INSTITUTE OF OCCUPATIONAL MEDICINE

Healthy Air for Workplaces…

…And Beyond

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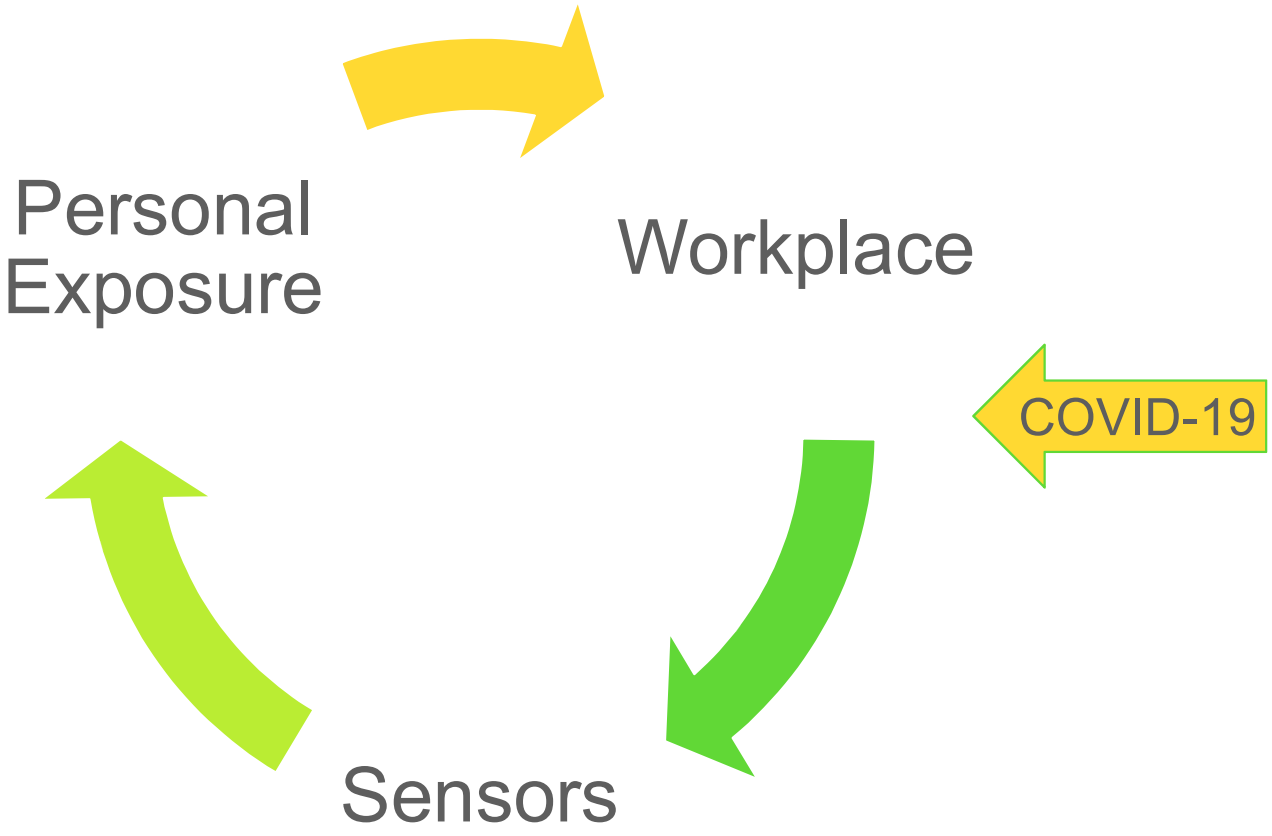
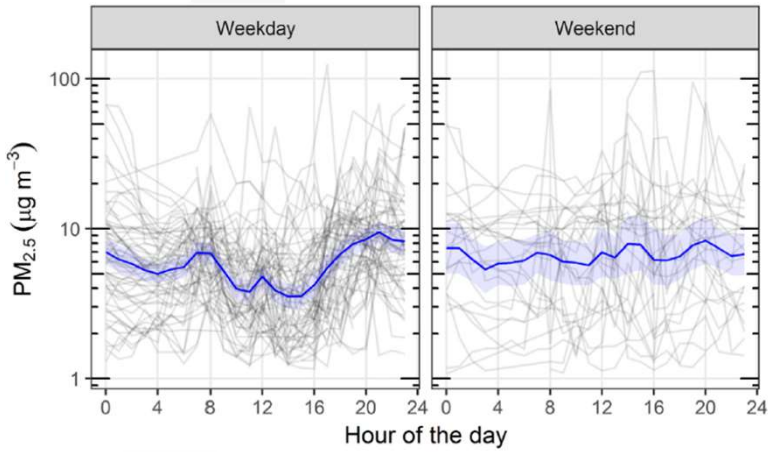
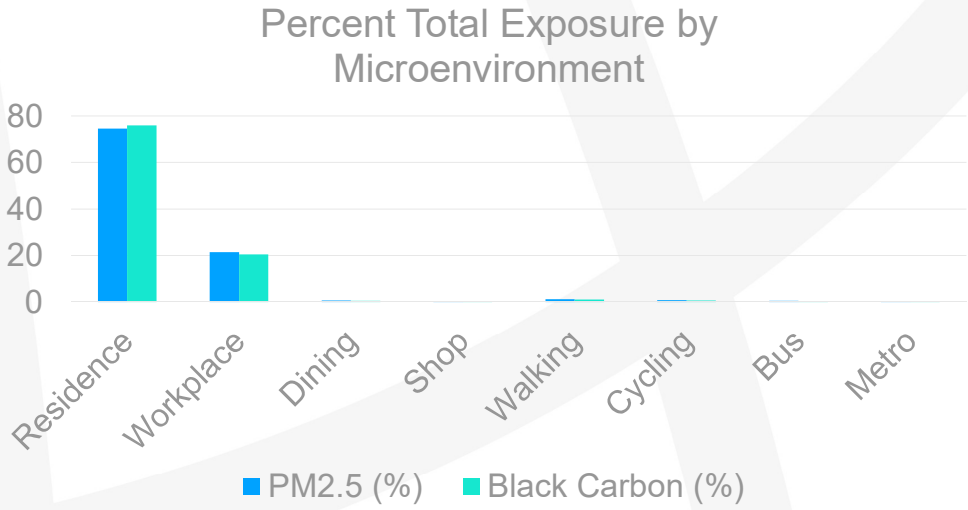

Personal Exposure
Workplace
COVID-19
Sensors

Air Pollution Exposures

- Exposure to air pollution at work is a part of our everyday lives
- About 90% of our time spent indoors – for many at least a third of that is at work



Mazaheri et al. 2018. *Env. Int.,* 120; 496-604



Adapted from Lin et al. Science of the Total Environment, 2020

VOC exposures

- Health risks can be driven by exposures (and sources) indoors
- Workplaces can be large contributors to personal exposure, even in everyday places

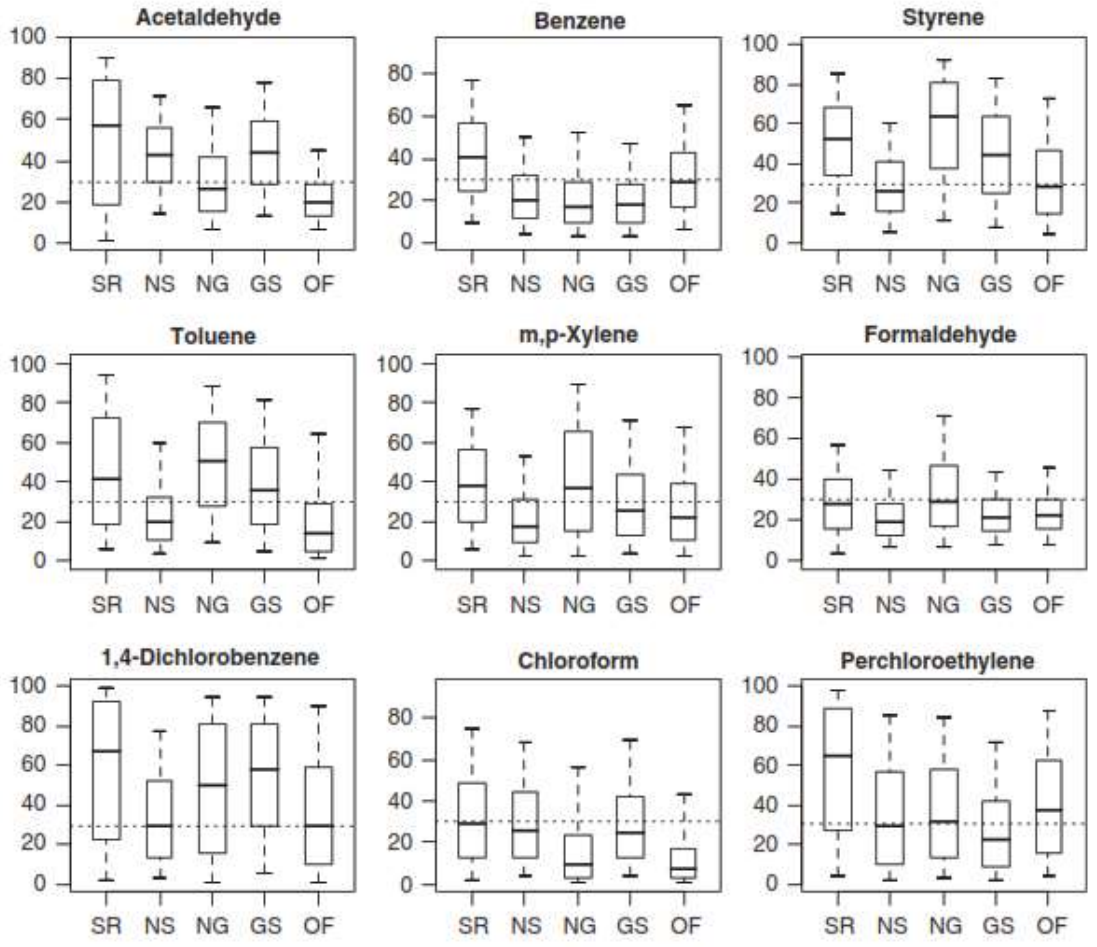


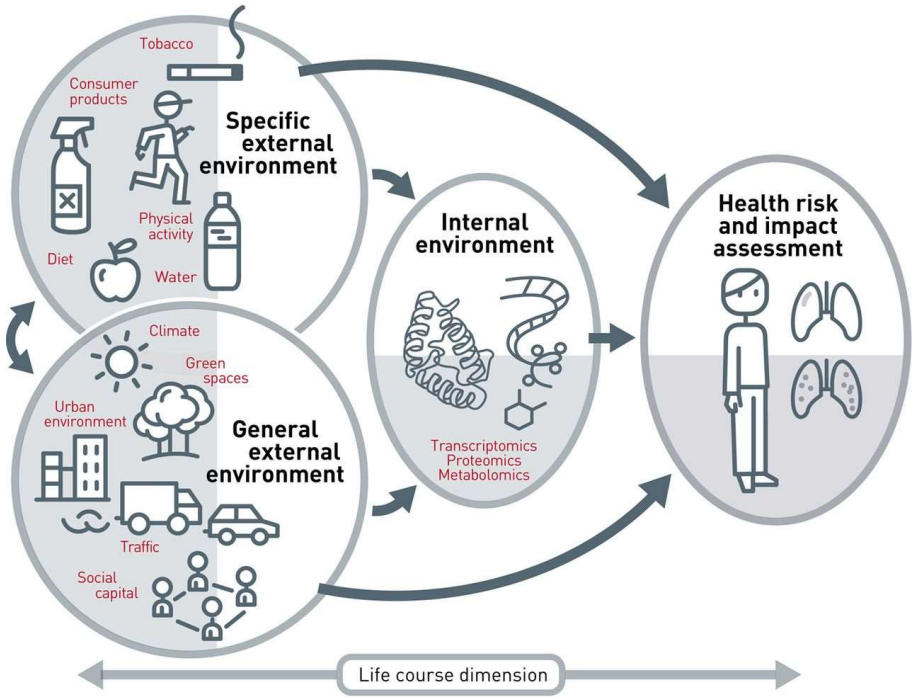
Figure 4. Percent of personal exposure to selected compounds from work for various workplaces. *y* Axes are in percent. Dotted line represents 30% of total exposure. Boxes indicate 25th, 50th, and 75th, and the whiskers indicate the 5th and 95th percentiles. SR = smoking restaurants, NS = non-smoking restaurants, NG = non-grocery stores, GS = grocery stores, OF = offices.

From Loh et al. 2009

Occupational Disease Research

EPHOR Exposome tools for a healthy working life

- Occupational disease worldwide: 5-7% mortality, 2-6% GDP
- Traditionally 'one-exposure, one-health outcome' approach to occupational health research
- Changing world of work - We need to widen our perspective to protect worker health
- Environmental and occupational health research shifting to an 'exposome' framework

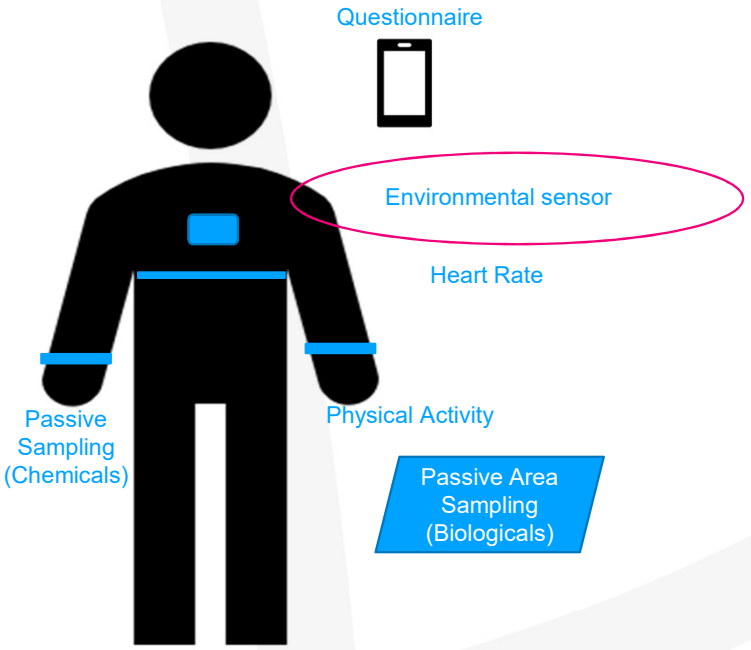


Vrijheid M
The exposome: a new paradigm to study the impact of environment on health
Thorax 2014;**69:**876-878

A new way of looking at exposures

- We want to measure multiple exposures at once
- We are evaluating exposures throughout the daily life of the worker
- Why?
  - We want to know about how work fits into personal exposure accumulated over a whole day
  - We want to know how work affects other aspects of their life, and vice versa and how this relates to their day-to-day and future health

What is our approach to exposure assessment?



Environmental sensor box

Particulate matter, noise, light, UV, temperature, humidity

Compared low-cost sensors with higher cost research or occupational hygiene field equipment

Compare in static monitoring sessions with a reference monitor

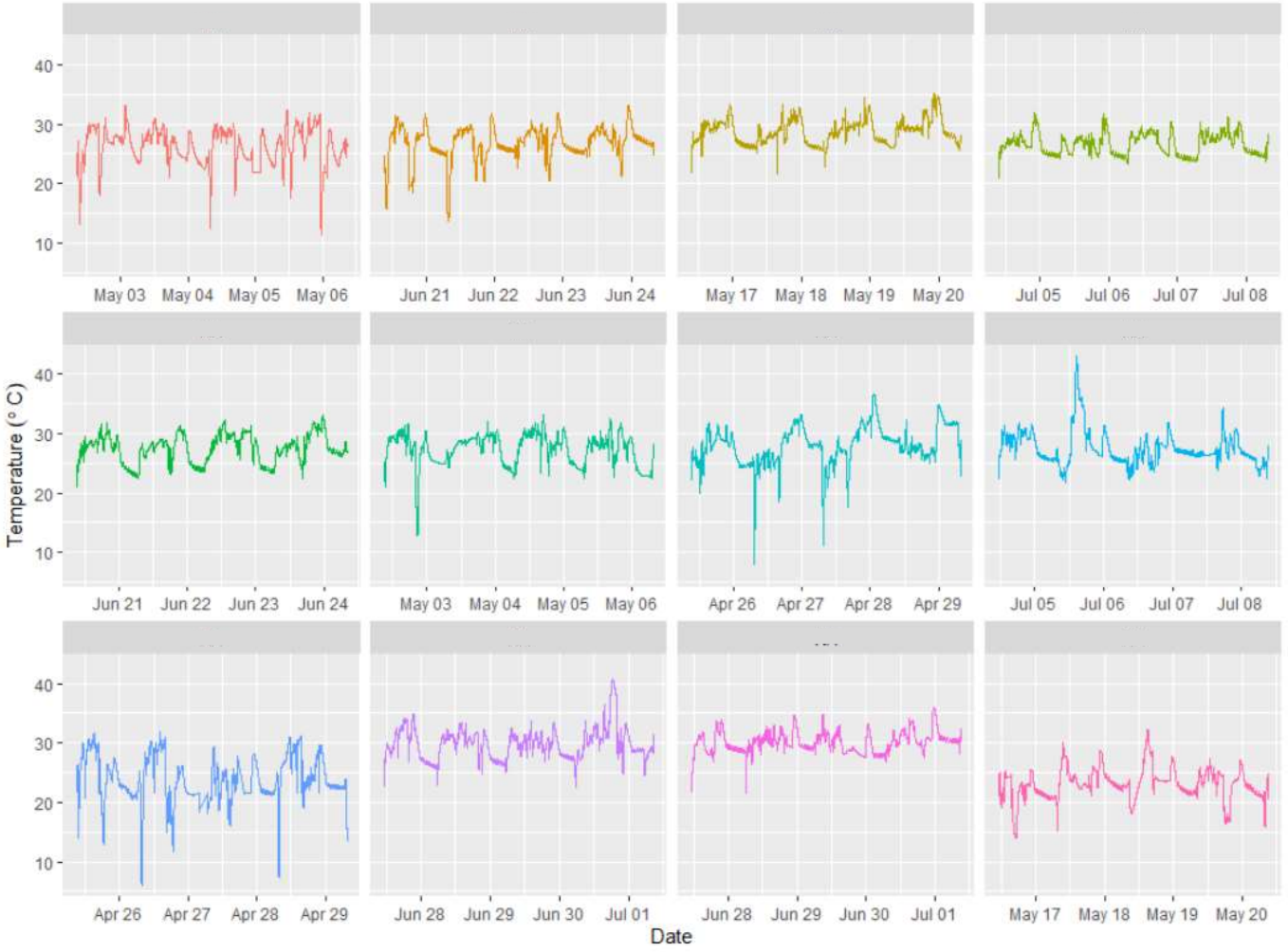
- Generally relationship allowed a clear calibration model to be generated
- Exploring 'general particulate matter' calibration model for different exposure settings

Currently being used in short-term (1 week) exposure-health studies (respiratory health and shift work)

Sensor data pre-processing

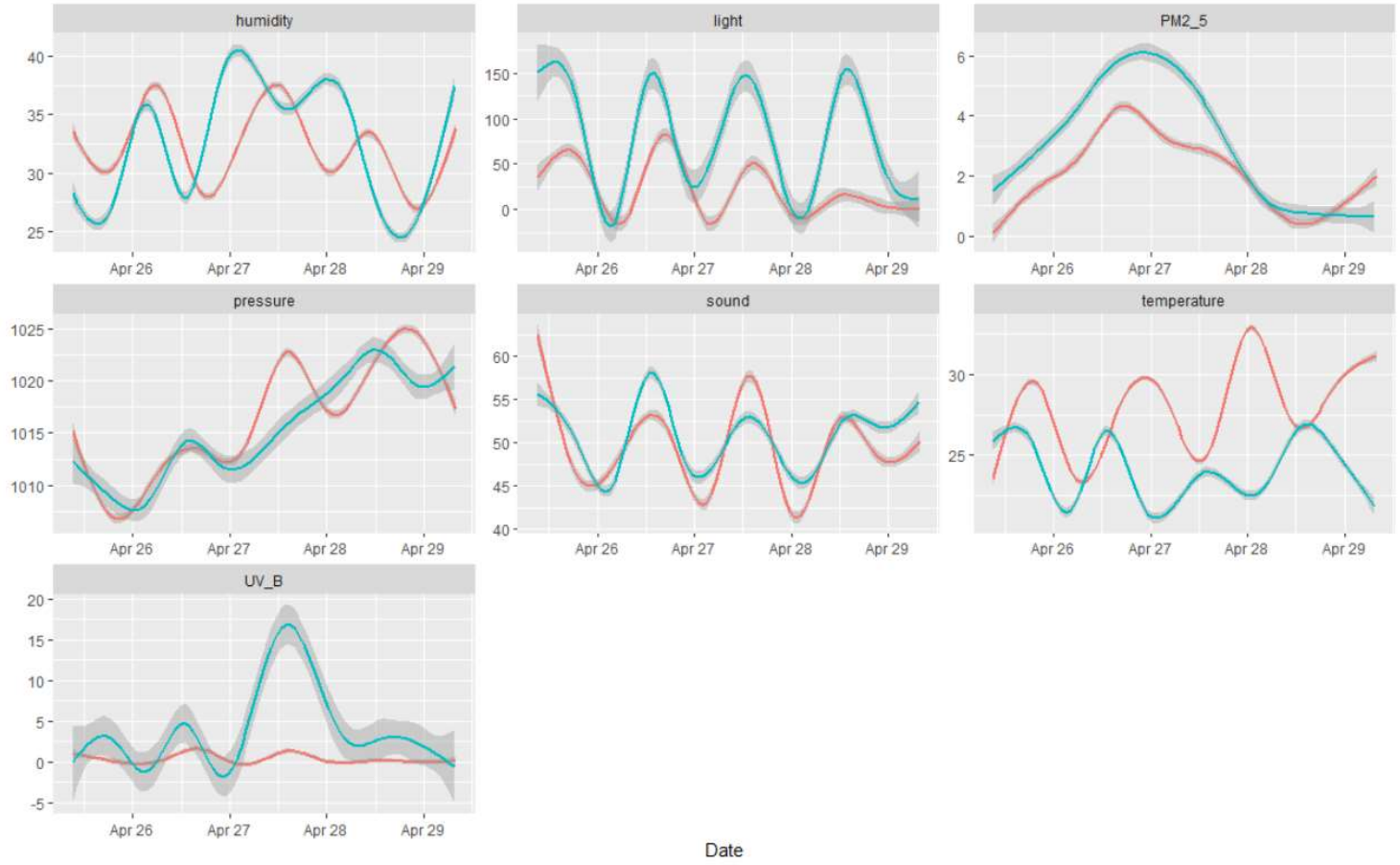
- 1 participant
- Working week

- Raw data
- Temperature only



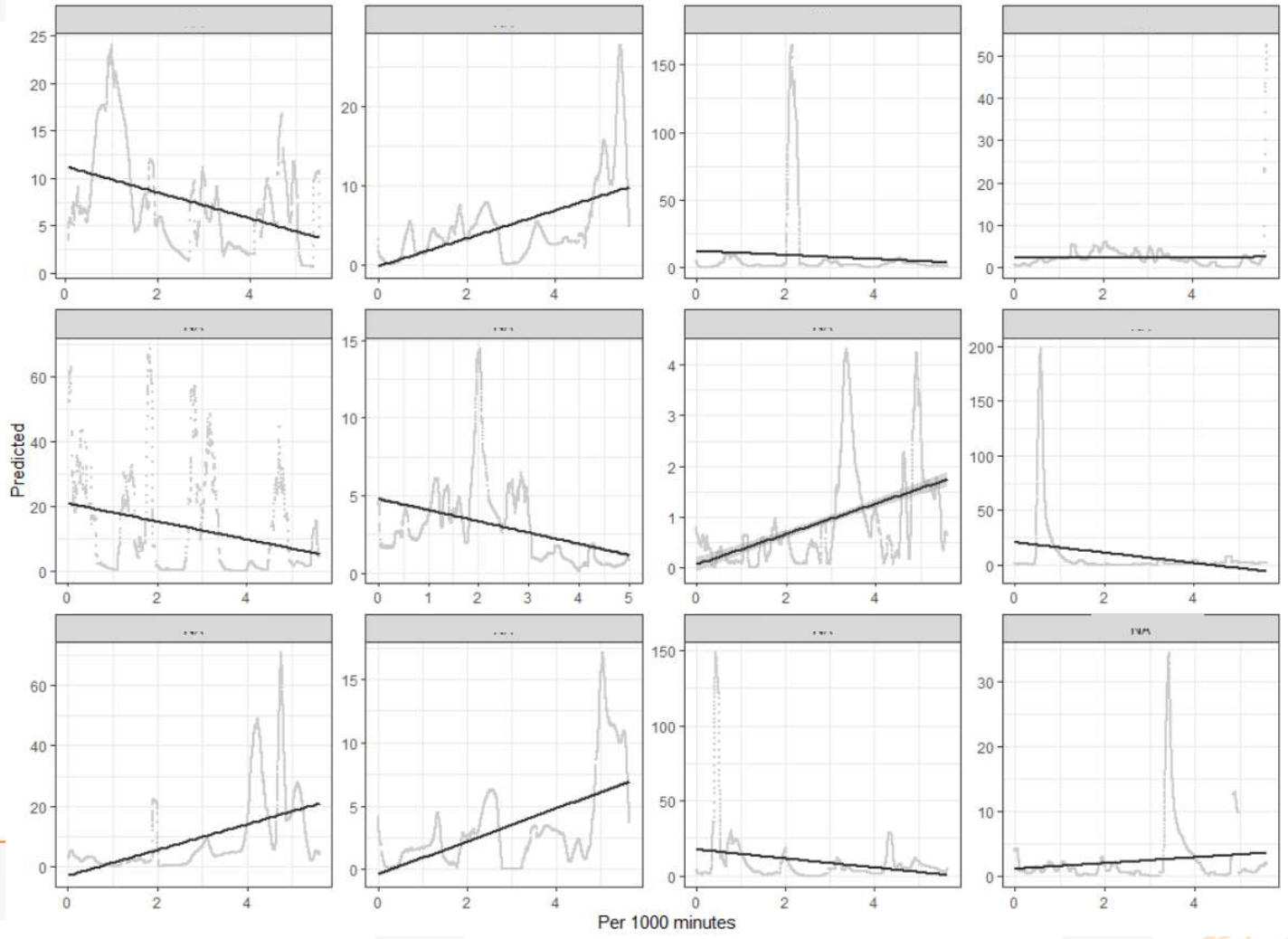
Sensor data pre-processing

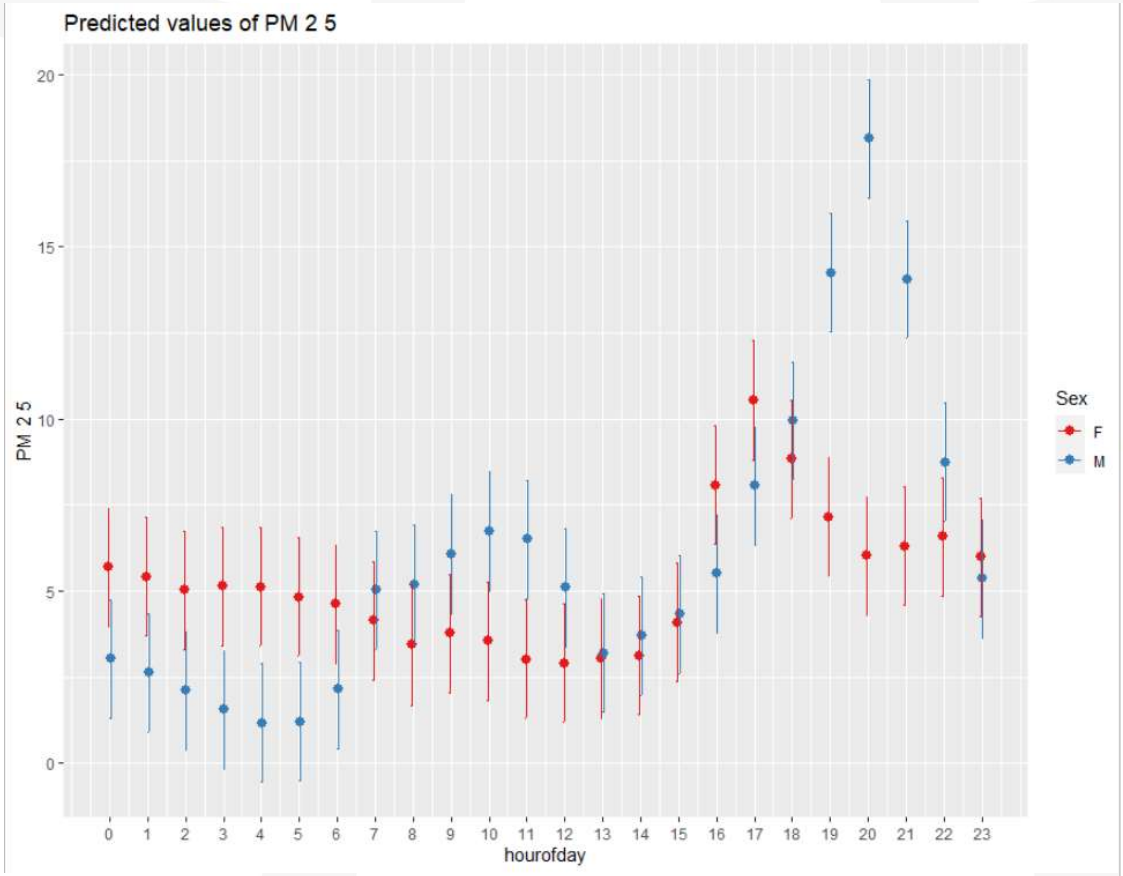
- 2 participants
- Smoothed data
- Multiple exposures

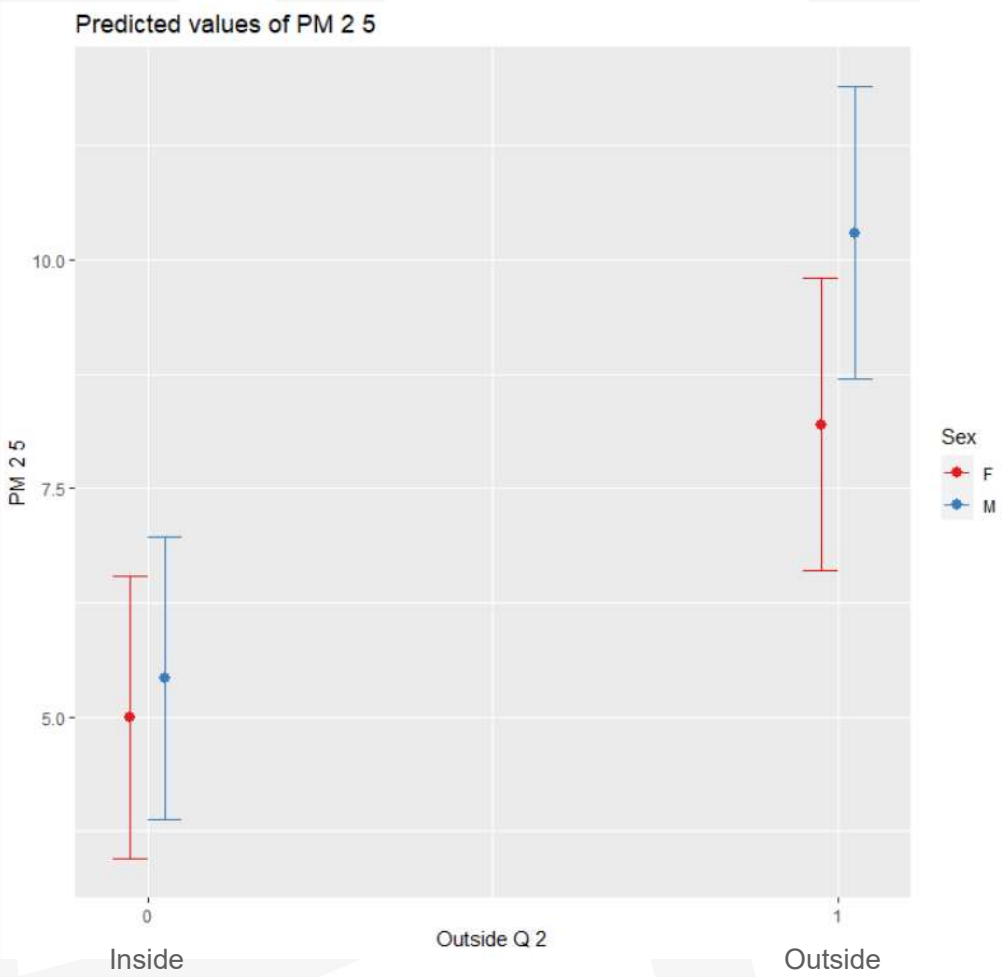


Particulate Matter

- 12 Participants
- Showing personal trends over data collection period
- Examine week-long trends in exposure with week-long health data







- Can explore impact of time of day and location of work

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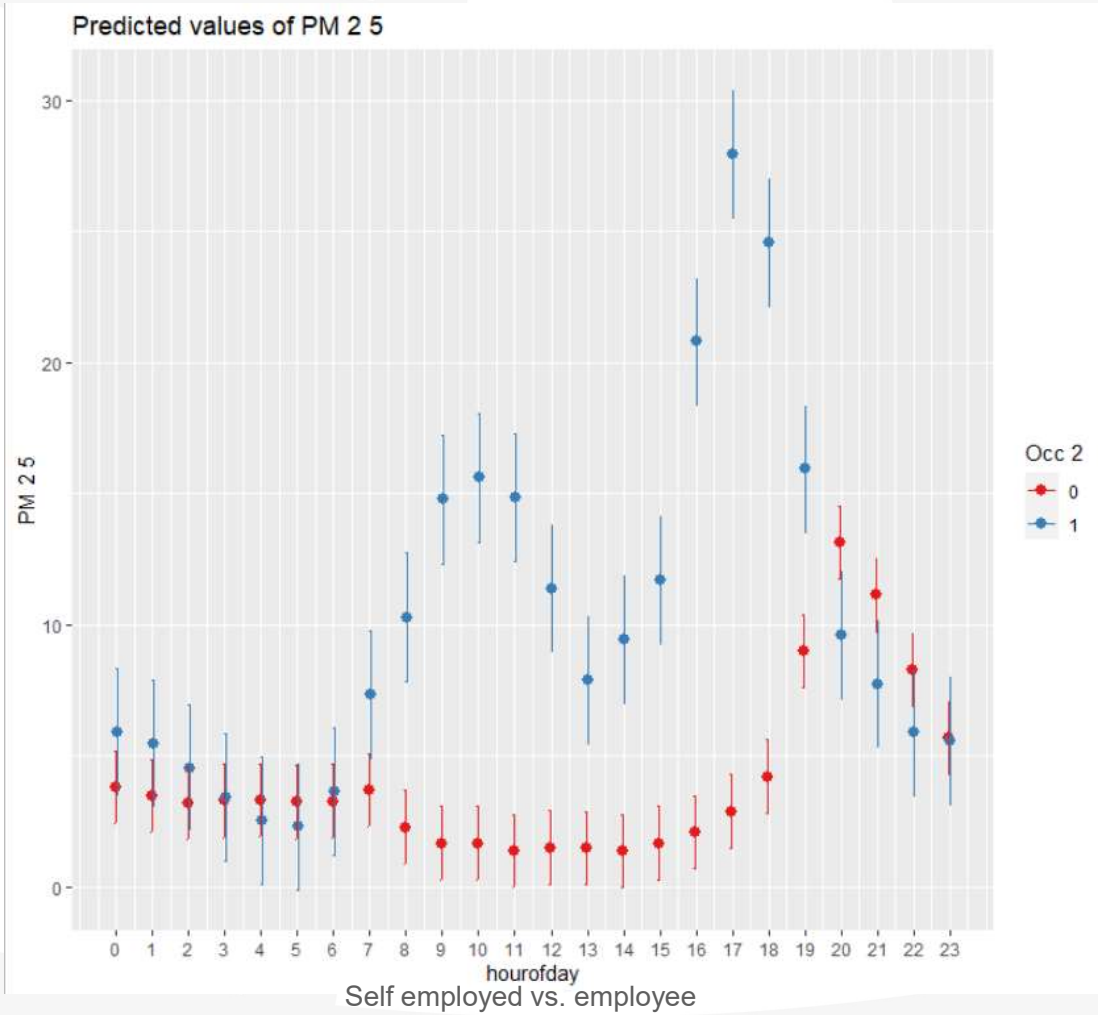
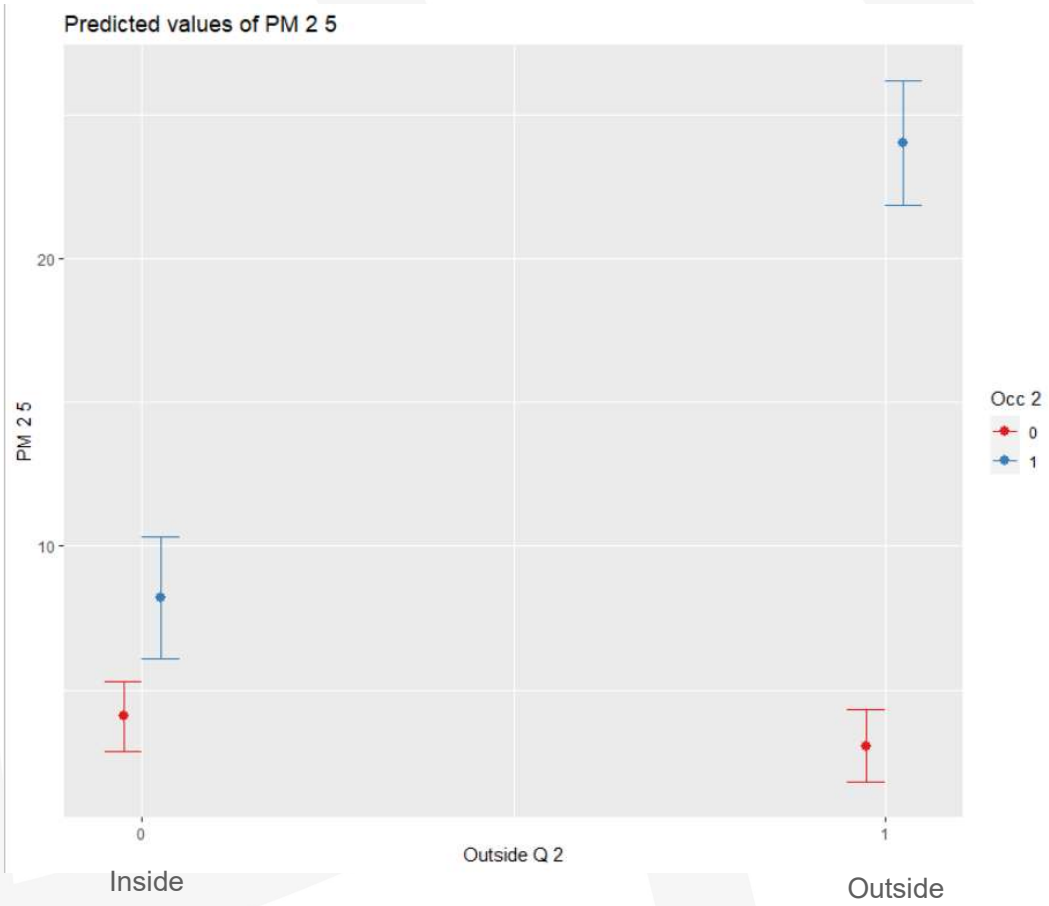


Self employed vs. employee

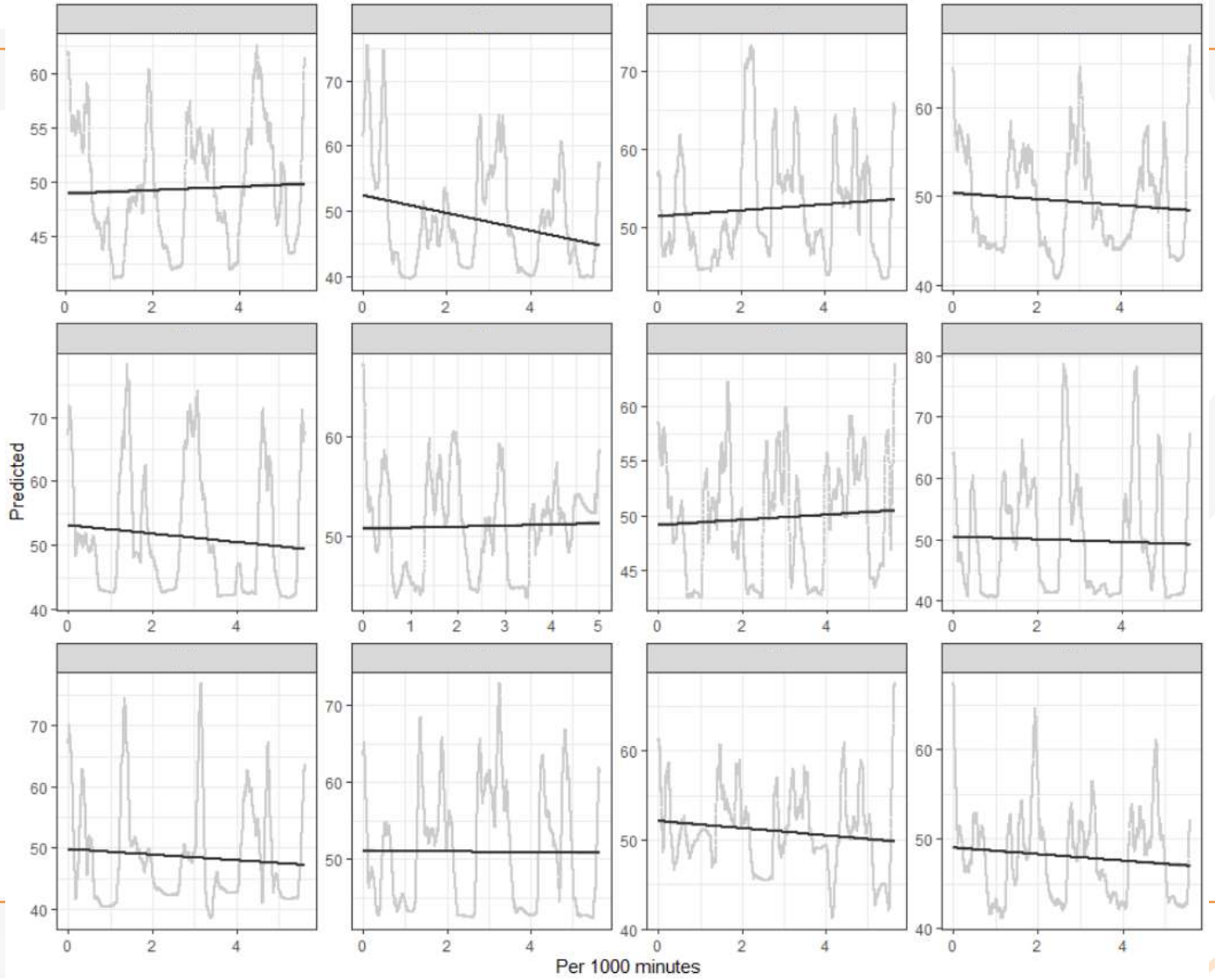


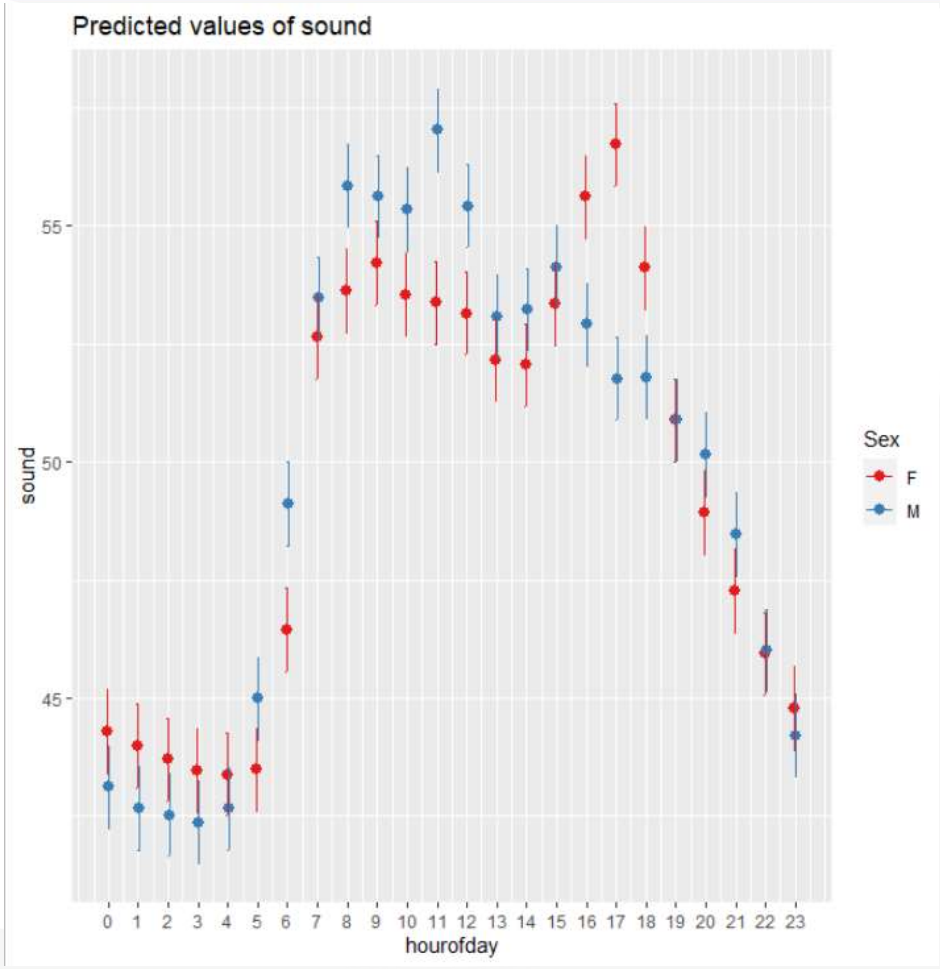
Inside

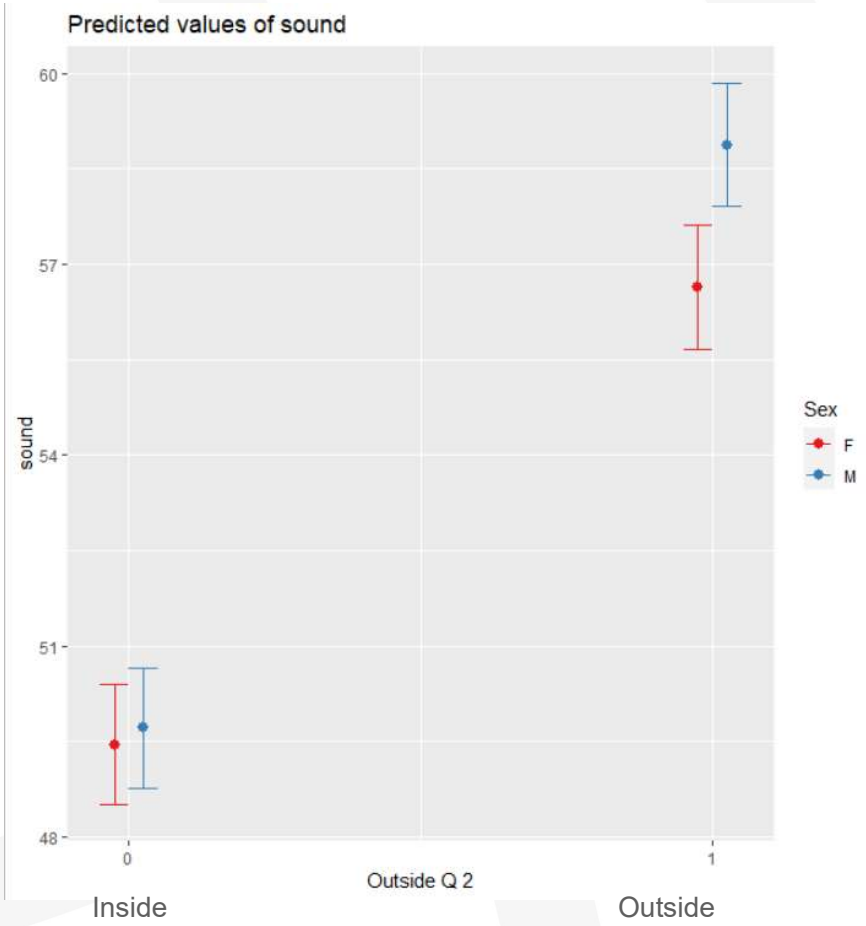
Outside

- … and whether those patterns vary by the type of work performed

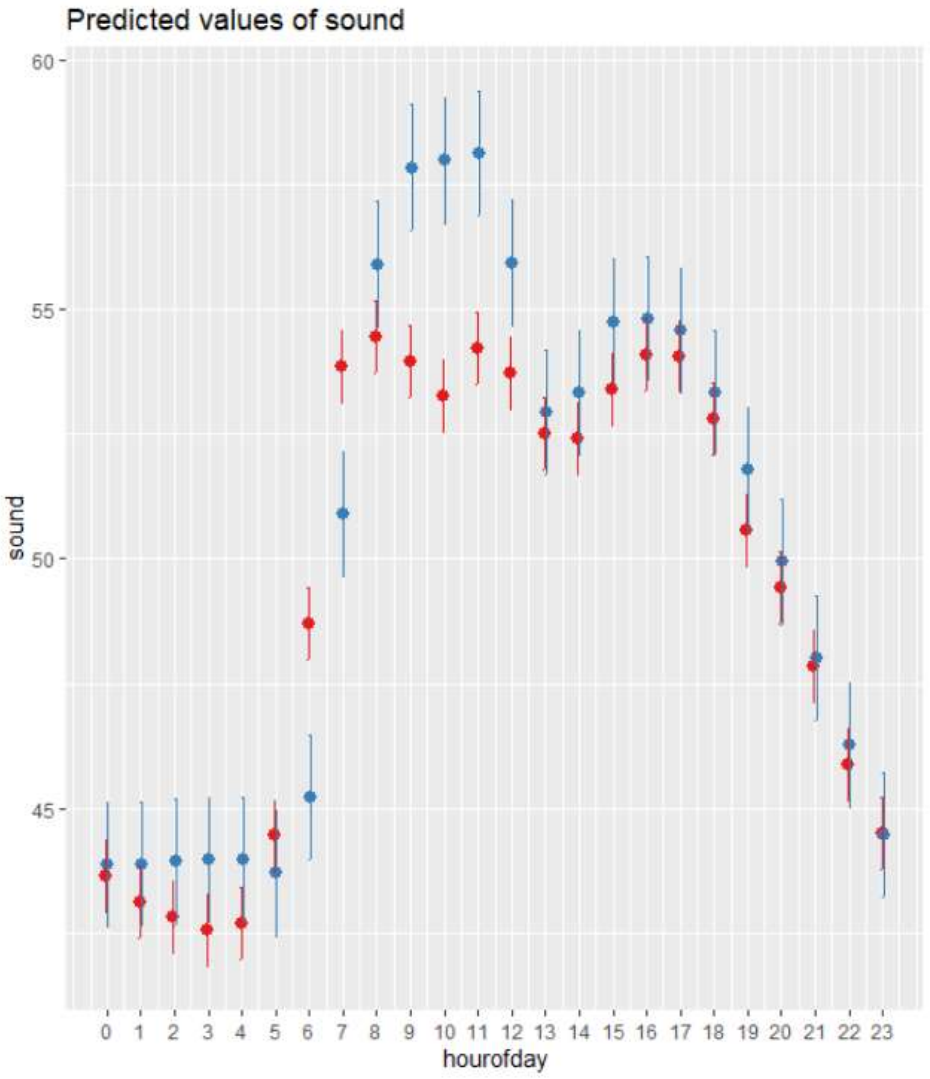
Noise

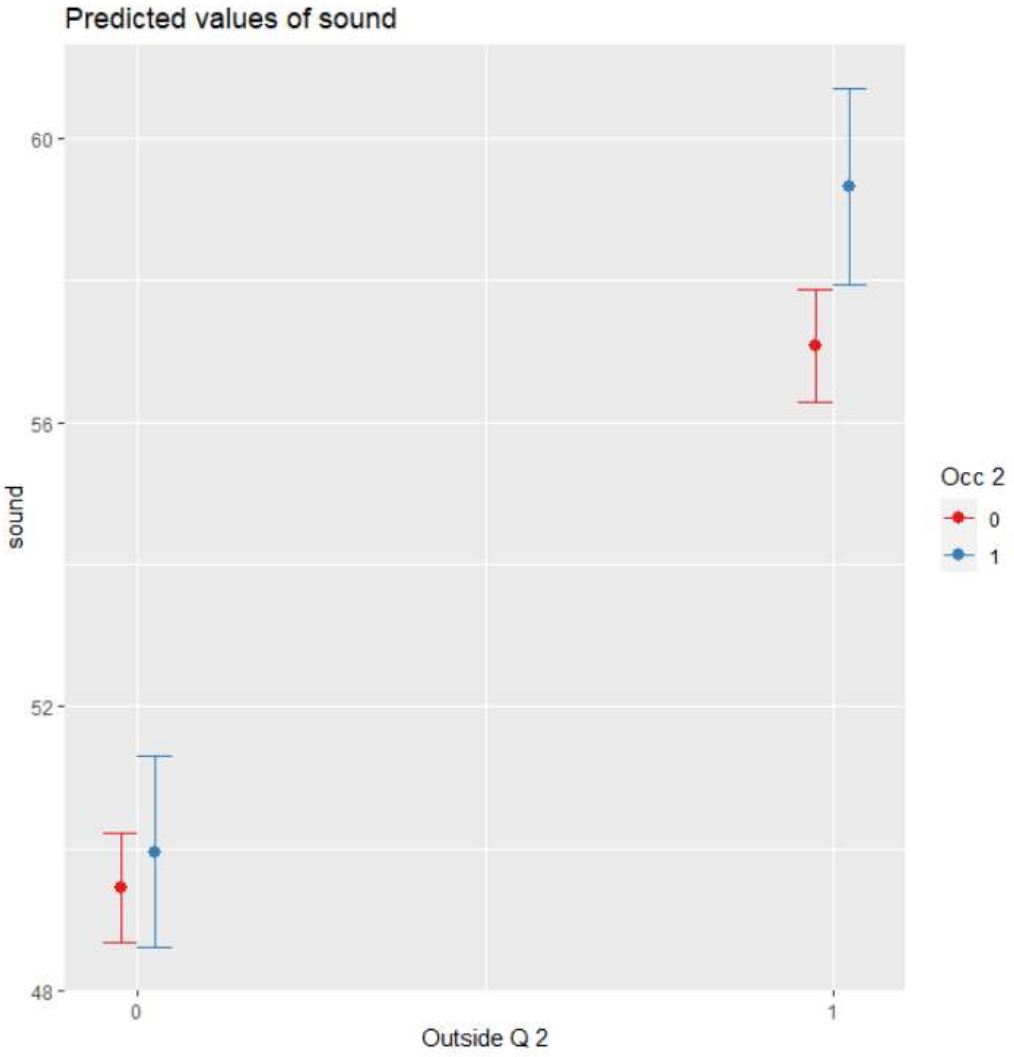






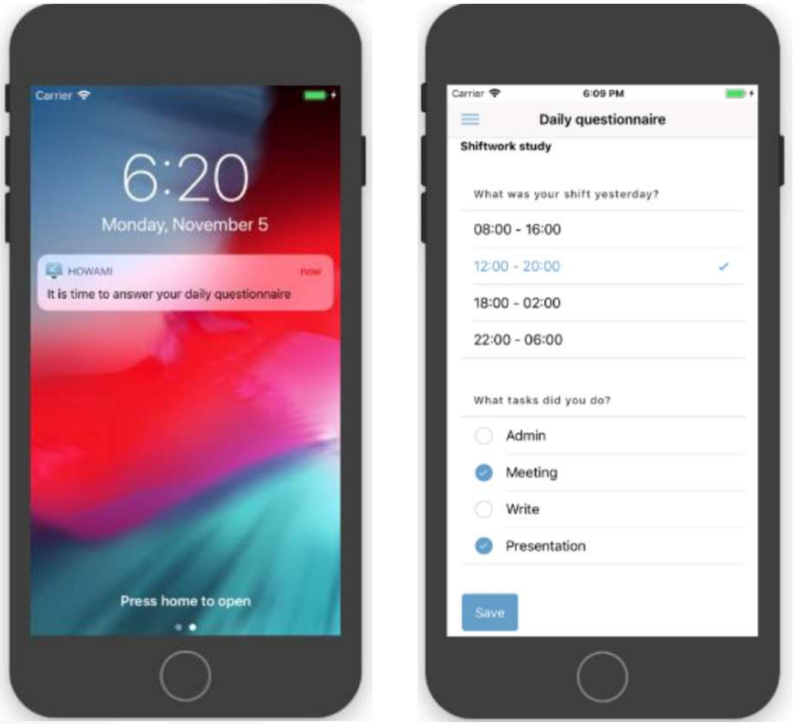
Inside Outside





Self employed vs. employee

Questionnaires



App downloaded to participant's phone

Can set times for alerts, select language

Will prompt for certain questions at certain times

- Shift related questions
- Anxiety and mood
- Sleep quality
- Respiratory symptoms

Future Analyses

Case Studies on shift work and respiratory health

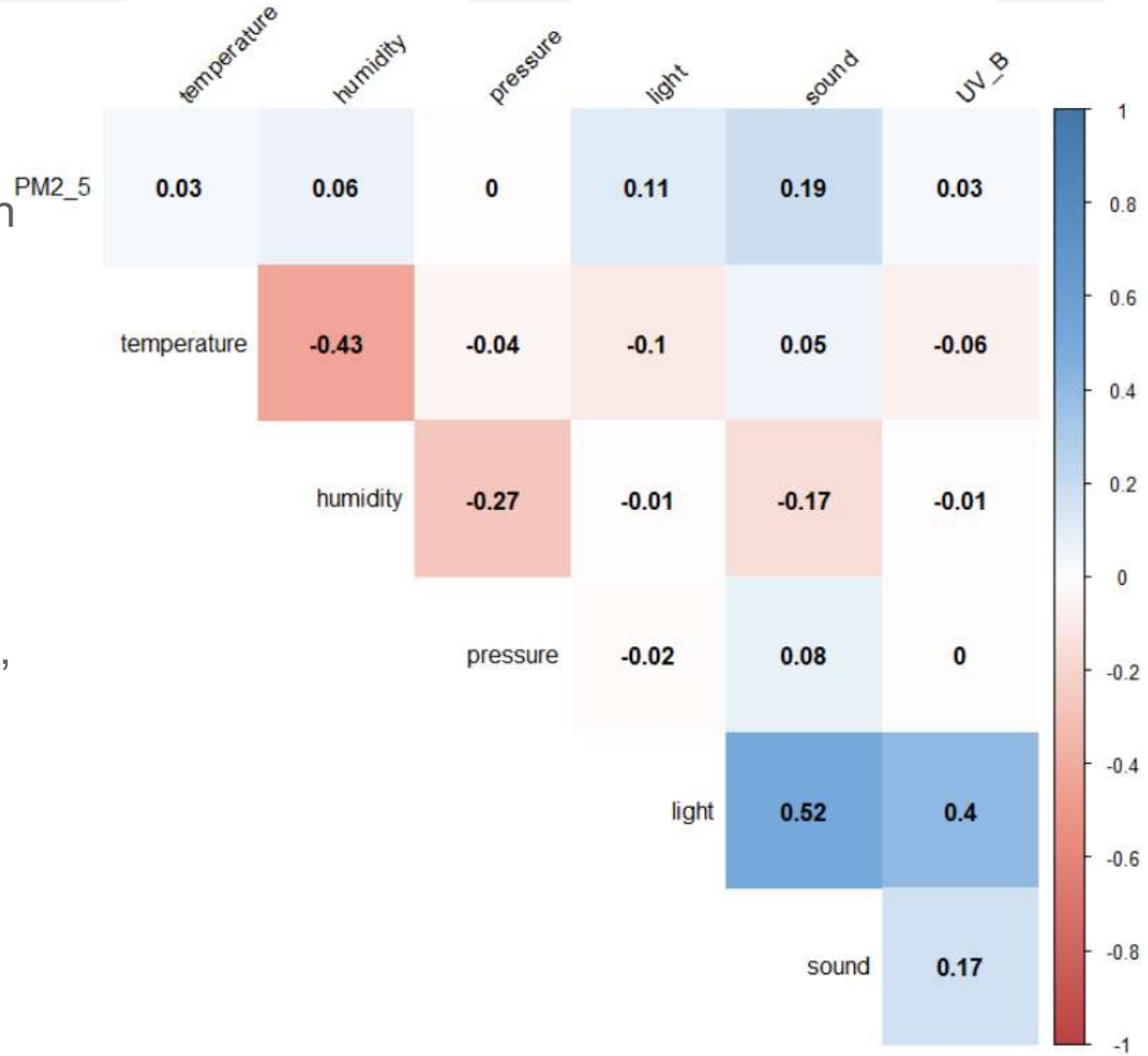
Target sample of 300 people

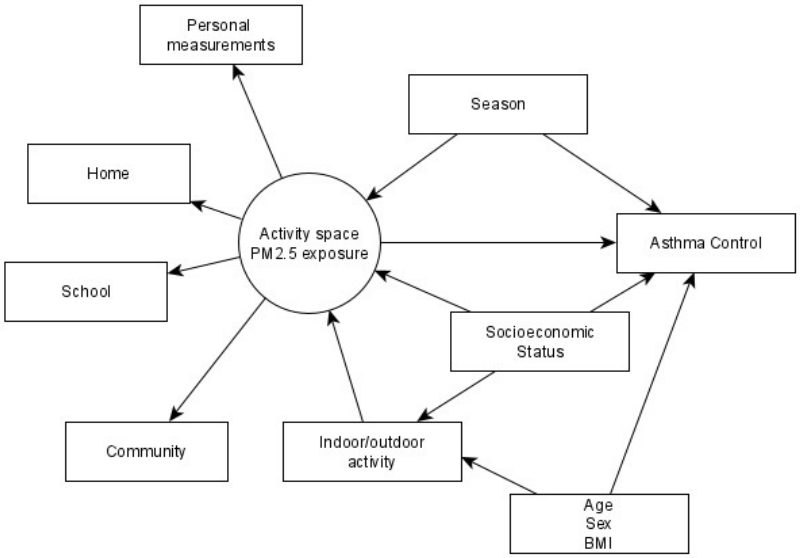
Correlation between exposures

Dimension reduction methods

Evaluate predictors of exposure

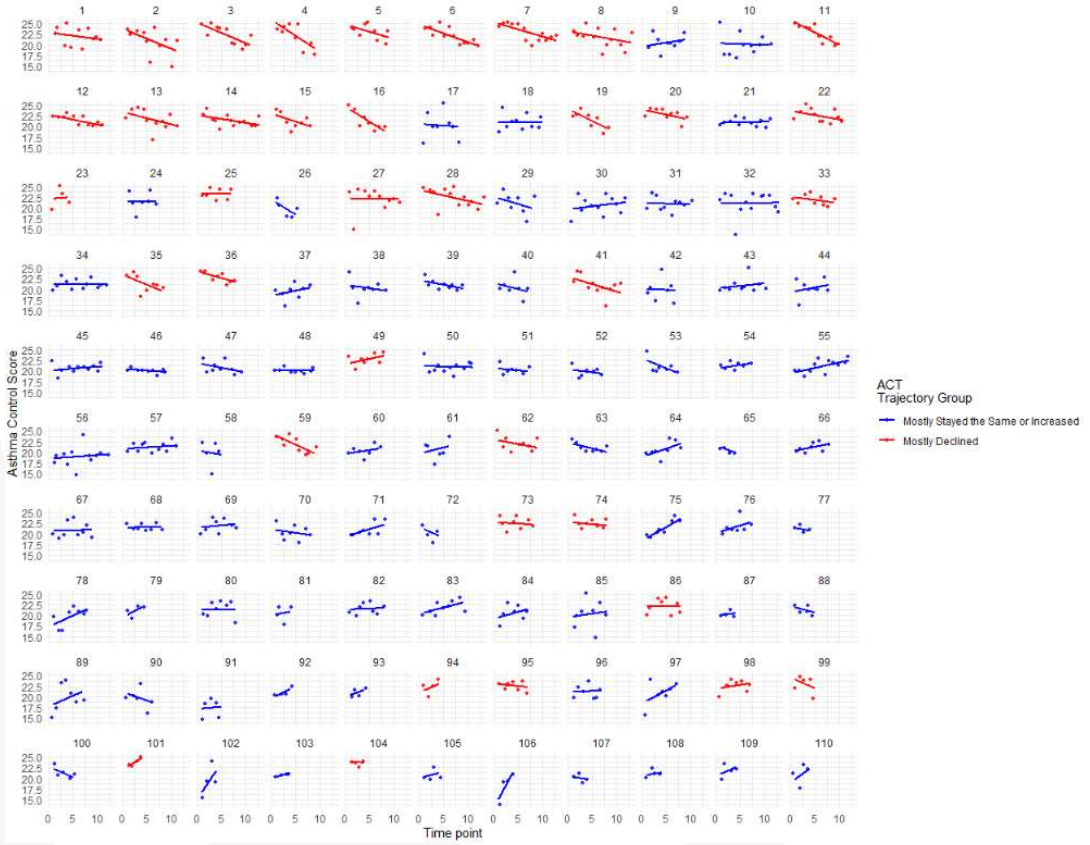
Use in health effects analyses (e.g. lung function, sleep, cardiovascular health)





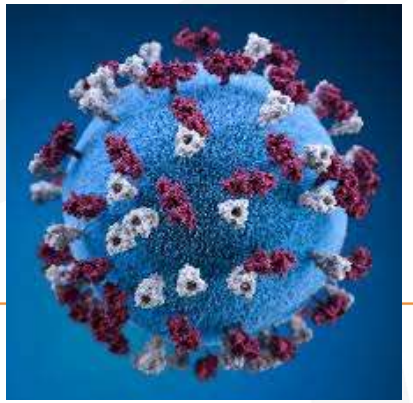
In a study of children in Delhi India

For every 10 μg/m^3 increase in personal level PM2.5 measurements, there was an 8% higher odds of being in a group of asthmatics where their asthma control worsened



Prevention of Covid-19 in the workplace

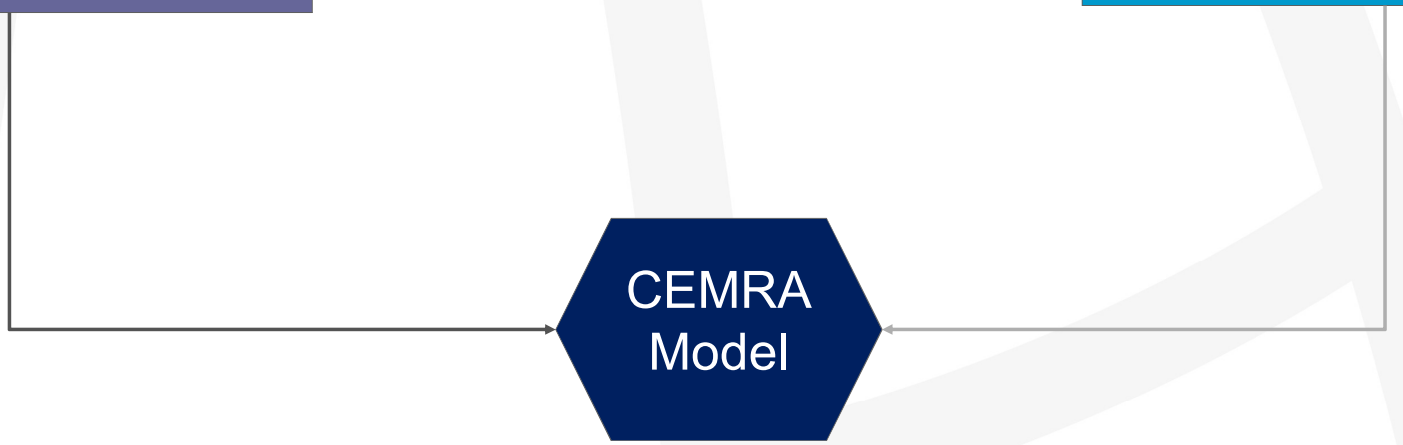
- Workers in healthcare settings potentially exposed to SARS-CoV-2 virus from patients and also from other staff
- Health professionals risk of death 1.67 (1.24-1.25) (Nafilyan, 2021)
- Help managers explore potential risk reduction from different (especially novel) interventions using QMRA modelling
- Balance risk of work-acquired vs. community acquired COVID-19



Project components

Environmental sampling
- Air and surface
- Ventilation
- Room layouts

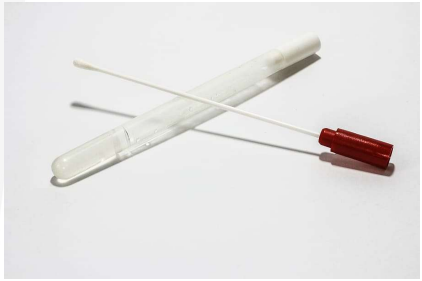
Worker activities
- Time spent near field vs. far field from patient
- Surfaces touched (with dominant hand)



Environmental sampling

- Evaluate levels in known positive wards and wards that may have ‘unknown’ Covid patients
- Hospital A: Covid positive ward
- Hospital B: Covid positive ward (B1); assessment ward (B2)
- Hospital C: Assessment ward
- Note that wards were not designed as treatment rooms, but repurposed for Covid-19

Environmental sampling



- Surface samples (n=127)
- Near patient areas; high touch areas; PPE donning/doffing; waiting rooms; nurse workstations
- Surface area swabbed 10-225 cm^2 with nylon flocked swab, placed in viral transport media
- Air samples (n=56)
- Coriolis Microsampler (Bertin, France)
- 200 LPM for 20 minutes
- Sampled during November-December 2020

Results of Environmental Assessment

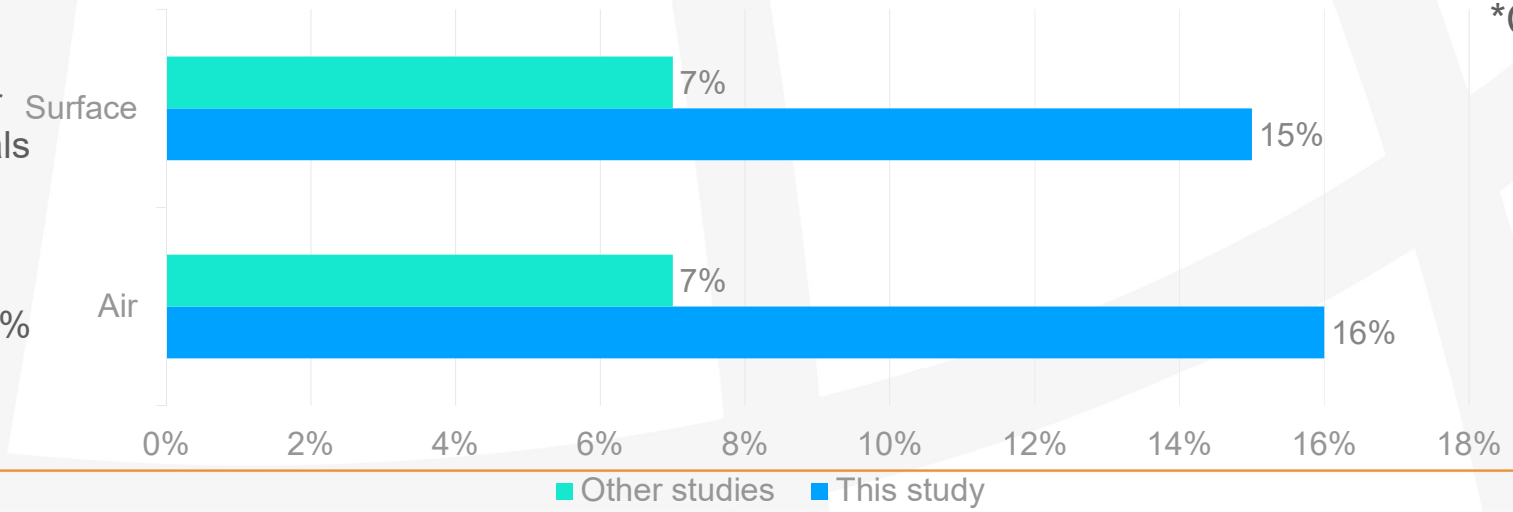
Sample types	n quantified	geomean	geoSD	Max	Cherrie et al.
Air (copies m^{-3})	9*	0.41	71	1717	0.01 (gm)
Surface (copies cm^{-2})	20*	0.03	45	378	0.001-0.049 (2 studies only)

*Covid-Wards only

Percentage positive samples this study compared to others

Median of other studies in hospitals shown

Ranged from 0 detections to 100% (air) and 74% (surface)



From Cherrie et al:
https://www.medrxiv.org/content/10.1101/2021.01.25.21250233v1.article-info

Results of Environmental Assessment

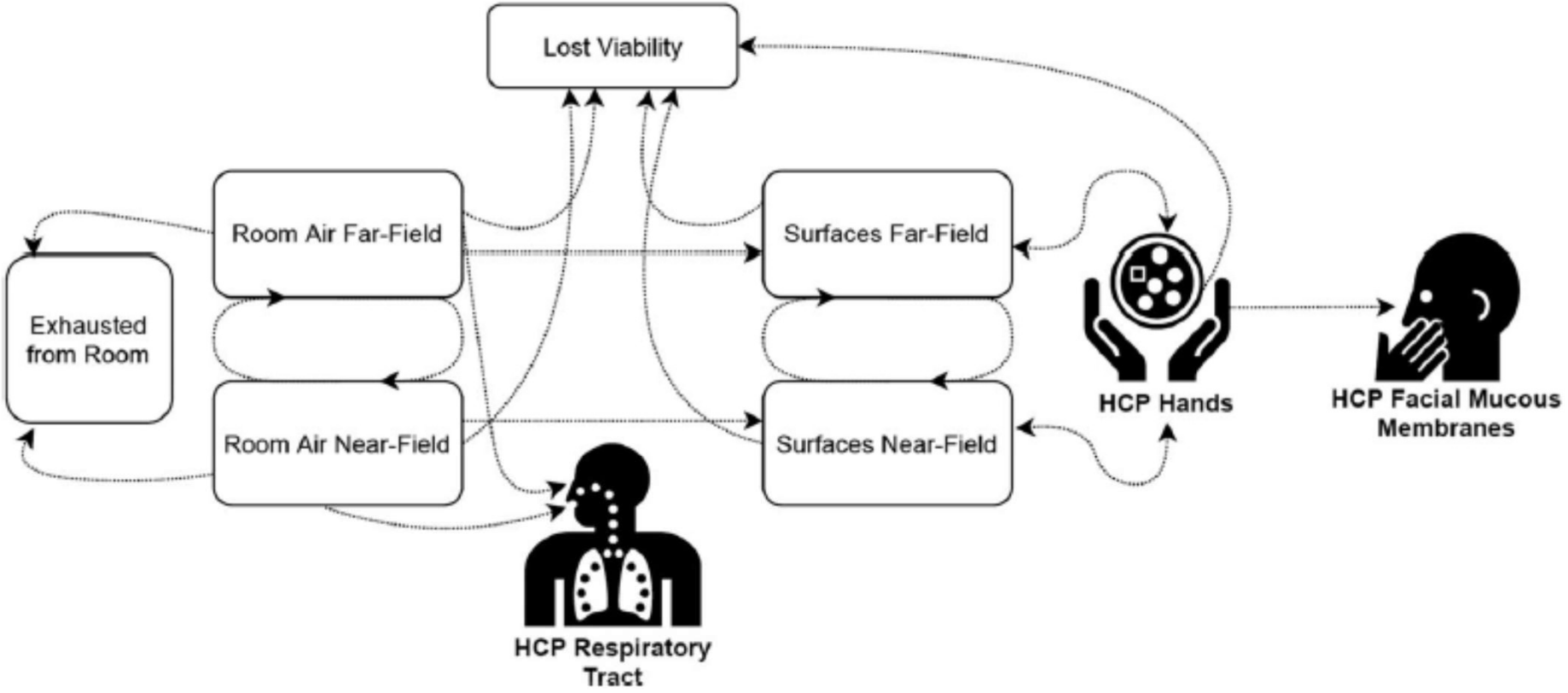
Sample types	geomean	geoSD	Cherrie et al.*
Hospital A			
Air (copies m^{-3})	0.89	51	0.01
Surface (copies cm^{-2})	0.12	0.28	0.001-0.049 (2 studies only)
Hospital B1			
Air (copies m^{-3})	12	9.7	0.01
Surface (copies cm^{-2})	0.15	0.12	0.001-0.049 (2 studies only)

*From Cherrie et al, *Annals of Work Exposures and Health*, 2021

Site features

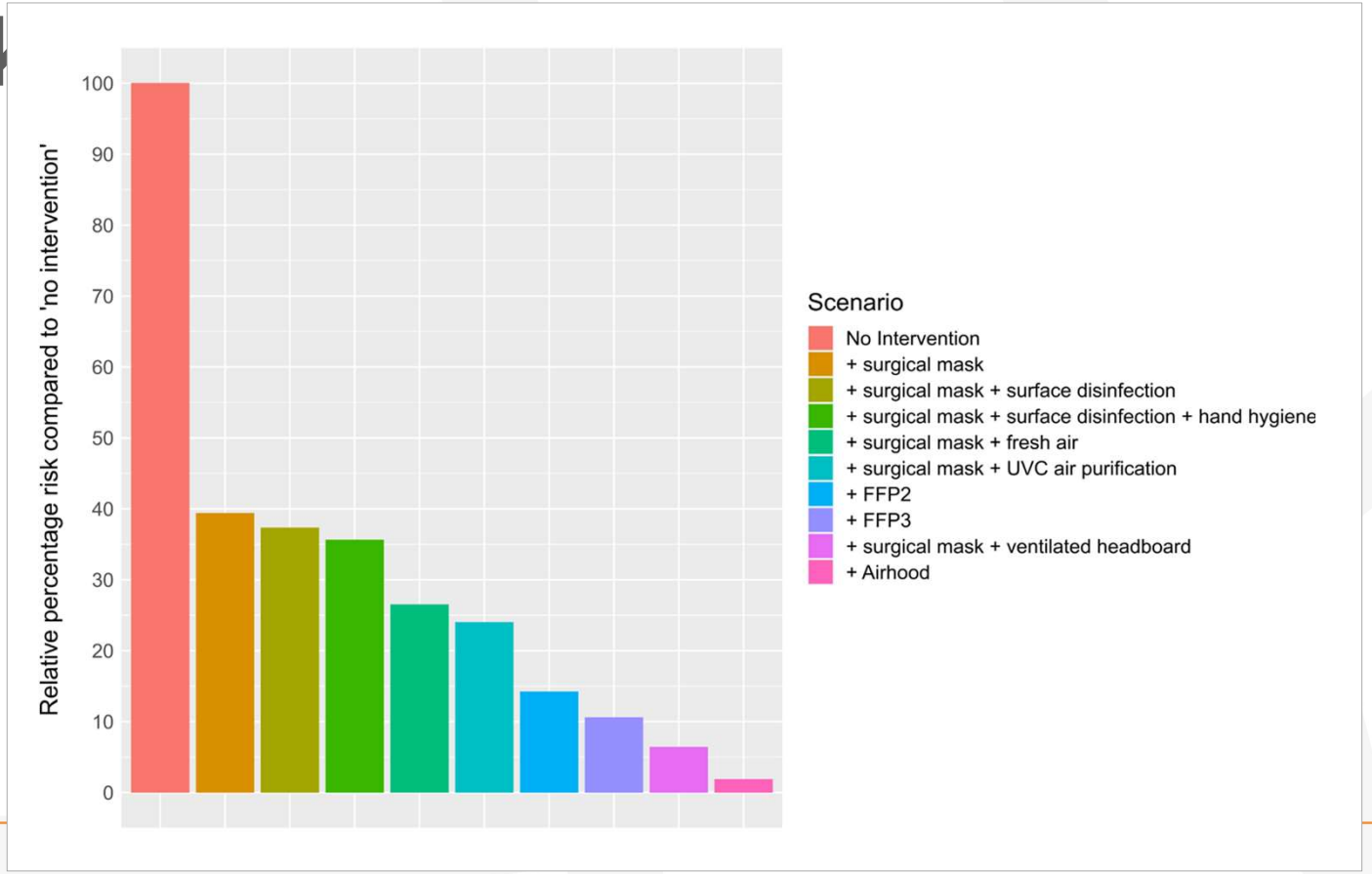
- Ventilation
  - Buildings were older – designed before most recent Scottish Health Technical Memorandum guidelines for healthcare ventilation
  - Bedrooms did not necessarily have mechanical ventilation and guidelines not always met
  - Some areas needed rebalancing to achieve pressure cascades
- Areas with positive/suspect samples
  - Primarily near patient beds
  - Toilet (light switch, handle)
  - CPAP room
  - PPE don/doff room
  - Waiting areas

Quantitative Microbial Risk Modelling



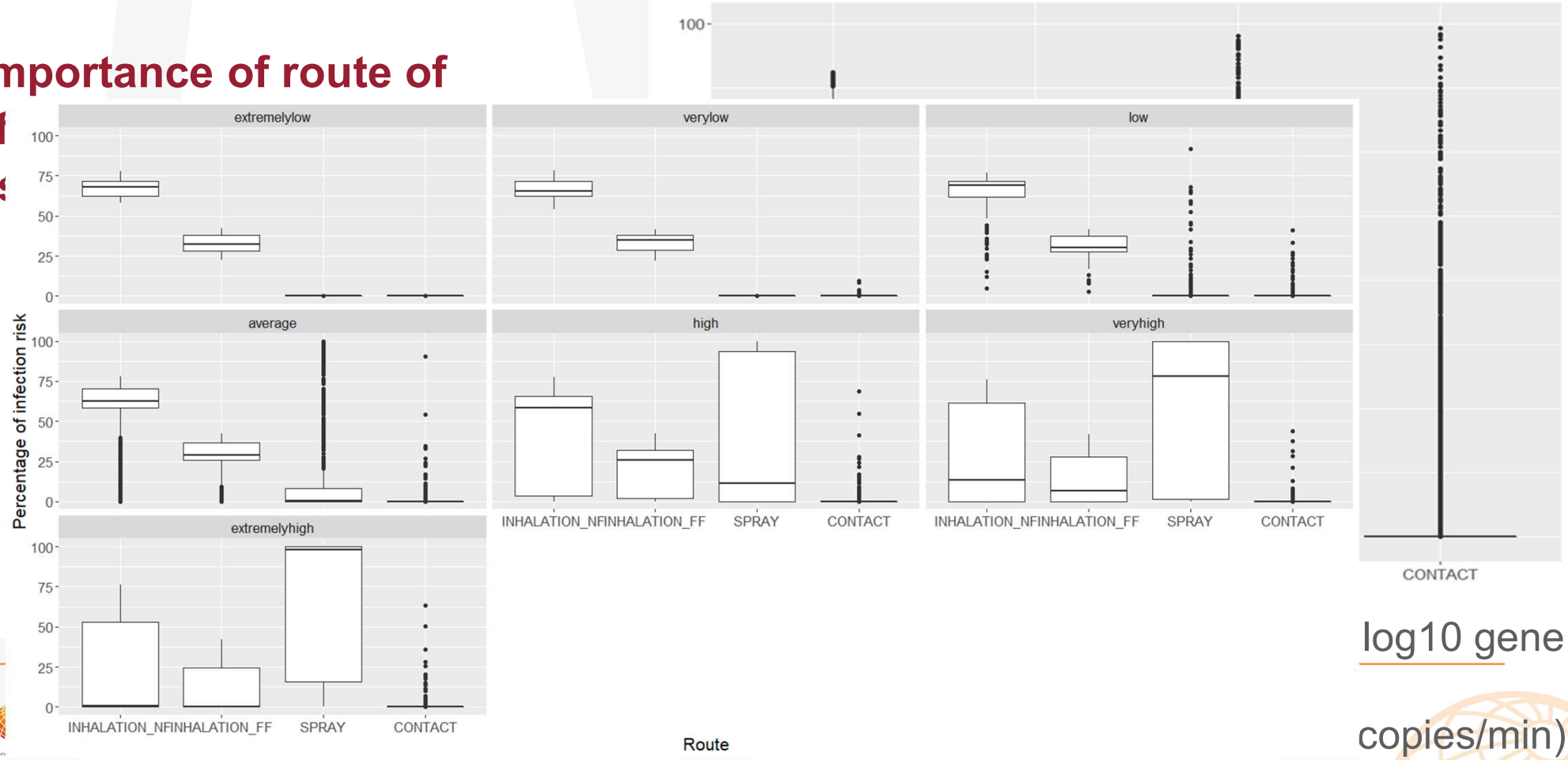
Jones, R.M., 2020. Relative contributions of transmission routes for COVID-19 among healthcare personnel providing patient care. *Journal of Occupational and Environmental Hygiene*, *17*(9), pp.408-415.

Risk


Relative percentage risk compared to 'no intervention'
100
90
80
70
60
50
40
30
20
10
0
Scenario
No Intervention
+ surgical mask
+ surgical mask + surface disinfection
+ surgical mask + surface disinfection + hand hygiene
+ surgical mask + fresh air
+ surgical mask + UVC air purification
+ FFP2
+ FFP3
+ surgical mask + ventilated headboard
+ Airhood

Predicted routes of infection

Importance of route of inf



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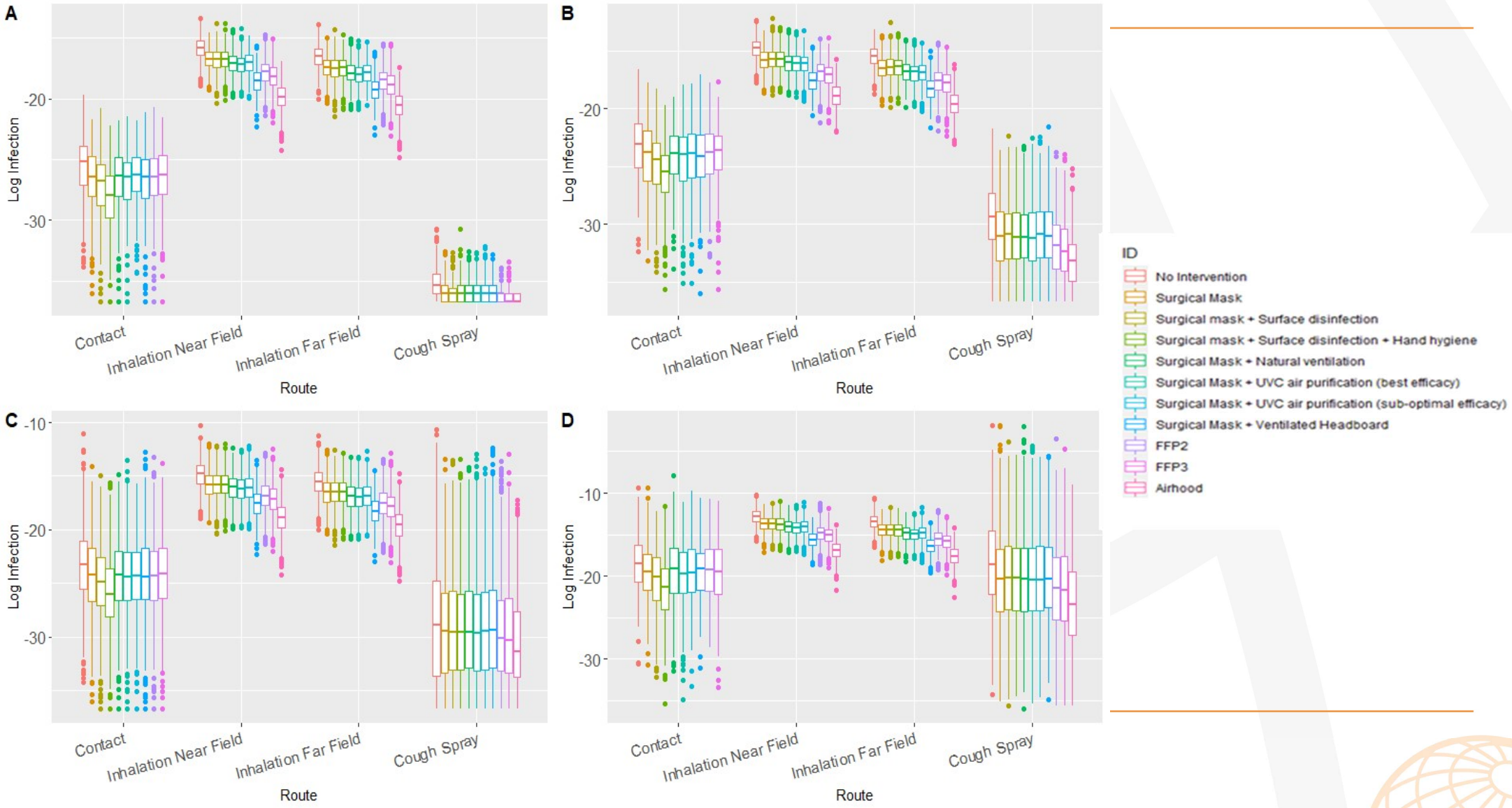

A
B
C
D
Log Infection
-10
-20
-30
Contact
Inhalation Near Field
Inhalation Far Field
Cough Spray
Route
ID
No Intervention
Surgical Mask
Surgical mask + Surface disinfection
Surgical mask + Surface disinfection + Hand hygiene
Surgical Mask + Natural ventilation
Surgical Mask + UVC air purification (best efficacy)
Surgical Mask + UVC air purification (sub-optimal efficacy)
Surgical Mask + Ventilated Headboard
FFP2
FFP3
Airhood

Sensors @Work

CO2 monitors popular since COVID-19 as an indicator of ventilation

Ventilation not frequently monitored in many spaces – most would not know their current status

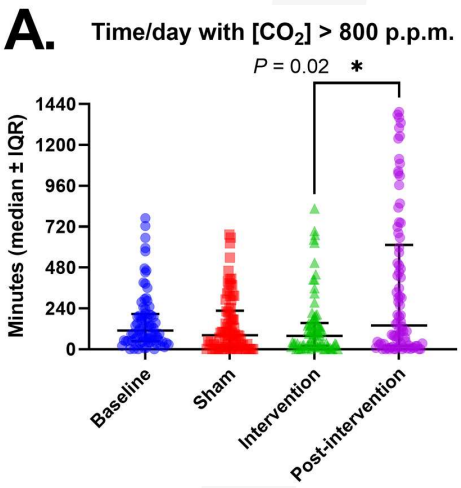
'Non-work' times and spaces at work considered potentially important

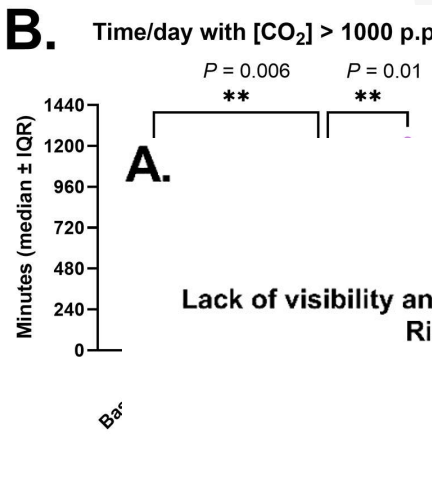
Many workplaces have aged infrastructure

- Hospitals
- Food and drink processing facilities

Role for CO_2 monitoring in hospitals?

Reported CO2 levels can exceed 1000 ppm, particularly without HVAC systems or with visitors (Laurent and Frans, *Science of Total Environment*, 2022)





Healthy Working Life

We are working longer – how can we maintain our health at work?

- Return to work after illness (e.g. cancer, COVID-19)

World of work is changing – how to deal with working at home? Working remotely? Gig economy?

Air quality is an important 'hidden' aspect of health and well-being

- Comfort
- Concentration
- Long-term health

How could sensors and mobile technology be applied for health management at work?

High resolution temporal data can provide insights about peak and short-term exposures

- With appropriate contextual information (e.g. location, activities) wearables can better target and reduce exposures
- Can provide real-time feedback to workers and managers
- Networks of area sensors can help manage hazard levels across space and time

Understanding ‘pulse’ of workers, especially if remote or not office based (e.g. stress)

Help track, e.g. lone workers for safety

Healthy habits

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Development of exposure protocols – Susanne Steinle, Darpan Das (IOM), Eelco Kuijpers, Sander Ruiter, Peter Tromp, Ferry Jagers (TNO), Jan Mink, Omar Mhaouch, JingJing Wang (VTEC), Anne Mette Lund Wurtz, Vivi Schlunssen (Aarhus University), Barbara Harding, Gemma Castaño, Manolis Kogevinas (IS Global)

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Data analysis – Mark Cherrie (IOM)

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TNO innovation for life

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Thank you

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