Behavioral consequences of ineffective vaccines: Theoretical and experimental evidence using an interactive vaccination decision making framework

Cornelia Betsch\textsuperscript{1,2}, Robert Böhm\textsuperscript{3,*}, Marina Groß\textsuperscript{3}, Lars Kom\textsuperscript{1,2}, and Nicolas W. Meier\textsuperscript{3}

\textsuperscript{1} Center for Empirical Research in Economics and Behavioral Sciences (CEREB), University of Erfurt, Germany
\textsuperscript{2} Media and Communication Science, University of Erfurt, Germany
\textsuperscript{3} School of Business and Economics, RWTH Aachen University, Germany

* Presenting author. Contact: robert.boehm@rwth-aachen.de

Objectives

Vaccination is one of the most effective preventive health measures (WHO, 2013). Vaccination provides direct benefits for the vaccinating individuals by reducing the likelihood of contracting infectious diseases at marginal costs, such as rare cases of vaccine-adverse events. In addition, most vaccines provide indirect benefits for unvaccinated individuals by reducing the spread of pathogens in the population (herd immunity; Fine, Eames, and Heymann 2011). When considering both its direct and indirect benefits, vaccination becomes a N-person volunteers’ dilemma in which individuals have an incentive to free-ride on others’ indirect protection with increasing vaccination rates (Bauch and Earn, 2004; Betsch et al., 2013; Böhm et al., 2016).

Previous theoretical and experimental research on interactive vaccination decisions assumed explicitly or implicitly that vaccinations protect effectively against contracting diseases, i.e., in 100% of the vaccinations. However, the effectiveness of vaccines varies widely, ranging from about 97% in case of the rubella vaccine to only 10-60% in case of the seasonal influenza vaccine (CDC, 2016, 2018). The present research aims (1) to investigate the behavioral consequences of ineffective (vs. effective) vaccines in a game-theoretical framework modeling interactive vaccination decision making, and (2) to provide experimental evidence on individuals’ vaccination behavior facing ineffective (vs. effective) vaccines using an interactive vaccination game (I-Vax Game; Böhm et al. 2016, 2017).

Methods

In a first step, using a model of interactive vaccination decisions (Betsch et al., 2013; Böhm et al., 2016), we determined the effect of vaccine (in)effectiveness on the game’s Nash-equilibrium and social welfare optimum. In a second step, we conducted online surveys using convenience samples of the normal population (\(N = 358\)) and health care workers (\(N = 138\)) to investigate individuals’ (hypothetical) vaccination intention when facing different levels of vaccine effectiveness. Lastly, we implemented an incentivized laboratory experiment (\(N = 288\)) to investigate the effect of an ineffective (vs. ineffective) vaccine on vaccine uptake in an interactive vaccination game.
**Results**

Our theoretical analysis reveals that with decreasing vaccine effectiveness, vaccination remains the dominant strategy even in case of increasing vaccination rates, more so than compared to effective vaccines. Ineffective vaccines therefore increase the individual incentives to get vaccinated because the indirect herd immunity effect decreases. Subsequent surveys, however, provide evidence for the opposite behavior, constituting a “vaccine effectiveness fallacy”: despite these increased incentives, participants of the normal population as well as health care workers reduced their vaccination intentions with decreasing vaccine effectiveness. In our laboratory experiment, we provided participants with full information about the direct and indirect effect of vaccinations and the corresponding consequences of decreasing vaccine effectiveness. In this case of full information, participants were indeed more likely to opt for vaccination when facing an ineffective (vs. effective) vaccine.

**Conclusions**

Our research provides first evidence for a vaccine effectiveness fallacy: Individual decision makers reduce their willingness to vaccinate in face of decreasing vaccine effectiveness, opposing to normative decision theory. We discuss the implications for vaccination policy and potential interventions to decrease this fallacy.

**References**


