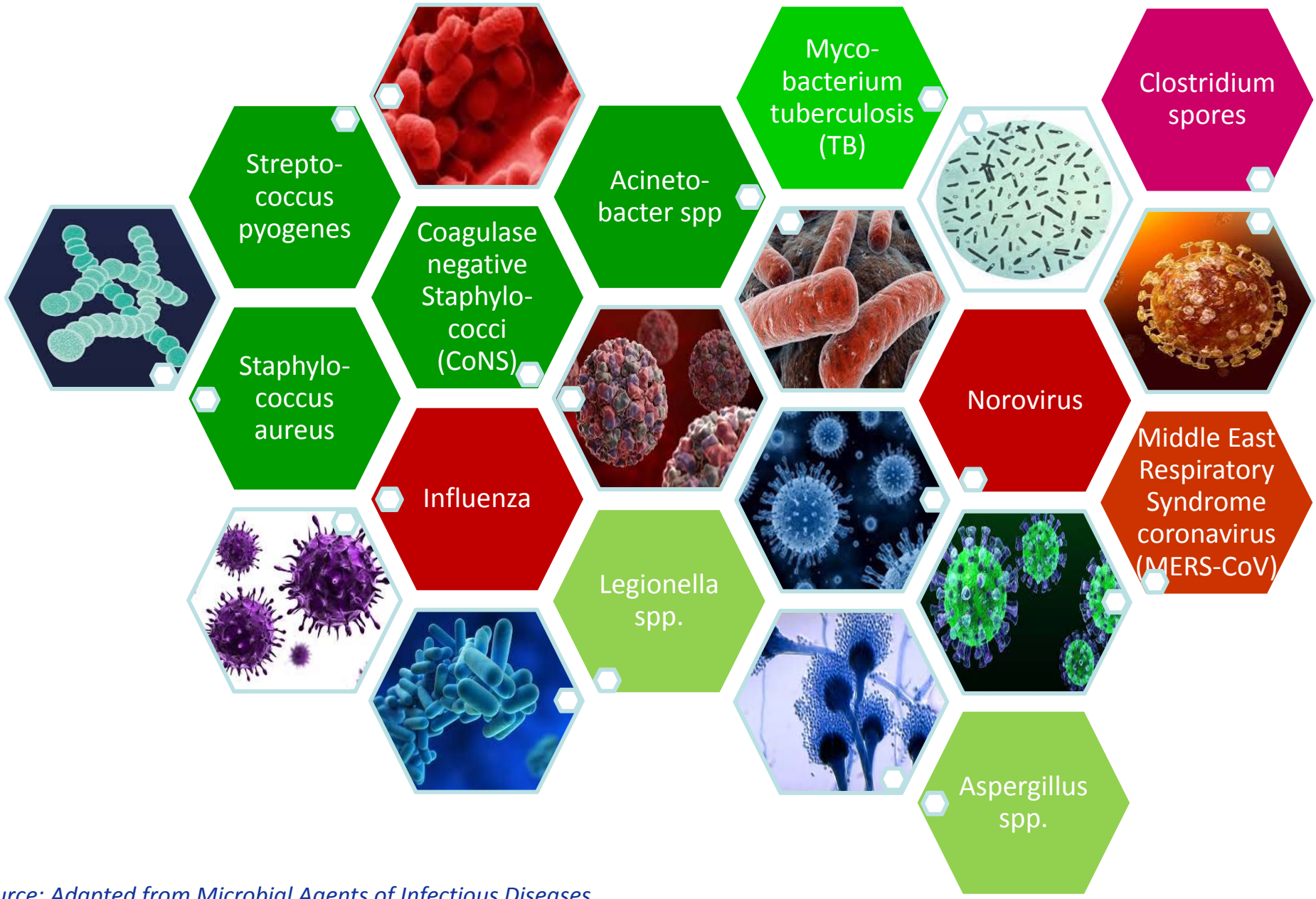
Infection caused by contaminated water

## Blood stream

Infection caused by pathogens in blood-stream and tissues

*Source: http://www.bode-science-center.com/center/glossary/transmission-paths.html*

# Airborne pathogen organisms



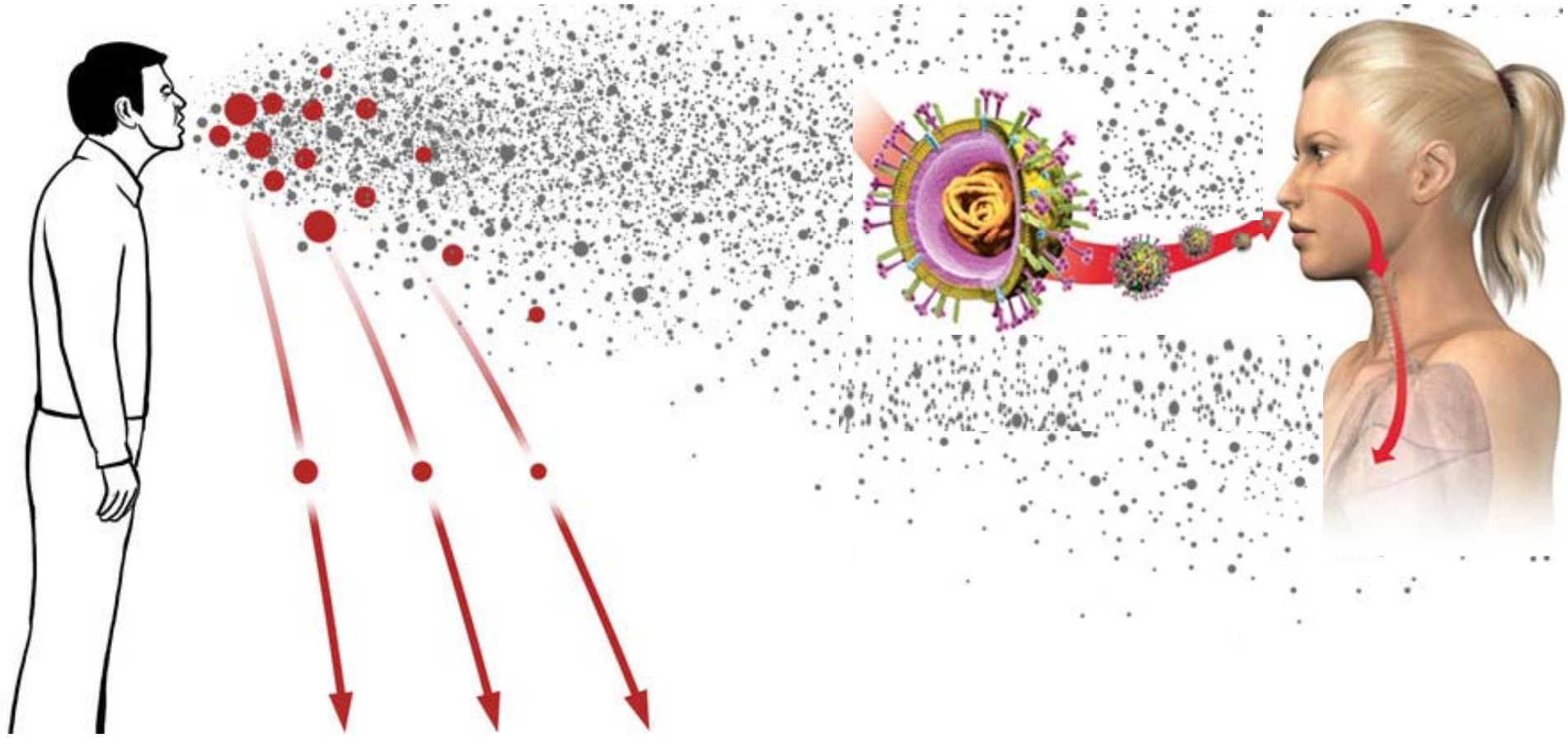

*Source: Adapted from Microbial Agents of Infectious Diseases*

# Airborne pathogen transmission routes

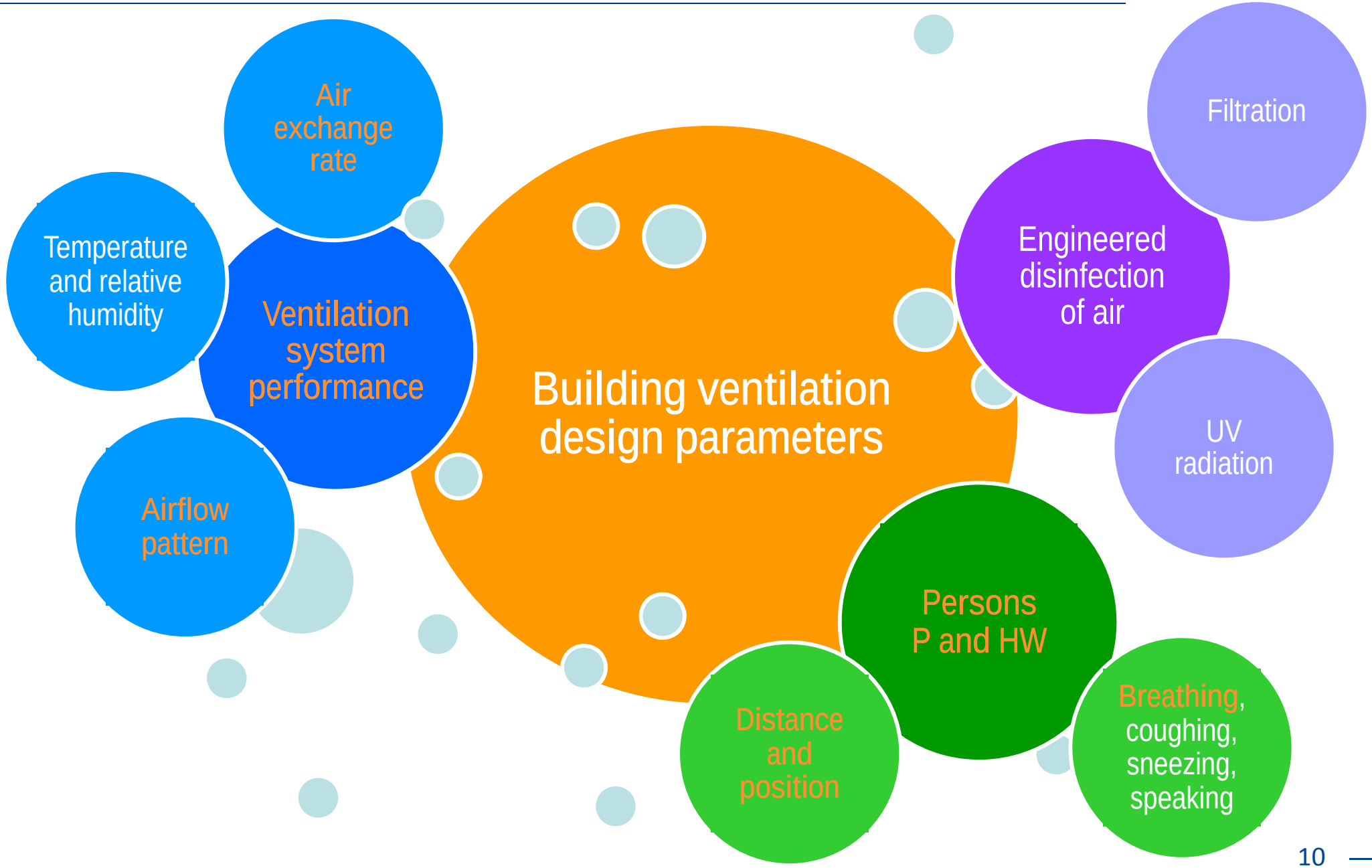
| | Droplets | Droplets nuclei (airborne) |
|---|---|---|
| |  |  |
| Source | Sneezing, coughing, talking | Breathing exhalation |
| Diameter | > 5 µm | ≤ 5 µm |
| Travel | < 1 m | > 1 m |
| Pathway | Settling, evaporation, inhalation | Inhaled by occupants |

*Source: Natural Ventilation for Infection Control in Health-Care Settings. Atkinson J, Chartier Y., Pessoa-Silva C.L., et al., editors, Geneva: World Health Organization; 2009.*

# Airborne pathogen transmission routes

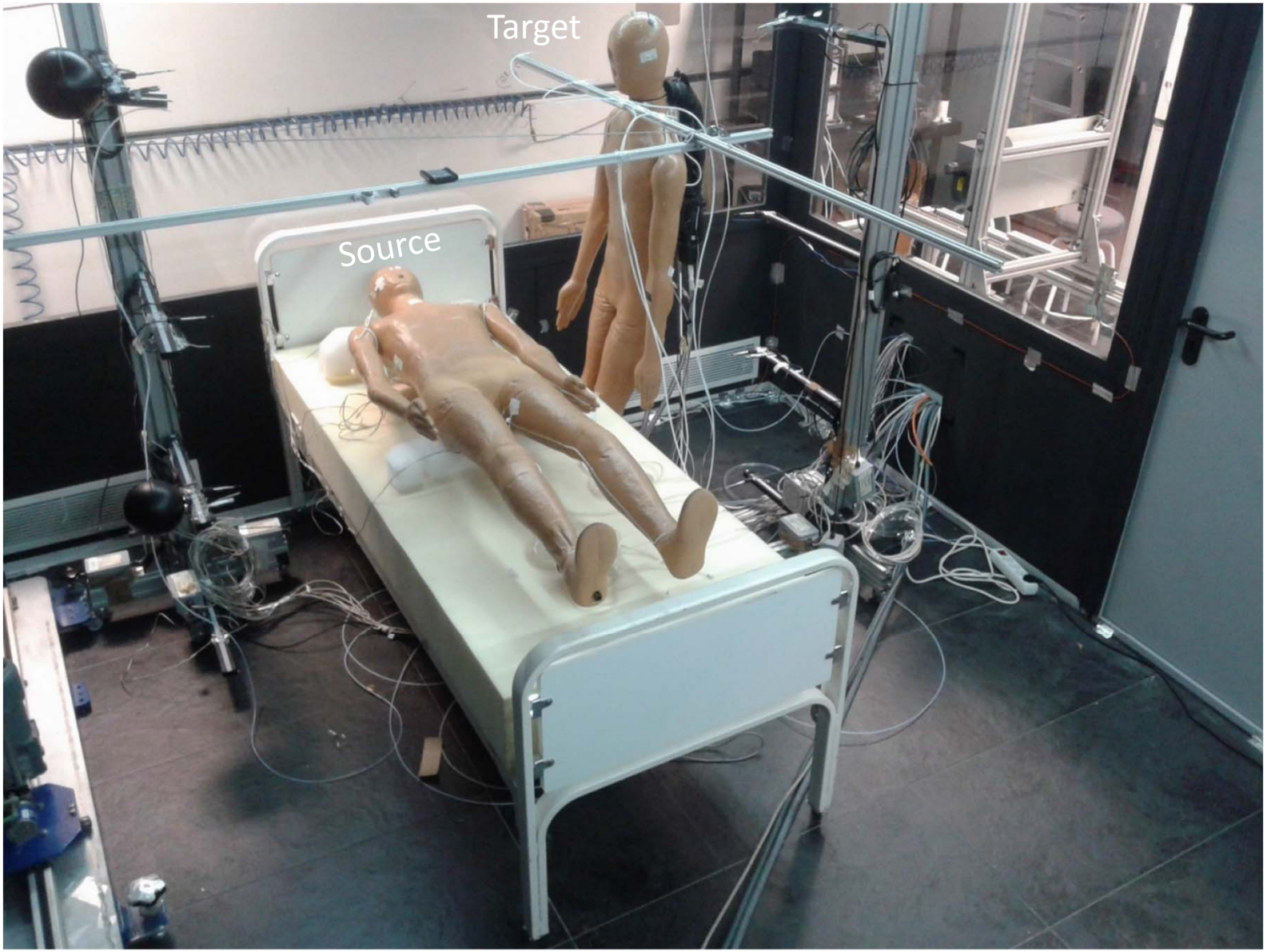


# Airborne infection risk and building ventilation design parameters

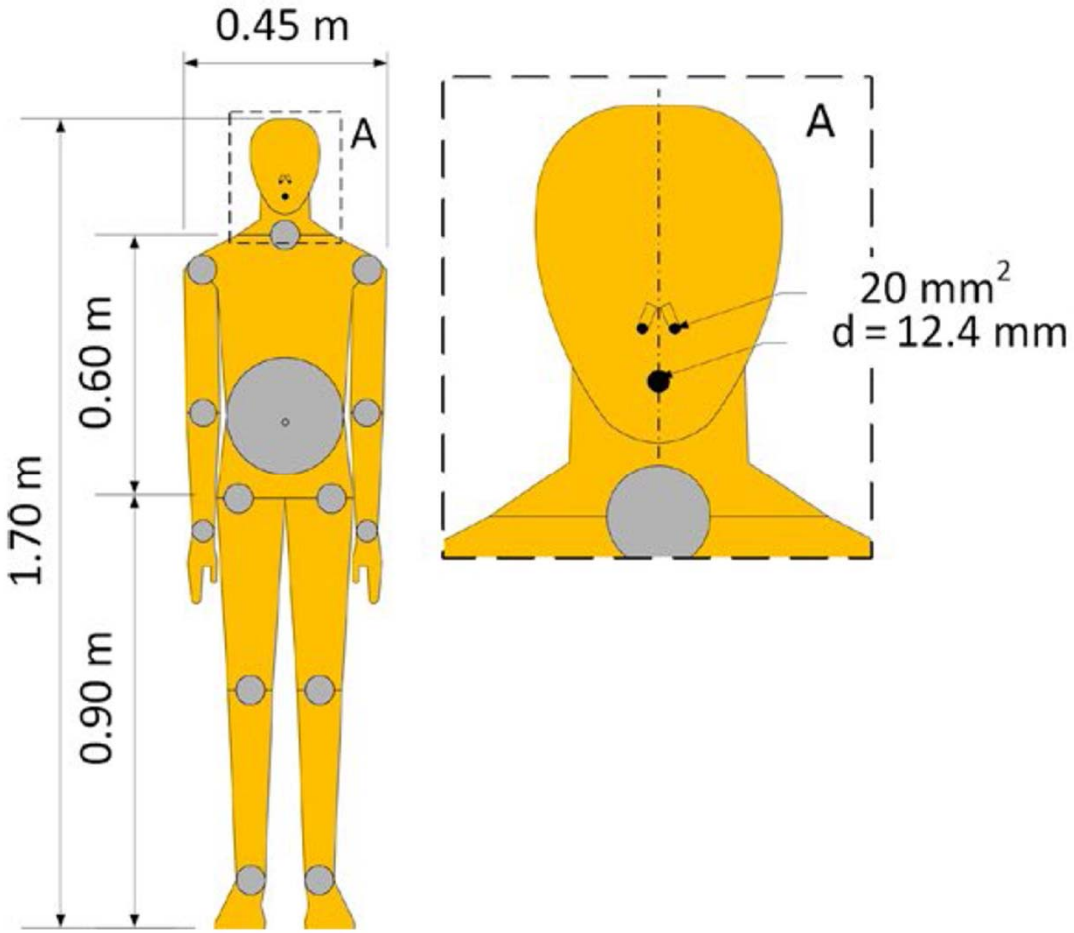


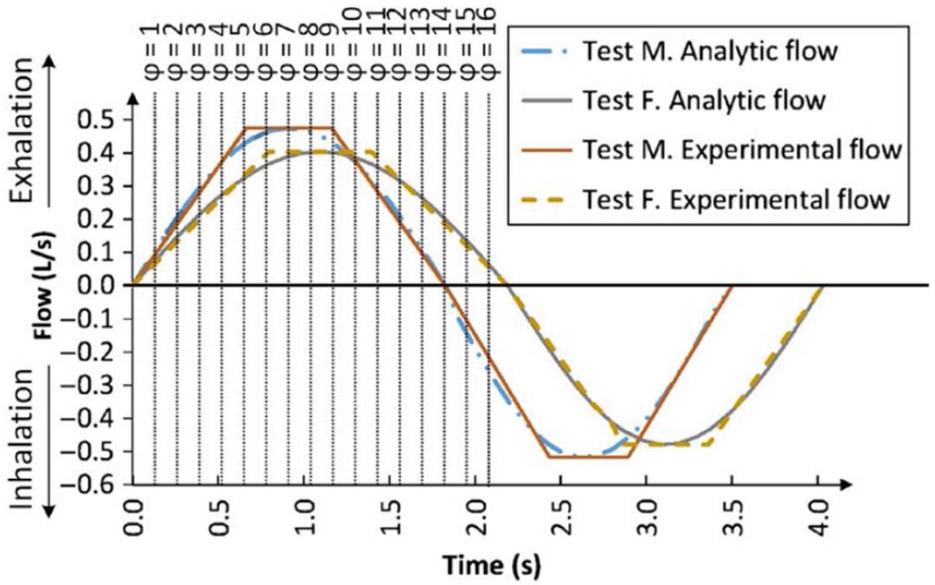
# Methodology

# Experimental setup. HVAC Lab at the University of Cordoba



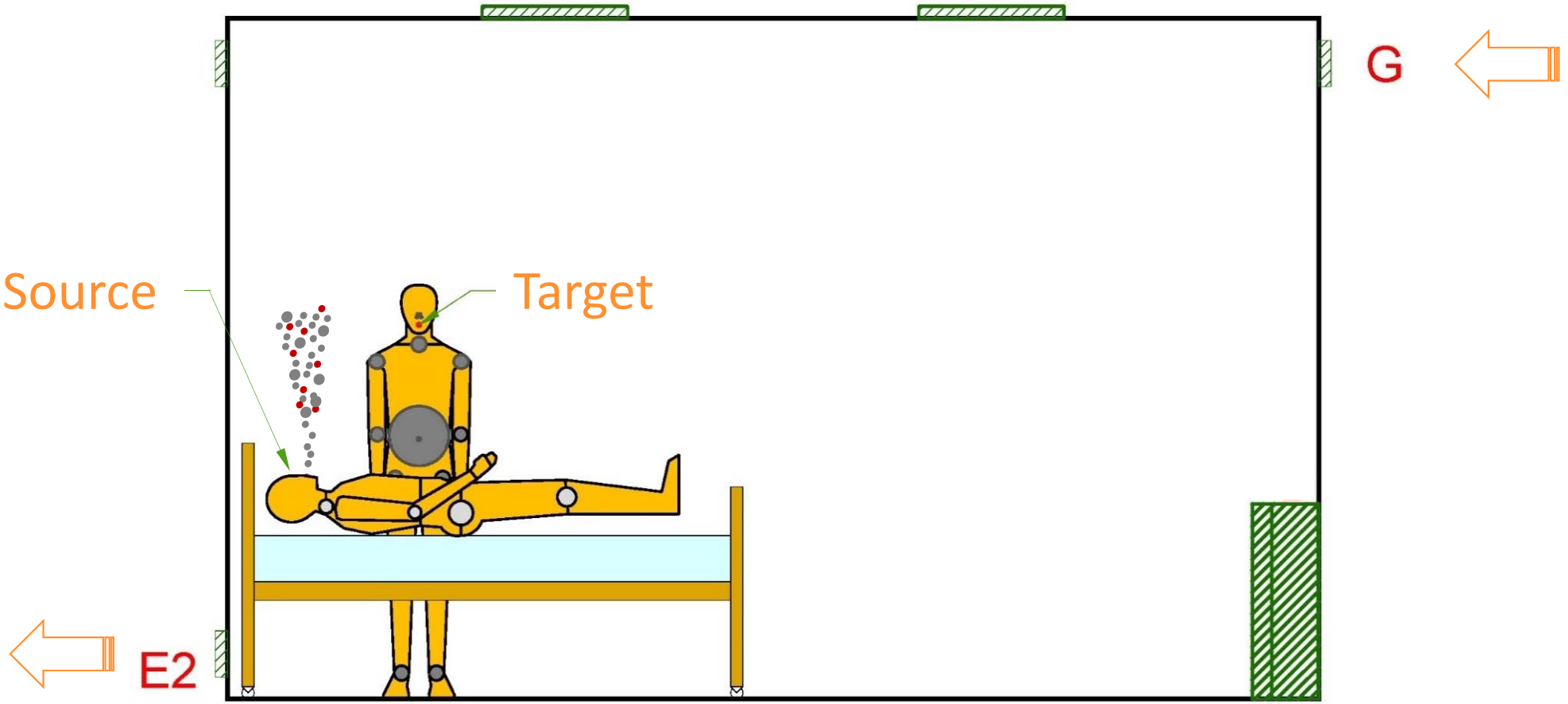
# Experimental setup. Breathing thermal manikins



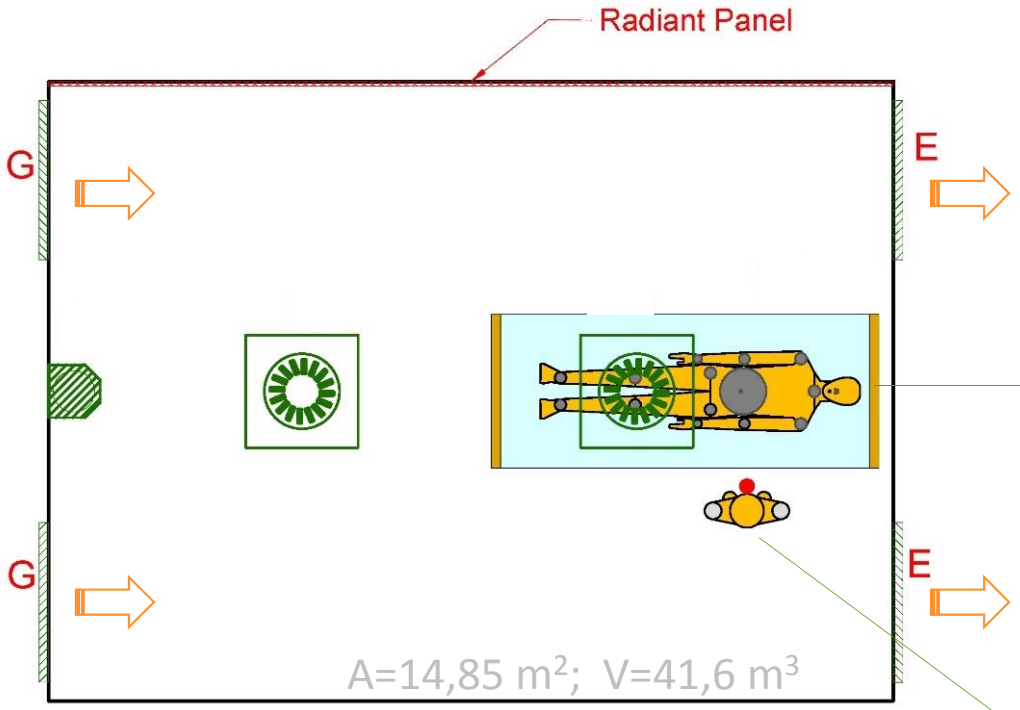




*Gupta JK, Lin C-H, Chen Q. Characterizing exhaled airflow from breathing and talking. Indoor Air. 2010;20:31–39.*
*Berlanga, F. A., Olmedo, I. and Ruiz de Adana, M. (2016), Experimental analysis of the air velocity and contaminant dispersion of human exhalation flows. Indoor Air, 00: 1-13. doi: 10.1111/ina.12357*

# Experimental setup. Ventilation system



# Experimental setup. Room experimental conditions



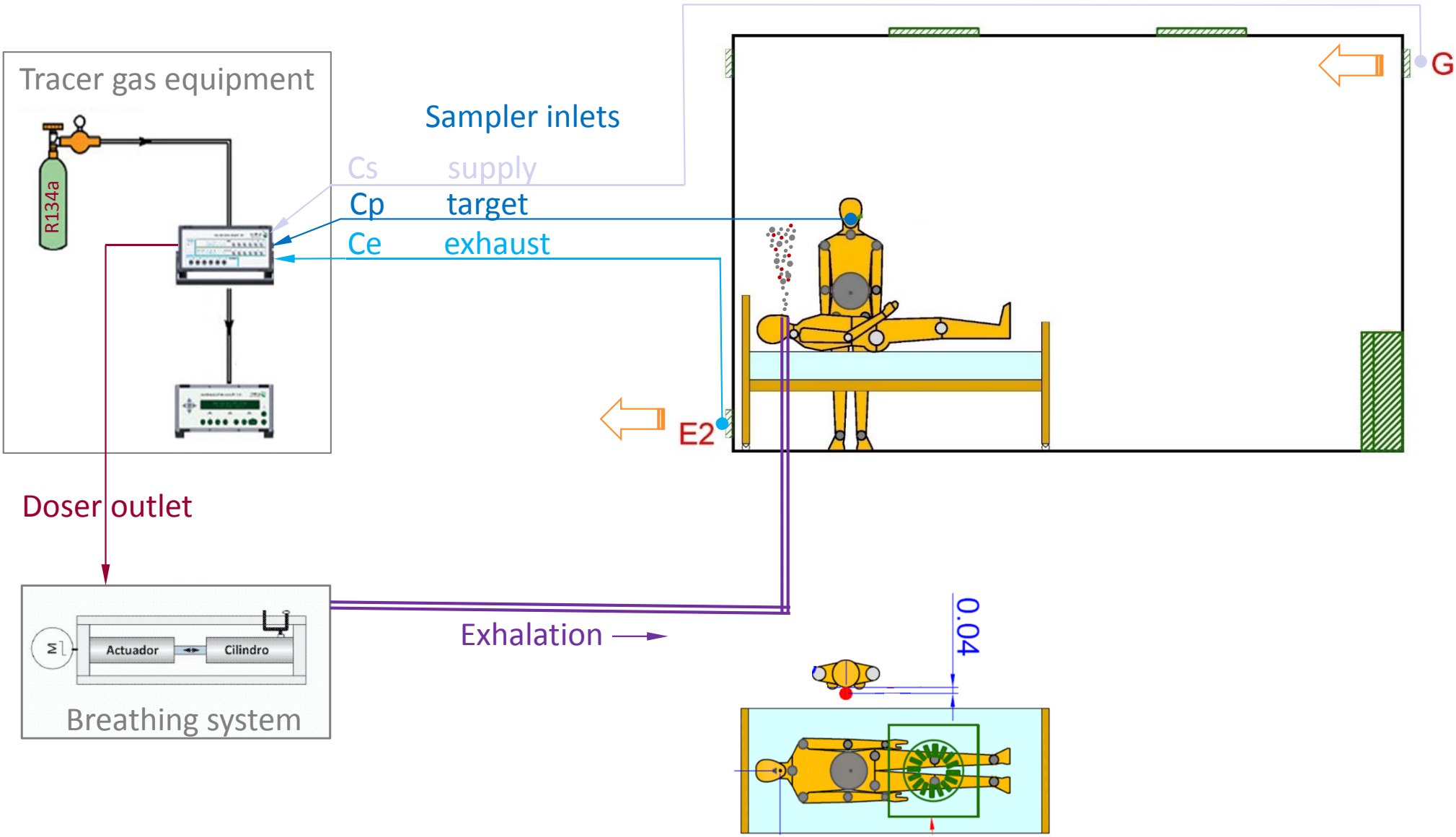

| | | Heat gains |
|---|---|---|
| Internal | [W] | 154.0 |
| External | [W] | 452.0 |
| **Total** | **[W]** | **606.0** |
| | **[W/m²]** | **40.8** |

| | | | Target (health worker) | Source (patient) |
|---|---|---|---|---|
| Ocuppants | Head | [W] | 5.5 | 4.8 |
| | Arms | [W] | 18.2 | 15.9 |
| | Torso | [W] | 13.4 | 11.7 |
| | Legs | [W] | 43.0 | 37.6 |
| | Breathing | [W] | 2.0 | 2.0 |
| | **Total** | **[W]** | **82.0** | **72.0** |

# Case studies

| Airflow pattern | Case | ACH | T air supply | Airflow rate |
|---|---|---|---|---|
| | | [$h^{-1}$] | [ºC] | [$m^3/h$] |
|  | M2_ACH6 | 6 | 18.2 | 250 |
| | M2_ACH9 | 9 | 20.6 | 375 |
| | M2_ACH12 | 12 | 21.8 | 500 |

# Tracer gas measurements



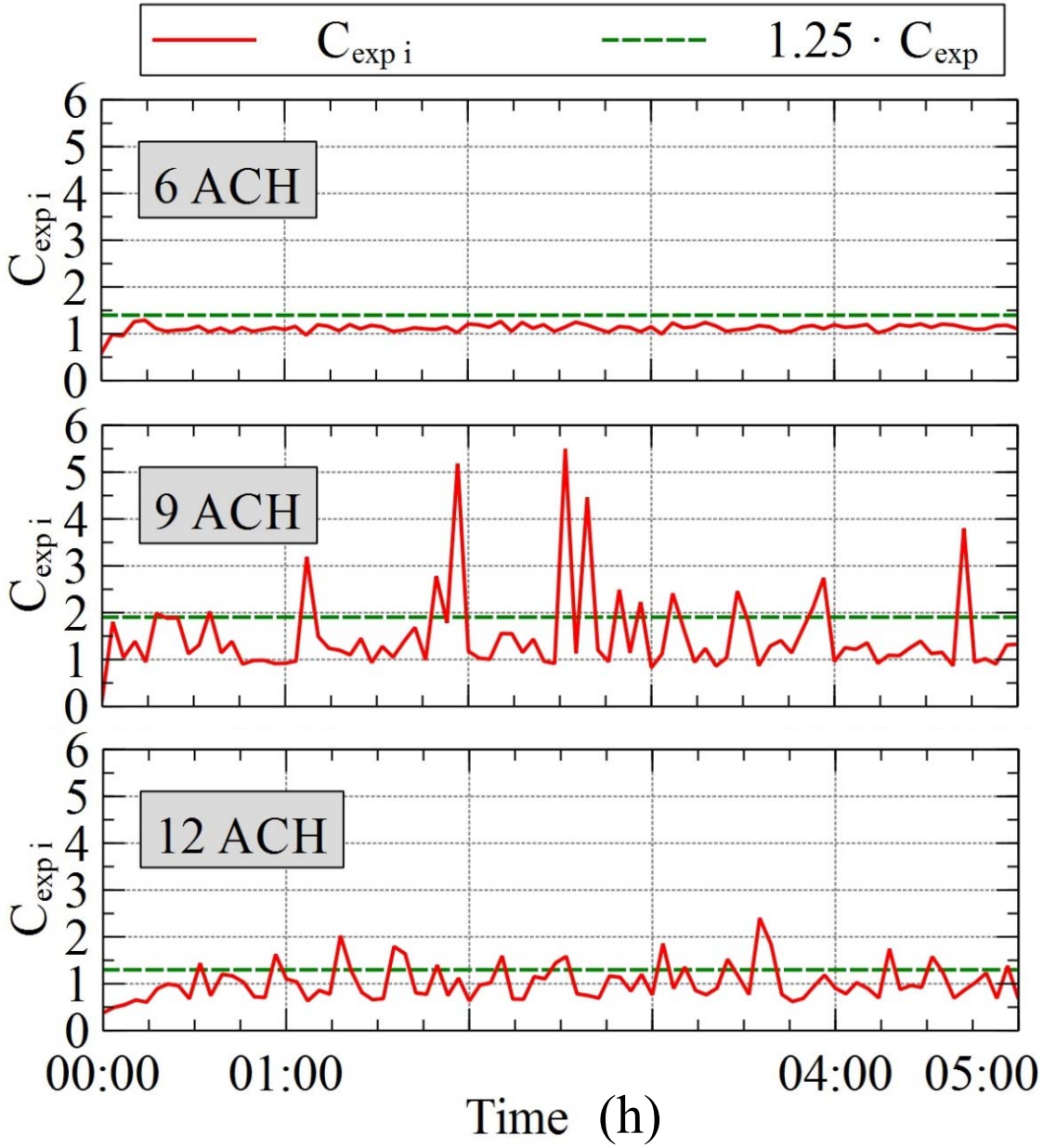
# IAQ asessment

| Local air quality index[1] | Exposure coefficient | Local maximum exposure coefficient |
|---|---|---|
| $\epsilon_p^c = \frac{c_e}{c_p}$ | $C_{exp} = \frac{c_p}{c_e}$ | $C_{exp,max} = \frac{\bar{c}_{p,max}}{c_e}$ |

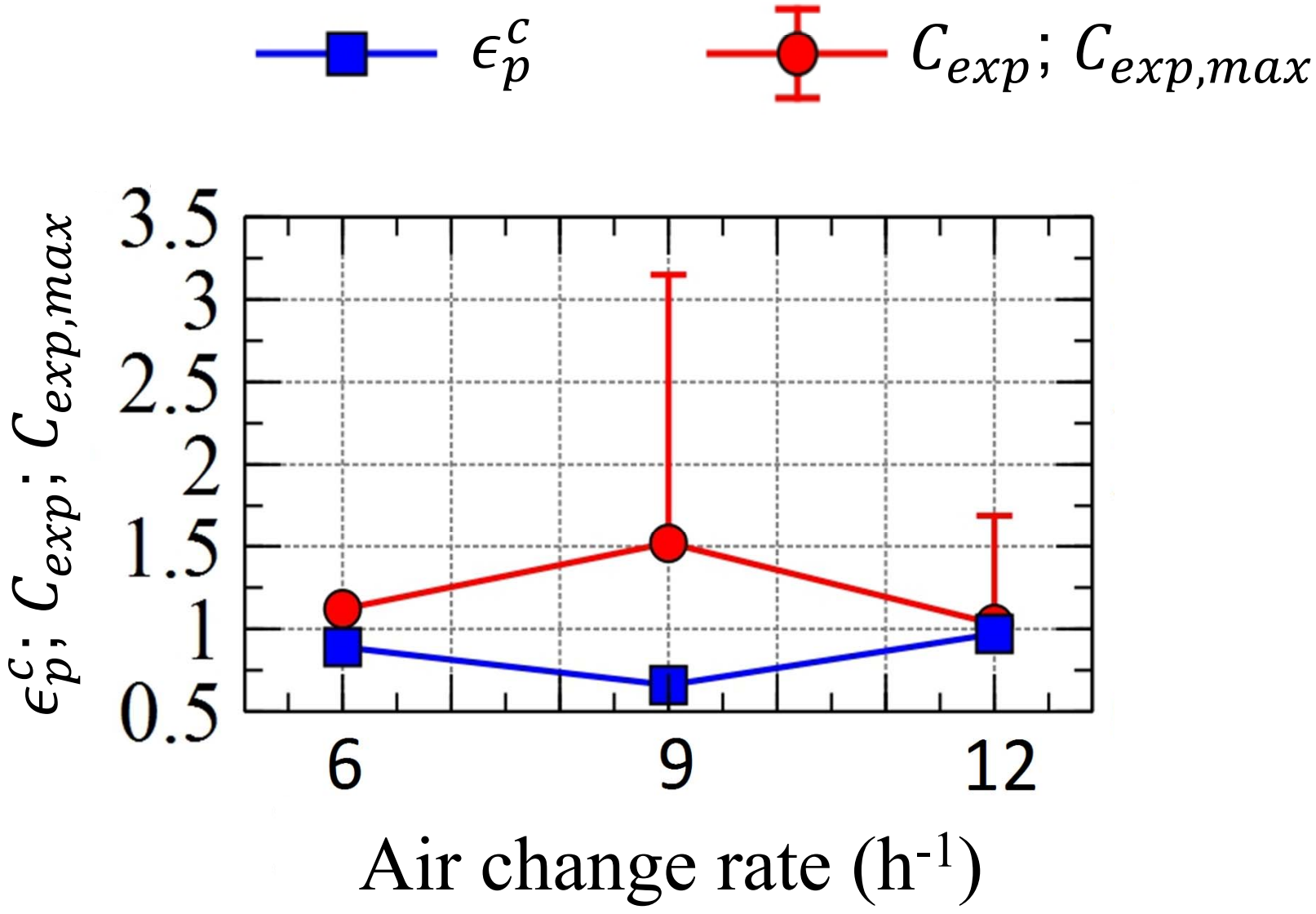
*(1) E. Mundt, H.M. Mathisen, P.V. Nielsen, A. Moser, Ventilation effectiveness, in: Rehva Guidebook No 2, Rehva, Brussels, 2004.*

# Results and discussion

# Exposure coefficient *vs*. time



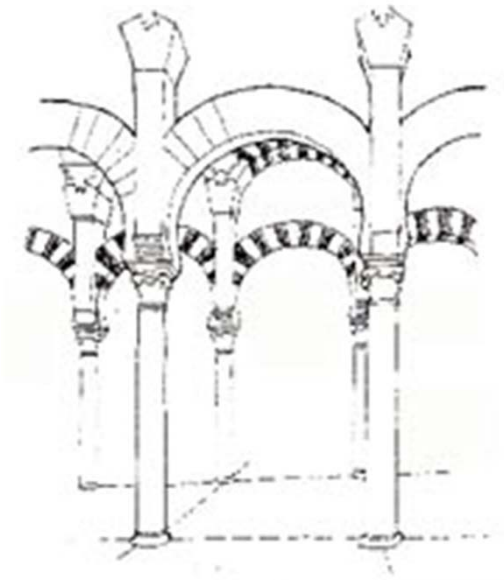
# IAQ indices *vs*. air changes rates



# Conclusions

# Conclusions

- Air instabilities (due to thermal plumes and air turbulences) can affect to the risk of airborne infection in hospital environments
- IAQ indices based on mean values concentration of contaminants could be not suitable to evaluate the risk of airborne infection when air instabilities are present
- IAQ indices related to peak exposure to contaminants could be used to improve the assessment of the risk of airborne cross infections in hospital environments




## Acknowledgements

GOBIERNO DE ESPAÑA · MINISTERIO DE ECONOMÍA, INDUSTRIA Y COMPETITIVIDAD · SECRETARÍA DE ESTADO DE INVESTIGACIÓN, DESARROLLO E INNOVACIÓN

**Research Proyect: DPI2014-55357-C2-2-R**

The authors acknowledge the financial support received from the Ministerio de Economia y Competitividad, Secretaría de Estado de Investigación, Desarrollo e Innovación, Spain, to the National R&D project TRACER with reference DPI2014-55357-C2-2-R,entitled "Ventilation system influence on airborne transmission of human exhaled bioaerosols. Cross infection risk evaluation." This project is cofinanced by the European Regional Development Fund (ERDF).


# Thank you for your attention!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