Recommendations on the continuing use of case-identification / contact-tracing / case and contact isolation (CCI) management to mitigate the impact of imported cases of Covid-19

Question

In this note we have attempted to answer the following questions:

(1) at which point should we cease contact tracing for UK cases;

(2) what are the specified trigger points for this to be identified.

Noting that:

(1) additional funding is available and should be assumed for this;

(2) the use of call centres should be considered in modelling capacity (and if use of call centres is not appropriate rationale for this will need to be included);

(3) that 'contact tracing' refers to the current case-identification / contact-tracing / case and contact isolation (CCI) model of management.

We are assuming that any commentary on opportunity cost, cost-benefit and cost-effectiveness are out of scope.

Caveats

The reported epidemic data from China is not sufficient to accurately to estimate many basic parameters of the epidemic potential of this virus. This problem has been well described already by SPI-M (O).

There are sufficiently different social, geographic and organisational differences between China and the UK that translation of the information that we do feel confident of may not be an accurate prediction of incursion behaviour of Covid-19 into the UK.

Nevertheless we have attempted to answer this question in good faith to the best of our ability.

Authorship

This report has been prepared by members of a modelling team whose members are drawn from:

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Executive summary

Prevention of a generalised epidemic of Covid-19 using a CCI approach is likely to be effective for incursions creating limited generational contacts (that is traceable first and second generation illnesses).

Where cases of higher generational numbers become predominant CCI is expected to be of limited benefit outside of certain special cases and should be discontinued.

The current PHE based capacity to provide CCI can be expected to be not sufficient, or sustainable, at the limits of controlling higher rates of incursions into the UK, and should be enhanced.

We recommend that a practical and reasonable level of enhancement should be to enable a 10-fold increase in Capacity to provide effective CCI controls.

We recommend that CCI should be discontinued when person to person spread is epidemiologically demonstrated to be dominated by second and subsequent generational cases, or, by the contact tracing effort exceeding the management of 8,000 CCI events per day as a proxy.

Potential end points for universal contact tracing

We can identify a number of potential endpoints where it may be decided that contact tracing and isolation should be abandoned:

(1) where the ability to trace and effectively isolate the numbers of imported cases, their associated contacts, and any undetected / uncontrolled secondary cases (and their contacts) becomes logistically impossible to manage;

(2) where it is shown that such measures are failing to impact on the reproduction number of the epidemic;

(3) it is necessary, or more appropriate, to allocate the tracing and isolation resources to the management of other priorities.

Clearly (3) is outwith the remit of this note as it touches on elements of opportunity costs etc.. and is not considered further.

Logistic and effectiveness based limits on tracing-isolation management

Currently cases are being traced that have arisen either from direct importation or as secondary infection following contact with these imported cases. Upon detection of a case, control measures are implemented for all contacts for a period of 14 days following their last contact with the case.

The effectiveness of this contact tracing is not yet known. By reference to other infectious diseases it is probably preventing at least 30% of potential transmission from these cases as the country and the health service are very well sensitised to act on a low level of suspicion, but are very unlikely to prevent all subsequent cases. This will be due to factors such as late recognition of cases or cases with mild or atypical symptoms not being recognised.

It is, therefore, to be expected that despite aggressive contact tracing and good quality isolation, that some additional cases will potentially arise following every incursion into the UK, or from secondary cases that have already been infected, before the primary case is identified.

The numbers of contacts that might be expected to arise from each such case, for each generation of a potential epidemic, have been estimated by reference to the POLYMOD database and this work is summarised in an appendix.

In summary, we have concluded that it may be expected that generation 0,1 and 2 cases will occur and fit within the current potential local team based contact tracing being practiced by PHE.

However, declining effectiveness of contact tracing across multiple generations, following the complete emergence of generation 3 and 4 cases is probably outwith current contact tracing methods.

Even with enhanced contact tracing systems that increase capacity the proportion of undetected contacts creating new focuses of infection with 2+ generations will create an absolute limit on the effectiveness of CCI controls (see later for an estimate of how quickly enhanced tracing systems would also be overcome).

Combining the intrinsic and unavoidable ability of CCI controls to fully detect every such case, and faced with continuing (and potentially escalating) incursion threats, it is possible to identify a number of possible points at which it may become appropriate to cease comprehensive CCI control measures. These foreseeably are:

(1) The numbers of primary incursion from outside of the UK rise above an assigned resource limit;

(2) The effectiveness of the CCI control model is identified as having insufficient impact on controlling an increasing number of observed cases of disease and that it has become inappropriate to support using this intervention on an evidenced based practice test;

(3) Despite a proven and sufficient degree of effectiveness of CCI control measures as a means of reducing the reproduction number, the numbers of incursions and /or residual reproduction number (despite intervention) outstrips our resources across increasing numbers of generations of infection.

Taking each of these in turn:

Primary incursion limit: If we assume that PHE can currently manage ~800 contact events per day using its internal enhanced response model then it is mathematically simple to estimate that without further resource, and good control using the CCI control model, up to 5 new incursions per week can be managed (noting that each incursion carries a 14 day management tail).

Scaling this response up, using for example a call-centre type system to support the local PHE teams, should be possible and feasible.

However escalation of numbers of primary incursion cases is not likely to be the most immediate resource limiting problem as long as all countries with meaningful numbers of movements to and from the UK are effectively implementing appropriate control measures as well. The signal that we would be unable to control this threat will arise from epidemiological monitoring of other countries and the weekly incursion detection rates into the UK.

Effectiveness of the CCI control measures: this cannot be known *a priori* but will become apparent from review of the initial isolated incursion incidents; and it is not likely to be a deciding step in when to stop using the current identification-contact tracing-isolation system on its own.

Presence of increasing numbers of generations of infection: this is the most important of these three elements to identify. As each new generation of infection becomes established the growth in numbers of cases grows exponentially if uncontrolled. The step change in the speed at which the epidemic may grow is such that even a reserve ability to contact trace significantly more cases as are established at any one point in time can be quickly outstripped.

Reproduction number (R_0) is the key parameter which in a UK setting currently unknown. If we take as a baseline PHE's current estimate of an ability to make up to 800 contacts per day, and have in reserve a capability of escalating that to 8,000 contacts per day; then a simulation with R_0=1.5 suggests that additional capacity would be consumed by an expansion in case numbers within 4 weeks. If R_0=3.0, that excess capacity would be exhausted in 2 weeks.

A more complete modelling of the growth of the potential epidemic, where generation 2 and above cases have become established in the UK, and using case ascertainment rates of 30% and 70% has

been developed. This model suggests that if a high case ascertainment level is achieved (e.g. 70%) then the epidemic will continue to grow, but in a relatively slow manner (and at least in the early months somewhat linear), with contact tracing numbers that could be managed within the current PHE system. However, given what is known of the virus, and the observation of significant numbers of cases being relatively mild, the potential for lower case ascertainment is very real. With a case ascertainment rate of 30%, which may be the more realistic value of the two values chosen to model, this analysis suggests that where generation 2 and above cases have become established then exponential growth is firmly established within 30-40 days. This would outstrip current PHE contact tracing capability, and would probably outstrip an increased resource of 8,000 contact tracing events per day capacity within a further2-4 weeks (for the reasoning given above)

Summary

(1) Whilst the threat to the UK is limited to (a) the management of incursion cases, (b) the tracing of secondary cases from these incursions and (c) such contact tracing remains demonstrably effective - then we recommend that the current system of identification-contact tracing-isolation management should be retained and if necessary scaled up using additional resources such as call centres. This should continue until it is apparent that there is a significant loss of similar controls in bordering countries that renders widespread unidentified incursion inevitable. This cannot be sensibly modelled, but must be decided by interpretation of emerging epidemiological data; in practice this would probably be signalled by a shift away from aggressive control measures by other major European and US authorities, thus exposing UK borders.

(2) The degree of imperfection intrinsic to even the best contact tracing and isolation measures is such that the appearance of second and higher order generations of infection can be foreseen. In theory ever increasing levels of resource can be allocated to continuing a trace and isolate policy; however our modelling suggests that such resources would become relatively rapidly overcome at a certain point. We suggest a reasonable limit, which would be associated with person to person spread being dominated by second and subsequent generational cases as identified by the FF100 study, or by the contact tracing effort exceeding the requirement for more than 8,000 contacts per day[1].

(3) We recommend that the provision of additional contact tracing capacity to supplement the current PHE systems is sensible. This will allow a better judgement about the actual dynamics of disease incursions into the UK to be made both in terms of deciding whether the impact of aggressive CCI management is proving effective, and to provide a better evidence base for its abandonment. If such capacity is to be provided then we recommend that a reasonable ceiling is to enhance current capability 10-fold; but also advise that any further provision above that level would probably not be justified. If that level of tracing is consumed by an epidemic, then having reached that limit is of itself a good end measure that attempting to control the epidemic by CCI management is no longer effective.

[1] We estimate that should an enhanced capacity for 8,000 CCI contacts be exceeded this will also be a clear indication that second and higher generation order infections are established in the community and therefore the daily CCI contacts count can be used as a proxy measure for this end point.

Appendix: A simple model for estimating the number of contacts that would need to be traced from the first few hundred cases (FF100) arising if a case of nCoV-19 was imported into the UK has been developed.

This model takes as a baseline a study (generally referred to as the POLYMOD data set) of the numbers of social interactions derived from diary studies using a pooled group of 7,290 participants from Belgium , Germany, Finland, Great Britain, Italy, Luxembourg, The Netherlands, and Poland[2].

In the POLYMOD data contact was defined as either skin-to-skin contact such as a kiss or handshake (a physical contact), or a two-way conversation with three or more words in the physical presence of another person but no skin-to-skin contact (a non-physical contact). Total contacts being a sum of the physical and non-physical contacts. Only UK data from POLYMOD was used.

- Generation 0 (G0) cases represents the introduction of a case into the UK
- Generation 1 (G1) cases represents the total number of cases infected by G0
- Generation 2 (G2) cases represent the total number of cases infected by G1, and so on …

Using these definitions, the model shows the following numbers of contacts that may be expected to arise from a single introduction (G0) if allowed to progress through G1 … G4 generational steps under specific transmission assumptions. The table then shows the cumulative average number of cases and contacts expected including all past generations.

	---------- *Cumulative Averages* ----------		
Generation	*Number of cases arising at each generational step*	*Number of physical contacts arising from each generational step*	*Number of contacts of all type arising from each generational step*
G0	1	7	17
G1 (+G0)	4	29	66
G2 (+G1+G0)	13	93	214
G3 (+G2+G1+G0)	50	286	658
G4 (+G3+G2+G1+G0)	131	864	1992

For droplet spread diseases POLYMOD envisaged that the contacts of all type data would be used as this includes the risk of face-face meeting <2m apart. That is, ideally we are looking to control the numbers of contacts in column 4 of the above table.

[2] Mossong J, Hens N, Jit M, Beutels P, Auranen K, Mikolajczyk R, et al. (2008) Social Contacts and Mixing Patterns Relevant to the Spread of Infectious Diseases. PLoS Med 5(3): e74. https://doi.org/10.1371/journal.pmed.0050074

It should be noted that the behaviour of G0 cases may not be typical of contact pattern observed in POLYMOD and so contacts may be higher in early generations although even doubling G0 contacts only has a small impact on cumulative contacts by G4. For simplicity, the effects of mutual friends is omitted from this model; their inclusion would likely cause a small reduction to the total number of cases and contacts needed to be traced.

Practically, however, the numbers of contacts that may be traced by even the most careful process will only identify a proportion of all of these contacts, with the non-physical contacts being more likely to be underrepresented (but also probably of a lesser class of risk).

The model does not extend webs of new cases arising from cases not traced and controlled in the G1, G2, G3, G4 etc.. generations; and the probability of undetected cases rises as new generations are allowed to occur.