The disease-induced herd immunity level for Covid-19 is substantially lower than the classical herd immunity level

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Abstract

Most countries are suffering severely from the ongoing covid-19 pandemic despite various levels of preventive measures. A common question is if and when a country or region will reach herd immunity h. The classical herd immunity level h_C is defined as $h_C = 1 - 1/R_0$, where R_0 is the basic reproduction number, for covid-19 estimated to lie somewhere in the range 2.2-3.5 depending on country and region. It is shown here that the disease-induced herd immunity level h_D, after an outbreak has taken place in a country/region with a set of preventive measures put in place, is actually substantially smaller than h_C. As an illustration we show that if $R_0 = 2.5$ in an age-structured community with mixing rates fitted to social activity studies, and also categorizing individuals into three categories: low active, average active and high active, and where preventive measures affect all mixing rates proportionally, then the disease-induced herd immunity level is $h_D = 43\%$ rather than $h_C = 1 - 1/2.5 = 60\%$. Consequently, a lower fraction infected is required for herd immunity to appear. The underlying reason is that when immunity is induced by disease spreading, the proportion infected in groups with high contact rates is greater than that in groups with low contact rates. Consequently, disease-induced immunity is stronger than when immunity is uniformly distributed in the community as in the classical herd immunity level.

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