Transmission risk in transport: towards a model of multi-route exposure for TRACK

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To understand scale of risk and choose appropriate mitigation measures to minimise infection on transport we need to understand the role of different routes of transmission
  - Close range, small aerosol, surface contact

The Environment and Modelling Group (EMG), a sub-group of SAGE, together with DfT, academic partners, PHE and Dstl, have developed a programme of work to create a transport risk model

UKRI have approved £1.6m of funding to be made available for TRACK. DfT are providing £156k to fund DSTL support with modelling
Leeds/Dstl/Manchester

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.

Building on combined expertise in modelling airborne exposure and surface transfer
  - **Microscale stochastic risk model** using a quantitative microbial risk assessment approach
  - Rapid planning tool building on microscale results

Data from the other WPs will be incorporated into the model during the project

**Stochastic risk model**
- Mechanistic representation of transmission
- Three transmission routes
- Simulate multiple journeys
- Randomised passenger properties and contact behaviour
- Can simulate mitigation measures
- Requires many 1000s of runs

**Planning tool**
- Captures key results from stochastic model
- Allows effects of high level parameters to be explored
Transmission of Virus in Carriages (TVC) model

- Dstl modelling work focused on stochastic risk model using approach based on Lei et al (2018)
- Initial model based on London Underground (LU) Victoria Line carriage
  - Northbound/Southbound route
  - Internal volume and surface area
  - Ventilation details
  - Frequently touched surfaces tracked – handrails and seat rests
  - Discrete events – alighting, boarding, transit between stations
- Passengers
  - Individual entities that can board or alight at any station (toy data, LU data)
  - Probability of being infectious
  - Cumulative dose by each potential route of infection

Lei et al, 2018
Initial methodology will be updated and incorporate data as it becomes available.

**Airborne exposure - small aerosol (< 5µm dry particle diameter)**
- Infectious passenger(s) acts as source once on board
- Assume a single well-mixed zone including ventilation, deposition & viral decay
- Analytical calculations for concentration and exposure after Fitzgerald and Parker et al (2014)

**Close range exposure – droplet transmission**
- Location of passengers not tracked explicitly
- For each infectious passenger, the number of co-passengers within 0-1 m and 1-2 m estimated based on passenger density and distribution of available areas

**Surface contact exposure**
- Assume that infectious passenger has initial virus contamination on hands
- Deposition from respiratory activity during travel included
- Decay on surfaces included
- Passengers are assumed to touch a fixed number of surfaces at random on boarding / alighting
• Initial parameters as basis
• One infected passenger and 30 min co-occupancy
• Source strength is the key parameter (and subject to the greatest uncertainty)
  – Baseline is a high estimate of $10^8$ virus/mL in saliva and Duguid (1946) data (<20µm wet droplets) in line with Jones (2020)
• High air change rate on LU carriage means very limited influence from:
  – Deposition rate
  – Decay rate

Duguid (1946) https://doi.org/10.1017/s0022172400019288
Close range exposure

- Preliminary example with toy passenger data:
  - 10 stations
  - 20 passengers board for first five
  - Passengers travel for five stops
- One infectious passenger boards at the start
- Colours show proximity
  - Note change with passenger density
- Quantitative estimate for exposure currently being implemented after Lei et al (2018)
  - 2m zone for large droplets with mucous membrane settling and inspiration
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Preliminary results using the same toy data
Plotting non-infectious passenger hand and surface contamination without coughing onto hands or surfaces
  - Rapid fall in mean concentration as contamination spreads
  - Proportion of passengers with some contamination rises with number of stops
  - The assumed number of surfaces touched has an important effect
Third plot show sensitivity to:
  - Coughing/sneezing onto hands or surfaces
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Summary and next steps

- Preliminary stochastic model of exposure via three routes developed
  - Concept and design
  - Software implementation and QA underway
  - Initial parameters selected and limited sensitivity analysis performed

- Initial next steps include
  - Close range exposure
  - Dose-response estimate
  - Parameter review and update
  - Full sensitivity analysis and output for planning tool – including relative effects of passenger loading and mitigation
Further ahead
- Extend model to bus and overground train environments
- Include more sophisticated passenger behaviour
- Update and validate model using observed data and wider scientific evidence

Stochastic risk model and planning tool, together with outputs from other WPs, will provide:
- Assessment of likely risk of COVID-19 transmission through small aerosol, close range and surface contact routes for typical bus, tube and train scenarios
- Support to DfT policy teams to design interventions and transport operators to assess risk with the potential for read across to other sectors
Any questions?