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A renewal equation model for disease transmission dynamics with contact tracing

Contact tracing is one of the most cost-effective and widely adopted non-pharmaceutical interventions to counteract the spread of infectious diseases in the absence of effective treatments and vaccines. We have developed a deterministic model for disease transmission dynamics, structured by time since infection, that includes diagnosis of symptomatic individuals and contact tracing. A mechanistic formulation of the processes at the individual level leads to an integral equation (delayed in calendar time and advanced in time since infection) for the probability that an infected individual is detected and isolated at any point in time. This is then coupled with a renewal equation for the total incidence to form a closed system describing the transmission dynamics involving contact tracing. When applied to the case of SARS-CoV-2, our results show that only combinations of diagnosis of symptomatic infections and contact tracing that are almost perfect in terms of speed or coverage can attain control, unless additional strong measures to reduce overall community transmission are in place. Under constraints on the testing or tracing capacity, the interruption of contact tracing may be irreversible and, depending on the overall growth rate and prevalence of the disease, may lead to outbreaks even in cases when the epidemic was initially under control. This is based on joint work with Francesca Scarabel and Lorenzo Pellis (University of Manchester, UK) and Nicholas H Ogden (PHAC, Public Health Agency of Canada).