Annex 1 to SPI-M-O Statement on population case detection: Modelling assumptions, courtesy of Brooks-Pollock, Danon, and McLean

- The reproduction number is based on data from the Social Contact Survey – detailed methods below.
- The probability of symptoms increases linearly with age of index case from 25% in cases under 18 years of age to 75% in cases aged over 65 years (Dr R. Eggo, personal communication).
- Contact tracing means that $CT\%$ of social contacts of a case (with symptoms) do not occur.
- Mass testing detects asymptomatic cases.
- The probability of identifying an asymptomatic case is $7/T,$ where T is the frequency of testing in days and we assume that an asymptomatic case will test positive for 7 days.
- Under mass testing, the percentage of secondary cases arising from a positive test for an asymptomatic person depends on the frequency with which the contact occurs. If the contact is a regular one, it has the same impact on transmission as with symptomatic contact tracing. So:
    - $CT\%$ of contacts that occur more often than once a week are prevented
    - $(CT/T)\%$ of new and infrequent (less than once a week) contacts are prevented (Grassly et al 2020).
- Children under 11 years of age are assumed to be 50% as infectious as everyone else.
- "COVID secure" interactions reduce the transmission probability across a contact and apply to non-household contacts of cases over 11 years old only.

Data description

- The Social Contact Survey surveyed 5,861 individuals in the UK in 2010 about their social contacts during a single day. Participants were recruited using three approaches: a paper survey sent to people in the post, an online survey and an online survey aimed specifically at school-aged children. Participants were asked to complete demographic information about themselves including age, occupation and about their social contacts on the previous day. Participants were asked to report the number of people they met, the duration of the contact (<10 minutes, 10 to 59 minutes, 1 to 4 hours, 4+ hours), the context (home, work/school, travel, other/leisure), and whether the contact involved touch, e.g. a handshake, hug or kiss. To ease the ability to report large number of contacts per day, participants could report contacts as individual contact or groups of contacts; this methodology better captures the right-hand tail of the degree distribution. Participants were also asked about transitive interactions between contacts.

Estimating the Reproduction Number from social contact data

We use an individual-based approach to calculate a reproduction number of each of the participants of the Social Contact Survey study. The reproduction number for an individual is given by:

$$R_{ind} = \tau \sum_{i=1}^{k} n_i d_i \tag{1}$$

where k is the number of contact events reported by each participant, n_i is the number individuals in that contact (participants could report groups of similar contacts), d_i is the duration of the contact and τ is the probability of transmission. Because we do not have ages of contacts, this is an ego-centric estimate of R, and does not include local depletion of susceptibles.

The population-wide reproduction number, Rt, is calculated using the age-adjusted mean of the squared individual reproduction numbers, i.e.

$$R_t = \frac{\sum_{j=1}^{N} \alpha_j \varepsilon_j \left(R_{ind}^{j}\right)^2}{\sum_{j=1}^{N} \alpha_j}, \tag{2}$$

where N is the number of participants in the Social Contact Survey, $0 \leq \varepsilon_j \leq 1$ is the relative infectiousness of children relative to adults. α_j is the age-specific weighting for participant j, estimated to match the age distribution in the UK population, calculated as the ratio of the proportion of individuals aged a in the UK, $P_{UK}(a)$, to the Social Contact Survey sample, $P_{SCS}(a)$,

$$\alpha_j = \frac{P_{UK}(a_j)}{P_{SCS}(a_j)}. \tag{3}$$

The uncertainty associated with the reproduction number is estimated by bootstrapping the contact data, weighted by age, using the boot function in R. We report the bootstrapped mean and 95% percentile confidence intervals.