Measurement of effectiveness of risk mitigation measures in reducing transmission

- COVID security is considered as a parameter that measures the effectiveness of risk mitigation measures in reducing the risk of transmission associated with a particular setting and its immediate significant links.
- It is challenging to create a metric for COVID security, however it is potentially feasible to do this through studying outbreaks and/or creating mechanistic models of infection transmission.
- Measuring COVID security will require substantial new data collection from outbreaks and on virus transmission characteristics. Data from TTI will be essential as part of this.
- COVID security within a setting will be influenced by the interactions between that setting and other settings. Settings with a well-defined population and a single site are likely to be more straightforward to measure. Those with complex interactions (e.g. public transport) are very challenging to measure.
- Measuring COVID security at a community, regional or national level is very challenging and is not likely to be a reliable measure.

Rationale for measuring effectiveness of risk mitigation

We aim to explore whether it is feasible to measure the effectiveness of risk mitigation in different settings, and whether it is possible to aggregate this to assess risk at a community, regional or national level. We have termed this measure of effectiveness “COVID security”.

COVID Security is, at the moment, a theoretical quality that will need to be quantified if measures to reduce transmission are going to be effectively and efficiently targeted. Without this quantification, there will be activities permitted which are not COVID secure and activities prevented which are.

The ultimate aim is to get back to pre-COVID levels of activity with very low risk of transmission which is tolerated by society. The goal is to achieve this without large scale lockdowns through effective testing and tracing and by making settings COVID secure by applying a combination of physical, administrative and behaviour measures.

Transmission occurs when infectious people have contact with non-infectious people in a setting that permits transmission. Keeping infectious people out of settings (e.g. by policies that enable people to take sick leave without detriment, tackling any culture that places pressure on people to work while ill, and reinforcing messages about engagement with the NHS Test, Trace and Isolate system) can reduce transmission. Keeping a low incidence/prevalence in the community reduces the rate/risk of introduction into any setting. It is potentially possible to estimate the number infectious people in circulation (i.e. not isolated) by time and place.

There are two related but separate measurements of the effectiveness of COVID secure implementation: (1) overall reduction in rate of transmission and (2) reduction in the transmission within clusters/outbreaks. Given understanding of COVID transmission patterns, reduction in the risk and severity of clusters/outbreaks might be disproportionately important for control, and is highly likely to be important for build up of prevalence locally. We suggest that COVID security in settings where clusters/outbreaks are most likely should be the priority for assessment and, where necessary, action. This may include single settings (e.g. a nightclub, a church) or linked settings (e.g. shared/dormitory type accommodation associated with a particular workplace).

COVID Secure within a setting

We consider COVID security in the first instance as a parameter that measures the risk of transmission associated with a particular setting and its immediate significant links, as this aligns to back to work and education strategies. As detailed below, it is potentially feasible to use appropriate measurements or models to create a metric that represents the COVID security of a setting. This would take into account both the mitigation measures within the setting and the inherent risk present due to the type of environment and human interactions that take place within it.

However, it should be noted that the effectiveness of mitigation measures in a particular setting will be influenced by the wider social and domestic interactions of people in connected settings. In some cases, this could be very substantial. For example, consider a single university department with 100 staff and 800 students. Connections will include other departments within the university, multiple social and housing locations, connections to schools within the city and across a geographic region, connections to multiple other workplaces (including care and NHS), and connections through other aspects of the daily lives of staff and students including shops, transport networks, etc. Staff and students will have national and international family and professional connections. Application of COVID security within the department may be very effective, yet the risks of transmission may remain high due to the vast array of wider connections. As such COVID security of the department will be influenced by adherence to key public health actions of staff and students in their everyday lives (social distancing, hand hygiene, restricting social networks) as well as the measures within the workplace itself.

Settings in which transmission could be high, but clusters cannot realistically be found (i.e. highly visited, disseminated settings such as supermarkets and public transport) should be considered separately and precautionary approaches taken. For example, it is not currently feasible to quantify the risk of transmission in supermarkets or public transport without significant further research, and so guidelines will have to learn from measurement in other settings such as workplaces and leisure facilities.

COVID security is likely to be much easier to measure for settings that have well defined boundaries (e.g. a Care home) compared to those that have complex interactions on multiple sites or with transient members of the public.

COVID security at a regional or national level

While it is feasible to measure COVID security in a single setting, it is very challenging and may even be impossible to create a meaningful metric that is representative of a regional or national level of risk mitigation. While R gives a measure of the transmission it is not able to differentiate the impacts of different workplace mitigation strategies.

To create an aggregate value that represents a community or a region, it will be necessary to understand the distribution of COVID security across different settings, and to consider how weaknesses in one setting could compromise another. This could well be non-linear with one setting counteracting good practice in more than one other setting. It is likely to be very challenging to collect sufficient measurements across enough settings to make an aggregate measure meaningful, and there is a risk that there are too many variables to have confidence in the data.

The connections between settings are a key part of this, and are very difficult to measure. A systems approach may give an understanding of the complexity of interdependencies between settings. This could possibly be used with network models to explore the relationships between risk mitigations in connected settings. Further research to explore this would be beneficial.

It may be possible to estimate regional or national levels of COVID security from past data, by considering transmission rates under different levels of lockdown measures. This can potentially estimate the impacts of large scale actions, particularly where there is good understanding of the levels of compliance, but it is unlikely to be able to disaggregate the raft of mitigations that workplaces have implemented.

Measuring COVID security

There are two general approaches to measurement: mechanistic and empirical.

Empirical approach:
Observational data on the relative risk of transmission in different settings from either an infection perspective (i.e. rates of transmission from infections in different settings) or setting perspective (i.e. rates of transmission in different settings accounting for presence of infections). Estimation of clusters/outbreak risk is easier than estimation of sporadic transmission rates.

Observations can be either at an infection (i.e. per infected person) perspective, or a setting perspective.
<u>Infection perspective</u>:

- Given that prevalence is currently low, and with current guidelines for self-isolation, this will have to be retrospective. Contact tracing (forwards and backwards) will provide the most data, but the data available are probably of limited quality. It is essential that data in TTI are collected on the settings visited by index cases, and that this is linked to infection outcomes in contacts. This data collection should include information on any actions that the index case has taken to minimise their risk in each setting (e.g. frequent hand hygiene, compliance with physical distancing, wearing a face covering). Where feasible it would be beneficial to collect data on interventions in a setting, although this may be hard to achieve, and may be subject to bias particularly where people are asked to recall actions. Nonetheless, research studies based on diagnosed infections are likely to be more productive.

- Outbreak investigations may provide information on very risky environments or super spreading events, but cannot quantify relative risks due to lack of denominator data. Retrospective case-control studies or analysis of physical environments might be used to identify relative risks of exposure, but these are likely to be highly confounded (i.e. cases will have multiple, correlated risk factors etc). Approaches such as meta-analysis of data, or other forms of cluster analysis, across multiple outbreaks may be feasible to identify common features and key risk factors, especially if a consistent approach has been used for data collection.

Setting perspective:

- There are two aspects of measurement of risk: the intrinsic risk of the setting, and the effectiveness of interventions.
- Taking a setting perspective has the advantage that data collection can be prospective, and interventions trialled in high risk settings, i.e. research protocols to test hypotheses. Comparisons between interventions are possible in comparable settings in terms of cluster/outbreak prevention, but probably not for transmission unless in particular circumstances with repeated testing, e.g. care homes and prisons. Households are particular settings that require special attention, particularly those that are large/multi-family and/or overcrowded.
- Studies of work settings should also record data on other exposure routes, e.g. modes of travel to work, demographics, social interactions. Special consideration of those settings in which transmission is possible both in work and outside, e.g. migrant workers in shared accommodation or “dormitories”, and students in shared houses.
- Data regarding potential social and financial dis-incentives that may affect self-isolation and other key protective behaviours should also be collected (e.g. use of zero hours contracts, sickness absence policies, use of agency staff etc)…There are two aspects to security: whether the setting is adapted (i.e. structural compliance), and whether the attendees adhere (i.e. behavioural compliance)
- HSE inspection data – measures with compliance of structural and behavioural guidelines. The majority of inspections are based on employee complaints and announced, although unannounced inspections are becoming more common
    - So far, 80% of workplaces comply to their own guidelines on the day of inspection
    - Examples of potential good practice (e.g. COVID marshals)
- Measurements include assessment of generic of COVID secure behaviour (e.g. mask wearing) and setting specific interventions
- Routine environmental sampling is unlikely to be informative, especially if transmission is episodic, however it may be useful in clusters.
- Remote measurement, e.g. CCTV, can be used for assessing contact with surfaces, physical distances, mask wearing (this approach will benefit from improvements in technology).

Mechanistic approach:

By considering the transmission routes, environmental parameters and interactions in a setting it is theoretically possible to model the effectiveness of interventions. At the most detailed level this would use the QMRA approach detailed by EMG that considers the detail of transmission through close-range droplets, contact with surfaces and aerosols. It would also be possible to model the effectiveness through simpler parameters within compartmental models.

Models require data on the effectiveness of interventions:

- Data on the theoretical efficacy of most interventions can be estimated from laboratory or physical modelling studies using proxy measures. For example the theoretical effectiveness of a facemask can be measured by using a controlled study with particles and a manikin head, a computational fluid dynamics simulation of flow through the material, fit testing to protect a person under controlled challenge studies or human studies using marker microorganisms.
- Real-world efficacy of an intervention is more challenging, particularly where it relies on individual behavioural compliance. An engineering intervention (e.g. ventilation, physical layout) is likely to be close to the theoretical performance, while a measure such as hand hygiene or mask wearing is highly dependent on behaviour. This influences whether the measure is implemented or not as well as whether it is applied correctly and consistently.
- Compliance data could be measured to various degrees through surveys (self report, report on others), direct observational studies, indirect monitoring (e.g. soap usage, CCTV) but may be subject to a range of reporting and behavioural biases (i.e. when someone knows they are being watched, they may adjust their behaviour accordingly). There are likely to be challenges in identifying and quantifying small but important behavioural aspects, for example wearing face coverings incorrectly.

Such models, validated with data from RCTs and other forms of study where available could potentially be used to build a score (or more likely probability distribution) by simulating different measures in a realistic scenario. For example for it may be possible to estimate the % reduction in risk for effective with hand washing, mask use and ventilation, either alone or together. This could consider both the theoretical effectiveness and the real-world effectiveness.

Building these models is feasible, but challenging as there is a lot of data missing, including critical information around viral shedding and dose-response. The proportion of transmission by different routes is currently unknown and may have to be assumed, and capturing complex behavioural data within a model is difficult. However, it should be possible to create an initial methodology with some first approximations, that could then be refined as we improve knowledge of the disease. Such an approach would be advantageous to carry out alongside the empirical evaluation outlined above.

If there is a quantitative estimate of the risk if all guidelines are complied with, then compliance might become a relative measure of risk. However, factoring in the oddities of human behaviour will also be required. For example, how do we factor in the various ways a face covering can be incorrectly used? This is may be setting specific, although comparisons between similar settings is likely to be possible.

Other approaches/observations:

- Epidemiological, model-based approaches: given an estimate of given unmitigated R_0, measures of behaviour (e.g. Comix, google movements, FaceBook co-location) and estimates of the effective R, the correlation between movement/work attendance and transmission can be estimated

    - Increased COVID security reduces the correlation between behaviour and R (ideally we get back to full work etc and R remains below one)
    - The relationship will be dynamic, and potentially heavily influenced by both immunity (riskier environments are infected first) and learning (people / institutions adapt). Consequently, its unlikely to be very informative.

- The correlations between work type and social/household/leisure behaviour and household make measurement of risk of settings difficult, for example, if uber drivers don’t have gardens, or HCW tend to socialise with HCW