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Selfish-rational non-vaccination: Experimental evidence from an interactive vaccination game☆

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ABSTRACT

This paper provides an experimental game model – the Interactive Vaccination (I-Vax) Game – in order to investigate the behavioral consequences of risks from disease and from vaccination, and the epidemiological interdependence of vaccination decisions. Results from a controlled laboratory experiment provide evidence for selfish-rational non-vaccination: individuals react to the interactive incentive structure and make strategic vaccination decisions. We also find support for additional psychological factors determining behavior: individuals with stronger positive other-regarding preferences are more likely to vaccinate. Moreover, costs from action (vaccine-adverse events) have a stronger impact on behavior than costs from inaction (disease), which is evidence for the omission bias. Overall, we suggest that variants of the I-Vax Game can contribute to a better understanding of vaccination behavior and vaccine hesitancy. It can further be a useful experimental tool for testing interventions aiming at increasing vaccine uptake.

1. Introduction

Vaccines against infectious diseases are among the most effective preventive methods available to modern healthcare, saving approximately three million human lives per year (WHO, 2012). Nevertheless, vaccine hesitancy is a severe threat to the success of national and international immunization programs, which are of utmost importance for the prevention and control of morbidity and mortality within societies. In fact, vaccination rates repeatedly fall below the critical thresholds which are necessary to eliminate diseases such as measles or polio. This drop in vaccination rates repeatedly jeopardizes the attainment of global public health goals (WHO, 2013). It is therefore an important challenge for the medical and the social sciences to understand people's underlying motivation to decide in favor of or against vaccination. Understanding the processes behind vaccine hesitancy will enable the creation of more effective interventions in order to finally achieve public health goals (Betsch et al., 2015).

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Vaccination has been typically described as an individual decision making task in which the risks of being unvaccinated and contracting the disease are weighted against the risks of getting vaccinated, which may lead to mostly mild – but in some very rare cases also to severe – adverse events. As the risks involved in getting vaccinated are usually lower than the risks involved with the disease itself, vaccination constitutes a rational choice (Weinstein, 2000). Thus, vaccine hesitancy can be seen as a result of biased information processing or ill-informed decision making, for example because the risks involved in getting vaccinated are skewed and inflated (e.g., Betsch et al., 2011; Brewer et al., 2007; Chen, 1999; Hollmeyer et al., 2009; WHO, 2013). For instance, it has been shown that the same symptom occurring as a consequence of vaccination is evaluated more negatively than when it is evaluated as a symptom during the corresponding illness (Brown et al., 2010). This has been interpreted to be the result of the omission bias, that is, the tendency to evaluate negative events as more negative when they are due to an action rather than due to an inaction (e.g., Spranca et al., 1991; Asch et al., 1994).

The individual perspective focuses only on the direct effect of vaccination, i.e., the probability of certain consequences as a result of a person's own vaccination decision. According to this perspective, non-vaccination must be the results of psychological biases or errors. However, vaccination also yields an indirect effect because it reduces the transmission of a disease (Anderson and May, 1985). Considering this indirect effect, non-vaccination might not be the result of biased decision making but rather the result of selfish-rational behavior. Accordingly, the decision in favor of vaccination not only benefits the decision maker but also provides a positive externality on other individuals in the population because it decreases the likelihood that the disease spreads, an effect called *herd immunity* (Fine et al., 2011; Stiglitz, 2000). This implies: the more individuals are vaccinated in a population, the less attractive (relative to non-vaccination) vaccination is because an infection becomes less likely, while the likelihood of vaccine-adverse events remains stable. The individually selfish-rational solution (non-vaccination) may therefore differ from the collectively optimal solution (vaccination), leading to a social dilemma (Dawes, 1980, Kollock, 1998).

A growing body of theoretical and simulation-based evidence demonstrates that strategic-interactive reasoning and other-regarding preferences may be relevant for real-world vaccination behavior, that is, that individuals may free-ride out of rational selfishness or vaccinate out of a prosocial motivation (e.g., Bauch and Bhattacharyya, 2012; Bauch and Earn, 2004; Bauch et al., 2003; Cohen et al., 2013; Galvani et al., 2007; Manfredi et al., 2009; Oraby et al., 2014; Madrian, 2014). As a prominent example, Bauch and Earn (2004) use game-theoretic models to show that due to the indirect protection provided by herd immunity, even small increases in perceived vaccine risk may lead to declines in vaccine uptake. They conclude that "[. . .] it is impossibe to eradicate a disease through voluntary vaccination when individuals act according to their own interests" (p. 13392). Furthermore, a review of surveys and interview studies by Quadri-Sheriff et al. (2012) suggests that the indirect effect of herd immunity is indeed considered by parents when deciding whether or not to immunize their children. However, there is only little behavioral evidence as to whether people do indeed react to the interactive and dynamic incentive structure of vaccination decisions. It is important to note that previous work using experimental games neglect the psychological consequences of vaccine-adverse events.

The present paper provides an experimental game model that integrates the epidemiological and economic interedpendence of individuals' vaccination decisions (e.g., Bauch and Earn, 2004; Fine et al., 2011). With this, we are able to investigate the psychological consequences of risks from disease and from vaccination, and their effects on vaccination behavior in a realistic interaction setting. In a controlled laboratory experiment, we test for selfish-rational non-vaccination (i.e., free-riding on others' indirect protection). Furthermore, we investigate additional psychological factors that may either increase (i.e., positive other-regarding preferences) or decrease (i.e., omission bias) the likelihood of non-vaccination. We show that individuals react to the interactive incentive structure and get vaccinated strategically. Prosocial individuals, i.e. those who also regard the outcomes of others in their decisions, are more likely to vaccinate than proself individuals, who focus solely on their own outcome. Additionally, participants are more likely to change their behavior if they encounter negative consequences after vaccination (vaccine-adverse events) rather than after non-vaccination (disease). Thus, we find support for selfish-rational behavior with regard to vaccine uptake and vaccine hesitancy as well as additional psychological factors determining vaccination behavior. Our experimental game model helps to better understand the motivations underlying vaccine hesitancy and vaccination by adding evidence that also rational calculation can be a reason for non-vaccination (cf. Betsch et al., 2015). It can serve as a tool to pilot interventions in order to finally increase vaccination uptake.

The remainder of the paper proceeds as follows: In Section 2, we discuss related experimental literature on vaccination as a strategic interaction, Section 3 devises the novel game, Section 4 presents the methods and results of a laboratory experiment, and Section 5 discusses the findings and provides conclusions.

2. Related literature

There have been only a few attempts to experimentally explore vaccination behaviors or intentions, while considering both the direct and indirect effects of vaccination. In an experimental survey study, Betsch et al. (2013) found that vaccination intention decreased when the individual benefit from herd immunity was made salient, whereas vaccination intention increased when other people's benefit was emphasized (i.e., social benefit), given that the vaccination costs were low. In a similar vein, Vietri et al. (2012) presented participants with hypothetical vignettes, orthogonally varying the individual's own risk of infection and the number of people who would indirectly benefit from that individual's vaccination. They particularly showed that under conditions of low risk of infection, vaccination intentions increased, the more others benefited from the vaccination. Moreover, Attari et al. (2014) found that the second most important reason for an individual to have the

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