Factors that influence COVID-19 transmission on ground public transport

Indoor Air Management of Airborne Pathogens for Public Transportation

Professor Susan Grant-Muller, University of Leeds

Q: How much transmission happens on public transport?

Very hard to directly measure

- Highly transient environment
- Variation between different modes of transport
- Variation between demographics
- Little record of who travels where for most settings

Examples of Epidemiological Evidence

- Bus outbreak China (Shen et.al 2022) – people on bus with 1 infected person 41.5 x risk of infection c/f bus with no infected person, highlights airborne exposure
- Baden-Wuerttemberg: 0.2% of cases on transport - outbreaks may be under recorded on public transportation, because infections couldn't be identified and potential contacts difficult to trace (Dressler et. Al (2021)
- Zhao et. Al (2020): passengers originating in Wuhan to 6 cities, 'strong and significant association between travel by train and the number of COVID-19 cases' x10 pax -> 8.3% increase in imported cases.

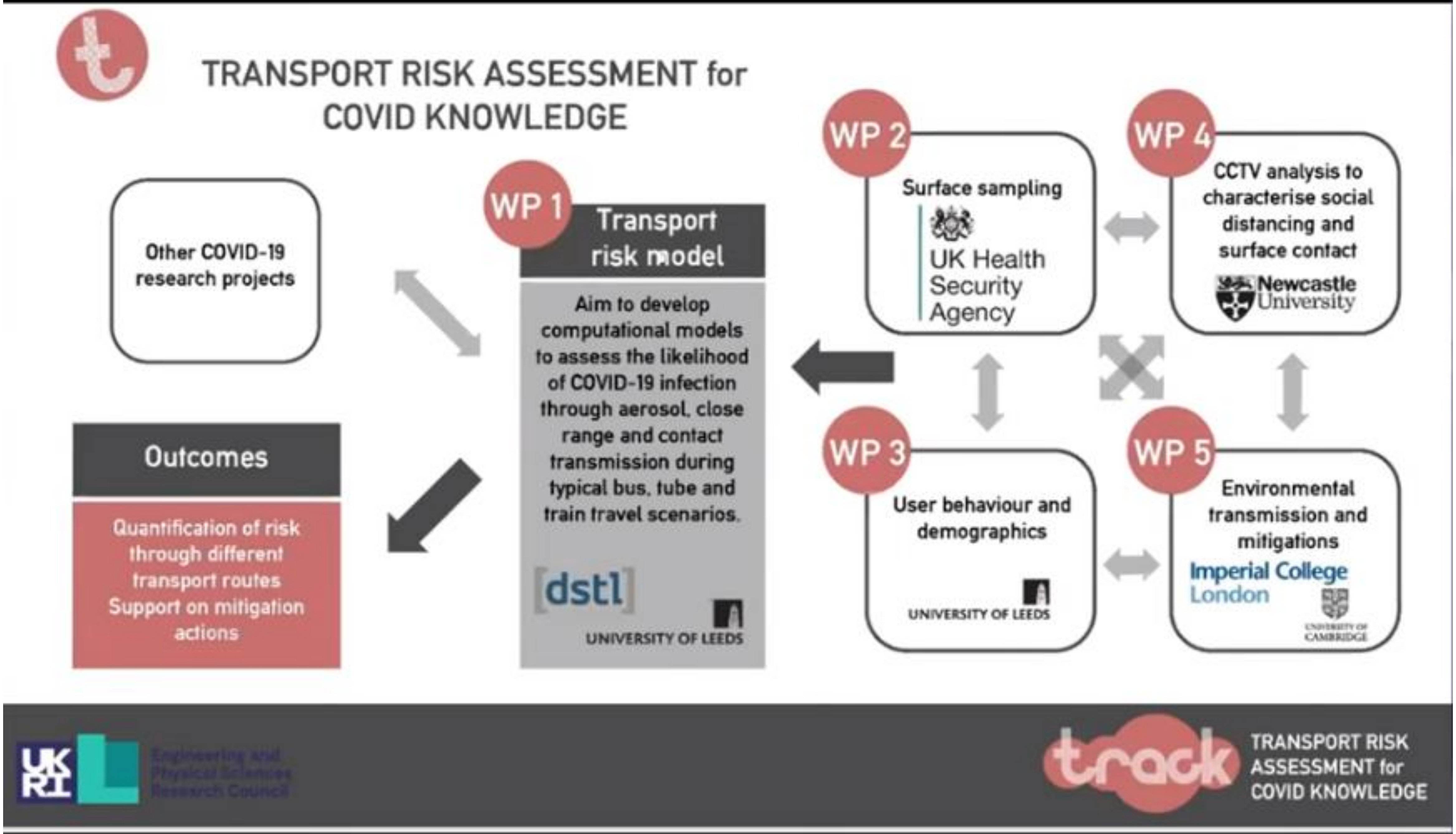
Unique set of complex factors

Environment

- High occupancy density with close proximity
- Limited ability for individuals to control the environment, especially the air
- High touch frequency setting – people hold on
- Connecting hubs link to social spaces (food/drink/retail)

Behavioural

- High connectivity in a community – large number of "strangers" come together
- Essential service, especially for those who work in more risky settings
- Relatively sedentary – lower aerosol emission?


TRANSPORT RISK ASSESSMENT for COVID KNOWLEDGE
Other COVID-19 research projects
WP 1
Transport risk model
Aim to develop computational models to assess the likelihood of COVID-19 infection through aerosol, close range and contact transmission during typical bus, tube and train travel scenarios.
dstl
UNIVERSITY OF LEEDS
Outcomes
Quantification of risk through different transport routes
Support on mitigation actions
WP 2
Surface sampling
UK Health Security Agency
WP 4
CCTV analysis to characterise social distancing and surface contact
Newcastle University
WP 3
User behaviour and demographics
UNIVERSITY OF LEEDS
WP 5
Environmental transmission and mitigations
Imperial College London
UNIVERSITY OF CAMBRIDGE
UKRI
track
TRANSPORT RISK ASSESSMENT for COVID KNOWLEDGE

Who is using public transport?

Population Characteristics

By Gender?

By Age?

By Ethnicity?

By Income Level?

Activity Characteristics

Trip Purpose

Time of Day

Modal Characteristics

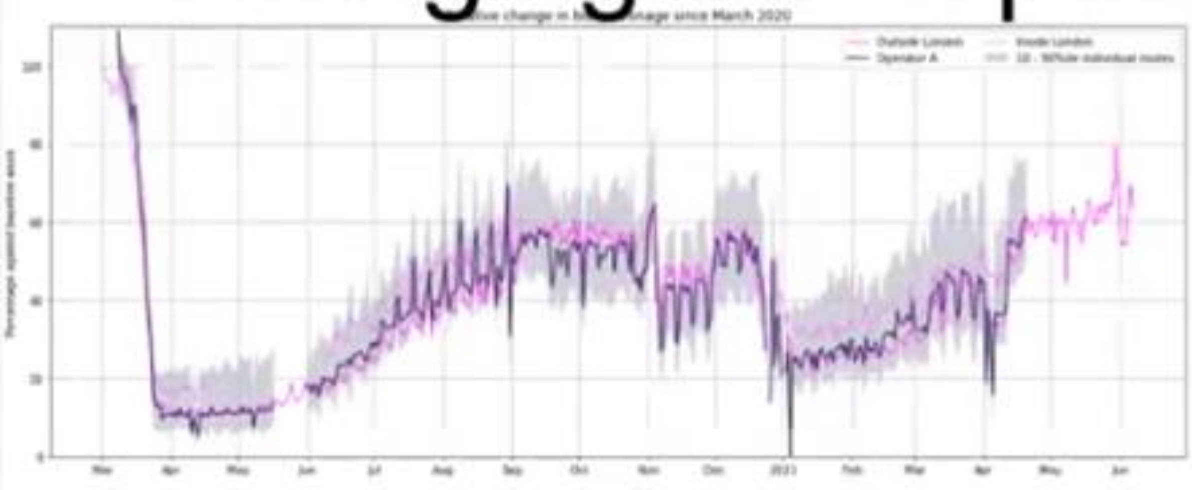
Route

Cost

Journey Time

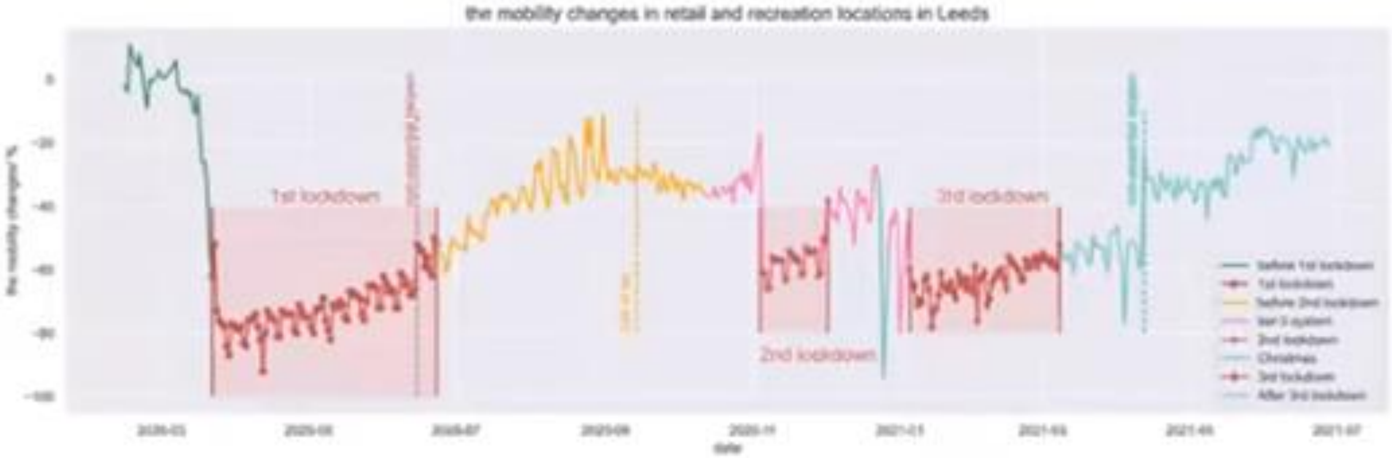
https://www.intelligenttransport.com/transport-articles/73413/european-bus-coach-passenger-rights/

Changing travel patterns



Patronage data from operator – first 15 months

Google mobility data for Leeds – retail and recreational locations



Modelling multiple factors

Chance of infected person → Long range airborne / Close range aerosols & droplets / Surface (fomite) contamination → Exposure to virus → Infection

- Prevalence
- Number of passengers
- Adherence to “stay home when sick”
- Frequency of travel

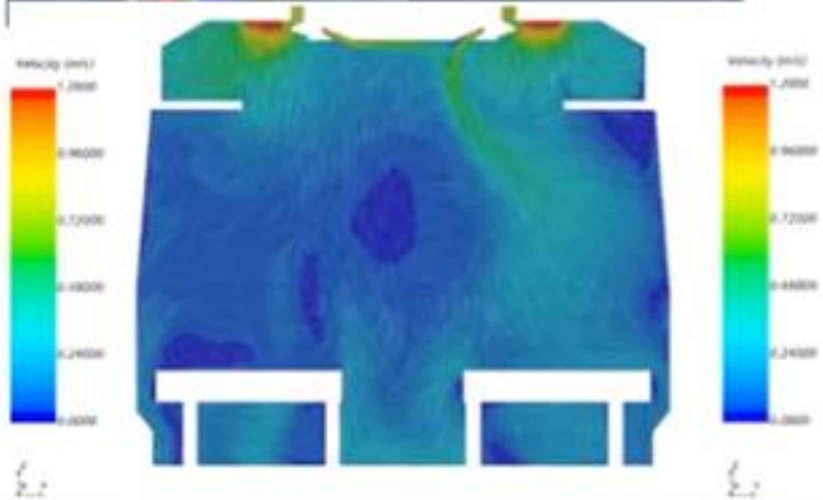
- Viral load
- Activity
- Face coverings
- Hygiene behaviours
- Surface touching

- Duration of time
- Proximity
- Ventilation
- Hygiene behaviours
- Face coverings

- Infectious dose
- Variant
- Vaccines
- Immunity
- Transmission route

Assessing ventilation

- Measuring the potential pathway for airborne transmission
- Multiple approaches:
  - CO2 and particle measurements on transport vehicles;
- Lab studies using analogue models;
  - Analytical and computational models



Practicalities of ventilation

Commuter train/bus/subway

- May be mechanical or natural ventilation
- Short journeys – ventilation has less impact
- Opening doors/windows may help

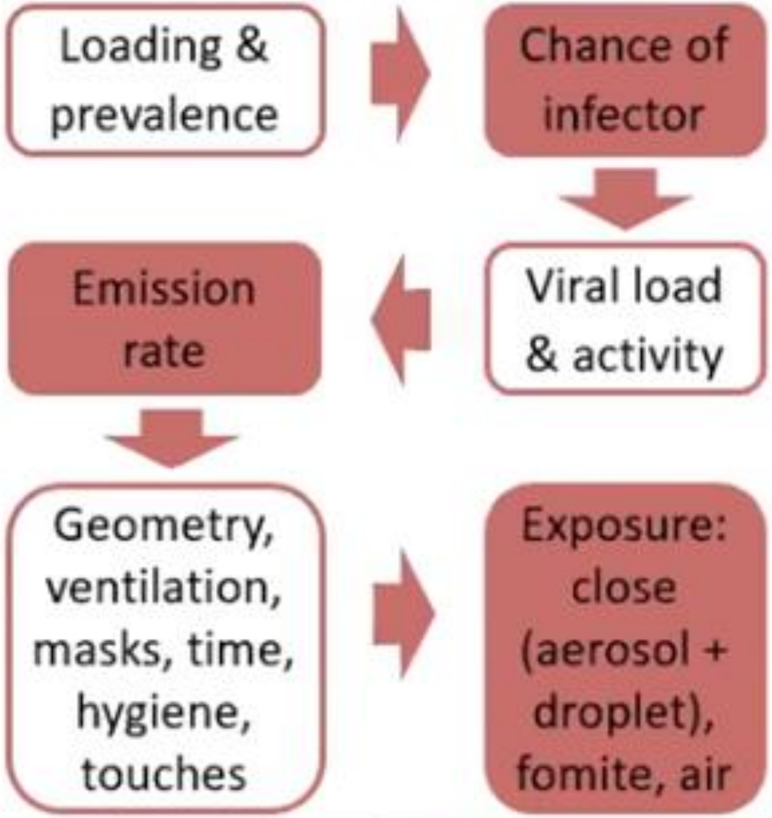
Intercity train

- Usually fully mechanical vent, often with demand control
- Long journeys – ventilation important
- Very little opportunity to increase easily – longer term redesign
- Challenges with power consumption

Commuter journeys – multi-route risk

TVC Model: Agent-based subway stochastic model

- Predicted risk of exposure – overall low
- Prevalence and loading - dominant factors
- Highest doses – small % people in close proximity to infected person
- Small % people could get high fomite dose from contaminated surfaces.
- Long range airborne exposure - lower with short journey + high ventilation rate
- Masks - can reduce all transmission routes



Miller, D., King, M. F., Nally, J., Drodge, J. R., Reeves, G. I., Bate, A. M., ... & Noakes, C. J. (2022). Modeling the factors that influence exposure to SARS-CoV-2 on a subway train carriage. *Indoor air*, *32*(2), e12976.

Can we estimate relative airborne risk?

- Comparisons are hard - modes of transmission, time in a setting
- Factors that reduce travel risk: passive behaviours, short journey, lack of familiarity
- Factors that increase travel risk: frequency of journeys, number of people, proximity

		1 quanta/h	100 quanta/h
Train 1 hour	Individual risk	0.043%	4.2%
(136 people)	Number of new cases	0.058	5.6
Office 8 hours	Well ventilated (10 l/s/p)	0.27%	23.4%
(40 people	Poor ventilation (5 l/s/p)	0.53%	41.3%

Longer journey where ventilation exposure may dominate, quanta = no infectious particles need to infect a susceptible person.

Woodward, H, de Kreij, RJB, Kruger, ES, et al. An evaluation of the risk of airborne transmission of COVID-19 on an inter-city train carriage. *Indoor Air*. 2022; 32:e13121.

Learning so far

- Individual risk is likely low, especially on short journeys
- Population risk increases with the number of journeys
- Prevalence and loading likely to dominate risk
- Close range airborne transmission can happen anywhere people are in proximity – higher with increased loading
- Fomite transmission probably low but high surface touching could increase risks
- Long range airborne transmission is likely to be most important on long distance journeys

Knowledge gaps

- Actual transmission on PT still extremely challenging to measure (hence exposure approach)
- Need for improved knowledge on PT risks vs other environments
- Q of what is safe air quality on ground public transport – considering wider risk types
- Can AQ be improved within other operational constraints (energy efficiency, temperature, cost…)?

Mitigating actions

Policy/transport operator

- Strategies to enable good ventilation
- Strategies to reduce virus prevalence – testing, isolation,
- Provision of facilities for hand hygiene
- Ticketing strategies to minimise crowding
- Cleaning may be less important

Individual, supported by policy/operator

- Avoid travel when sick
- Wearing face coverings
- Hygiene behaviours – hand cleaning, face touching, cough behaviour
- Keep windows open
- Support social distancing

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Thank you to all of the TRACK team, DfT colleagues and support from transport operators and stakeholder groups

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