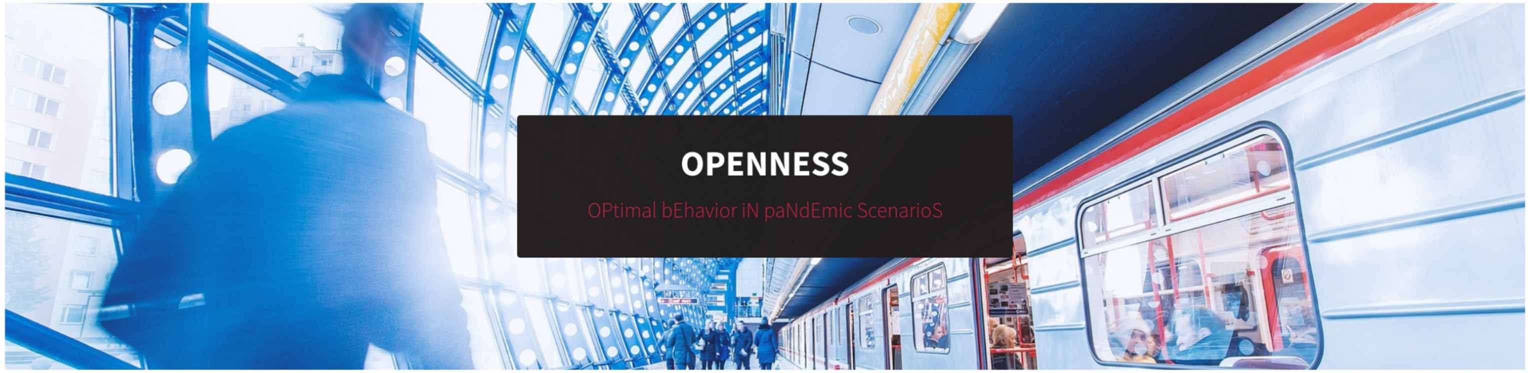


Consiglio Nazionale delle Ricerche

1921 UN SECOLO DI STORIA DAVANTI A NOI 2021

UNIVERSITÀ CATTOLICA del Sacro Cuore

Dr. Cosimo Savoia

Research Seminar – 13/09/2022

Goal and partners

The main goal of **OPENNESS** is to design and implement an AI decision support system to help experts in the prevention and control of epidemic and pandemic diseases; the support provided by the system consists in the elicitation of the behavioural rules that should be followed to reduce the spreading of an infectious disease within a given environment, or urban area.

Consortium

Partners:

Collaborators:

Project at a glance

Fact sheet

Grant Number	A0375-2020-36616
CUP	B85F21001280002
Official Start Date:	15th April 2021
Duration:	24 Months
Total investment:	€ 149.923,72
Grant:	€ 149.923,72
IASI-CNR's Grant:	€ 119.266,92
Università Cattolica Sacro Cuore's Grant:	€ 30.656,80

Founders

OPENNESS is a research project founded under the call: POR FESR LAZIO 2014-2020. Public Notice: "Progetti Gruppi di Ricerca 2020"

Contacts

- http://openness.iasi.cnr.it
- openness@iasi.cnr.it

REGIONE LAZIO | LAZIO EUROPA IL PORTALE DEI FINANZIAMENTI REGIONALI ED EUROPEI | PSR LAZIO PROGRAMMA DI SVILUPPO RURALE 2014 - 2020

Introduction and background

UCSC commitment to OPENNESS project:

Epidemiological evaluation of COVID-19 spreading within different indoor settings and the retrieving of mathematical models' biological and environmental parameters concerning indoor facilities, in order to assess, in a quantitative manner, the transmission of the disease in different contexts.

Background:

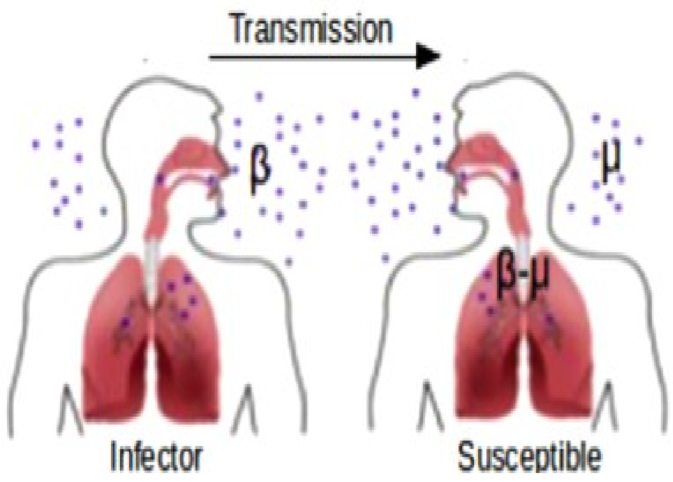
The main route of transmission of SARS-CoV-2 is airborne diffusion

(aerosol vs droplets?)

Most cases of transmission of SARS-COV-2 infection were observed in indoor environments.

Parameters influence this transmission:

- The physical characteristics of the indoor facility (such as ventilation, temperature, and humidity)
- The intrinsic characteristics of the individuals present in it (position and movement of the individuals, thus also interpersonal distance)
- The number of viral elements free in the environment in the form of droplets (viral quanta), inter-individual contact (time, distance, and type of contact)
- The individual susceptibility status and the personal protective equipment used



Methods

Research question:

What is the risk of COVID-19 transmission in indoor settings, such as confined urban settings, and what parameters influence the spread of COVID-19 within these type of environments?

Search string and eligibility criteria:

A search was conducted on PubMed, Scopus and ISI Web of Science.

The query adopted was: COVID-19 AND transmiss* AND (risk AND ("assessment" OR "estim*")) AND indoor* NOT outdoor*

Data extraction:

85 articles published in English between 2020 and 2022 on quantitative risk assessment of indoor airborne transmission of COVID-19. Of these, 2 articles were selected; each article provides a different type of mathematical model as an example, considering similar parameters in the analysis of COVID-19 spreading in indoor different settings: a probabilistic model (by Parhizkar et al., 2021) and a deterministic model (by Buonanno et al., 2020)

Results: transmission characteristics of COVID-19

Biological parameters:

- Viral biological parameters and exposure time:
  - Diameter of the virus (~100nm): viral load
  - Viral quanta
  - Exposure time
- Individual biological parameters:
  - Individual susceptibility and personal protective equipment used
  - Type of contact
  - Contact time
  - Displacement of the individual
  - Interpersonal distance

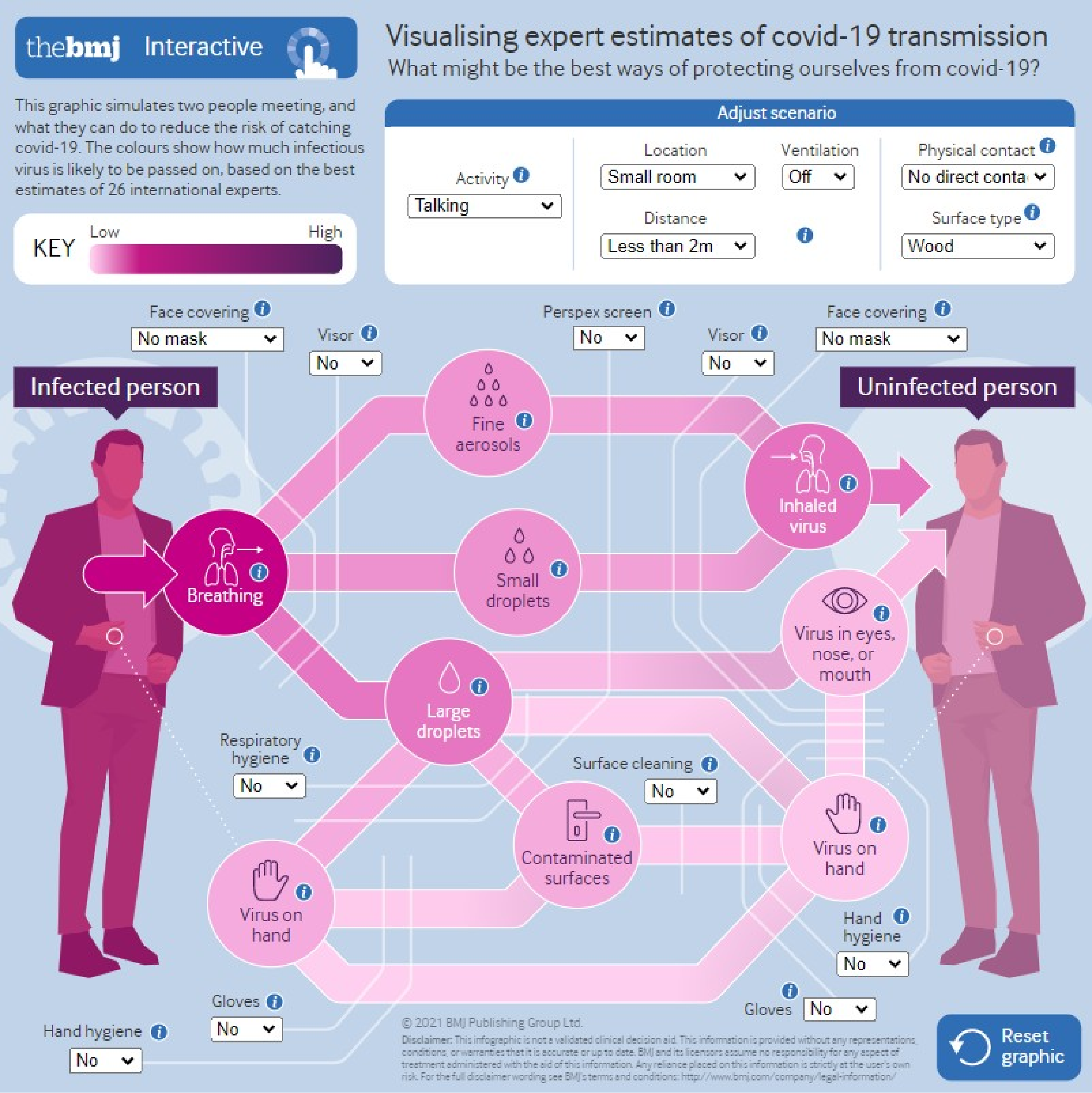
Environmental parameters:

- Ventilation
- Temperature
- Humidity

Results: measures to be taken to mitigate COVID-19

As a result of the analysis implemented in the previous section, several measures can be taken to attempt to mitigate viral transmission:

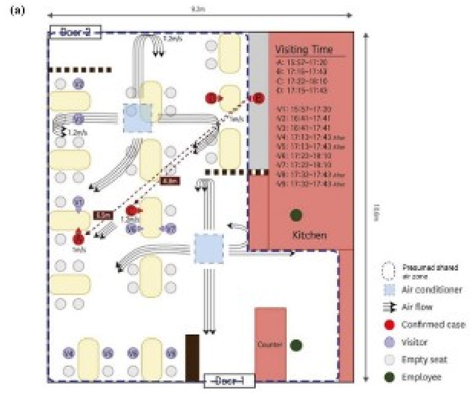
- Airflows: aerosols and droplets vs airflows. It is important to maintain abundant and constant airflows in terms of direction and time
- Distance: the greater the distance from the source of infection, the lower the chance of infection
- Maintaining a constant degree of humidity: around 60% in the room within the acceptable range for thermo-hygrometric comfort.
- Maintaining a constant degree of temperature: an acceptable environmental temperature let to reduce the drying of droplets and the number of respiratory act.
- Displacement of the individual: individuals should be allowed to move as little as possible
- Clean hands or contaminated objects before they come into contact with mucous membranes.

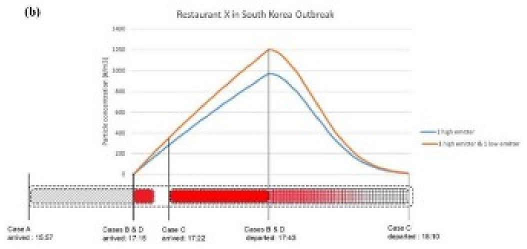


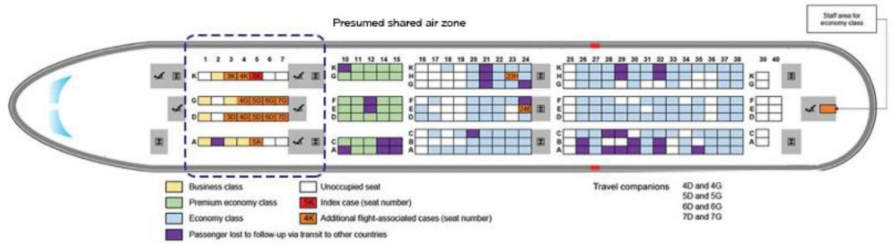
Differences between **probabilistic** and **deterministic models** on COVID-19 transmission

Deterministic/mechanicistic model features by Parhizkar et al.

- Individuals divided into 2 groups:
  - High emitters: coughs 8 times per hour: each cough emits 54,000 particles and size resolved number of cough particles defined by case #8 in Lindsley et al. (2012). The emitter spends 20% of the event time speaking at an elevated amplitude with size-specific emissions as per Asadi et al. (2019)
  - Low emitters: same as high emitter but without cough and median amplitude
- Scenario evaluation: 4 different COVID-19 outbreaks considered
  - Bus Riders in Eastern China
  - Two Choir Rehearsals in Skagit Valley
  - 10-hour Flight from London to Hanoi (figure in the corner)
  - Restaurant in South Korea (figure on the right)
- Aerosol infection transmission risk estimation model: considered equations
  - Time-dependent Particle Number Concentration:
  - Deposition of Particles in the Respiratory System:
- Outcome: estimation of the probability of infection





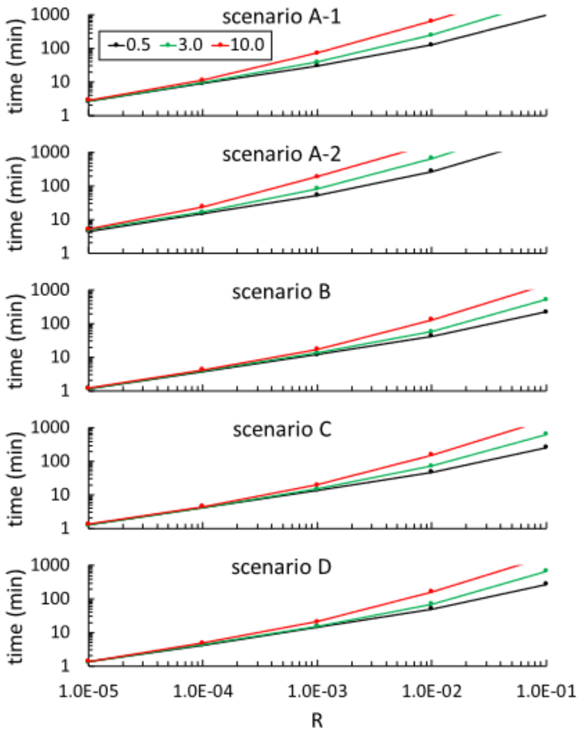


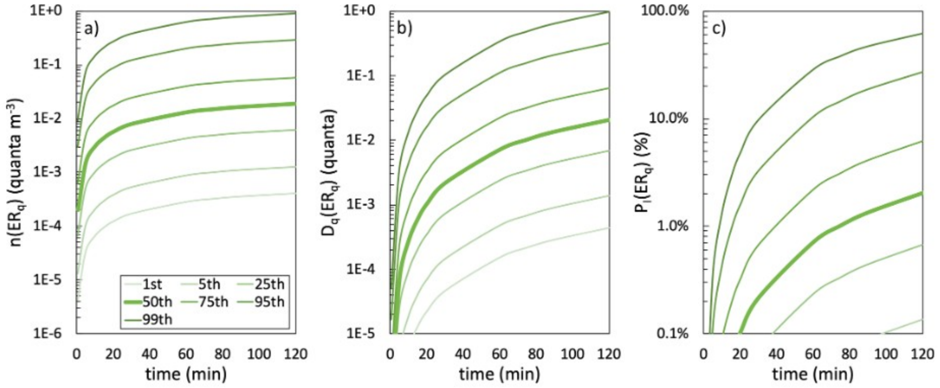
Differences between **probabilistic** and **deterministic models** on COVID-19 transmission

Probabilistic model features (by Buonanno et al.):

- Individuals divided in different emission profiles, evaluated as combination of expiratory activities and activity levels:
  - Oral breathing during resting
  - Oral breathing during heavy activity
  - Speaking during light activity
  - Singing (or loudly speaking) during light activity
- Four-step approach to quantify the probability of infection:
  - Evaluation of the quanta emission rate:
  - Evaluation of the exposure to quanta concentration in the micro-environment:
  - Evaluation of the dose of quanta received by an exposed susceptible subject:
  - Estimation of the probability of infection based on a dose–response model:
- Scenario evaluation: different considered scenarios (figure on the right)
  - Hospital room (Scenario A)
  - Gym (Scenario B)
  - Public indoor environments [e.g., restaurant, bank] (Scenario C)
  - Conference room or auditorium (Scenario D)
- Outcome: trends of quanta concentration, dose of quanta, and probability of infection as a function of time and quanta emission rates resulting from the Monte Carlo simulation

  (figure in the corner: quanta concentration (a), dose of quanta (b), and probability of infection (c) as a function of time (here shown for 2 h of exposure) and quanta emission rates resulting for exposure scenario D)





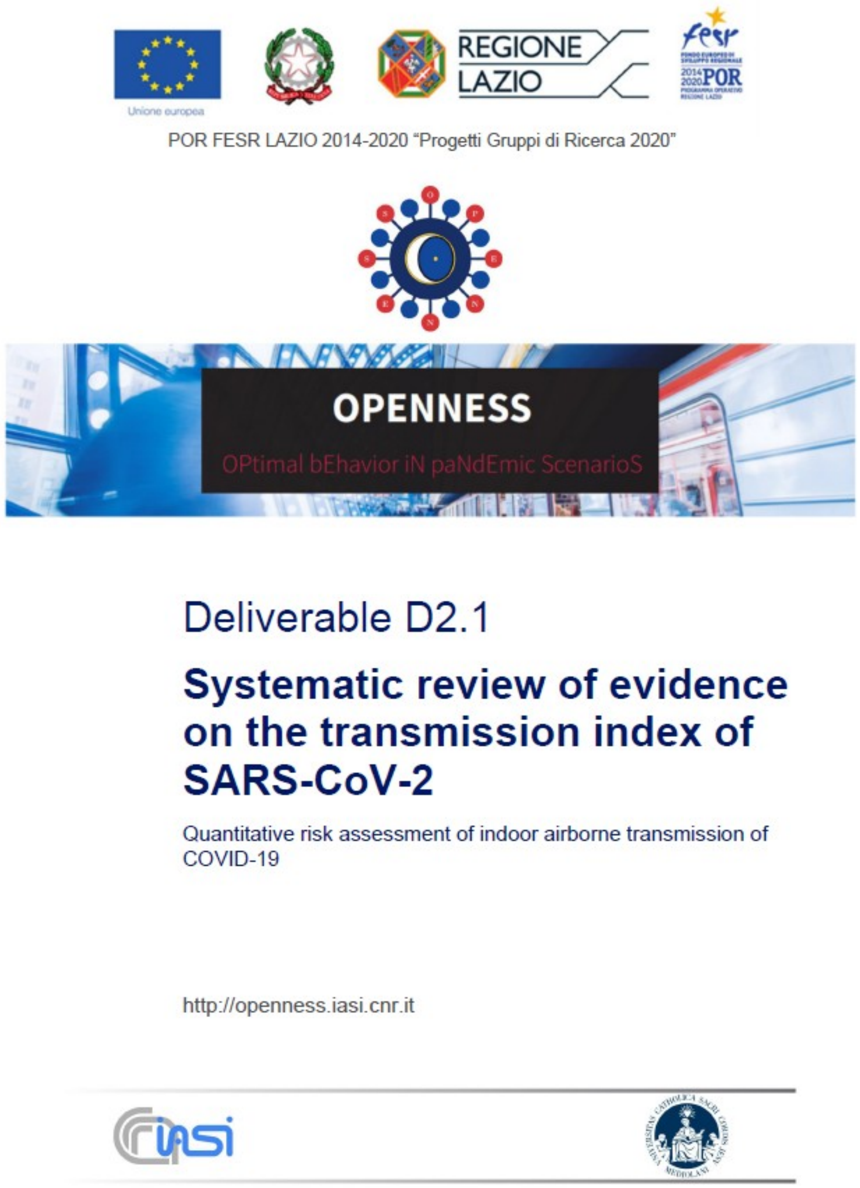
Conclusions

Differences between deterministic and probabilistic models: pros and contros

Mechanistic models are more able, than standard probabilistic models, to account for particle deposition to indoor materials, filtration, and deposition of particles in the respiratory system of receptors.

In addition, they provide added insights into how building-related factors affect relative infection risk associated with inhaled deposited dose.

Probabilistic models, on the other hand, are more helpful and offer more accurate findings in environmental conditions where parameters are less clearly specified or in specific types of settings where deterministic models have not been tried.



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POR FESR LAZIO 2014-2020 "Progetti Gruppi di Ricerca 2020"

OPENNESS

OPtimal bEhavior iN paNdEmic ScenarioS

Deliverable D2.1

Systematic review of evidence on the transmission index of SARS-CoV-2

Quantitative risk assessment of indoor airborne transmission of COVID-19

http://openness.iasi.cnr.it

Deliverable D2.1 – completed on July 2022

Deliverable D2.2 – work in progress deadline on November 2022


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OPENNESS

OPtimal bEhavior iN paNdEmic ScenarioS

Deliverable D2.2

Transmission index of SARS-CoV-2 in different environmental and urban settings

Quantitative risk assessment of indoor airborne transmission of COVID-19

http://openness.iasi.cnr.it

Many thanks to all my team!

Professor Stefania Boccia

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Dr. Flavia Beccia, Dr. Francesco A. Causio

Dr. Sara Farina, Dr. Tommaso Osti, Dr. Nicolò Scarsi