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Asymmetry, uncertainty, and limits in a binary choice experiment with positive spillovers☆

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ABSTRACT

This study examines behavior in binary choice games designed to characterize individual vaccination decisions. Subjects make decisions from a menu of one-shot games, deciding in each between a certain payoff option and an option with payoffs decreasing in the number of individuals that choose it. The certain payoff option represents the decision to vaccinate. The uncertain payoff option represents the decision not to vaccinate and potentially get sick, with one's likelihood of illness increasing with the number of unvaccinated individuals. Both symmetric and asymmetric treatments are considered with probabilistic and non-probabilistic payoffs. In some sessions, a theoretically non-binding limit on the certain payoff option is imposed, representing a limited stock of a vaccine. The results suggest that for symmetric, non-probabilistic treatments, subjects behave close to the inefficient equilibrium prediction, representing undervaccination. Subjects behave more efficiently for probabilistic treatments and asymmetric treatments with non-binding limits, representing an increase in vaccination following the announcement of a vaccine limit.

1. Introduction

When individuals receive vaccines, there are positive spillovers to unvaccinated individuals. For each additional individual vaccinated, unvaccinated individuals' chances of catching the disease in question decrease.[1] Traditional economic models based on own income maximization predict that, in finite games, people do not take this positive externality into consideration when making vaccination decisions, which could result in vaccination rates below the socially optimal level.

There is a considerable literature studying the game theoretic dimensions of vaccination decisions. Funk et al. (2010) provides a review of studies modeling the dynamic interaction of human behavior, including vaccinations, with the transmission of infectious diseases.[2] While the majority of the literature focuses on dynamic settings, Heal and Kunreuther (2005) develop a static vaccination-choice model in which individuals decide whether or not to vaccinate by comparing economic costs and benefits without knowing who else has vaccinated or witnessing the spread of the disease. This model simplifies

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[1] For vaccines that are not 100% effective, there may also be smaller but positive spillovers to other vaccinated individuals. I do not consider this possibility in this paper.

[2] See also Bauch and Earn (2004), Chen (2006), and Anderson and May (1985).

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the decision environment from those discussed in Funk et al. (2010), and is itself important since many vaccination decisions are made in the absence of the actual disease and/or the knowledge of others' vaccination decisions.[3] The authors find that for fully effective vaccines, equilibrium vaccination levels are usually below socially optimal vaccination levels, due to the positive externality created by vaccinating. Because of its importance and relative simplicity, this static model is the one that I will focus on in this paper.

Similar to the theoretical predictions, vaccination rates in the U.S. frequently fall below the recommended levels. Since 2010, the Center for Disease Control and Prevention (CDC) has recommended annual influenza vaccination for all individuals of at least 6 months of age.[4] Despite this recommendation, fewer than 50% of the eligible population actually received an influenza vaccine in 2013.[5] These facts seem to be in line with the theoretical predictions and may indicate that individuals are free riding off others' vaccination benefits. Field experiments (de Janvry et al., 2010; Rao et al., 2007) and empirical research on vaccination decisions (Tsutsui et al., 2012; Shahrabani et al., 2008, 2009) have made great strides in identifying factors that influence individual vaccination decisions.[6] These types of studies have several inherent limitations however. First, we cannot fully observe individuals' heterogeneous costs of getting vaccinated. Some workplaces provide free flu shots, making the cost of receiving a shot very low. On the other hand, others may have to take time off of work, drive to the doctor's office, and pay for the shot. Additionally, despite medical advice, individuals have widely varying beliefs about the effectiveness of vaccines, the severity of diseases, and their own risk of getting infected. With the increased control of the laboratory setting, the experiments in this paper account for these factors as much as possible. The main objective of this study is to determine whether vaccination rates would still be inefficiently low if individuals held accurate beliefs about the costs and benefits of vaccination. Additionally, I seek to identify factors that may influence individual decisions and reduce inefficiencies.

This study examines binary choice decision settings designed to characterize individual vaccination decisions, similar to those of the static-choice models in Heal and Kunreuther (2005) and Xu (1999). In each decision setting, individuals independently and simultaneously select one of two possible options. The first option represents the decision to receive a 100% effective vaccine, and yields a certain payoff to the individual. With a fully effective vaccine, individuals who vaccinate receive a certain payoff, since they know that they will not get sick. This is a simplification of the natural world in which vaccines may carry additional risks, beyond the monetary cost of the vaccine. In order to simplify the decision task for subjects, and to provide a first step in analyzing individual behavior in this environment, I do not include any additional risk from vaccination. The second option represents the decision not to vaccinate, and results in a payoff or expected payoff that is decreasing in the number of individuals that choose it. Unvaccinated individuals are at risk for getting sick and the greater the number of unvaccinated individuals, the greater the likelihood that a given individual will get sick, since there are more individuals that could potentially infect them, and so the lower their expected payoff. Consequently, when individuals choose the first option (i.e. vaccinate), they create a positive externality for everyone who chooses the second option (does not vaccinate).

Although not directly comparable, the extensive experimental literature on Voluntary Contribution Mechanisms (VCM) may give us some insight into individual behavior in the above model. It has been repeatedly shown in VCM experiments that individuals may contribute more to a public fund than predicted in equilibrium.[7] This has been partly attributed to individuals not being purely rational and selfish economic agents (Andreoni, 1995; Fischbacher et al., 2001). The presence of such individuals may indicate that behavior in this study will be more efficient than the Nash equilibrium, and closer to the social optimum.

The model in this study does differ from the standard VCM setting in an important way however. In the standard VCM setting, contributing to the public fund creates a positive externality for all other group members, regardless of those group members' own actions. In this study, only the individuals who choose the option that does not create a positive externality may receive a benefit from others' actions. In terms of the vaccine example, getting vaccinated creates a positive externality only for individuals who are not vaccinated. This difference may reduce the presence of altruistic behavior.

The experiments in this study are perhaps the most theoretically similar to those of market entry games. In both models, agents face a binary decision with no dominant strategy. In the simplest entry games, symmetric agents decide whether or not to enter some market. Agents who do not enter the market receive a certain payoff, unaffected by others' actions. This is analogous to the first option in this study, or the decision to receive a vaccine. Agents who enter the market receive a payoff that is decreasing in the number of market entrants. This is analogous to the second option in this study or the decision not to vaccinate. In the first set of such market entry experiments (Kahneman, 1988), the number of market entrants routinely approached equilibrium ("capacity"). Further experiments found similar results (Rapoport, 1995; Sundali et al., 1995). Unlike

[3] For example, when parents vaccinate their children against diseases like Measles, Mumps, and Rubella, the diseases are frequently not present in their society. Similarly, many individuals decide whether or not to receive a flu vaccine in September and October, which is often before the first case of flu has been diagnosed in their area (www.cdc.gov/flu/about/season/flu-season-2014-2015.htm).

[4] CDC. Prevention and Control of Influenza with Vaccines: Recommendations of the Advisory Committee on Immunization Practices (ACIP), 2010. MMWR 2010; 59 (No. RR-8).

[5] http://www.cdc.gov/flu/fluvaxview/coverage-1213estimates.htm.

[6] Tsutsui et al. (2012) and Shahrabani et al. (2009) find that individuals' beliefs about disease severity, vaccine effectiveness, and risk and susceptibility significantly influence vaccination behavior. Tsutsui et al. (2012) find these beliefs to be inaccurate in general.

[7] Isaac et al. (1984, 1994), Weimann (1994), Laury et al. (1995), Gächter and Fehr (2000), Fischbacher et al. (2001), and Fischbacher and Gächter (2010).