Health Care Management Science

A tit-for-tat mechanism for increasing vaccination uptake in repeated COVID-19 vaccination mandates

--Manuscript Draft--

Manuscript Number:	HCMS-D-22-00081
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Article Type:	Current Opinion
Keywords:	
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Abstract

Mainstream German politicians have long dismissed the idea of a COVID-19 vaccine mandate for the general population but are rethinking the issue as cases rise and uptake of first doses continues to be sluggish. If vaccination became mandatory in Germany and unvaccinated individuals failed to comply, they would likely face fines. The purpose of this paper was to suggest a novel tit-for-tat (TFT) mechanism using rewards and fines to spur COVID-19 vaccination rates in repeated mandates. Compared to restricting options to punishment and no punishment, the addition of a reward option is considered an extra financial incentive to spur vaccination. The reward option can further increase vaccination uptake by fulfilling the criteria of a decoy option. It can also satisfy the condition of budget neutrality if it is financed entirely from the revenue generated by fines.

Background

In Germany, 72% of the total population is fully vaccinated (Robert Koch Institute 2022). Here, vaccine hesitancy exists on a continuum from “willing to get vaccinated” to “vaccine denial” (COSMO 2022). Among people who are vaccine-hesitant, 63% currently belong to the group of vaccine deniers (COSMO 2022). Mainstream German politicians have long dismissed the idea of a COVID-19 vaccine mandate for the general population but are rethinking the issue as cases rise and uptake of first doses continues to be sluggish. In addition, most Germans favor a COVID-19 vaccine mandate for the general population (Tagesschau 2021). If vaccination became mandatory in Germany, and unvaccinated individuals failed to comply, they would likely face fines. An alternative financial incentive system is a vaccination reward scheme. However, the German government has neither implemented nor contemplated a cash-reward system. One of the largest concerns regarding cash rewards is the budget impact, because cash rewards must be distributed not only to late adopters, but also to all vaccinated individuals for fairness. This situation becomes more complex when considering that a waning immune response following vaccination necessitates regular booster shots. In this situation, repeated COVID-19 vaccination mandates may be logical. The purpose of this study was to suggest a novel tit-for-tat (TFT) mechanism using rewards, in addition to fines, to spur vaccination rates in repeated mandates.

Main body

Past research

TFT means “an equivalent given in return” and “retaliation in kind” (Merriam-Webster). In a series of well-known tournaments, Axelrod (1984) demonstrated the effectiveness of a TFT strategy in a two-player iterated prisoner’s dilemma (IPD). This strategy cooperates in the first move; then, it does whatever its opponent has done in the previous move. If the opponent was cooperative in the previous round, the TFT strategy is to cooperate. If the opponent defected in the previous round, the TFT strategy is to defect. The experience of immediate punishment, followed by a reward for changed behavior, tends to stop opportunistic behavior by the opponent and restore cooperation (Cooter 1996). In the presence of asymmetries in power (i.e., unequal parties), one may predict that weak players will respond to punishment from strong partners with increased cooperation in the next round, whereas one may not expect such an effect when strong players are punished by weak or strong partners (Bone 2016). Nevertheless, previous empirical research has failed to show that power asymmetries stabilize cooperation when punishment is possible (Bone 2016).

A recent laboratory experiment (Wang 2018) explored the impact of cognitive bias on cooperative TFT actions in an IPD. Wang et al. supplemented the options of ‘cooperate’ and ‘defect’ with a new, decoy option, ‘reward.’ In general, the decoy option refers to a new alternative in the choice set that increases the choice of one of the existing alternatives that dominates the new one. This effect assumes that consumers tend to change their preference between two options (‘cooperate’ and always ‘defect’) when presented with a third option (‘defect’ plus ‘reward’) that is asymmetrically dominated by one of the initial options (‘cooperate’ or always ‘defect’). An option is asymmetrically dominated when it is inferior in all respects to one option (say ‘cooperate’), however, in comparison to the other option (say always ‘defect’), it is inferior in some respects and superior in others (Sellers-Rubio 2015). When the ‘reward’ decoy option was present, the participants showed an increase in cooperative TFT actions despite the fact that they did not choose the decoy option often (Wang 2018).

Proposal

The proposal envisages a situation in which booster shots for COVID-19 vaccines in the general population will be mandated on a regular basis (e.g., annually). Hence, it foresees a sequence of repeated, time-limited vaccination mandates. This situation is considered equivalent to a two-player IPD where the two players represent the government and an unvaccinated individual, and where the rounds of iterations correspond to time-limited vaccination mandates. Although the upper limit of the duration of one iteration is defined by the duration of protection from a booster, it is possible to have much shorter (e.g., monthly) time limits.

Both the government and the unvaccinated individual have two options, 'cooperate' or 'defect'. In the case of the government, 'defect' and 'cooperate' refer to fining and not fining, respectively. In the case of the unvaccinated individual, 'cooperate' and 'defect' refer to vaccination and no vaccination, respectively. The government is considered a TFT player who cooperates in the first round, that is, it does not adopt a fine policy (i.e., a vaccination mandate). In all subsequent plays, the government copies the opponent's previous move.

Power asymmetry between the government (the strong player) and the unvaccinated individual (the weak player) is incorporated into the IPD. However, given the lack of evidence in asymmetric games, it is not clear whether punishing increases the likelihood that an unvaccinated individual would cooperate in the next round. Given power asymmetry, the government is also allowed to exert a third option, which is to intervene by rewarding the unvaccinated individual. The third option satisfies the condition of budget neutrality because the reward scheme, including its administrative expenses, is financed entirely by the revenues generated from the fines. Hence, compared with a reward-only scheme, TFT in combination with a reward is cheaper. It avoids a retroactive reward for more than 70% of the population that has already been fully vaccinated. The additional administration costs of a reward scheme seem to be small compared to those of a penalty-only scheme because it is relatively easy to identify vaccinated individuals as opposed to unvaccinated individuals.

Compared with restricting the options to punishment and no punishment (i.e., 'defect' and 'cooperate,' respectively), the addition of a reward option yields an extra financial incentive to spur vaccinations starting in the second round. The reward option can further increase vaccination uptake by fulfilling the criteria of a decoy option. This necessitates that vaccination,

in conjunction with reward plus fine, is dominated by immediate (i.e., first-round) vaccination. To this end, the reward must be lower than the fine. In addition, a positive time preference leads to the discounting of the reward. Notably, it is likely that unvaccinated individuals display a higher time preference rate than vaccinated individuals (Guo 2020, Gandjour 2022). Based on the findings of Wang et al. (2018), we hypothesize that although unvaccinated individuals would rarely choose the decoy option, its availability increases overall cooperativeness significantly (i.e., immediate vaccination).

One may object that the TFT mechanism could offer an opportunity to delay vaccination by gaming, that is, paying a fine first and then receiving a payback at the time of the following mandate. However, the domination of the reward option reduces the probability of gaming. To ensure dominance, the expected disutility caused by a fine must not be fully compensated by the expected utility gain caused by a reward and the delay in vaccination. The resulting overall utility loss incentivizes vaccination at the time of the first mandate. In addition, a decoy effect would be present. If so, unvaccinated individuals who anticipate the punishment-reward sequence are predicted to be more, and not less, willing to receive vaccination than those who face punishment only.

To increase the effectiveness of a decoy option, the TFT mechanism must be announced with certainty even before the first mandate. While risk aversion in the face of uncertainty may reduce the potential for gaming, an uncertain dominance relationship could prevent the decoy from exerting attraction (Ert 2018).

The pre-announcement of a TFT mechanism may also be useful to signal the willingness of the government to cooperate and rehabilitate deviant individuals. Rewarding prosocial actors may reduce tension and reap reputational benefits (Wu 2021). However, a reward by itself may be seen as corrupting medical decision-making (Persad 2021). Nevertheless, given that the enactment of a fine policy precedes that of a reward system and appears to be more coercive (Giubilini 2018), it is conceivable that adding a reward would reduce coercion. Therefore, the risk of adding a reward dominated by immediate vaccination appears to be small.

About incentive size, theoretical studies based on evolutionary game theory suggest that if the incentive size is very small, both reward and punishment have no effect on promoting cooperation, and selfish players maintain a free-riding strategy. If the incentive is sufficiently

large, then both reward and punishment compel all players to cooperate (Dong 2019). The upper limit of the incentive can be defined based on the value provided by vaccination (Gandjour 2021). However, if the fine is smaller than the vaccination value, both parties lose in the case of no vaccination.

In contrast to cash rewards, lotteries appear to be particularly attractive at a late entry point in a vaccination campaign because they exploit the reasons for vaccine hesitancy (Gandjour 2022). However, lotteries may weaken their effectiveness as decoys because unvaccinated individuals, who tend to be risk-prone with respect to money (Gandjour 2022), may consider the expected utility of paying a fine and entering a lottery to be higher than that of immediate vaccination.

The TFT mechanism may not only be applied to first vaccinations, but also to booster vaccinations. Notably, booster refusers may not display resistance to first vaccinations.

Previous research suggests that punishment mostly acts to sustain cooperation after it has been implemented (Góis 2019). Thus, this research justifies a punishment scheme for booster refusers rather than for vaccine refusers.

Because a reward incentive is set after fining, it addresses vaccine or booster refusers. This should avoid undermining the intrinsic motivation of those with high intrinsic motivation. It also holds for repeated booster shots because rewards are paid only to booster refusers.

Conclusions

This paper suggests a TFT mechanism using a reward decoy option to incentivize COVID-19 vaccination rates. The suggestion to supplement a fine with a reward decoy primarily stems from the idea of enhancing cooperation by exploiting a cognitive bias. To ensure dominance by immediate vaccination, the reward must be smaller than the fine. Laboratory evidence, although from an unrelated setting (Wang 2018), suggests that introducing a reward decoy option is unlikely to hamper the incentive set by a fine, in the sense that unvaccinated individuals would decrease their response to a fine. Nevertheless, supplementing a penalty with a reward is not a sufficient condition to induce cooperation. Owing to insensitivity to further losses, unvaccinated individuals may not accept the reward but rather pay additional fines in subsequent rounds. In particular, vaccine deniers may not respond to financial incentives.

By restricting the reward to vaccine/booster refusers, the TFT mechanism suggested in this paper is cheaper than a reward-only scheme and ensures budget neutrality. In contrast to a reward-only scheme, it also avoids decreasing the intrinsic motivation for repeated boosters in individuals who have received previous vaccinations.

If the goal is to achieve a basic level of protection through natural infection or vaccination and all unvaccinated individuals eventually get infected, the vaccination mandate may not be repeated for repeated booster shots. Nevertheless, even for a one-time booster mandate the advantage of supplementing a fine with a reward stimulus still exists.

A two-player prisoner's dilemma has been discussed before with regard to COVID-19 vaccinations, but for a game with two equal parties (The New York Times 2020). In this game, the two equal parties are considered individuals who decide on vaccination and no vaccination. If individuals choose not to be vaccinated when infection rates are low, they effectively get a free ride, reaping the benefits of reduced virus transmission generated by people who opt for vaccination. However, free riders generate a collective threat (The New York Times 2020). Nevertheless, this prisoner's dilemma is not comparable with the one described in the paper because it is symmetric and does not involve fines or monetary rewards. Furthermore, it only applies to a situation in which infections rates are low. When infection rates are high, it is rational to defect only for a small group of individuals including those with a contraindication to vaccination (e.g., patients with fever or those in the first trimester of pregnancy).

The TFT mechanism suggested in this paper is expected to be more effective than a TFT mechanism without a decoy. Empirical evidence is needed to substantiate the latter assumption; however, as a TFT mechanism has not yet been implemented in vaccination mandates for any virus, empirical evidence would need to be built on laboratory experiments. Evidence generated in this manner may not generalize to the real world, however, because research participants may not experience the same level of emotional involvement as in the real world. This would hold particularly when laboratory experiments are conducted on vaccinated participants with the purpose of mimicking the unvaccinated population.

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