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Resonance between contact patterns and disease progression shapes epidemic spread

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The spread of a contagious disease clearly is affected by the contact patterns of infected individuals. But it remains unclear how individual contact patterns interact with the infectious and non-infectious stages through which a disease progresses over time. Here, we investigate this interplay of contact patterns and disease progression using real-world physical proximity data from the Copenhagen Networks Study. We find from the data that the number of encounters following a potential infection event varies significantly over time — with clear daily and weekly variations of encounter probability. These variations can accelerate or slow down the spread of infectious diseases, depending on how they are aligned with the infectious periods. Remarkably, the resulting resonance strongly depends on the latent period, which, although non-infectious and often neglected, is key to the degree of alignment of the infectious period with the weekly modulation. We demonstrate that this resonance effect can be reproduced by a generative process with a time-dependent encounter rate that reflects the daily and weekly modulation found in the data. Including this non-Markovian generative process into a well-mixed, mean-field spreading model, we show that resonances between contact patterns and disease progression can change the basic reproduction number considerably — in our example we find changes of up to 20% compared to randomized data and variations up to 30% between different latent periods. Surprisingly, a change in latent period can thereby make epidemic spread stronger even if the individual infectiousness is unaltered.