April 24, 2024

Abstract

In response to epidemic outbreaks, health authorities implement control strategies such as travel restrictions, lockdowns, and quarantine guidelines to isolate infected individuals and curb disease spread. These strategies require the allocation of limited resources, which have impactful consequences on both social and economic activities. Given the constraints on resources, they are further influenced by disease characteristics such as infection, recovery, and incidence rates, all of which impact the best cause of action to undertake.

Here, we analyze the necessary conditions for optimal control and derive explicit solutions for minimizing the size of an outbreak. We suggest optimal strategies for a model focusing solely on isolation, one exclusively on travel restrictions, and another that combines both approaches.

The strategies proposed here have several notable elements that distinguish them from previous research. Interestingly, isolation is a more effective tool than travel restrictions. The latter often play a negligible role in influencing epidemic trends if most infections are from inbound, except in regions with low disease incidence and large numbers of infected travellers or where epidemics are on the verge of reaching tipping points for exponential growth.

Moreover, a critical factor in determining the best course of action is whether the resources are sufficient to contain the disease during the outbreak. A higher u_{max}, indicative of more rigorous control, can lead to a marked reduction in outbreak magnitude, demanding fewer total resources, and the reverse is also true.

Thus, decision-makers should consider the local infection rates, the trajectory of the epidemic, and the patterns of movement in and out of the region when addressing resource constraints and enacting disease control measures.