

## Policy Implications of Estimates of the Reproduction Number

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We thank the other speakers in this informative discussion meeting, and appreciate all the discussants for their insightful remarks. We believe three major issues deserve further emphasis:

- (1) As recognized by all, the effective reproductive number is a single summary measure that is, by definition, multifactorial. Estimation necessarily depends on the generation interval which is very hard to capture accurately at the beginning of an outbreak of a new pathogen, an interval that ultimately may change significantly over time (as has been observed with virus variants). Uncertainty about the generation interval presents several challenges to estimation of the reproductive number as illustrated in comparisons across variants as discussed by Professor Dagpunar. Spatial and demographic variation in reproductive number estimates—let alone those arising from different models—make reliance on summary statistics problematic. Other alternatives, such as the growth rate discussed by Parag, Thompson and Donnelly face similar related issues, as pointed out by Professor Pellis. Feedback mechanisms that both respond to, and affect, transmission patterns are often ill-understood, as noted by Professor O’Neill.
- (2) Focus on estimation of the reproductive number and its application to policy decisions risks ignoring the basic design and implementation of comprehensive, linked, coordinated data surveillance systems as well as rapid and targeted mechanisms to assess key epidemiological parameters. The latter point is a key recommendation from Professor Richardson which we support strongly. The UK had been more successful initially in regard to population surveillance than the US, and we strongly echo Professor Riley’s emphasis on the value of repeated population survey assessments throughout a pandemic, a point we made in our contribution. This lack of basic epidemiological assessments (who, where, and when) has been sadly and inexplicably lacking in several locations where necessary resources were surely available. The reliance on data that is subject to the vagaries and availability of testing resources has been a concern from the outset of the COVID-19 pandemic.
- (3) We urge further attention to the practical implication of summary measures in informing the public and serving as the basis and barometer of public policy decisions. We are in agreement with Professors Lessler and Metcalf that more is needed than reliance on well-intentioned but flawed “averages” of reproductive number estimates. Reproductive numbers are retrospective at their core. This observation does not understate the value of understanding where we have come from, and where we are, but indicates that they may not be the best guide to actions that will take us where we want to go. Much of the debate about the

wisdom of certain policy decisions ignores stark public health conundrums in a pandemic: (i) at the outset, we cannot fully practice direct evidence-based interventions because we don't have enough specific information at hand, and (ii) for major infectious disease outbreaks, successful public health interventions must necessarily be implemented before the case burden seemingly justifies broad-based action (ironically, such interventions are often criticized as unnecessary if successful since outbreaks are stopped or reduced).

In summary, there remains significant challenges to defining a credible and reliable surveillance and reporting system to detect the arrival of as yet unknown pathogens in addition to resurgences of known outbreak sources, as noted by Professor Diggle. We believe focus on these issues is imperative now if we are to avoid the many missteps in several approaches applied to the COVID-19 pandemic.