

Supplementary information 1: Quantitative basis for visualisation of transmission

The structure of the diagram shown in Figure 1 in the main paper can be considered conceptually as a weighted directed graph (a mathematical description of a network as opposed to a chart for visualising data) whose nodes are the circles and whose edges are the arrows between the circles. The intention of the related visualisation is to show the importance of the different routes in contributing to transmission and the overall rate of virus transmission. The weight of each edge in the graph reflects the rate of viable virus transferred between the two nodes that it connects. The graph is analogous to a flow network with the input from the infected person and the output reaching the susceptible person. The flow through the branching and recombining network is determined by splits defined wherever more than one edge leaves a node and through reductions because of environmental factors and mitigation measures applied.

The following properties are defined for the graph:

1. Nodes have no capacity. In other words, virus does not build up in any node. This is equivalent to assuming steady state conditions for the network. While this is a necessary simplification for data elicitation and communication, it is an important consideration when interpreting the visualisation.
2. The sum of inflows to each node equals the sum of outflows from each node
3. Splits define the fraction of viable virus flowing between each outflow from a node. These splits sum to 1.0 (100%).
4. For a given environment, the amount of viable virus flowing along an edge may be reduced by multiplying by a factor between 0 and 1.0. Only a single environment applies for a given scenario.
5. For each mitigation factor applied, the amount of viable virus flowing along an edge may be reduced by multiplying by a factor between 0 and 1.0. A mitigation measure may apply to one or more edge. Multiple mitigation measures can be applied at the same time and their reduction effect multiplied together.
6. The input to the graph depends on the activity of the infected person and the overall flow rate through the network will scale with this factor.

It is important to note that the graph and the edge weights describe a flow of virus per unit time. The overall amount of virus transmitted in a given scenario will depend on the duration of the exposure.

To calculate the edge weights of the graph the following algorithm can be used:

1. Start from the input from the infectious person
2. Calculate the outflow from the node (equal to the defined input for the infectious person or the sum of the inflows for all other nodes)
3. Multiply each edge by the defined split fraction to determine the outflow along the edge
4. Multiply the edge weight by the chosen environment reduction factor
5. Multiply the edge weight by the applied mitigation reduction factors for all of the mitigations in force
6. The resulting edge weight then forms the inflow into the downstream node
7. Repeat for each node in order. The directed graph can be considered as a partially ordered set and used to determine the appropriate order. Outflows from nodes cannot be calculated until the weights for all inflows have been determined.

The resulting edge weights for a given environment condition and selection of mitigating measures can then be used to scale a visualisation of viral transmission for example using colour, size or a combination of both. The use of elicited data provides the values for the scaling factors required.

The approach described above is not a quantitative model for viral transmission. The approach is deliberately simplified to support the communication of relative transfer of virus between two individuals in a form that can be used to elicit data from experts and to compare environments and mitigation measures. In addition, the approach only considers the transfer of virus between individuals and does not necessarily imply that virus exposure by different routes will result in the same degree of risk.