Effects of behavioral response and vaccination policy on epidemic spreading - an approach based on evolutionary-game dynamics

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[1] Ren, J., Wang, W. X., & Qi, F. Randomness enhances cooperation: a resonance-type phenomenon in evolutionary games. *Physical Review E* **75** (4), 045101 (2007).

[2] Lü, L., Chen, D.-B. & Zhou, T. The small world yields the most effective information spreading. *New Journal of Physics* **13**(12), 123005 (2011).

[3] Barabási, A.-L. & Albert, R. Emergence of scaling in random networks. *Science* **286**(5439), 509–512 (1999).

[4] Newman, M. E., Strogatz, S. H., & Watts, D. J. Random graphs with arbitrary degree distributions and their applications. *Physical Review E*, **64** (2), 026118 (2001).

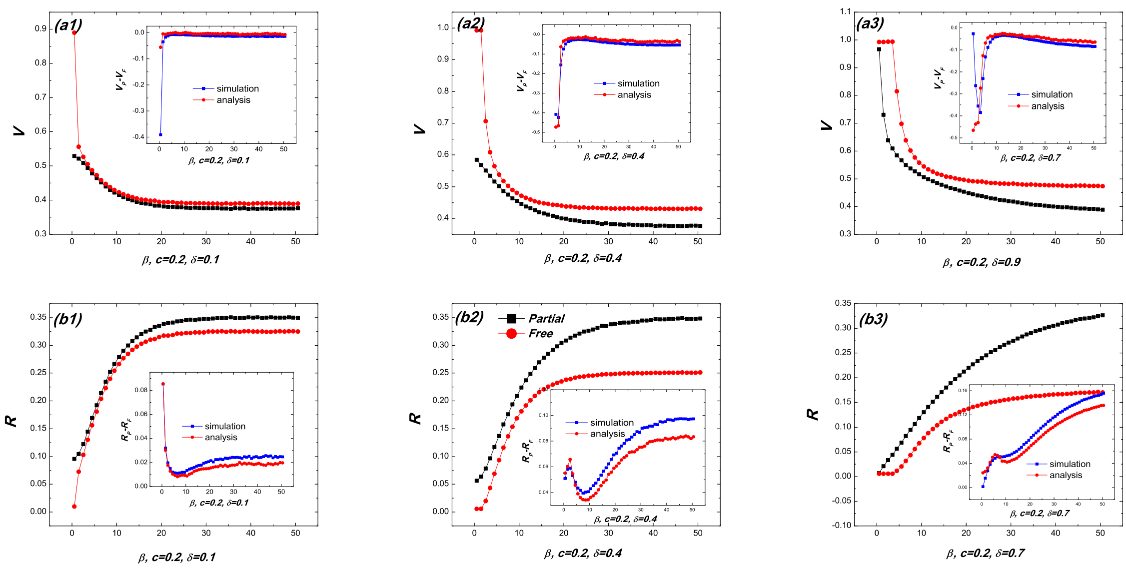

Figure S1: **Quantitative characterization of impacts of the selection strength β on epidemic spreading for partial- and free-subsidy policies for small vaccination cost**. For homogeneous small-world networks [1, 2] and cost of vaccination $c = 0.2$, vaccination coverage (V, top panels) and epidemic size (R, bottom panels) for the two subsidy policies for $\delta = 0.1$, 0.4 and 0.7 (corresponding to the left, central, and right panels, respectively). Insets in the top panels show the difference in the vaccination coverage, $V_P - V_F$, between the partial- and free-subsidy policies. Insets in the bottom panels display the difference in epidemic size, $R_P - R_F$, between the two subsidy policies. Blue squares in the insets are simulation results, and the red circles are the theoretical predictions based on the mean-field method (see analysis in **Methods** in main text). Other parameters are: network size $N = 1000$, transmission rate $\lambda = 0.072$, $\mu = 0.25$ and average degree $\bar{k} = 10$.

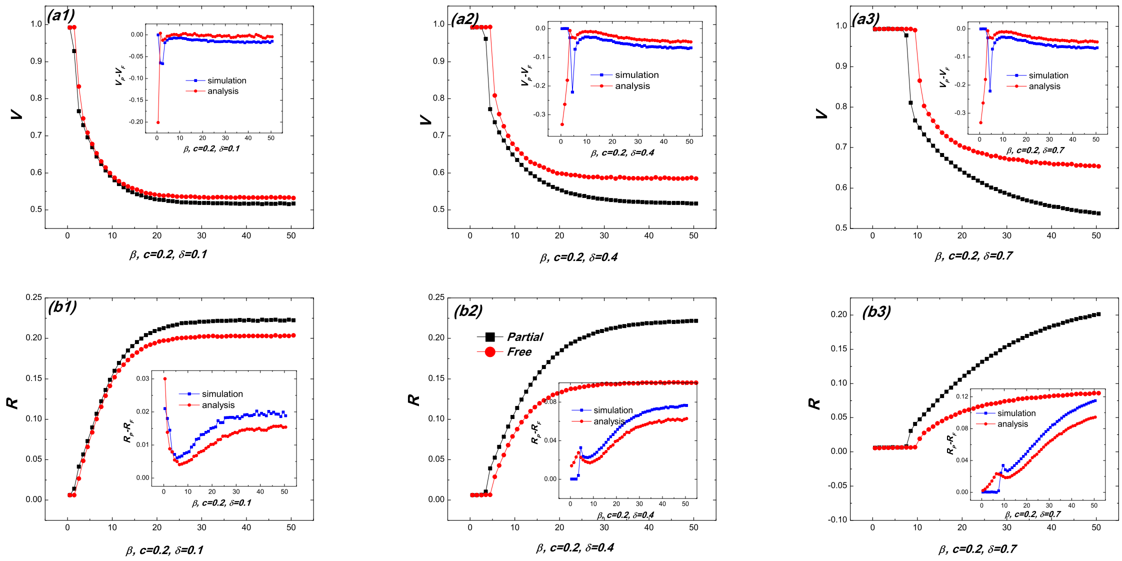

Figure S2: **Impacts of the selection strength β on epidemic dynamics for the Barabási-Albert scale-free networks [3] for small vaccination cost.** Vaccination coverage V (top panels) and epidemic size R (bottom panels) under the two subsidy policies for scale-free networks for $c = 0.2$ and $\delta = 0.1$, 0.4 and 0.7 (corresponding to the left, central, and right panels, respectively). Insets in top and bottom panels show the difference in the vaccination coverage, $V_P - V_F$, and the difference in the final epidemic size, $R_P - R_F$, respectively, between the two subsidy policies, where the blue squares and red circles are simulation results and mean-field based theoretical prediction (see analysis in **Methods**), respectively. Other parameters are: $N = 1000$, $\lambda = 0.18$, and average degree $\langle k \rangle = 6$.

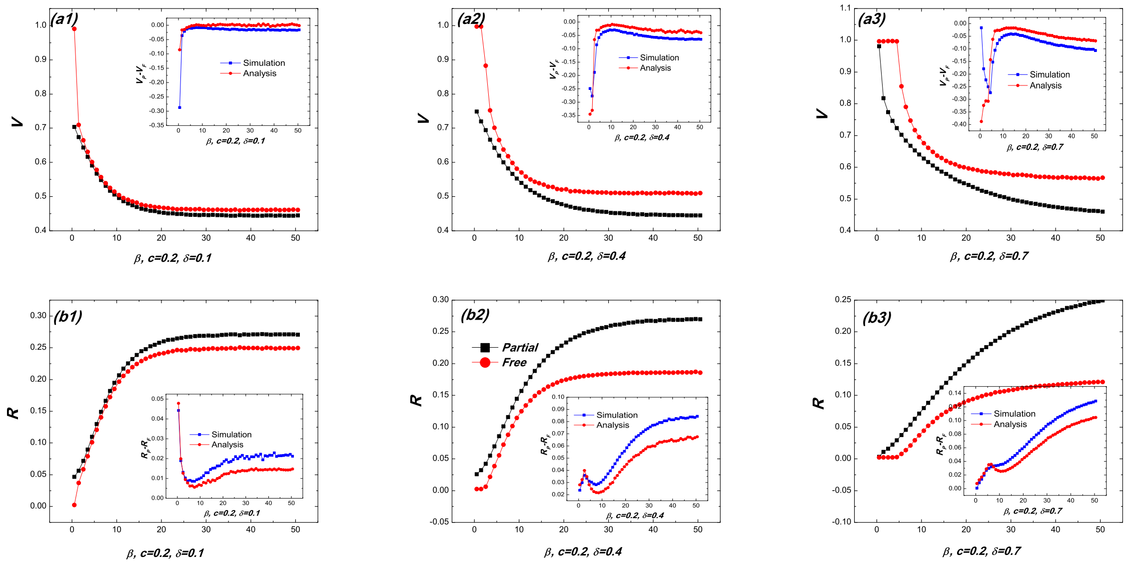

Figure S3: **Quantitative characterization of impacts of the selection strength β on epidemic spreading for partial- and free-subsidy policies for small vaccination cost**. For configuration network [4] (degree distribution $P(k) \sim k^{-3}$ with network size $N = 2500$, minimum degree $k_{min} = 4$, and maximal degree $k_{max} = 50$.) and cost of vaccination $c = 0.2$, vaccination coverage (V, top panels) and epidemic size (R, bottom panels) for the two subsidy policies for $\delta = 0.1$, 0.4 and 0.7 (corresponding to the left, central, and right panels, respectively). Insets in the top panels show the difference in the vaccination coverage, $V_P - V_F$, between the partial- and free-subsidy policies. Insets in the bottom panels display the difference in epidemic size, $R_P - R_F$, between the two subsidy policies. Blue squares in the insets are simulation results, and the red circles are the theoretical predictions based on the mean-field method (see analysis in **Methods**). Other parameters are: transmission rate $\lambda = 0.15$, $\mu = 0.25$ and average degree $\langle k \rangle = 8$.

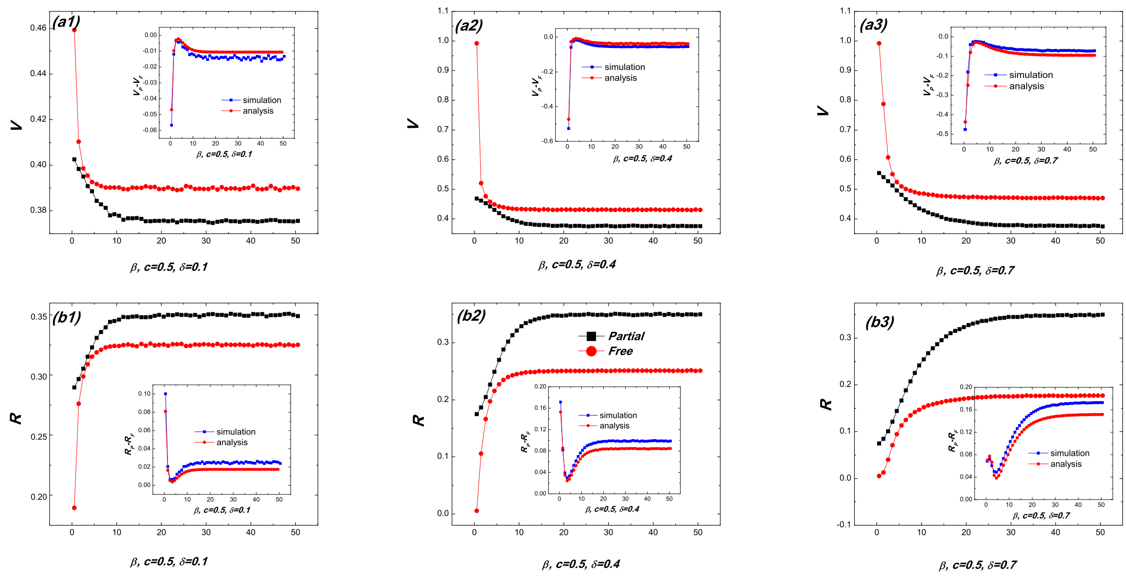

Figure S4:**Quantitative characterization of impacts of the selection strength β on epidemic spreading for partial- and free-subsidy policies for intermediate vaccination cost**. For configuration network and cost of vaccination $c = 0.5$, vaccination coverage (V, top panels) and epidemic size (R, bottom panels) for the two subsidy policies for $\delta = 0.1$, 0.4 and 0.7 (corresponding to the left, central, and right panels, respectively). Others are the same as for Fig. S3.

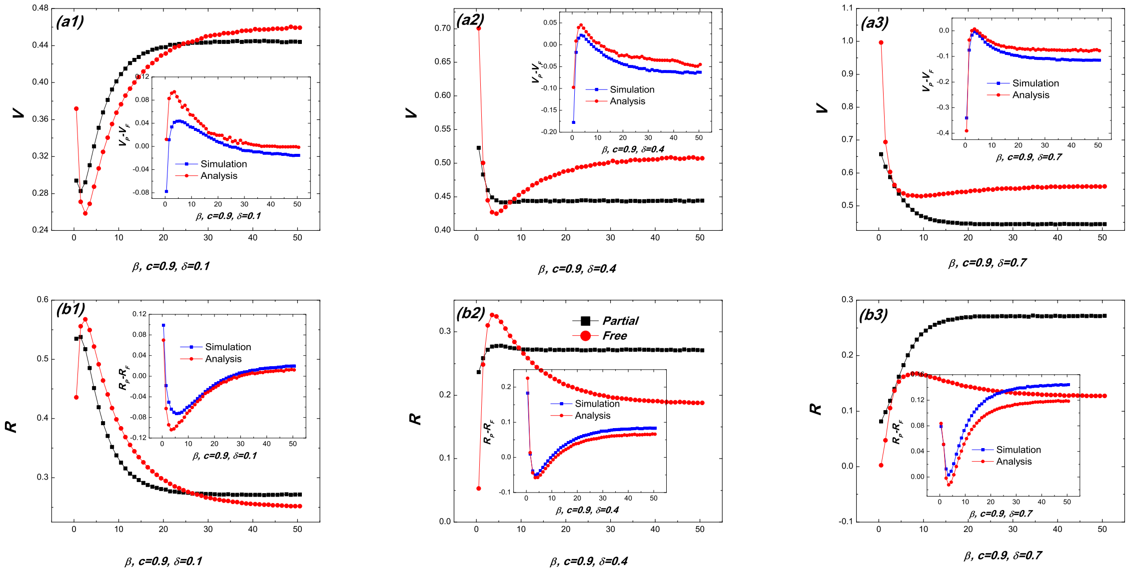

Figure S5:**Quantitative characterization of impacts of the selection strength β on epidemic spreading for partial- and free-subsidy policies for large vaccination cost**. For configuration network and cost of vaccination $c = 0.9$, vaccination coverage (V, top panels) and epidemic size (R, bottom panels) for the two subsidy policies for $\delta = 0.1$, 0.4 and 0.7 (corresponding to the left, central, and right panels, respectively). Others are the same as for Fig. S3.