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PUBLIC HEALTH

This message must be herd

Immunization against vaccine-preventable diseases not only protects the individual but also has a social benefit. A study now shows that communicating this effect, known as herd immunity, can have a substantial impact on a person's inclination to vaccinate, an insight that could be leveraged in vaccine advocacy.

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Vaccination is a good thing. Because of it, smallpox has been eradicated and a number of serious diseases are on the decline. From 2000 to 2015, immunization against measles prevented an estimated 20 million deaths according to the World Health Organization[1]. The cases of polio decreased from 350,000 in 1988 to less than 100 in 2015[2], fueling hopes that polio can be eradicated in the near future.

Clearly, pathogens that depend completely on humans as hosts can be eliminated if 100% of the population are immune. The persistence of diseases is related to a small but significant fraction of the population that is not immune. Individual decisions to vaccinate or not are always associated with the perceived risk or costs of infection on one hand and vaccination on the other. Perceived risks in turn depend on factors that are difficult to assess, including the cultural background of a person, social environment, infectiousness of a disease, public health policies, media reports or vaccine scares, and the prevalence of a disease. In fact, an increased immunization coverage that decreases disease prevalence can decrease the perceived risk of infection[3]. On a population level, this balance yields a situation in which the vaccine uptake is less than 100% (ref. [4]; Fig. 1).

The good news is that because many human infectious diseases require human interactions, my own immunity not only protects myself but also others. Across a population, this effect is known as herd immunity and implies that only a critical fraction, $V_c < 100\%$, of the population must be immune for disease eradication.

Surprisingly, this collective and social effect is hardly ever communicated to the public in vaccination advocacy, which usually puts the individual's benefit in the spotlight. One might expect that emphasizing this social benefit (in addition to the individual benefit) must have a positive effect. However, having understood herd immunity, one may decide not to vaccinate because others do.

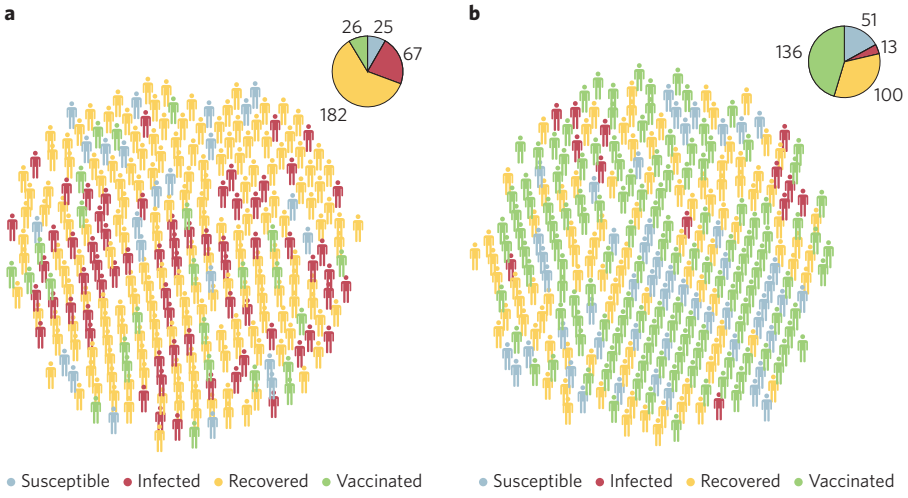

Figure 1 | How herd immunity works. **a**,**b**, The panels depict a simple agent-based computer model that captures the mechanism of herd immunity. In the model, agents can be susceptible (grey), infectious (red), recovered (yellow) or vaccinated (green). Infected individuals can transmit the disease to susceptibles in their vicinity. Infected individuals recover and become immune after some time. New agents enter the population (birth) either as susceptible or vaccinated. When the probability of vaccination is too low (**a**), the disease prevails in the population, because the supply of newborn susceptibles and transmission of the disease balance. When vaccination intention is increased (**b**), transmission events become less likely and eventually the disease cannot be sustained and will disappear. In their study, Betsch *et al.* used an interactive tool to illustrate this mechanism, a similar tool is available at http://rocs.hu-berlin.de/D3/herd.

This effect is known as free-riding. In fact, recent theoretical insights suggest that following a selfish rational strategy will not result in reaching the critical vaccine uptake threshold for any perceived risk of vaccination[5].

In this issue of *Nature Human Behaviour*, Betsch, Böhm, Korn, and Holtmann[6] investigate whether communicating the mechanism of herd immunity may increase an individual's intention to vaccinate or alternatively trigger free-riding, and how changes in intention depend on other factors, for example, the cultural background, the infectiousness of a disease, and the existing vaccine uptake in the population.

The authors devised a clever online experiment involving more than 2,000 subjects from 6 different countries (South Korea, Vietnam, Hong Kong, United States, Germany and the Netherlands) and cultural backgrounds. In the experiment, subjects were given information about a hypothetical disease and the population's vaccine uptake, and then pretended to be a member of that population and made a choice to vaccinate or not.

The mechanism of herd immunity was communicated in different ways to subsets of subjects. One group had access to reading material (text-based) prior to the task. The benefit of herd immunity was communicated in one of two different ways: (i) the benefit of an individual's immunity to others or (ii) the benefit of others' immunity to the subject. In yet another variant of the experiment, subjects were able to explore

the effects of herd immunity interactively in a simple agent-based epidemic game in which they were able to tune the population's vaccine uptake and observe the induced changes in disease prevalence (see, for example, http://rocs.hu-berlin.de/D3/herd). All experiments were compared with controls in which no information on herd immunity was communicated.

The authors grouped individuals into two cultural background categories, 'eastern' (South Korea, Vietnam and Hong Kong) and 'western' (USA, Germany and the Netherlands), each group with approximately 1,000 subjects. The reasoning for this choice of categories is based on the fact that in western cultures individualism dominates, whereas eastern cultures are more collectivistic. The authors also provide statistical and quantitative back-up for this categorization. The hypothesis here is that eastern cultures are more susceptible to conveying the social benefit of vaccination, whereas western cultures may be less prone to considering the social effects of their decisions and more susceptible to information that underlines the individual benefit.

The authors first investigated a virtual scenario with a highly infectious disease. In this scenario information on the population's vaccine uptake had essentially no impact on an individual's intention to vaccinate. The lack of any impact indicates that free-riding played no role. Also, communicating the benefits of herd immunity only had a marginal impact on the subject's intention, independent of their cultural background. The conclusion here is that highly infectious diseases are perceived more like an external risk independent of the behaviour of others. This is interesting because the individuals' intuition is perfectly aligned with reality here because for highly infectious diseases the relative risk reduction by herd immunity is small.

Interestingly, the situation changes significantly when the disease is less contagious. For all subjects, the intention to vaccinate was smaller than in the highly contagious scenario, as expected. However, a significant boost (from 45 to 57%) in the intention to vaccinate was observed in western-culture subjects when informed about herd immunity compared with agnostic controls. In eastern-culture individuals, the overall intention was high at 61%, irrespective of what was communicated. This may be interpreted as an intrinsic awareness of the social benefit of vaccination in eastern cultures. The good news is, though, that westerners also act as a collective when informed about the benefit of their action to others.

A very intriguing pattern emerged when the authors compared the different modes of communicating herd immunity to the subjects. Exploring the effects of herd immunity using an interactive tool outperformed the text-based method significantly. This is quite interesting and important because communication of public health topics and information is still dominated by texts.

The study by Betsch, Böhm, Korn, and Holtmann is important and clever on a number of levels. Generally, psychological experiments of this nature are limited to small groups of subjects. Leveraging modern technologies like online experiments allows larger samples and extraction of statistically significant signals. This might be a starting point for more studies on human behaviour and decision processes along similar lines. The results obtained by the authors clearly speak for this.

Their results are also an eye-opener for policymakers and public health workers that develop communication techniques in vaccine advocacy. Currently, information policies predominantly focus on the benefit of vaccination for individuals. The results presented by the authors may convince professionals to communicate vaccination as a social action as well. In a world in which selfish protectionism and anti-social movements are on the rise, this is an important message in general. ❐

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Competing interests

The author declares no competing interests.