

# Airborne virus exposure mitigation: advancing RPE testing with a fluorescent tracer

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ISES Europe Workshop 2024

O9: Exposure at school and public spaces

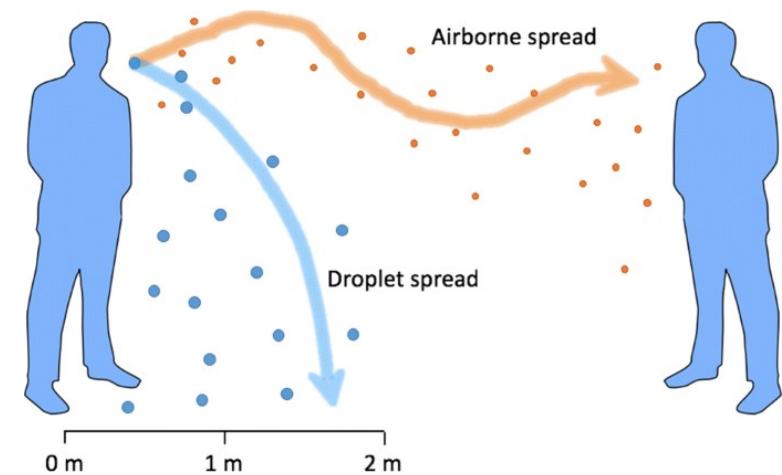


## ADVANCING RPE TESTING WITH A FLUORESCENT TRACER

### INTRODUCTION

- The COVID-19 pandemic revealed gaps in understanding airborne virus transmission
- Current European standards (EN149:2001 + A1:2009) do not cover exposure to viruses
- Understanding of the role of aerosols may lead to more effective mitigation strategies

Mitigation Strategies for Airborne Infection Control (MIST)  
By the Dutch Research Council (NWO)

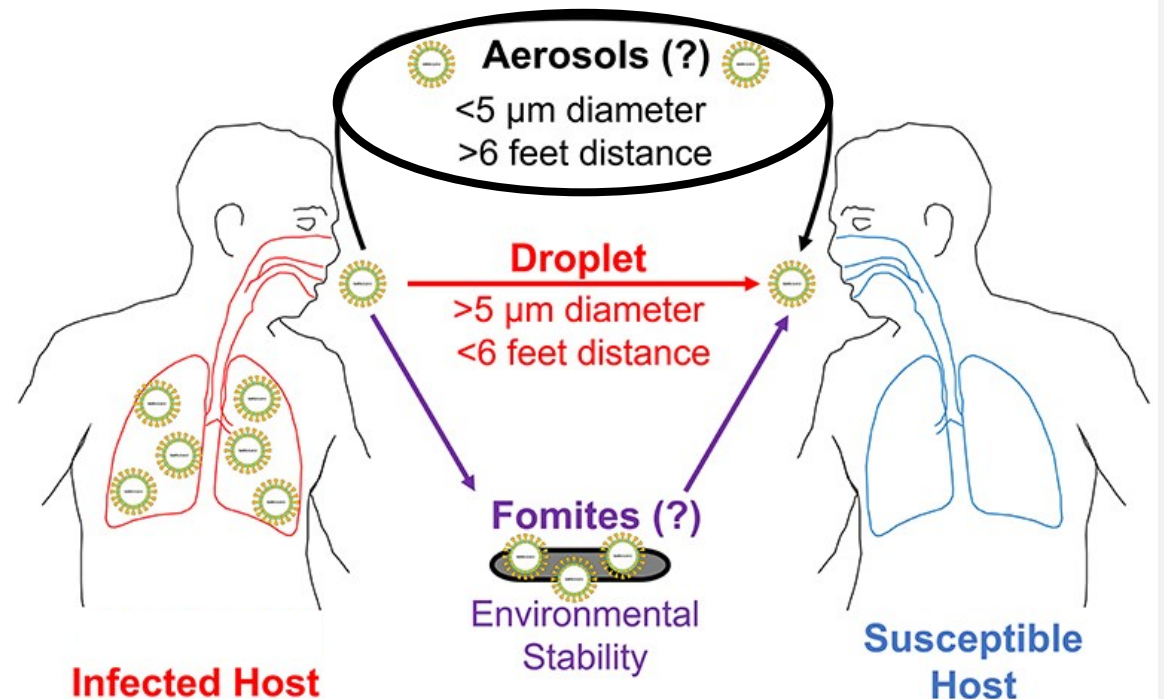


Source: Božič & Kanduč, 2021

## ADVANCING RPE TESTING WITH A FLUORESCENT TRACER

### INTRODUCTION

- Aerosols (< 5  $\mu\text{m}$ ) carry viruses over distances greater than 1.5 m (6 ft)
- The influence of environmental conditions on infection risk
- Exploring the presence, transmission, and dynamics of aerosols as carriers of viruses



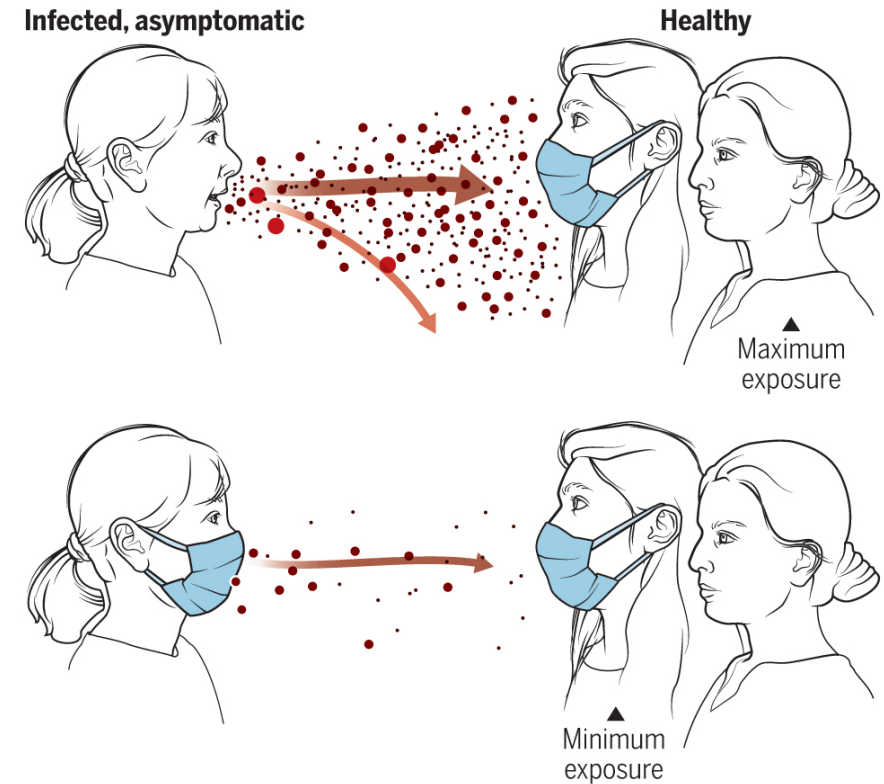
Source: Galbadage et al., 2020

# ADVANCING RPE TESTING WITH A FLUORESCENT TRACER

## INTRODUCTION

### Respiratory Protective Equipment (RPE)

- Specifically face masks (e.g., FFP2 respirators or surgical masks)
- Dispersion (shedding) of expelled droplets at home, on the workplace or in public space such as public transportation and schools
- Estimation of the virus load of water droplets
- Viral load of body fluids (e.g., in 'super spreaders')
- Threshold of infection
  - Depending on host factors
- Face mask fit and filtration performance testing of different types of face mask designs



Source: Prather et al., 2020

## ADVANCING RPE TESTING WITH A FLUORESCENT TRACER PREVIOUS RESULTS

Total Inward Leakage (TIL) is defined as the combination of

- Face seal leakage
- Penetration through the filter

TIL has already been investigated in previous research

- 17.7% lower TIL in surgical masks at 30 cm
- 21.7% lower TIL in surgical masks at 60 cm



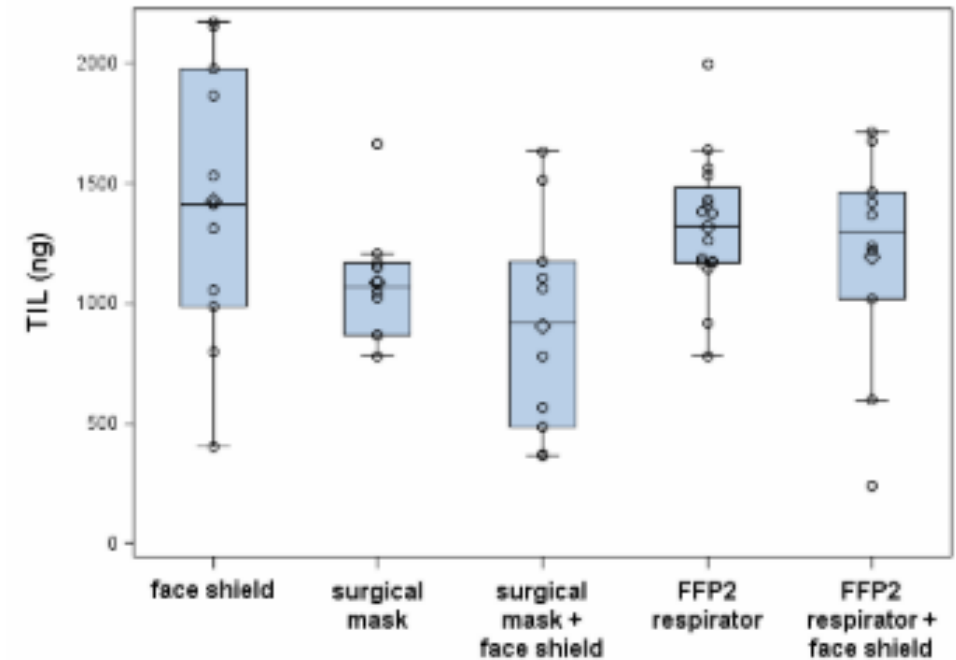
International Journal of  
*Environmental Research  
and Public Health*



Article

### Comparative Performance Testing of Respirator versus Surgical Mask Using a Water Droplet Spray Model

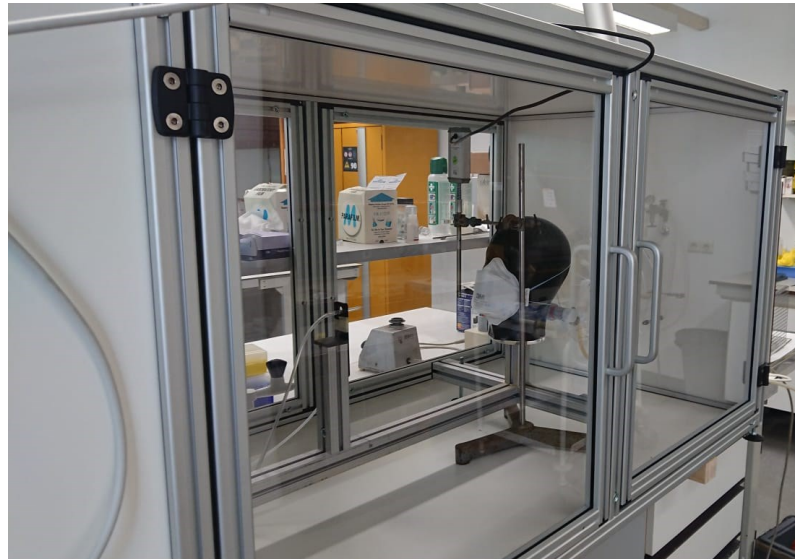
Paul T. J. Scheepers <sup>1,\*</sup>, Heiman F. L. Wertheim <sup>2,3,†</sup>, Maurice van Dael <sup>1</sup>, Rob Anzion <sup>1</sup>, Henk Jan Holterman <sup>4</sup>, Steven Teerenstra <sup>5</sup>, Martijn de Groot <sup>6</sup>, Andreas Voss <sup>2,3,7</sup> and Joost Hopman <sup>2,3</sup>



Source: Scheepers et al., 2021

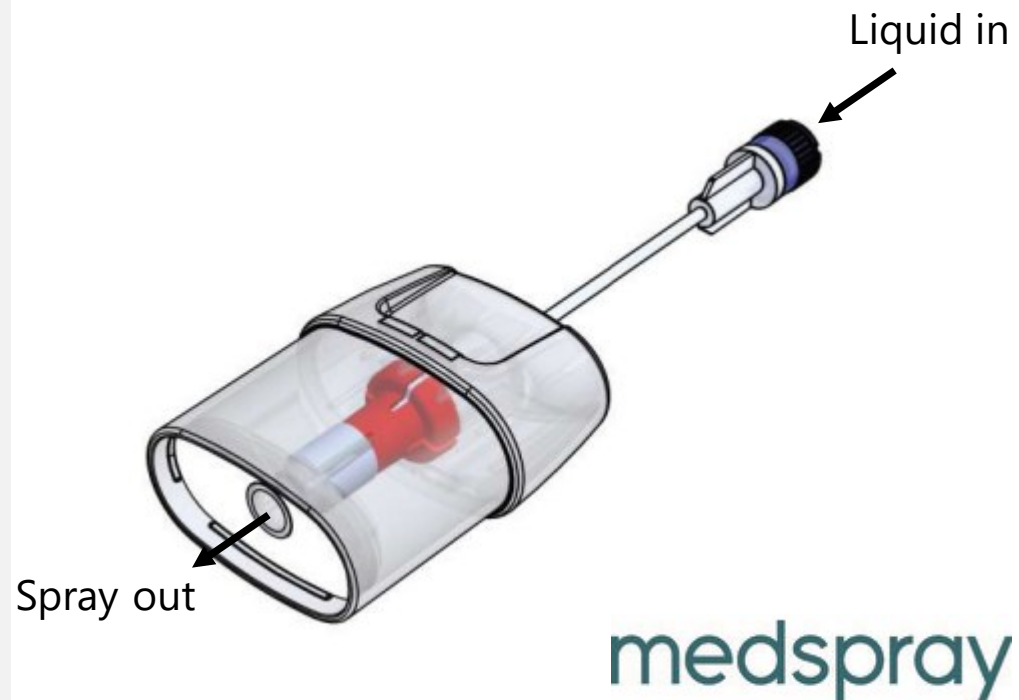
## ADVANCING RPE TESTING WITH A FLUORESCENT TRACER METHODS

- **RPE testing** based on the use of fluorescein, a fluorescent tracer
  - Tracer-calibrated performance testing does not require Biological Safety Laboratory (BSL)
- The sum of filter penetration and face seal leakage was assessed
- Recovery of the fluorescein tracer on a membrane filter was determined



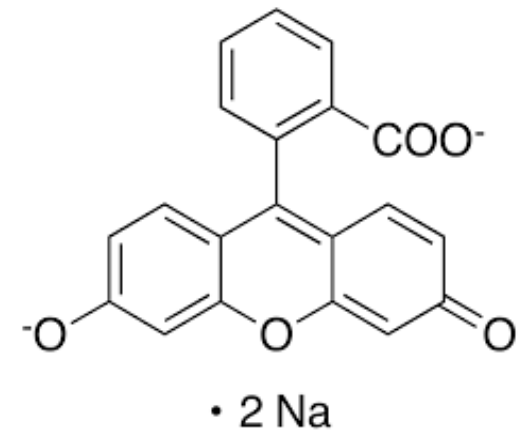
## ADVANCING RPE TESTING WITH A FLUORESCENT TRACER METHODS

- Generation of inhalable droplets by the Pulmospray® **nebulizer** from MedSpray®
  - Particle size ranging from 6.5 to 14.8  $\mu\text{m}$



## ADVANCING RPE TESTING WITH A FLUORESCENT TRACER METHODS

IUPAC name:	Disodium;3-oxospiro[2-benzofuran-1,9'-xanthene]-3',6'-diolate
Molecular formula:	$C_{20}H_{10}Na_2O_5$
CAS:	518-47-8
Molecular weight:	376.3 g/mol
Water solubility:	Approximately 100 mg/mL at 20°C
Vapor pressure:	Negligible
Use:	Diagnostic aid in corneal injuries and corneal trauma Approved for use in externally applied drugs and cosmetics
Fluorescence:	Excitation 498 nm and emission 517 nm Note: <b>Fluorescein</b> can be visualized when in water solution (dried fluorescein is not fluorescent)





## ADVANCING RPE TESTING WITH A FLUORESCENT TRACER METHODS

- Compare several face masks with the **Sheffield dummy head**
  - Nebulizing fluorescein at 10 cm
  - Detecting fluorescein in samples with a plate reader



Surgical mask



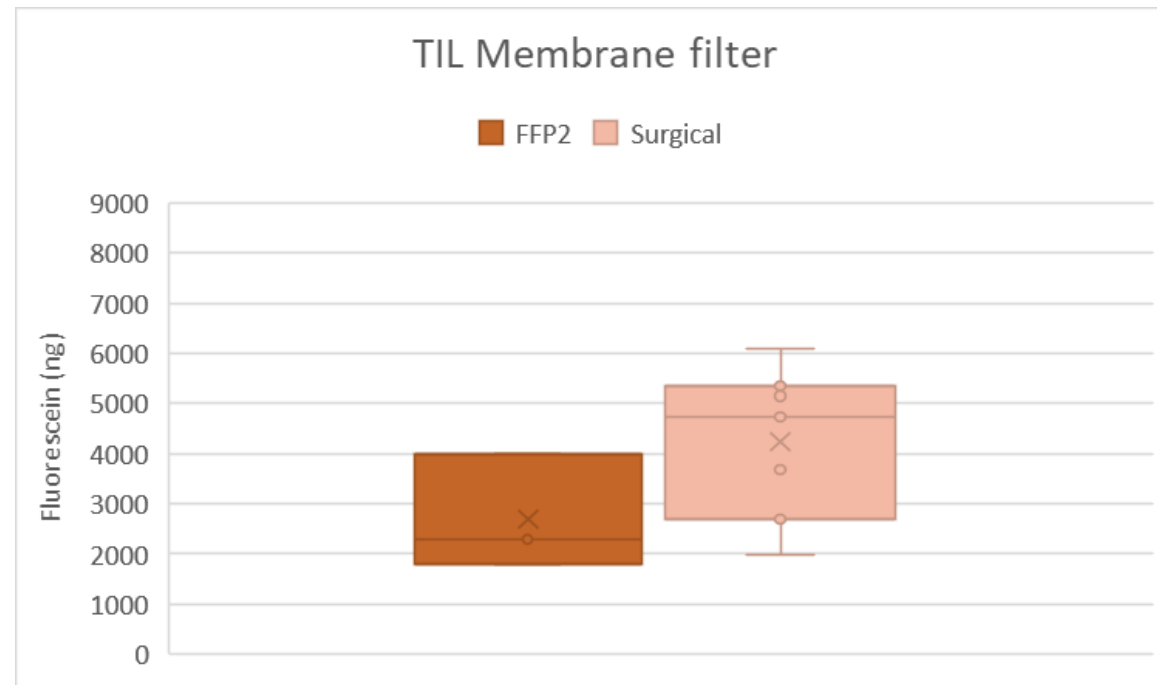
FFP2 respirator



Sheffield dummy head:  
*EN 149:2001 standard*

## ADVANCING RPE TESTING WITH A FLUORESCENT TRACER RESULTS

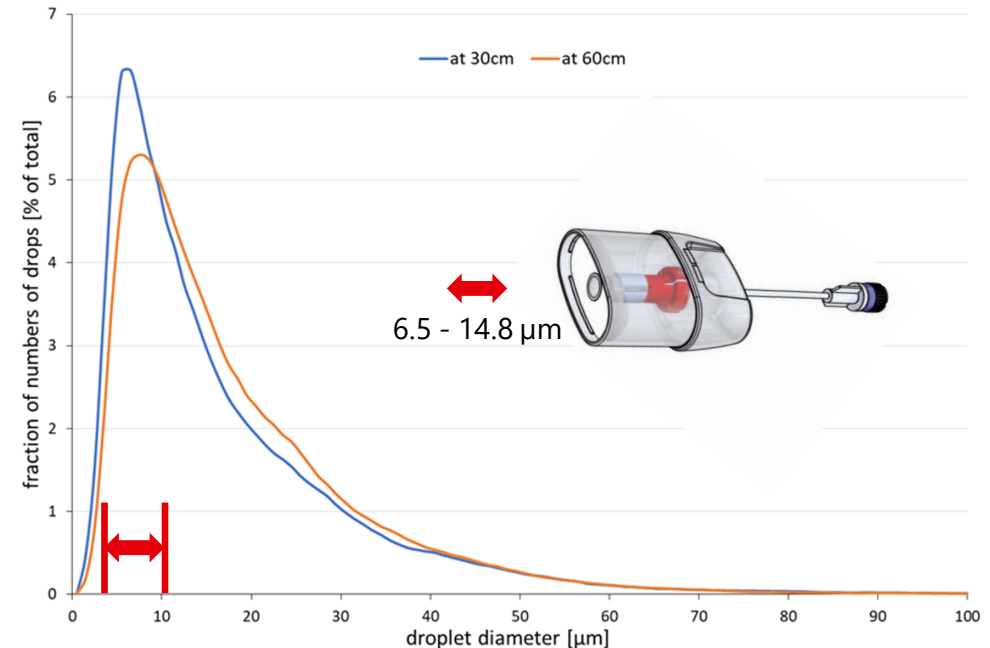
- TIL of FFP2 respirators (N=3) vs. surgical masks (N=7) tested at close range (10 cm)
  - 57.4% higher leakage in surgical masks compared to FFP2 respirators
  - Overall efficiency of 97.3 and 98.3%



## ADVANCING RPE TESTING WITH A FLUORESCENT TRACER

### DISCUSSION AND CONCLUSION

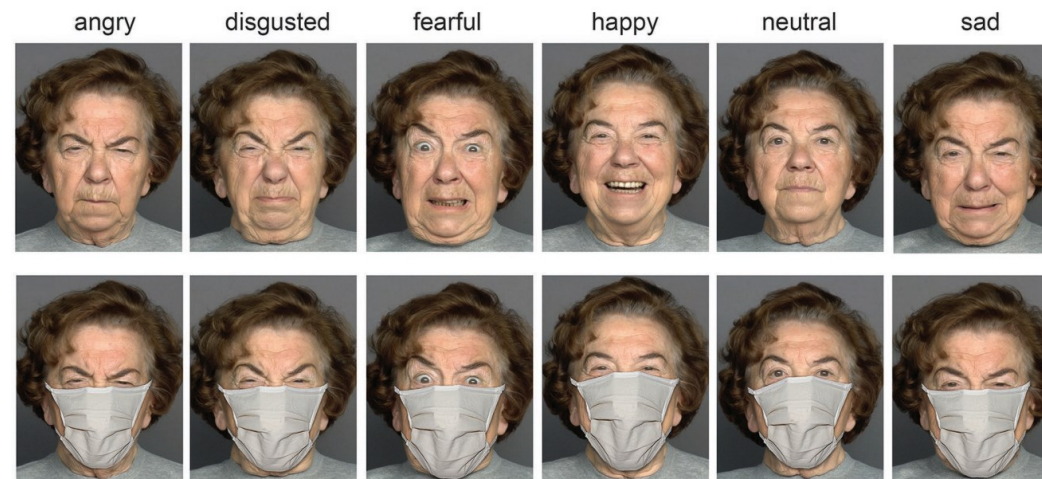
- We observed a 58% higher TIL in surgical masks compared to FFP2 masks
- Preliminary research showed that surgical masks had a 17.7% lower TIL compared to FFP2 face mask at 30 cm distance and 21.7% lower at 60 cm
  - Studies differ in distance to the source and the droplet size distribution
- The use of a fluorescent tracer may be considered as a new approach to test RPE for virus protection efficacy



Source: Scheepers et al., 2021

## ADVANCING RPE TESTING WITH A FLUORESCENT TRACER FUTURE RESEARCH

- Performing TIL tests at larger distances to the source, in a new refined measurement set-up with increased reproducibility
- Drafting the study proposal for the human volunteer study
  - Study person-to-person variability due to face-seal leakage

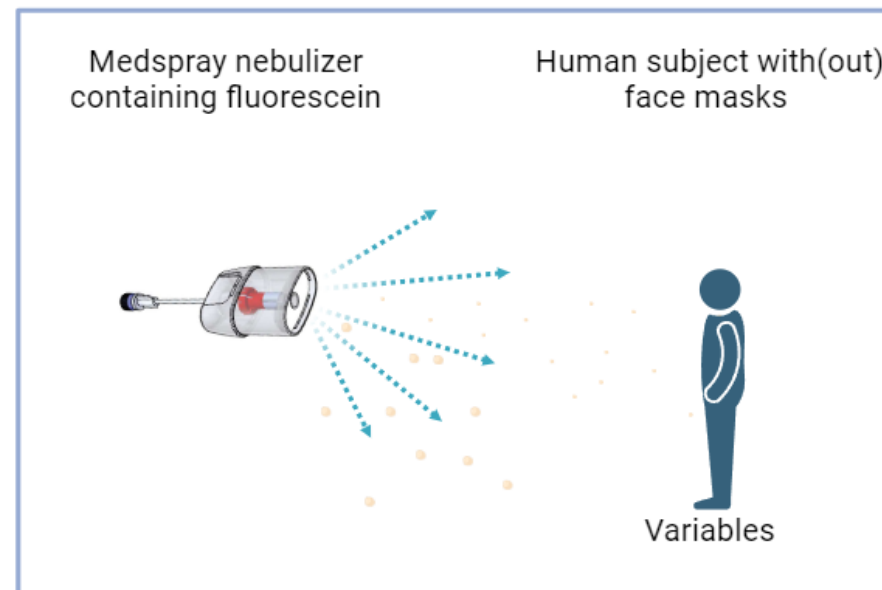


Source: Carbon, 2020

## ADVANCING RPE TESTING WITH A FLUORESCENT TRACER FUTURE RESEARCH

- Set-up for face mask leak testing in human volunteers
  - Development of a risk assessment approach to the infection risk in populations using developed methodology in chemical risk assessment

### Total inward leakage study



## ADVANCING RPE TESTING WITH A FLUORESCENT TRACER

### TAKE HOME

- Virus load can be studied using fluorescent tracer (no BSL needed)
- Filtration efficiency and face seal leakage of face masks depend on
  - Particle size distribution of the water droplet spray
  - Distance from the source
- Next steps
  - Calibrate fluorescein tracer concentration with SARS-CoV-2 virus load
  - Study shedding by humans breathing, talking, coughing, etc.
  - Move from Sheffield head to testing face masks on human volunteers
  - Study face seal leakage dependent on facial biometrics and growing a beard

## ACKNOWLEDGMENTS

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### MIST consortium



Thank you for your attention!

Questions?