PROTECT
A COVID-19 National Core Study

The role of environmental assessment in workplace COVID-19 outbreak investigation to understand SARS-CoV-2 transmission

PROTECT COVID-19 CONFERENCE

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HSE

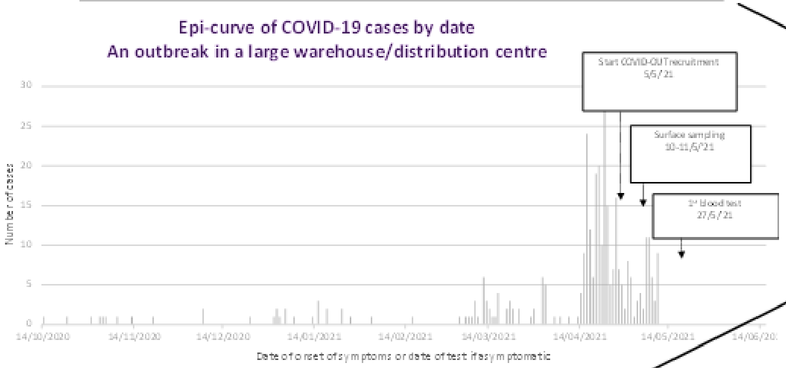
Background

In the UK, investigation of COVID-19 workplace outbreaks are undertaken by public health bodies and regulators…..but they do not necessarily collect consistent information across outbreaks and data quality can vary, limiting meaningful analysis

COVID-OUT plan – **to develop and deploy a methodology to collect a consistent and comprehensive set of data in a systematic way from workplaces that are experiencing an outbreak**

Data Framework

Outbreak investigation
- Contextual information
- Detailed list of positive cases



Surface sampling

Company testing data (de-identified)

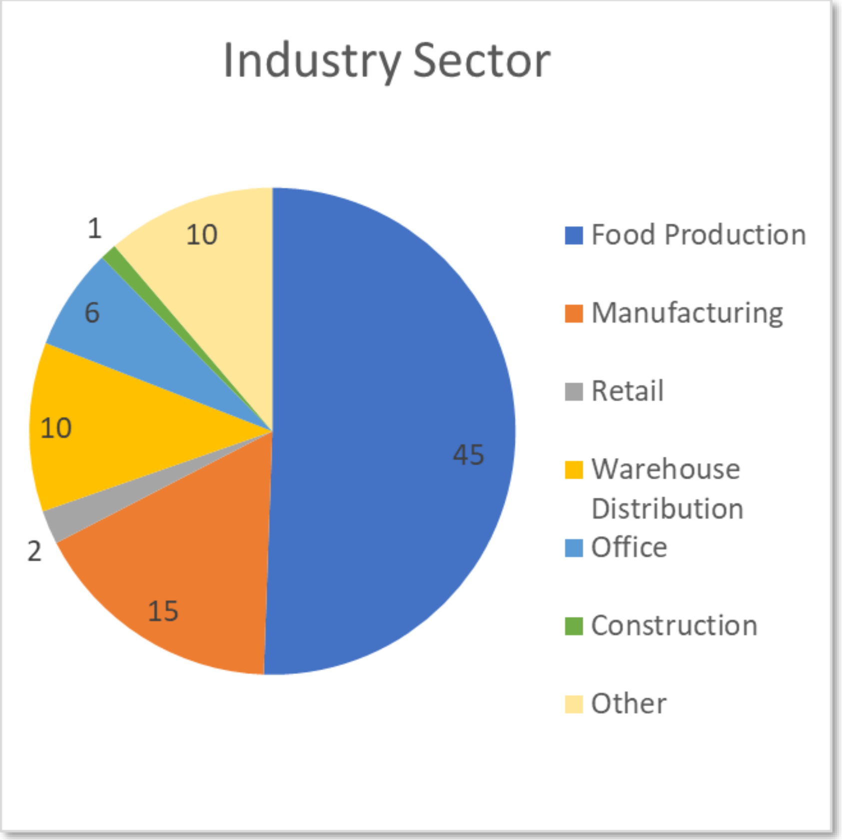
COVID-OUT

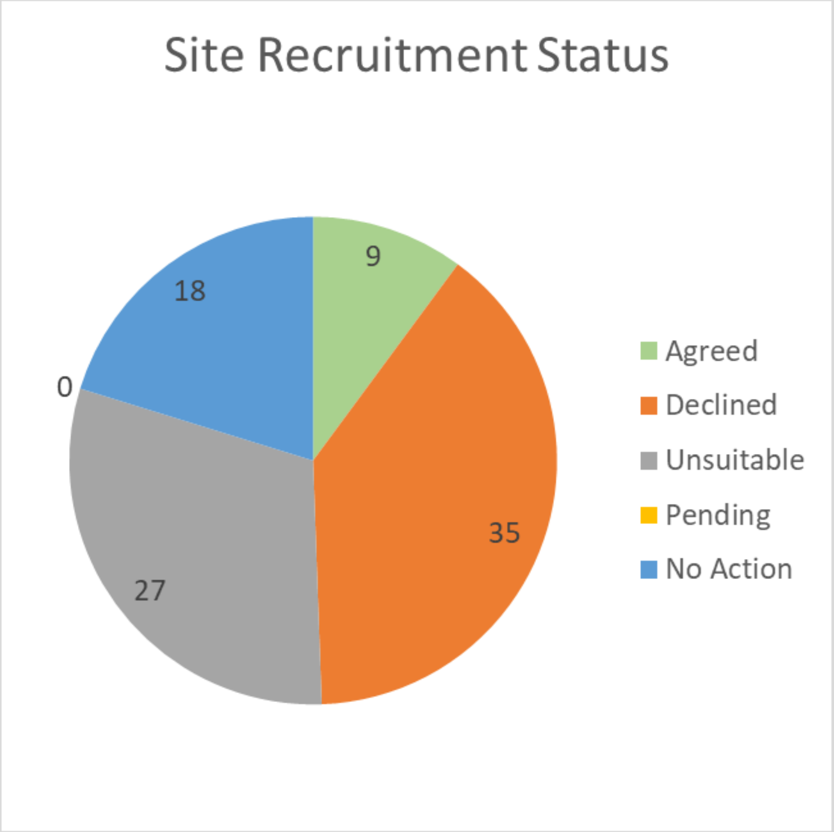
Environmental assessment
- Workforce details
- Outbreak details
- Detailed site description:
- Maps, worker activity levels, access control, cleaning regime, temperature humidity, noise levels, ventilation

Participant data
- Questionnaires
- Blood tests
- Nose and throat swabs
- Hand wipes

Progress (13th Oct 2021)

Total number of outbreak notifications 89, of which 48 were contacted





Insights

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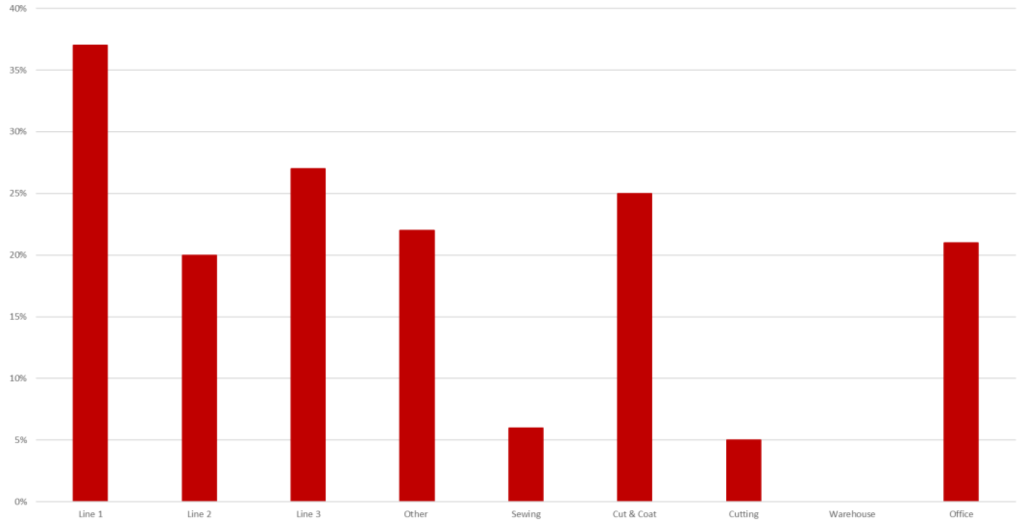
Outbreak in general manufacturing premises in East Midlands, UK (March – April 2021)

Heterogeneous attack rate in different work areas

CO_2 levels in all areas were low (<700ppm), indicating adequate ventilation

Attack rate higher in more densely populated areas

Low-level of environmental contamination (Ct values > 32.0)



Attack rates by work area for all employees, as reported by the employer

Insights

Outbreak in office environment – August 2021

High degree of public facing activity

Attack rate approx. 50%

Some mobile staff moving around the workplace

Surface contamination in localised areas – additional cleaning

Rapid communication in advanced state of drafting

Insights – social distancing

Frequently not achieved in manufacturing

Difficult to re-arrange complex production areas containing large items of fixed equipment

Noise and face coverings combined impair verbal communication

Control ‘fatigue’ ?

Insights – ventilation

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COVID General Ventilation Initial Assessment Tool

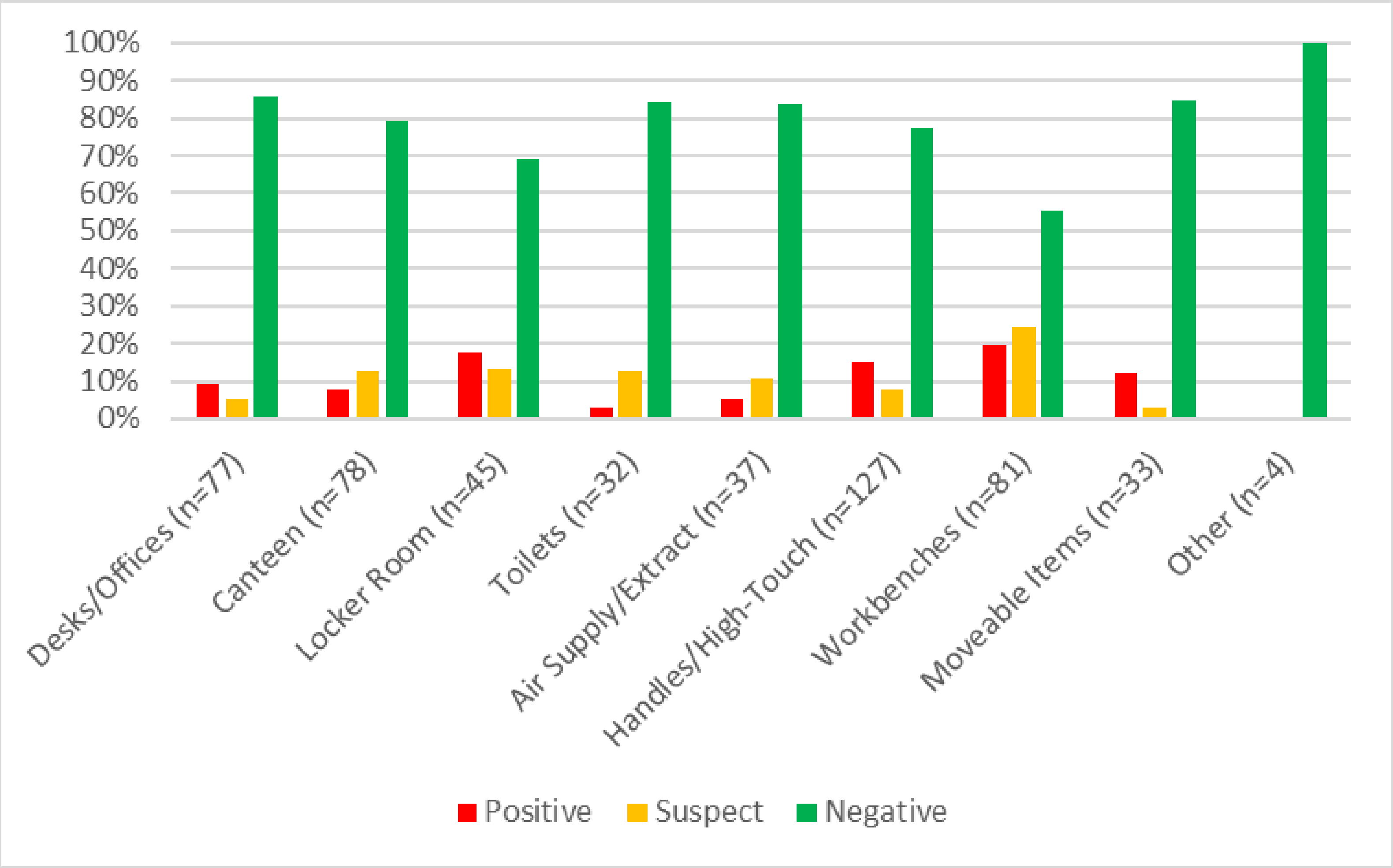
BREATHE FREELY

Workspace	Size of Workspace	Population Density	Ventilation Provision	Score (level of risk)
Modern Office	150m² x 3m height	Moderately populated	HVAC on recirculation	1 (very poor ventilation)
Apprentice Classroom	55m² x 2.2m	Moderately populated	Partial Open Windows	3 (poor ventilation)
Large Production Space (metal fabrication hall)	300m² x 7m	Sparsely populated	Open Windows, Open wall vents	6 (satisfactory ventilation)
Canteen/Break room	80m² x 2.2m	Densely populated	Windows open with insect screens	2 (very poor ventilation)

BOHS British Occupational Hygiene Society
The Chartered Society for Worker Health Protection

Possibly the biggest challenge in terms of risk control

Surface sampling



Summary

Study recruitment – very challenging

Environmental assessment – very challenging

BUT

Summary

Real world insights add detail and ‘colour’ to epi studies, support the development and validation of models, support the production of improved (audience appropriate) risk control guidance and help to triangulate findings from other parts of PROTECT

Collaborators

HSE - Chris Keen, Vince Sandys, Andrew Simpson, Yiqun Chen, Gillian Frost, Joan Cooke, Matthew Coldwell, Derek Morgan, Chris Barber, Adam Clarke, Gary Dobbin, Helen Beattie

UKHSA – Barry Atkinson, Allan Bennett, Christina Atchison, Hannah Higgins, Alice Ibbotson, Helen Collins, Alice Graham

LSHTM – Elizabeth Brickley, Amber Raja, Tony Fletcher, Karin van Veldhoven, Neil Pearce

UoM – Martie van Tongeren, Aparma Verma, Sarah Rhodes

References

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Keen C, Sandys V, Simpson A, *et al.*: Environmental assessment data collection framework - COVID-OUT study. 2021. http://www.doi.org/10.17605/OSF.IO/GPBY8

Keen C, Sandys V, Cooke J, *et al.*: Information Sheet for Employers - COVID-OUT study. 2021. http://www.doi.org/10.17605/OSF.IO/7A285

Chen Y, Curran A, Atchison C, *et al.*: Information Sheet for Workers - COVID-OUT study. 2021. http://www.doi.org/10.17605/OSF.IO/GDXCN

Frost, G., Brickley, E. B., Graham, A., Higgins, H., Raja, A., & Chen, Y. (2021, October 5). Epidemiological data collection framework - COVID-OUT study. https://doi.org/10.17605/OSF.IO/3BE9V

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Thank you

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Modelling the physics of aerosol and droplet dispersion

Simon Coldrick

Theme 2, WP2.2.1

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WP2.2.1

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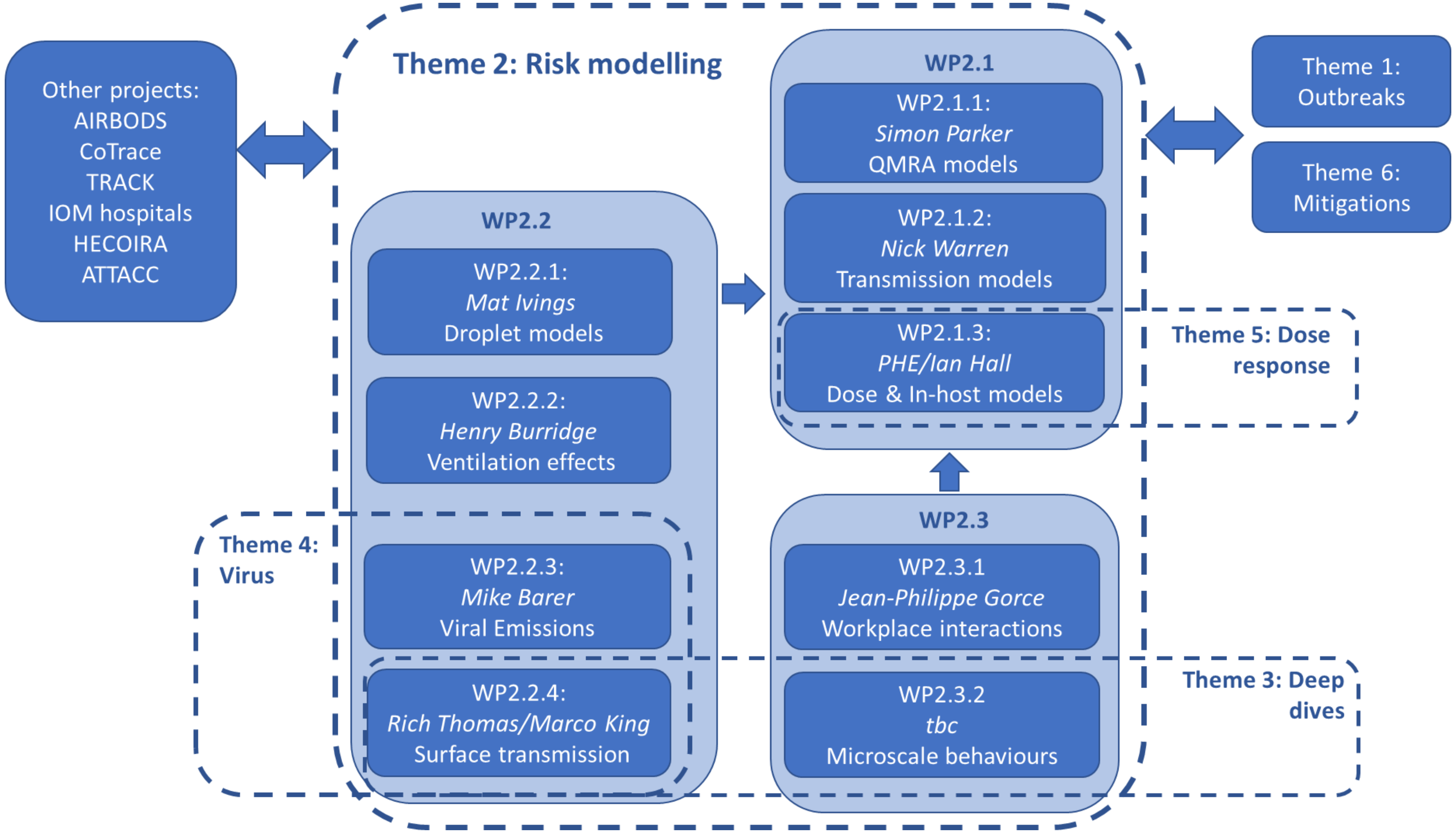


Contents

Aims

CFD modelling of exhalations

Application of the model

Conclusions

Aims

- To understand and characterise respiratory droplet dispersal

Example research questions

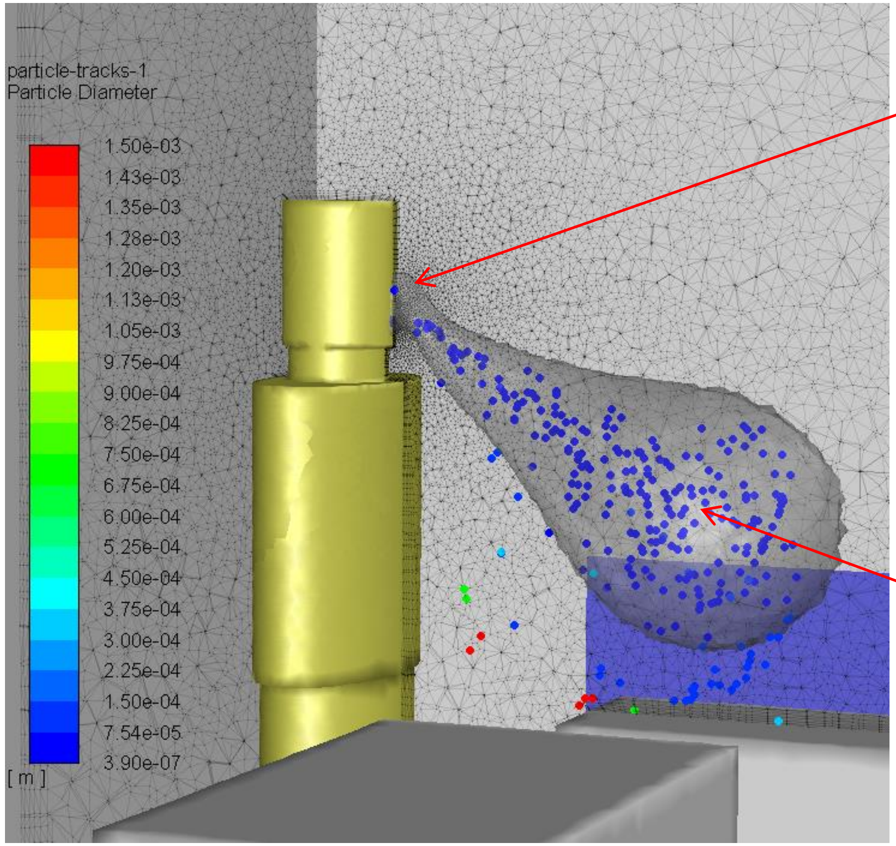
- What are the important fluid dynamics processes affecting dispersion of droplets?
- How effective are screens in reducing the risk of transmission?
- What affect do ambient temperature and humidity have on droplet distance travelled?
- What are the effects of distancing and ventilation?

Approach

- Develop a detailed CFD model that takes into account the key physics of the transport and dispersion of droplets emitted when a person is talking or coughing
- Model the behaviour of the different size particles as they evaporate, travel through the air and are affected by the environment / room ventilation

Dispersion model

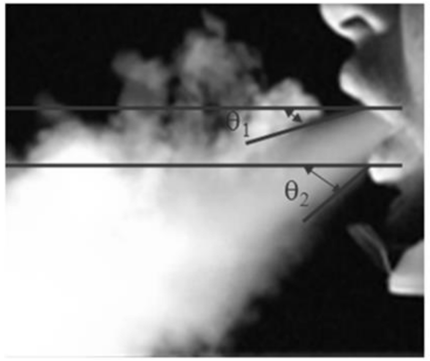
Computational Fluid Dynamics (CFD)

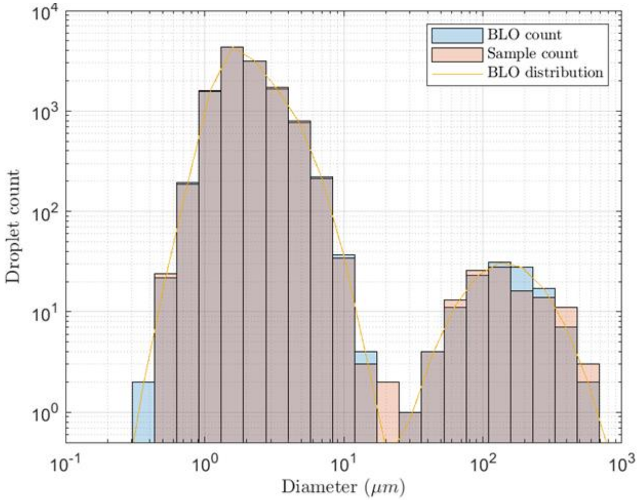


The flows of room air and exhaled breath are calculated on a mesh which is fitted to the geometry

The exhaled droplets are modelled as particles, which are injected with the exhalation flow and interact with the room air

- Diameter distribution
- Saliva model





What information can the model provide?

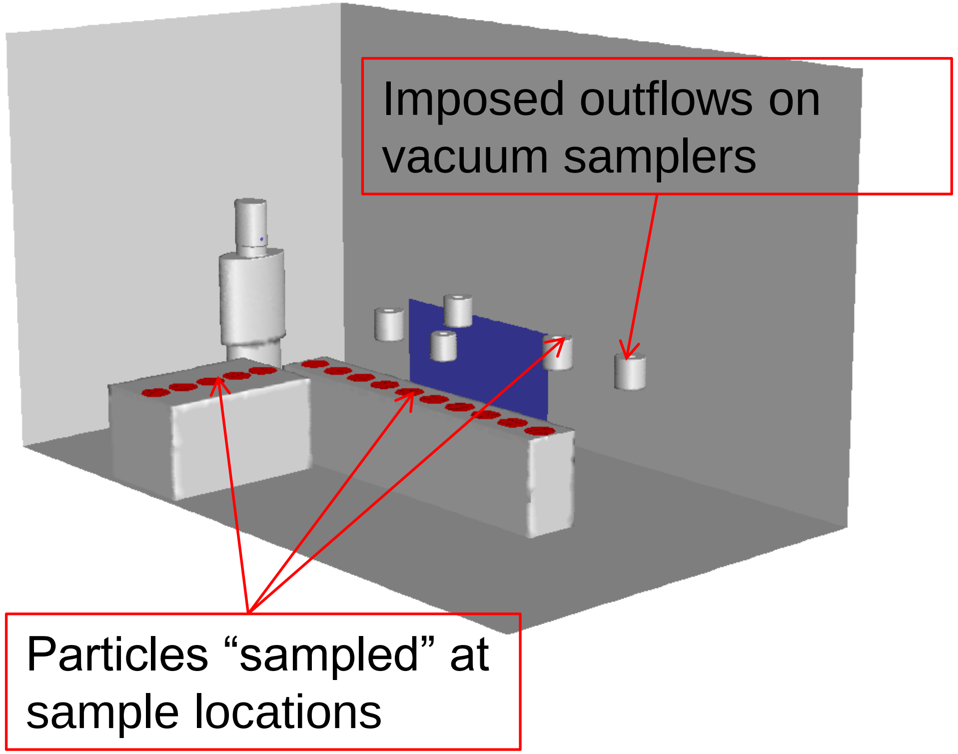
Advantages

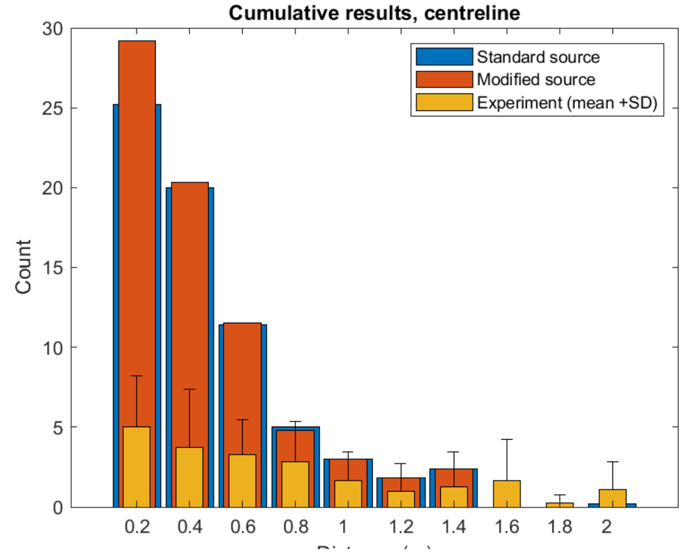
- Description of relatively complex geometries
- Ventilation and ambient flows
- Distributions of particle sizes and droplet evaporation
- Information on deposition/airborne fractions
- Assessment of viral load
- Visualisation to help understanding

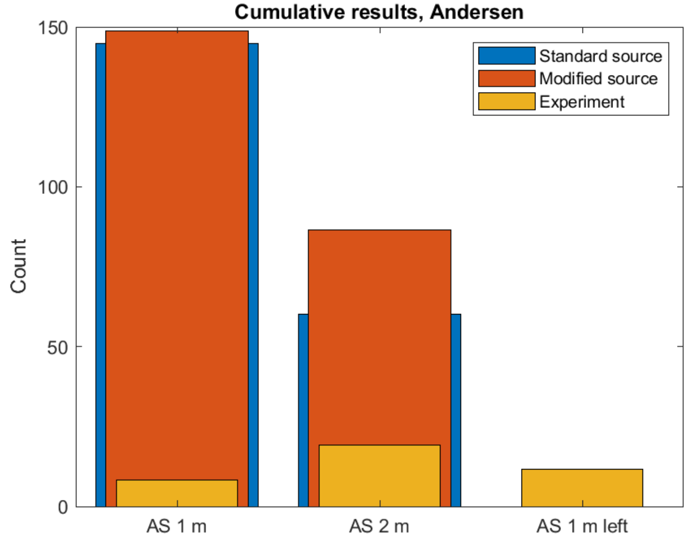
Limitations

- Modelling an idealisation, not reality (similar to an experiment)
- Models are limited by the strength of the input assumptions
- Models need to be validated for given scenarios and there is a lack of data in this field
- Model run times can be long
- There are many inputs
- Comparative, rather than absolute results

Model Validation







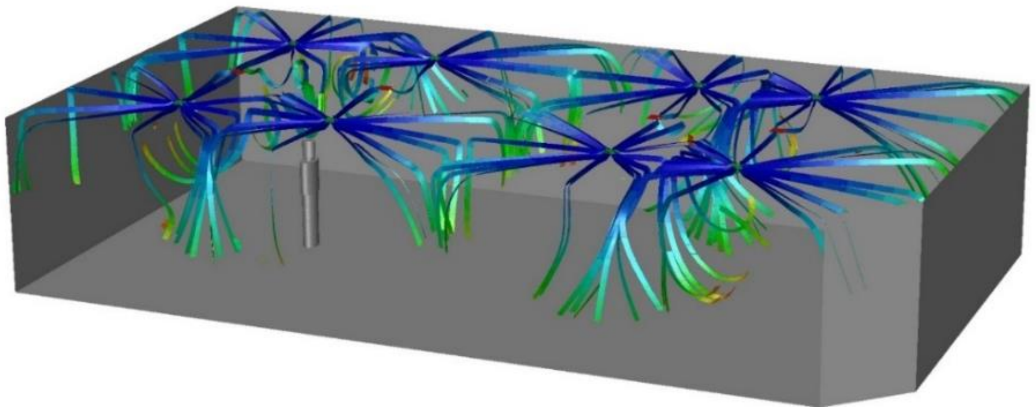
Short-scale aerosol and droplet generation with and without use of masks:

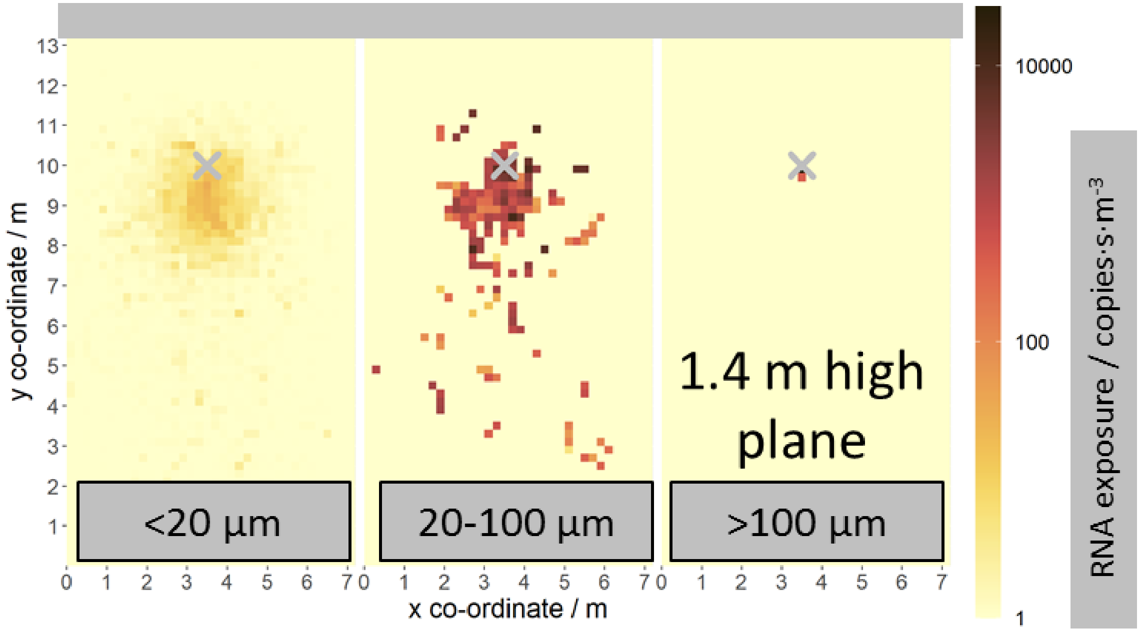
an initial analysis of a pilot study at PHE Porton Down (8 out of 10 participants)

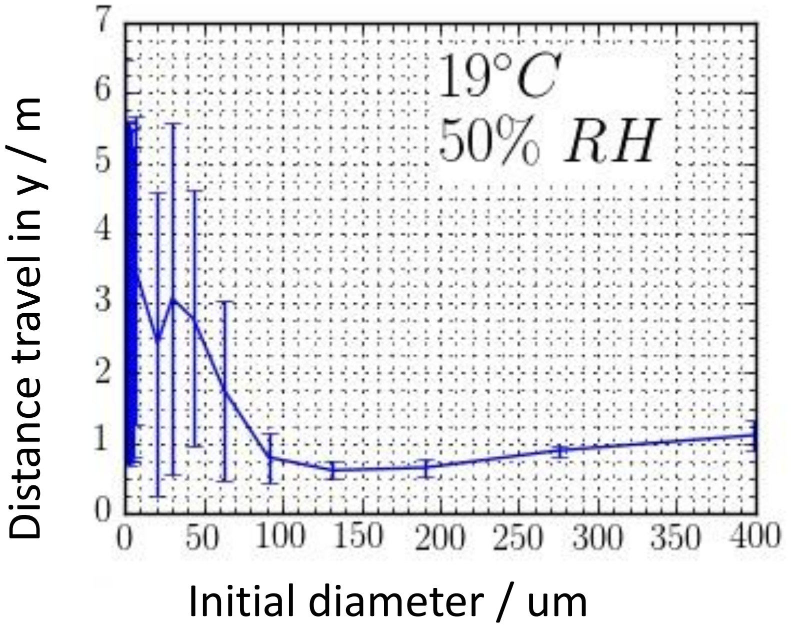
Ginny Moore, Simon Parks, Helen Rickard, Allan Bennett

The effect of temperature and humidity on dispersion

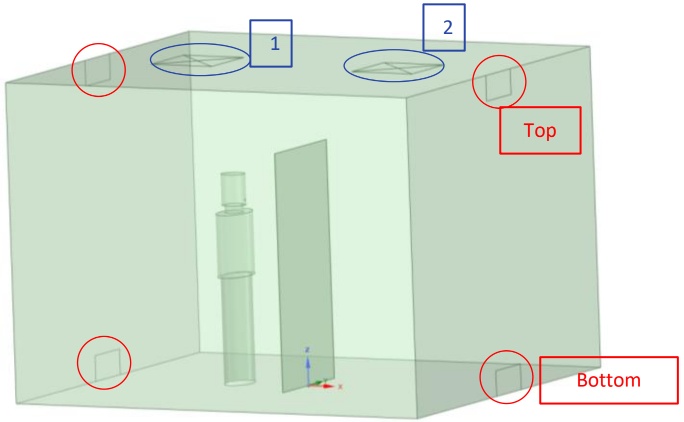
- Meeting room with mixing ventilation
  - Ceiling supply and extract
- No furniture
- Air change rate = 5 h^{-1}, no recirculation
- Average of 3 x cough, no mask
- 5 minutes mixing period per cough

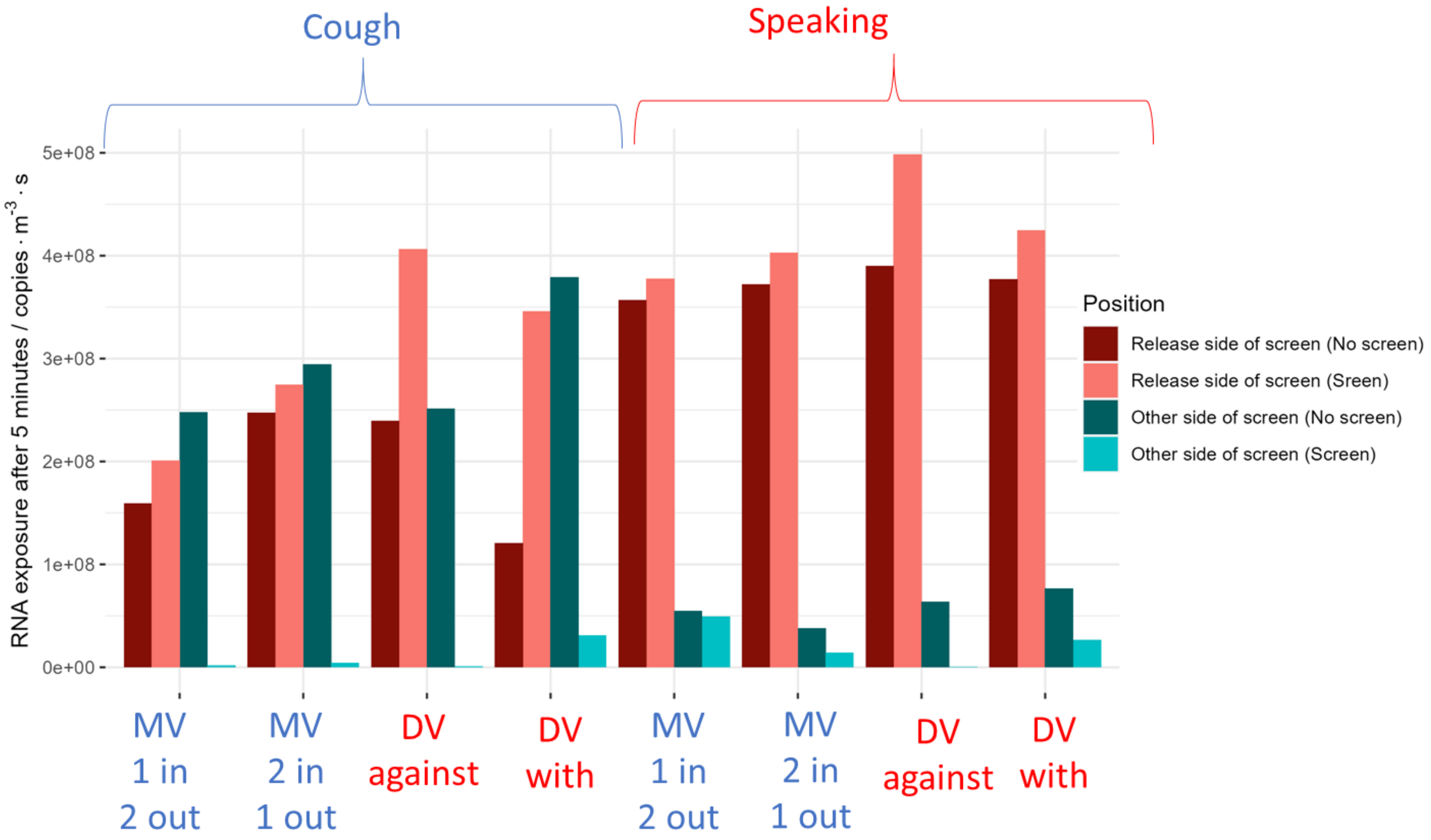




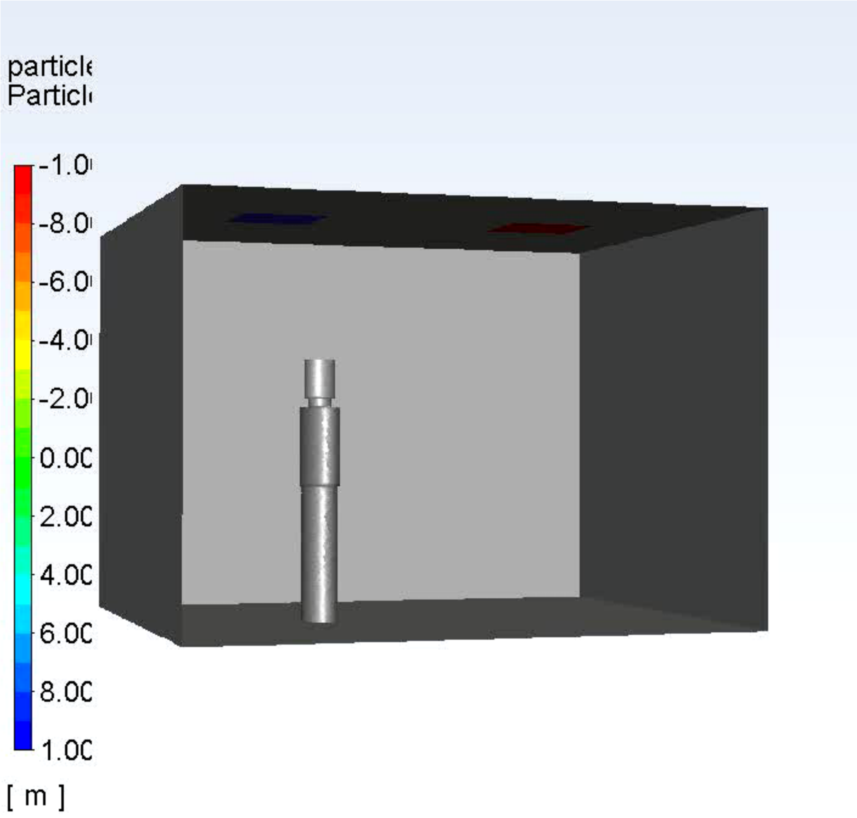


Application of the model (screens)





Animations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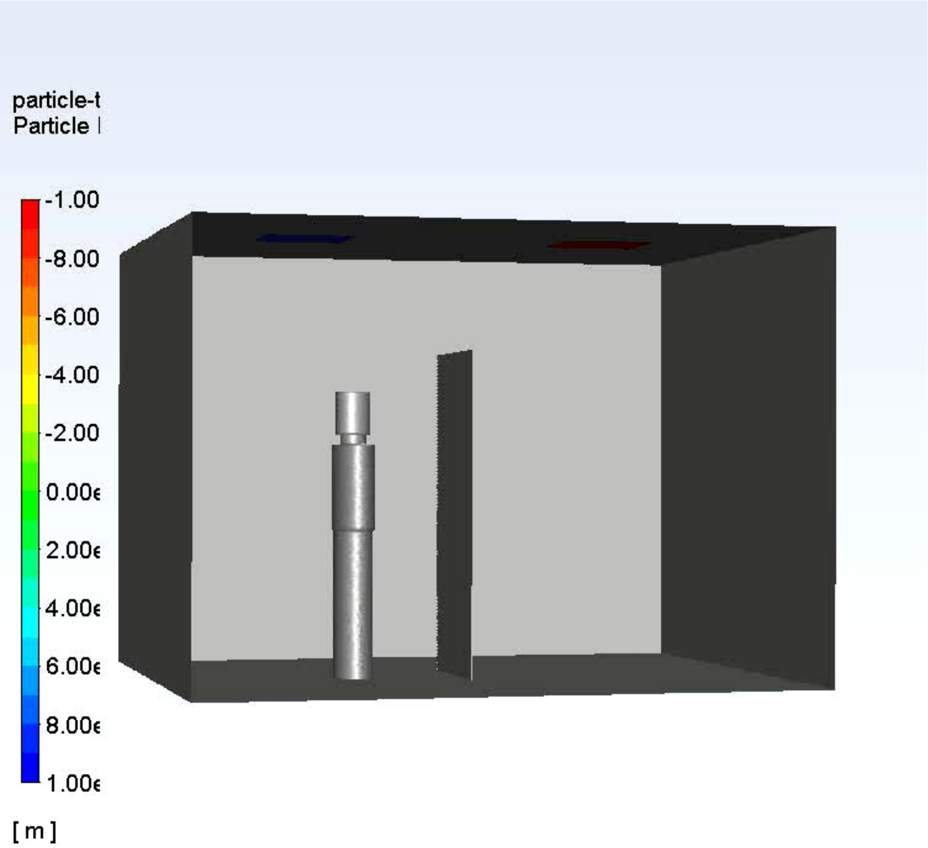
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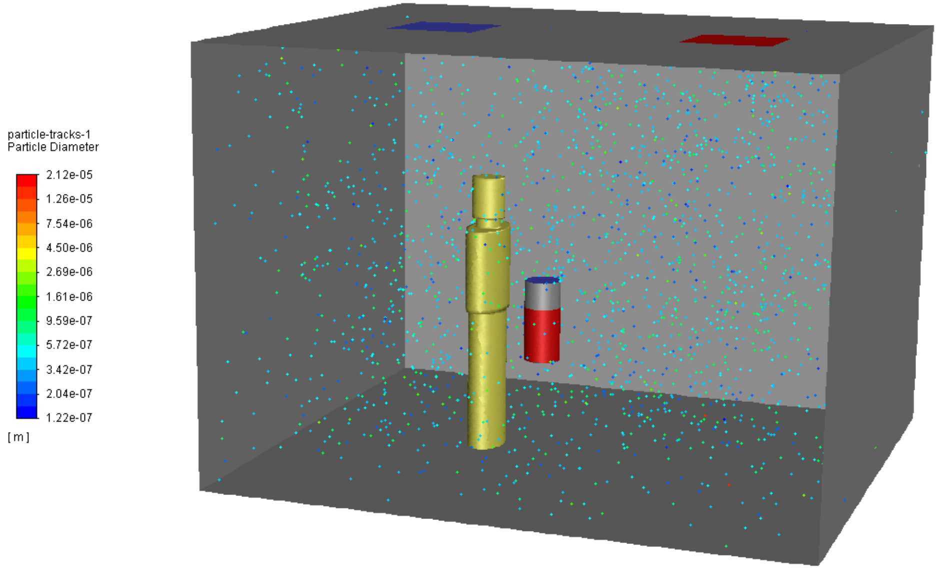
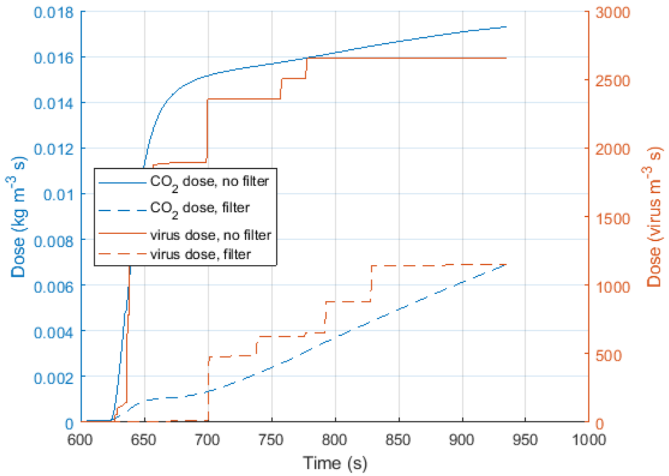
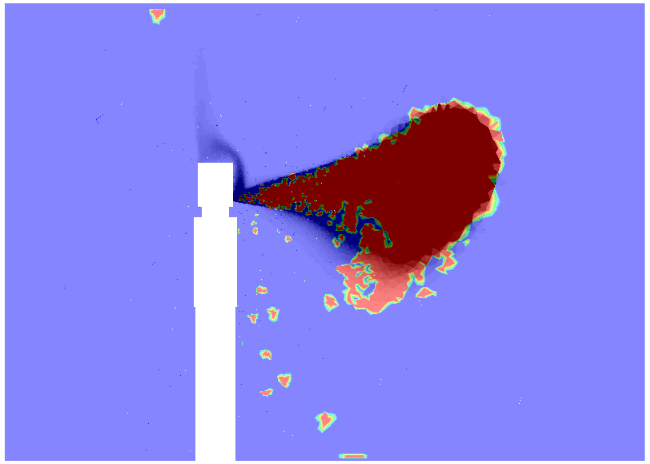
Application of the model (filter)

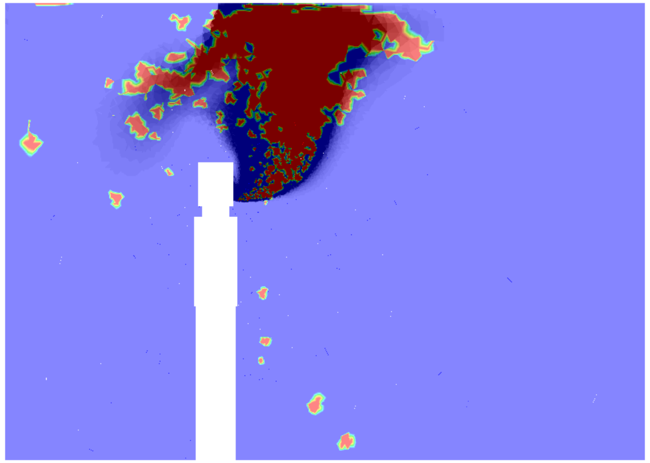
Particles/CO_2







Without filter



With filter

Conclusions

- A CFD model of exhalations has been developed:
  - It performed relatively well against the available experimental data
  - It has helped provide insight into the physics of exhaled droplet dispersion
  - It has been used to model a number of scenarios and provide input into other models and decision making
- Development of expertise
- Collaboration

Thank you

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Occupational Risk of COVID-19 Transmission

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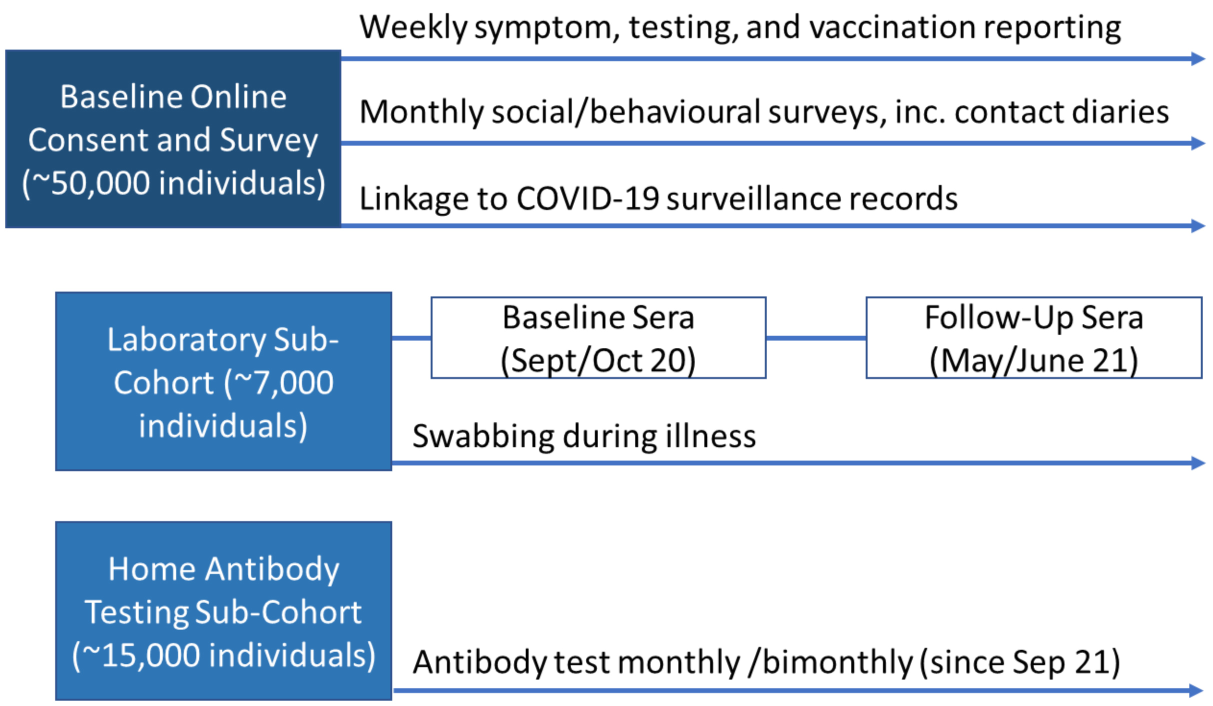
Research Questions and Design

Study 1

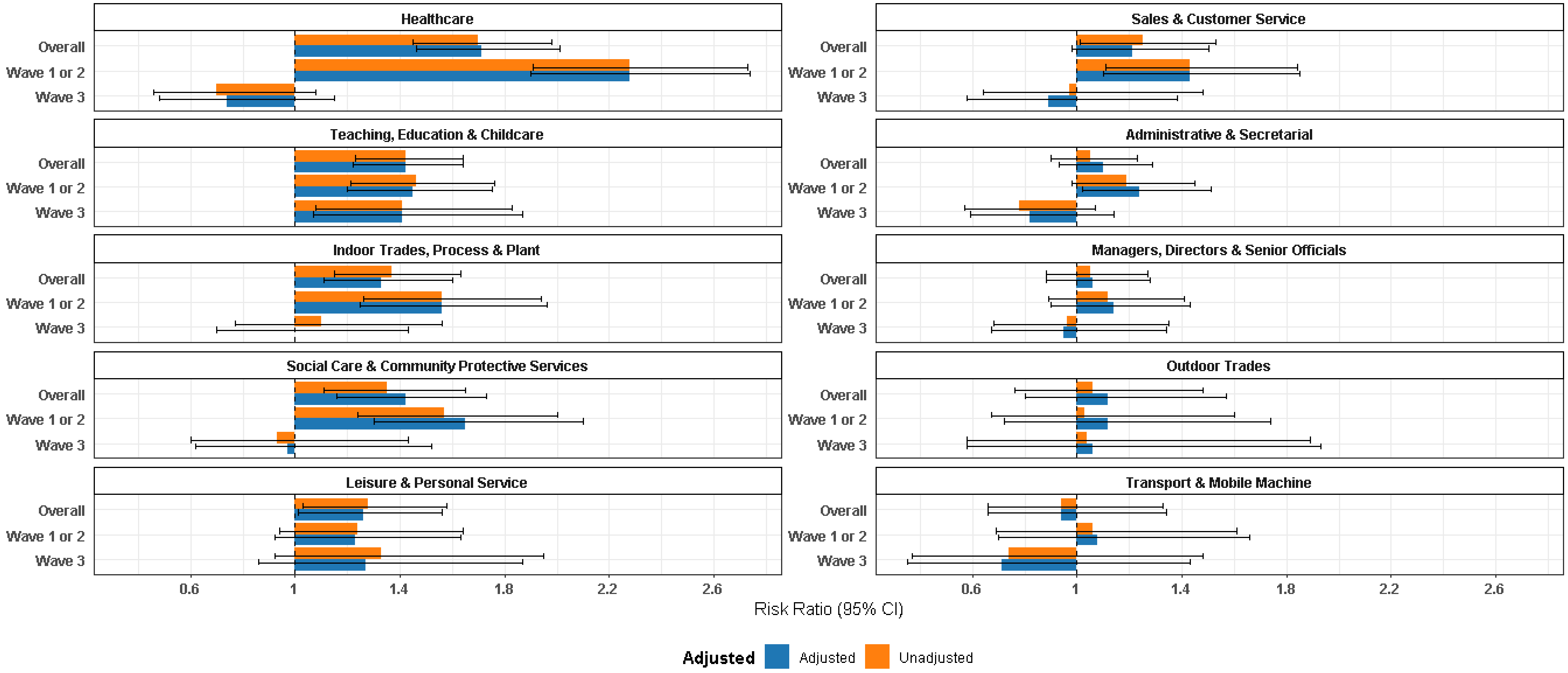
- How do occupations differ in their risk of SARS-CoV-2 infection beyond the effects of socio-demographic and health-related factors and non-workplace activities?

Study 2

- How do work-related contact patterns differ by occupations and over time?

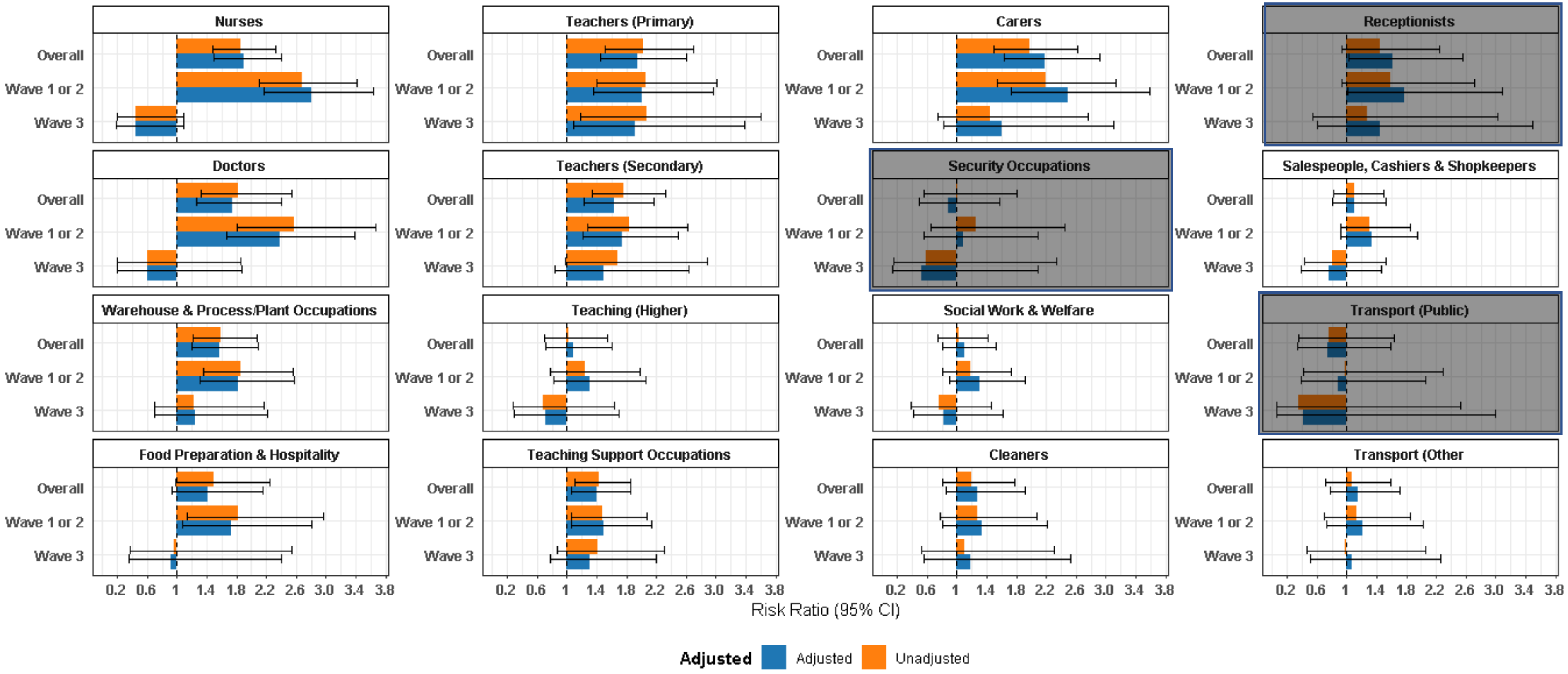


Infection Risk by Occupational Group



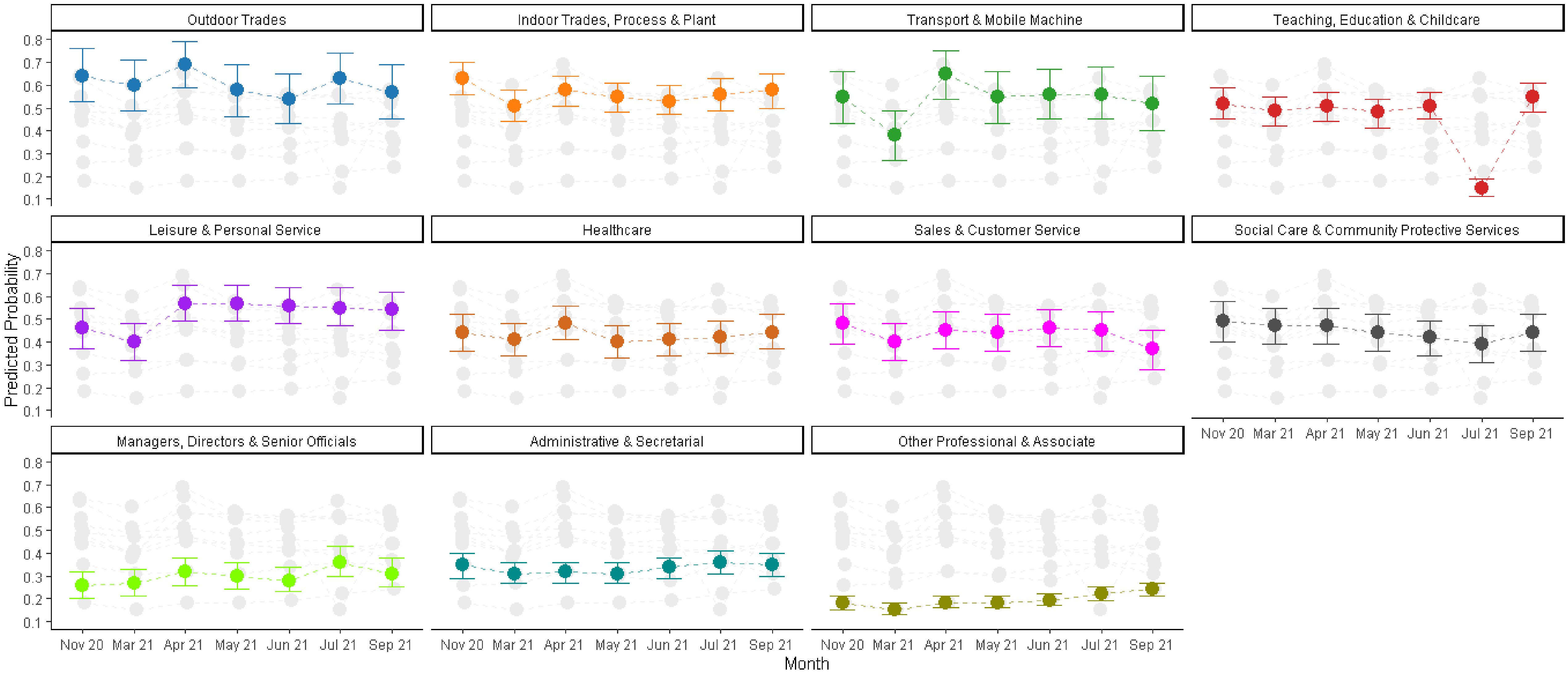
Attributable fractions (exposed): 42% for healthcare professionals, 29% teaching/education/childcare, 29% social care and community protective services, 25% indoor trades/process/plant, 20% leisure and personal service;

Infection Risk: Specific Occupations



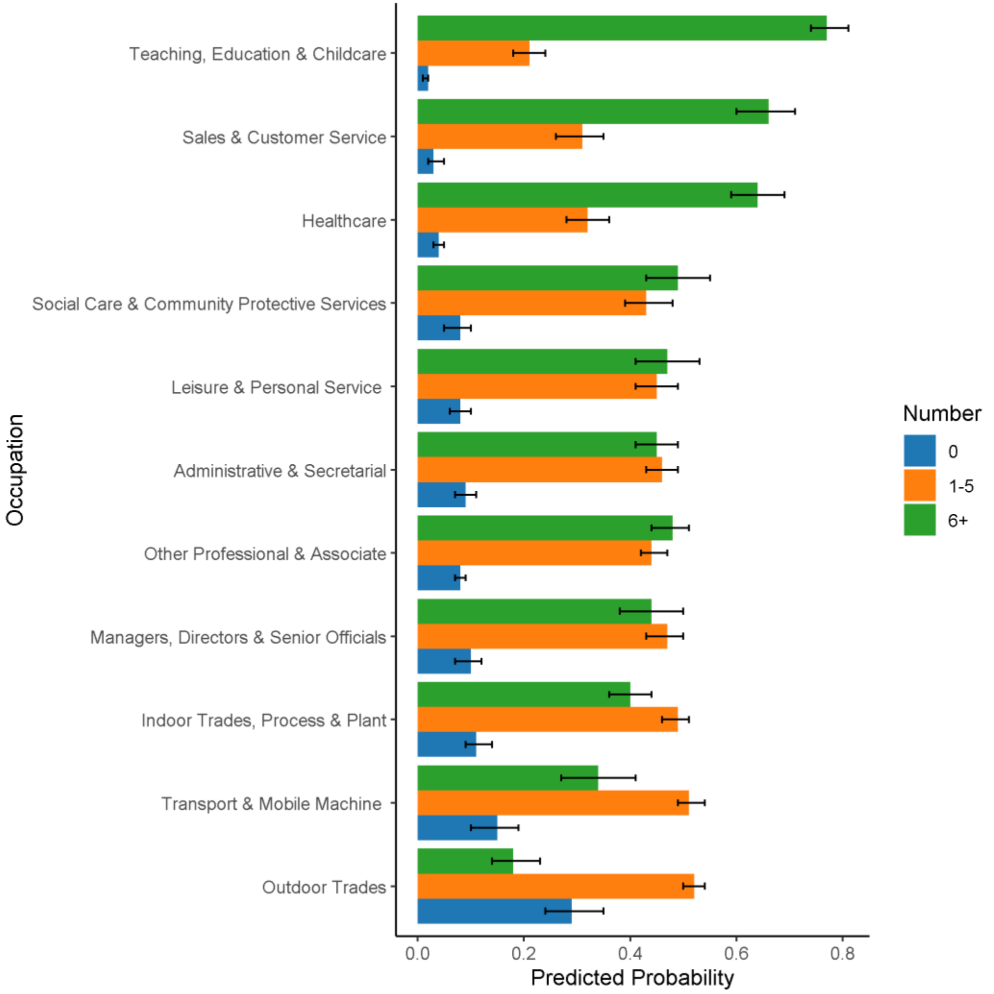
Attributable fractions (exposed): 54% carers, 48% primary school teachers, 47% nurses, 42% doctors, 39% secondary school teachers, 38% receptionists, 37% warehouse/process/plant occupations, 29% teaching support occupations

Work Outside the Home

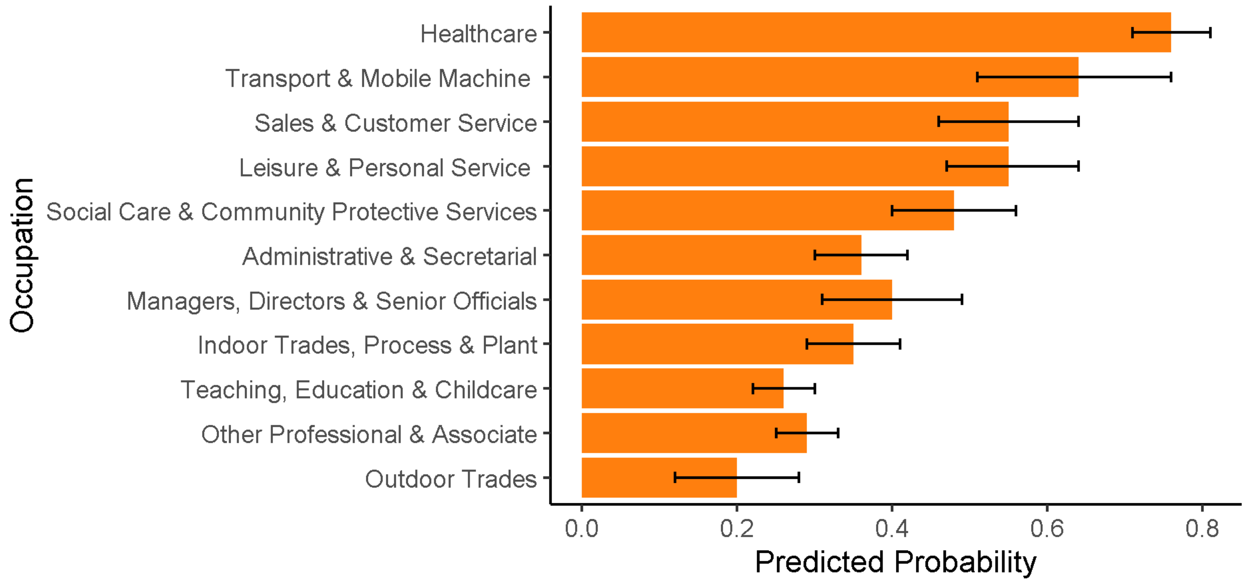


Contact at Work

- Long-term workspace sharing (4+ hours) the norm except for transport and outdoor trades
- Close contact less common than workspace sharing (range 14-26% predicted probability)
- Wearing face covering varied by occupation and time



Maximum number of people in workspace



Wearing face covering during close contact

Key Points and Next Steps

Virus Watch

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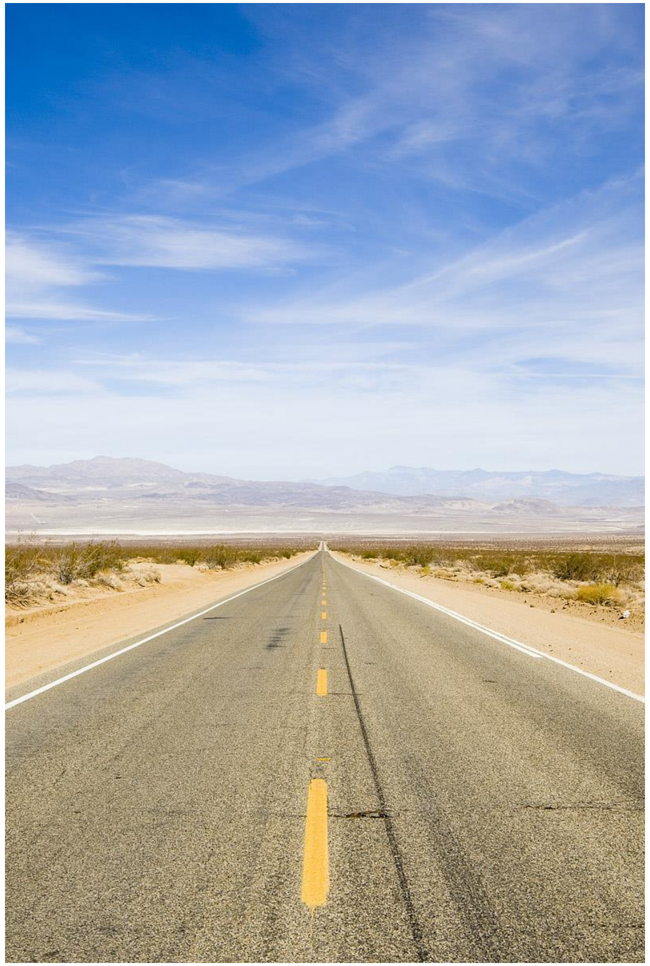
- Persistent differences in infection risk across occupational groups
- High-risk groups from Study 1 tended to demonstrate multiple contact-related risks in Study 2
- Potential to inform interventions, i.e. face coverings, social distancing, vaccination
- Limitations – generalisability, sample size esp. for some groups, challenges with adjustment, broad time intervals
- Next steps – linking contact-related factors with infection risk, understanding worker vulnerability by occupation



Effect of occupation using the ONS COVID-19 Infection Survey

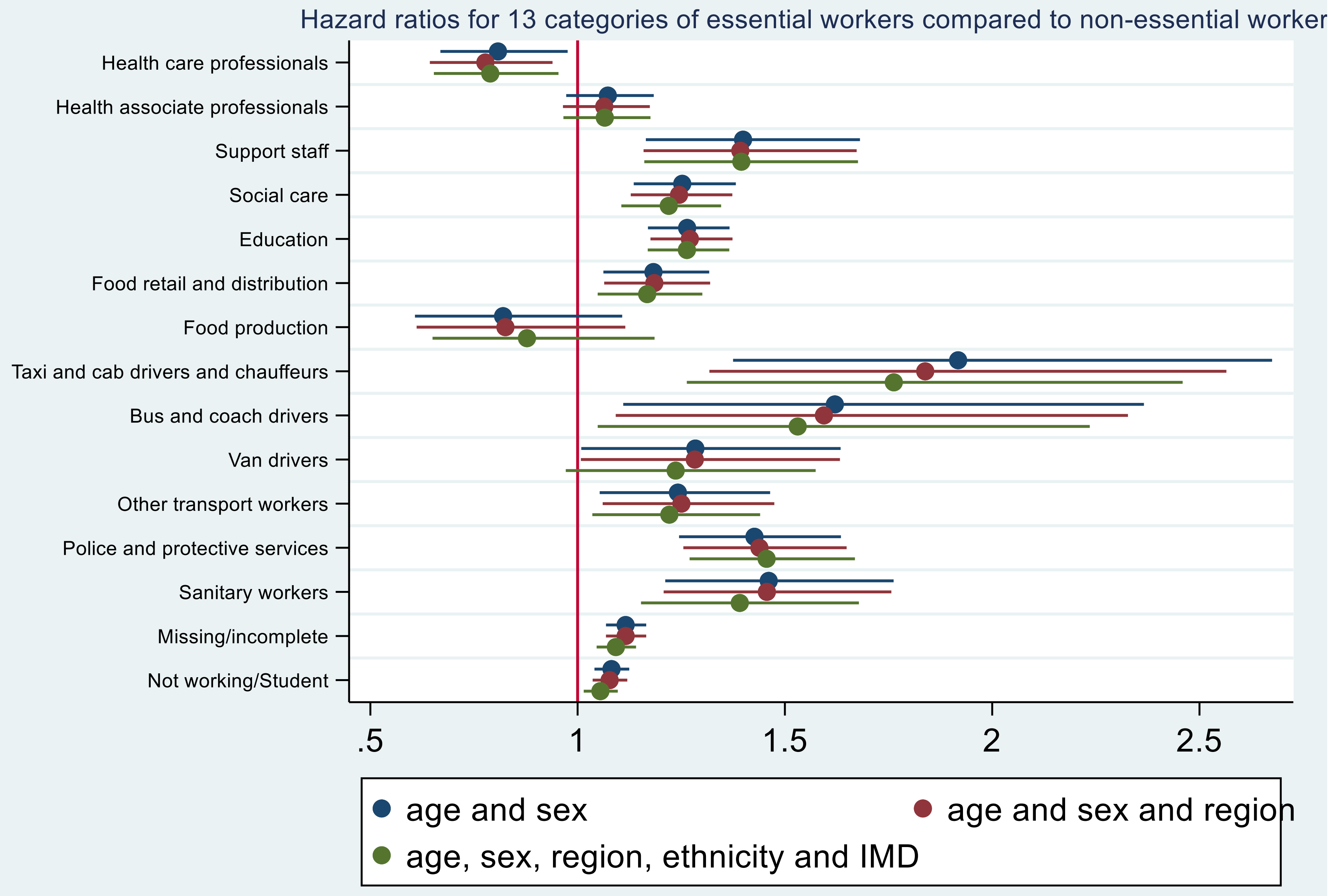
- Longitudinal survey including approx. 300 000 adults of working age
- Regular testing at survey visit
  - Minimises bias due differential testing by occupation
- Time to first CIS positive test
- Use of first available occupation information (classified using 4 digit SOC)
- Repeated using time tranches and including multiple infections per person
- Adjustment for a series of confounders

Results from ONS infection survey (April 2020 to Oct 2021)

Cox regression based on first available occupation code, using time to first infection

N=286 990

17 048 events



"This work was produced using statistical data from ONS. The use of the ONS statistical data in this work does not imply the endorsement of the ONS in relation to the interpretation or analysis of the statistical data. This work uses research datasets which may not exactly reproduce National Statistics aggregates."

Key points

- Similarities with Virus Watch
  - Increased risk for social care, education, and food distribution
- Similarities with ONS Mortality (Nafilyan 2021*)
  - Education and protective services showed increase risk in CIS
- Adjustment for potential confounders makes very little difference
  - Whereas it does for mortality
- Relative effects varied over time (as background rate and restrictions changed)

* https://www.medrxiv.org/content/10.1101/2021.05.12.21257123v1

Related work in Theme 3

Systematic review

Review of relative risks for Covid-19 related to working within occupational sectors where workplace attendance is essential

https://doi.org/10.48420/16558035.v1

Refining causal questions

Directed Acyclic Graphs (DAGs) for the study of effects of occupation on risk of COVID-19-related outcomes

https://doi.org/10.48420/16847158.v1

More on the ONS Covid-19 infection survey

Use of Job Exposure Matrix

Time varying effects

Other datasets

Mortality (linked/excess/proportionate)

Longitudinal linkage collaboration

Biobank

Thank you to our collaborators in the Virus Watch and PROTECT Theme 3 teams

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