Disease-induced resource constraints can trigger explosive epidemics

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Advances in mathematical epidemiology and network science have led to a better understanding of the risks posed by epidemic spreading and informed strategies to contain disease spread through prevention and treatment. However, a challenge that has been overlooked is that, as a disease becomes more prevalent, it can limit the availability of the capital needed to effectively treat those who have fallen ill. Here we use a simple mathematical model to gain insight into the dynamics of an epidemic when the recovery of sick individuals depends on the availability of healing resources that are generated by the healthy population. We find that epidemics spiral out of control into explosive spread if the cost of recovery is above a critical cost. This can occur even when an epidemic would not be predicted by a standard model that does not consider the reduction in resource generation as individuals fall ill. Through simulations and analytical solutions we show that the onset of explosive epidemics is very sudden, exhibiting a discontinuous transition under very general assumptions. We also determine analytically the critical cost and the size of the explosive jump in infection levels in terms of the parameters that characterize the spreading process. Our model and results apply beyond epidemics to other contagion dynamics that self-induce constraints on recovery, thereby amplifying the spreading process.