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Vaccination Lottery

Abstract

Ohio announced a Vax-a-Million Lottery in May 2021 to encourage people vaccinated. If people may avoid vaccination because (1) they worry about rare but critical side effects or (2) they want to free ride on herd immunity, the vaccination lottery may work better or worse than a lump-sum transfer to the contributors for herd immunity. I experimentally compare the effectiveness of the vaccination lottery over a lump-sum transfer. Overall, vaccination lottery works better, and it particularly incentivizes probability-weighting subjects.

Keywords: vaccination incentives, lottery, Covid-19, laboratory experiments.

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Vaccination Lottery*

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Vaccination is vital for a society to reach herd immunity and get back to normal. Even in the United States, where the COVID-19 vaccine shortage is not an issue, many people do not get vaccinated. Leaving two population groups—who would get vaccinated without incentives and who would never get vaccinated with any incentives—aside, what would be the proper incentive to vaccination? A vaccination lottery called a Vax-a-Million was implemented in Ohio State in May 2021.[1] Although it indeed boosts vaccinations by 33%, according to Ohio Department of Health data,[2] might it encourage people to

[1]Deliso, Meredith. May 13, 2021. Ohio will give 5 people $1 million each in COVID-19 vaccine lottery. *ABCNews*.

[2]Welsh-Huggins, Andrew and Kantele Franko. May 21, 2021. Analysis: Vaccinations jumped 33% after Vax-a-Million news. *Associated Press*.

free-ride more compared to the alternative situation where the lottery prize is equally distributed to those who get vaccinated? Simply put, is the vaccination lottery the most effective way of spending five million dollars?

In this note, I compare two vaccine incentives—a conditional/unconditional vaccination lottery and a conditional lump-sum transfer—and argue that their effectiveness would depend on the proportion of citizens who overestimate the chance of rare but critical side effects of vaccination. To begin with, rational risk-averse citizens would prefer a homogeneous lump-sum transfer that compensates the expected cost of vaccination over a lottery that gives the same expected compensation. Thus, if the lump-sum transfer exceeds the expected cost, it could effectively mitigate the free-riding incentives on herd immunity if the transfer is made after reaching herd immunity. However, it is well known that people tend to overweight an event with a small probability (Tversky and Kahneman, 1992). If this probability weighting, rather than free-riding motive, is the main driver behind vaccine avoidance, then a vaccination lottery would work better: For the probability weighting citizens, a small sure benefit (a lump-sum transfer) would not compensate a big loss with a small probability, but a huge prize with a small probability would.[3]

Which vaccination incentives would work better calls empirical investigations, and some ongoing policy experiments[4] should be analyzed later, but common challenges of empirical data such as different timings with varying vaccination rates and controlling for other coexisting incentives would hold. In this regard, this note aims to timely provide the first experimental evidence about which incentives work better, hoping that findings here would leverage the design of a large-scale field experiment or policy experiment.

The experiment compares two incentives that encourage participation (corresponding to vaccination) for collective actions with a control condition. Although only one session attains the collective goal (corresponding to herd immunity), the lottery incentive, both

[3]A similar argument can be found in Spencer (2020).

[4]Jett, Jennifer and Joy Dong. June 3, 2021. Hong Kong Is Dangling Incentives to Get Vaccinated. That May Not Be Enough. *New York Times*.

conditional on herd immunity and unconditional, brings significantly more participation than the transfer incentive and no incentives. As predicted with the cumulative prospect theory, subjects who exhibit the probability weighting tendency in both gains and losses respond more to the lottery incentive. Risk preferences weakly drive risk-averse subjects to participate less on the lump-sum transfer incentive.

A Conceptual Framework

This section elaborates on the predictions of the two different vaccination incentives. Suppose that the government has $B > 0$ amount of resources to improve social welfare. Herd immunity is achieved when Nh among N citizens get vaccinated, where h is a known probability, say, 0.8. Achieving herd immunity earlier is one way of improving social welfare, as "back to normal" would boost the economy. Denote the per-period utility level of a citizen before and after herd immunity by u_0 and u_H, $\Delta u := u_H - u_0 > 0$.[5] Consider the following three alternatives regarding the use of the budget B:

1. Distributing equally to those who get vaccinated,
2. Distributing exclusively to one lottery winner among the vaccinated, and
3. Distributing equally to every citizen.

The last one may correspond to the government's effort to compensate for everyone's loss due to the pandemic.

The cost of vaccination is $c > 0$, but with a small probability $p \in (0,1)$, vaccination brings a critical side effect, $L > 0$. I assume that $B/N + \Delta u \geq c + pL \geq B/N$, that is, the

[5] I did not consider the intermediate per-period utility level of those who enjoy the individual benefit of vaccination for two reasons. First, those who find the individual benefit is sufficient would get vaccinated without incentives, and those who find it never sufficient would not get vaccines with any incentives, so we deal with those whose individual benefit is not large enough to compensate the expected cost of vaccination. In this case, the underlying two motives—overestimating the chance of critical side effects and free-riding on other's vaccinations—remain unaffected. Second, although the experiment has four periods, I assume that the vaccination decisions are almost simultaneously made. Thus, an intermediate state in the static model has no practical implication here.

government's budget is sufficient to compensate the entire population's expected costs of vaccination upon reaching herd immunity, but not sufficient enough to make vaccination a dominant strategy.

In the sense that the society requires Nh vaccinated citizens to reach herd immunity, it resembles the threshold public goods provision problem (Palfrey and Rosenthal, 1984), and the concern of coordination failure plays a role here as well. Even when everyone is fully rational, one symmetric pure-strategy Nash equilibrium is for everyone to avoid vaccination, and this equilibrium may be viewed as more viable (Kalai, 2020). Compensating the cost can make vaccination attractive. To expedite herd immunity, the government may consider paying $B/(Nh)$ to the first Nh vaccinated citizens in a dynamic setup.

However, if some citizens overestimate the probability of the side effect due to their subjective probability weighting, $w(p)$ with $w(p) > p$ for small p, then compensating the cost might not work. That is, if $c + w(p)L > B/N + \Delta u \geq c + pL$, then the probability-weighting citizens will not get vaccinated, and herd immunity may not be achieved. A potential way of exploiting such probability-weighting citizens is to offer a lottery prize of B to randomly selected one of those who contributed to achieve herd immunity. While risk-averse rational citizens would find the lump-sum compensation more attractive, probability-weighting citizens would overestimate the probability of winning the vaccination lottery and thus be willing to get vaccinated if $v(1/N)B > c + w(p)L$, where $v(\cdot)$ such that $v(1/N) > 1/N$ is another probability weighting function regarding the lottery win.[6]

In sum, which incentive for vaccination is more effective than the other depends on how much people overestimate the probability of rare but critical side effects.

[6] $w(p)$ and $v(p)$ correspond to $w_-(p)$ and $w_+(p)$ in Tversky and Kahneman (1992).

Experimental Design

I consider three treatments and one control, with having abstract framing[7] in mind. The basic procedure of each treatment is as follows:[8] A session consists of 25 subjects, and they play a game for four periods. In each period, u_0 base points are added to the subject's account. In period 1, the subjects simultaneously choose [P] (for participation) or [NP] (for not participation). If a subject chose [P], 20 points with a 95% chance or 140 points with a 5% chance are deducted from his/her account. This participation is made only once, so after choosing [P] in any period, no further actions are required, and the subject earns base points. If 20 or more subjects have cumulatively chosen [P], then everyone's base points increase to u_H from the next period, regardless of whether the subject chose [P] or not. The points accumulated in the subject's account are exchanged to euro at 1 point = 5 cents.

On top of the base points, in one treatment (called Lottery), when 20 or more subjects have chosen [P], one of them is randomly selected to earn 250 additional points. Another treatment (called UnconLottery) considers an unconditional version of the Lottery treatment: regardless of how many have chosen [P], one of them is randomly selected to earn 250 additional points. In another treatment (called Transfer), every subject who chose [P] receives an equal split of 250 additional points when 20 or more subjects have chosen [P]. In a control session, no further incentives are offered, but I increase the base points by 3 to minimize a potential income effect. Table 1 summarizes the design of the experiments.

Two remarks on the design are worth mentioning. First, I do not consider uncon-

[7] Although it might be more straightforward to design experiments to test the effect of different vaccination incentives, one of the critical challenges is to control subjective appreciation of the contextualized setting. I avoid using terms such as "COVID-19," "vaccination," "side effects," and "herd immunity": Otherwise, interpretations of the experimental results could be confounded as there could exist an experimenter-demand effect (Zizzo, 2010). This abstract framing certainly loses some important features of the vaccination, as it might be involved not only in subjective probability weighting but also in wrong beliefs or misinformation. It would be worth conducting a large-scale lab-in-the-field experiment comparing the neutrally framed group with the contextualized group.

[8] The full instructions, post-experiment survey, and the entire dataset are in the Open Science Foundation repository.

Table 1: Experimental Design and Summary of Hypotheses

Treatment	#Sessions	u_0	u_H	$c+pL$	Additional payoff
Control	1	43	53	26	-
Transfer	1	40	50	26	After 20 [P]s, all of [P]s split 250
Lottery	2	40	50	26	After 20 [P]s, one of [P]s receive 250
UnconLottery	2	40	50	26	One of [P]s receive 250

ditional transfer treatment. I believe the government's budget must be used with a common cause. Otherwise, unconditional incentives will be associated with unfair allocations.[9] However, an unconditional lottery treatment is considered because it has been used in practice.[10] Second, although the conceptual framework considers a static model that asks everyone to decide simultaneously, I consider four periods to see how the participation rates evolve. To make a homogeneous environment across periods, I only informed subjects whether the threshold of 20 was reached by the previous period but did not tell them how exactly many subjects had chosen [P].

Experimental Procedure

The experimental sessions were conducted in English using laboratory subjects from Mannheim and Heidelberg on June 4 and July 12, 2021. I invited them to join an online meeting, distributed the unique link for the online experiment, and paid them via online transfers afterward.

An interactive online platform called LIONESS (Arechar et al., 2018) was used. Before the subjects joined an online meeting, they removed their profile photos and turned off the webcam. After joining the meeting, the subjects renamed their displayed names to two arbitrarily chosen letters so that their identities, hence decisions, remain anonymous. They read the instructions displayed on their screens and pass a comprehension

[9]See Volpp and Cannuscio (2021) for relevant discussions.

[10]An interesting difference between the conditional and unconditional lotteries is that as more people participate, participating in the unconditional (conditional) lottery becomes less (more) attractive as there are more people to compete with for the lottery.

quiz. In all the treatments, the participants filled out a post-experiment survey asking their basic demographic characteristics, cumulative prospect theory parameters,[11] and risk preferences. The average payment per subject was €7.55. The gender ratio and age distributions were ex-post similar across sessions. Each session lasted less than 30 minutes.

Results

Figure 1 shows the participation rates over periods. In Control, the participation rates start from 40% and end at 52%. Similar participation rates are observed in Transfer (36% to 44%). In both Lottery and UnconLottery, 74% of subjects on average end up participating. In one session of UnconLottery, they reached the threshold in period 3. The difference in participation rates between Lottery and UnconLottery is not significant, so observations from Lottery and UnconLottery are pooled for the remaining analysis. The difference in participation rates between Lottery and Control in period 4 is statistically significant at the 5% level of significance (t-stat=1.9802, p-value=0.0499), and the difference between Lottery and Transfer is statistically significant at the 1% level of significance (t-stat=2.7149, p-value=0.0076).

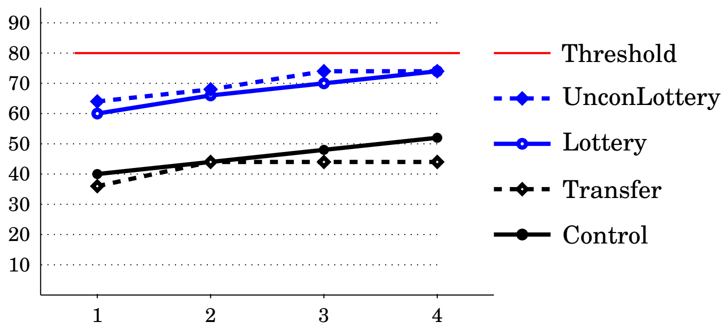

Figure 1: Participation Rates (%) over Period

Figure 2 shows the participation rates of each treatment by subgroups. Based on

[11]Three questions involve the willingness to pay for a lottery with possible gains, and another three questions asking the willingness to pay for avoiding a lottery with possible losses. Those questions are similar to what Rieger et al. (2017) used.

the risk preference survey questions, which enable me to classify them into seven risk preference ranks,[12] I divide the subjects into two groups. Half of the subjects in each treatment (called HighR) were more risk-seeking than the other half (LowR). In Transfer treatment, it is noticeable that the HighR group participated more than the LowR group (t-stat=1.0141), while in Lottery treatments and Control, no differences are observed. The lower participation of risk-averse subjects in Transfer treatment is perhaps because the incentive comes with two types of uncertainty, the small chance of a significant loss and the uncertainty about the success of collective action.

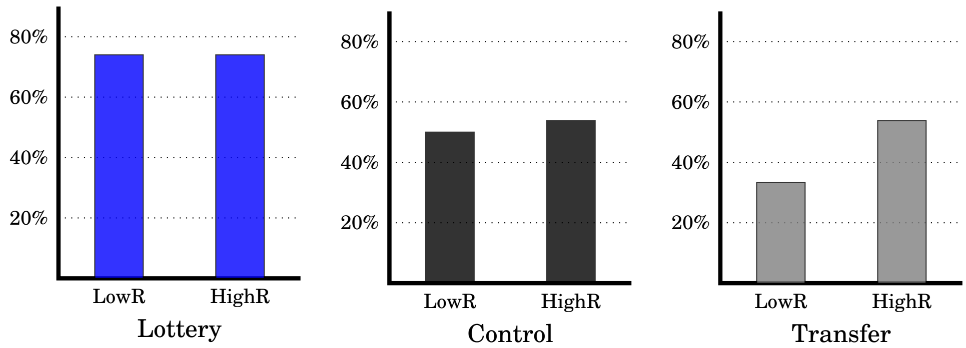

Figure 2: Participation Rates By Risk Preference

Figure 3 shows the participation rates of each treatment by the probability weighting tendency in both gains and losses.[13] Based on the answers to the probability weighting survey questions, I divide the subjects into two groups. Those who overweight smaller probabilities in both gain and loss cases participated (called PrW) more than the other group (NotPrW) in Lottery treatment (t-stat=1.1510). Compared to the NotPrW group in other treatments, the PrW group in Lottery treatments participated significantly more

[12]The subjects' risk preferences were measured by sequentially modified certainty equivalent questions. I asked the subjects to choose (A) a lottery (€10, 0.5; €2, 0.5) or (B) €5. If they answered those two are indifferent, no second question was followed. When the subject chose (A), the second question asked to choose between the same lottery and €6. When the subject chose (B), the second question asked to choose between the same lottery and €4. With at most two questions, we categorize a subject into one of seven ranks regarding risk preference. For example, subject i who prefers €5 over the lottery is more risk-averse than subject j who finds the lottery and €5 are indifferent, and subject j is more risk-averse than subject k who prefers the lottery.

[13]The post-experiment survey asks the willingness to pay (WTP) to buy a lottery with a 5%/15%/30% chance of winning and the WTP to avoid a 5%/15%/30% chance of losing. If $WTP_5/WTP_{15} > 5/15$ or $WTP_{15}/WTP_{30} > 15/30$, then I code that the subject exhibits the probability weighting tendency.

(t-stat=1.7438, p-value=0.0847). This observation is consistent with the prediction lead by the cumulative prospect theory: Those who overweight the small probability of significant losses and gains respond more to the lottery incentive.

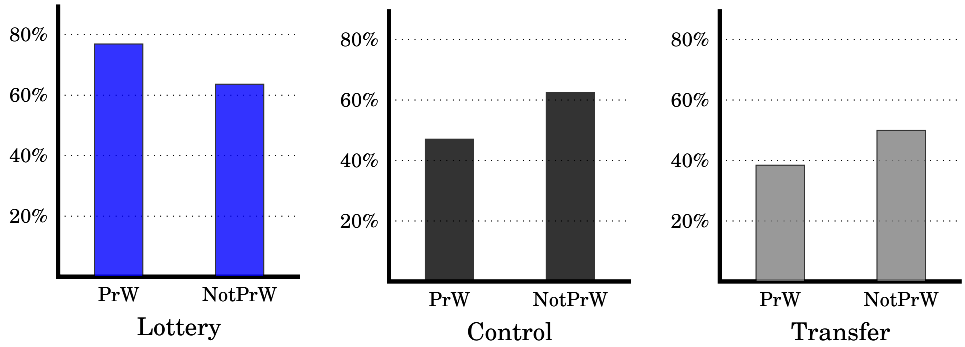

Figure 3: Participation Rates By Probability Weighting Tendency

Concluding Remarks

Motivated by currently discussed vaccination incentives, I compare a (conditional and unconditional) lottery and a conditional lump-sum transfer for incentivizing collective actions to reach a threshold level (corresponding to herd immunity) of participation (corresponding to vaccination). I report three findings. First, the lottery incentive works better than the transfer incentive. Second, the risk aversion discourages participation under the transfer incentive. Third, people overweighting small probabilities of significant losses or gains respond more to the lottery incentive.

There are many possible extensions. Since the side effects mostly involve loss in health conditions, it may not be directly comparable to monetary benefits. A similar but more contextualized study with larger samples can be considered. To simplify the complex situation, I considered that the utility level steps up only when herd immunity is achieved, but the society could enjoy a lower reproduction number of the disease transmission even if herd immunity is not achieved. Another extension is to examine the characteristics of those who responded to the vaccination incentives. Since I observe heterogeneous responses by risk preferences and probability weighting tendency, it would be worth examining the potential implications of incentivizing different populations to the society.

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