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Data-Driven Commentary

Everyone Wins: Vaccine Lotteries Can Cost-Effectively Increase COVID-19 Booster Vaccination Rates

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Booster vaccination remains a key strategy to address the ongoing threat of coronavirus disease 2019 (COVID-19). However, take-up has been slow. By the fall of 2022, less than 50% of eligible US residents had received a booster dose. It is a central tenet in health economics that incentives or penalties are necessary to reach optimal vaccination rates. Six rigorous real-world studies provide evidence that COVID-19 vaccine lotteries cost-effectively raised vaccination rates at an estimated cost of \$49 to \$82 per additional dose. The 5 studies that found no impact of lotteries used statistical methods that underestimated the impact: They were statistically underpowered to detect a small yet cost-effective impact and did not adequately address selection bias. Vaccine lotteries are cost-effective because they not only provide financial incentives but also influence the public via nonfinancial channels: They garner media attention, tap into social networks, combat procrastination, and signal the importance of sustaining high vaccination rates. In fact, vaccine lotteries are likely to be more effective for booster vaccination than for initial doses because barriers to vaccination are higher. The ongoing threat of COVID-19 presents a unique opportunity to develop and implement innovative, evidence-based public health policies like vaccine lotteries to address current challenges.

booster vaccination; COVID-19; evidence-based policy; health policy; vaccine lottery; vaccines

Abbreviation: COVID-19, coronavirus disease 2019.

Editor's note: The opinions expressed in this article are those of the authors and do not necessarily reflect the views of the American Journal of Epidemiology.

Booster vaccination remains a key strategy to address the ongoing threat of coronavirus disease 2019 (COVID-19) as the effectiveness of first doses wanes over time. However, booster vaccination take-up has been slow. Despite evidence that mRNA booster doses restored a degree of protection from COVID-19 infection and hospitalization comparable to the initial 2 doses (1, 2), by the fall of 2022, less than 50% of booster-eligible US residents and less than 75% of eligible US residents aged 65 or over had received a booster dose (3). Low rates are especially concerning for the elderly since they are at much higher risk of severe illness if they have not been boosted (4). Booster vaccination is also instrumental in preventing long COVID-19 cases by slowing transmission and limiting the persistence of symptoms (5).

It is a central tenet in health economics that incentives or penalties are necessary to reach optimal vaccination rates because most people do not fully consider benefits to themselves and others when making the decision to get vaccinated (6). Incentives are especially important to encourage booster vaccination among those who see themselves as at low-risk for serious illness—and who therefore may be more likely to transmit COVID-19 to others. Booster vaccination rates are low in part because few of the incentives and penalties used to encourage initial vaccine doses have been implemented for booster doses. This is a policy oversight.

This data-driven commentary demonstrates that innovative, evidence-based public health policies such as COVID-19 vaccine lotteries can cost-effectively raise vaccination rates. Although COVID-19 vaccine lotteries were initially met with concerns that they would be ineffective and wasteful (7), several real-world studies provide rigorous evidence that they are both effective and cost-effective (8–13).

Vaccine lotteries are cost-effective because they not only provide financial incentives but also influence the public via nonfinancial channels to address several barriers to vaccination at once. This combination presents a powerful blueprint for innovation in public health: Provide financial incentives where warranted, garner media attention, tap into the power of social networks, combat procrastination, and send a signal of the ongoing importance of public health goals.

RIGOROUS REAL-WORLD EVIDENCE

Rigorous real-world evidence demonstrates that statewide COVID-19 vaccine lotteries are both effective and cost-effective. All 6 published studies that examined the impact of Ohio's vaccine lottery on first doses found a statistically significant and economically meaningful impact with an estimated cost of \$49 to \$82 per additional dose (8–13). Robertson et al. (12) found that 10 of 12 statewide lotteries increased vaccination rates. Acharya and Dhakal (8) found that lotteries increased vaccination rates in Ohio, Maryland, Oregon, and Washington but not in Arkansas, Kentucky, or West Virginia.

The study with the most rigorous statistical approach compared Ohio border counties with neighboring counties in states that did not implement a vaccine lottery (10). Neighboring counties provide a valid counterfactual because they are likely to have similar underlying characteristics. The Ohio lottery induced an estimated one-half of 1 percent of the state population to get vaccinated before the deadline at an estimated cost of \$75 per additional dose (10). It was therefore highly cost-effective.

Policy makers should not be dissuaded by the apparent small magnitude of the lottery impact, because the return on investment is high. Each COVID-19 vaccine dose is highly efficacious at averting the high societal costs of severe illness. For example, even a 1-percentage-point increase in vaccination rates from a million-dollar lottery prize would more than meet the standard threshold of \$100,000 per quality-adjusted life year (QALY) to be considered highly cost-effective (14). These studies likely underestimate the overall impact, because the lotteries surely nudged many people towards COVID-19 vaccination, even if they were not vaccinated by the deadline, and they may have encouraged vaccination in nonlottery states via nonfinancial channels. Vaccine lotteries can also be targeted to high-risk groups to increase cost-effectiveness.

LIMITATIONS OF THE LITERATURE

The 5 published studies that found no overall impact of lotteries used methodological approaches that were prone to bias against finding a positive impact for 2 reasons: They were statistically underpowered to detect small but meaningful effects, and/or they did not adequately address selection bias.

First, these 5 studies were statistically underpowered because they used state-level rather than county- or individual-level data in the analysis, resulting in a smaller sample size (15–19). This means they were not designed to have enough

precision to detect the small yet cost-effective impact of vaccine lotteries that was estimated by more rigorous studies. For example, despite using daily vaccination data, Thirumurthy et al. (18) noted that their state-level study design was unable to rule out increases in vaccination rates of 10% or less, which would obscure the small but statistically significant effect found by studies with sufficient statistical power.

Second, these 5 studies failed to adequately address selection bias by choosing a valid comparison group to model the counterfactual trajectory of vaccination rates in the absence of the lottery. All 5 studies compared states that implemented a vaccine lottery to the set of all nonlottery states, which is not an apples-to-apples comparison. For example, Walkey et al. (19) showed that, during the period before the vaccine lottery, trends in Ohio's vaccination rate were very different from the rest of the country, indicating different underlying dynamics.

This choice of comparison group likely underestimated the impact of the lotteries: States with slow or slowing vaccination rates may have chosen to implement a vaccine lottery, whereas states experiencing a steady or rising pace of vaccination in the late spring or summer of 2021 would not have deemed it necessary to implement a vaccine lottery. The selection bias of comparing states that implemented a vaccine lottery to all other states would therefore make the lottery policy look less effective than it truly was.

By contrast, the 6 studies discussed above that found positive and significant impacts of vaccine lotteries addressed selection bias by using a comparison group that had vaccination rate trajectories before the lottery that were similar to those of the lottery states and would therefore be expected to have similar trajectories in the absence of the lottery. Brehm et al. (10) used a comparison group consisting of neighboring counties in a state that didn't implement the lottery; Acharya and Dhakal (8), Barber and West (9), and Sehgal (13) used a synthetic control group of states with similar pre-policy vaccination trajectories; Robertson et al. (12) used a synthetic control group of counties inversely weighted by distance to the lottery state; and Mallow et al. (11) used within-state pre-policy vaccination trajectories.

LOTTERIES OPERATE VIA NONFINANCIAL CHANNELS

Individual decision-making about vaccination is complex and not fully understood (20). There is no one-size-fits-all intervention. However, COVID-19 vaccine lotteries present a powerful blueprint for boosting vaccination rates since they are straightforward to implement and address several barriers to vaccination at once.

A robust literature has demonstrated that financial incentives influence public health behavior and that the incentive structure, framing, and context determine the magnitude of the impact (21). Large-jackpot lotteries add a new type of incentive that is only feasible for large entities like governments to implement. This can help overcome higher levels of hesitancy and raise vaccination rates, especially if people overestimate their relatively small chance of winning.

Broad-based vaccine lotteries are more than simply a financial incentive. They encourage vaccination via several

nonfinancial channels as well. This amplifies the impact of the lottery by increasing the likelihood that those eligible for vaccination are both informed enough and motivated enough to seek vaccination before the lottery deadline (22).

First, newsworthy public health interventions like state-wide vaccine lotteries receive widespread media attention because they are novel, broad-based, and achieve the important communal goal of reducing the negative impact of COVID-19. This free media helps raise awareness about vaccination, increase participation, and spread information about the benefits of vaccination while keeping program costs down. In fact, the information alone may induce some to get vaccinated even if they do not respond to the financial incentive per se, which is a key part of the program impact. Media coverage is especially important for COVID-19 booster vaccination since the initial mixed messaging about booster eligibility likely left many underinformed or confused about the benefits (23).

Second, lotteries tap into the power of social networks to influence vaccination decisions. The newsworthiness of the lotteries can prompt informal conversations about booster vaccination with family, friends, and acquaintances since everyone benefits from high vaccination rates around them. This is especially powerful for reaching those who may have tuned out COVID-19 news in an ongoing pandemic. Because lottery prizes are large enough to share, everyone is further incentivized to convince their family and friends to get vaccinated.

Third, lotteries help address procrastination so that people are more likely to be vaccinated or boosted before they are exposed to the virus. They impose an artificial deadline for vaccination in cases where it would be counterproductive to set a real one. The anticipation of regret at missing out on the lottery can be a powerful motivator especially since it mirrors the anticipated regret of contracting COVID-19 before getting a booster dose (24). Furthermore, the deadline nudges those who remain unsure about booster vaccination to gather more information and make a decision.

Fourth, vaccine lotteries enable elected leaders to send a clear signal of the importance of sustaining high vaccination rates and their willingness to allocate resources to achieve it. This helps shift norms around public health spending and collective responsibility for vaccination. It can also help overcome the ongoing confusion about whether COVID-19 booster vaccination is simply an optional top-up to vaccine protection or a necessary requirement given waning vaccine effectiveness.

Vaccine lotteries are likely to be more effective for booster vaccination than for initial doses because these barriers are more salient. There are few incentives to get a booster dose, there is little media attention on the eligibility criteria for and effectiveness of booster vaccination, there are fewer casual conversations about vaccination, there is no deadline for getting a booster dose, and few elected officials are making vaccination a priority. Additionally, the target populations for booster vaccination are likely more easily swayed by vaccine lotteries since they have already demonstrated their willingness to get vaccinated and may therefore be more responsive to a nudge.

VACCINE LOTTERIES IMPROVE HEALTH EQUITY

In addition to being cost-effective, large-scale vaccine lotteries can improve health equity by incentivizing vaccination without disproportionately burdening vulnerable populations. This stands in stark contrast to other proposed policies (7): Imposing employer mandates threatens job security for the most vulnerable. Restricting education and social opportunities to the vaccinated reinforces the cycle of alienation and misinformation that drives vaccine hesitancy in the first place. Increasing health insurance premiums penalizes those most at risk and reduces their access to health care. Moreover, vulnerable populations who are disproportionately harmed by COVID-19 benefit indirectly from interventions that boost population vaccination rates. Targeting vaccine lotteries by geographic area can further improve equity (25).

Many had concerns that large-scale lotteries would be difficult to implement, be unsustainable, and create undesirable precedents (7). But vaccine lotteries are so cost-effective that they are worth what might seem like a high cost—even after the novelty wears off and even if lotteries must recur to maintain high vaccination rates. The implicit monetary value of a lottery entry is too small to create perverse incentives or to be considered coercive. Vaccine lotteries are more palatable than vaccine mandates and less susceptible to legal challenges.

CONCLUSION

The COVID-19 pandemic exposed the wide-ranging consequences of underinvesting in public health. However, the ongoing threat of COVID-19 also presents a unique opportunity to develop, implement, and invest in innovative public health interventions to address current challenges. The promising initial results for vaccine lotteries provide a powerful policy blueprint for incentivizing public health behaviors that have significant community-wide benefits.

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