Finite-time scaling for epidemic processes with power-law superspreading events

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Epidemics unfold by means of a spreading process from each infected individual to a variable number of secondary cases. It has been claimed that the so-called superspreading events of the COVID-19 pandemic are governed by a power-law-tailed distribution of secondary cases, with no finite variance. Using a continuous-time branching process, we demonstrate that for such power-law-tailed superspreading, the survival probability of an outbreak as a function of both time and the basic reproductive number fulfills a “finite-time scaling” law (analogous to finite-size scaling) with universal-like characteristics only dependent on the power-law exponent. This clearly shows how the phase transition separating a subcritical and a supercritical phase emerges in the infinite-time limit (analogous to the thermodynamic limit). We also quantify the counterintuitive hazards posed by this superspreading. When the expected number of infected individuals is computed removing extinct outbreaks, we find a constant value in the subcritical phase and a superlinear power-law growth in the critical pase.