COVID-19 VACCINE LOTTERY FIELD EXPERIMENT

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1. Introduction

Coronavirus disease 2019 (COVID-19) has caused the largest public health crisis, and economic disaster of the 21st century so far (Kadkhoda, 2021: 471). According to the World Health Organisation (2021), COVID-19 has directly resulted in 4,859,277 deaths worldwide[1], and its impact on the global economy has been severe (World Bank, 2020). Policymakers are in urgent need of evidence-based strategies to contain the pandemic. As Fontanet & Cauchemez (2020: 583) report, one critical mechanism through which epidemics are controlled is herd immunity. Herd immunity arises when a sufficiently large proportion of the population achieves individual immunity to an infectious disease such that the transmission chain of the disease is halted (Kadkhoda, 2021: 471). One method of establishing herd immunity is through vaccination programs (Fontanet & Cauchemez, 2020: 583). Empirical evidence shows that vaccination strategies have helped subdue COVID-19. For example, Aldila, Samiadji, Simorangkir, Khosnaw & Shahzad (2021) find COVID-19 vaccines to be effective in Indonesia. Other countries have also implemented vaccine programs and the World Health Organisation (2021) reports that a total of 6,364,021,792 vaccine doses have been administered globally[2].

In line with the international approach, South Africa has issued vaccines in addition to social distancing and lockdown measures. The South African government has stated that it aims to have 67% of the population vaccinated by the end of 2021 (Department of Health, 2021a). However, many South Africans are hesitant to get the COVID-19 vaccine; the Department of Health (2021b) records that only 25% of South Africa's adult population has been fully vaccinated as of 11 October 2021. According to Burger, Maughan-Brown, Köhler, English & Tameris (2021), 20% of South Africans are concerned that COVID-19 vaccines are not safe, and a significant portion of South Africans still have to be convinced to take the vaccine[3]. While there are different ways to encourage vaccine uptake, such as mandatory vaccination or lump-sum transfers, insights from behaviourial economics could provide a more cost-effective solution: a vaccine lottery.

This essay[4] proposes a field experiment to investigate whether different vaccine lotteries – standard, regret and referral – could improve vaccination rates in South Africa. This essay is structured as follows. Section 2 reviews the relevant literature on behavioural economics and health interventions. Section 3 elaborates on the South African context. Section 4 describes the design of the experiment and discusses the theory of change. Section 5 outlines how the treatment will be administered and the data collection process. Section 6 gives a pre-analysis plan, and the final section (7) concludes.

[1] As of 13 October 2021
[2] As of 10 October 2021
[3] A sentiment report from Department of Health (2021c) shows an interesting break down of different communities' beliefs surrounding the vaccine
[4] This essay was written in R using the package Texevier by Katzke (2017)

2. Behavioural Economics and Health Interventions

Health professionals and policymakers are increasingly turning to behavioural economics to understand how people make health decisions and how behavioural insights can be used to improve public health outcomes (Loewenstein, Asch, Friedman, Melichar & Volpp, 2012: 1). Neoclassical economics assumes that people are perfectly rational, whereas behavioural economics uses psychology and economic theory to create more realistic models of human decision-making (Rabin, 2002). People are subject to certain biases and often make use of heuristics in their decision-making process, which can lead to predictable errors in judgment Kahneman & Tversky (1979). Behavioural economics literature investigates how these biases can be combated to improve welfare outcomes. Thaler & Sunstein (2008) introduced the idea of a nudge[5] as a way to guide people to make better choices. For example, changing the default option for organ donation to be opt-in as opposed to explicit consent could benefit potential donors (who were deterred by the registration process) and save more lives (Thaler & Sunstein, 2008: 176).

A similar type of nudge can be applied to flu vaccines. A study conducted by Chapman, Li, Colby & Yoon (2010) found that vaccination rates increased by 36% under an opt-in default than under an opt-out condition. Madrian (2014: 9) proposes other interventions for promoting vaccinations, e.g. encouraging people to plan the time and location they will receive their vaccination. This has been implemented in South Africa for the COVID-19 vaccine: the government has sent out SMS's reminding people to get vaccinated, and a self registration portal has been set up for citizens to enroll in the Electronic Vaccination Data System (EVDS[6]) (Republic of South Africa, 2021).

Behavioural economic theory and empirical studies suggest that lotteries can be a useful device for public health interventions. A lottery system can be a cost-effective mechanism for changing behaviour compared to direct transfers because people tend to overweight small probabilities. This is a key insight from the seminal work by Kahneman & Tversky (1979: 286) on prospect theory and implies individuals overestimate their chances of winning a lottery. Björkman Nyqvist, Corno, Walque & Svensson (2018) ran an experiment in Lesotho, where participants were entered into a lottery, and they could win a cash prize if they tested negative for sexually transmitted infections. HIV incidence decreased by 21.4% over two years because of the intervention. The study found that the lottery was particularly effective at targeting participants who were more prone to risky sexual behaviour (Björkman Nyqvist, Corno, Walque & Svensson, 2018). This supports the theory that risk-seeking individuals value lotteries more.

The concepts of loss aversion, reference dependence and regret avoidance can also be included in health interventions through a "regret lottery". Kahneman & Tversky (1979) describe loss aversion

[5] Nudge: an intervention that alters behaviour towards a desired action. In order for an intervention to qualify as a nudge, it should be cheap and easy to avoid (Thaler & Sunstein, 2008).

[6] This portal can be seen as a type of commitment device, in addition to being a data collection mechanism.

as a cognitive bias whereby people experience losses as more painful than the pleasure they receive from an equivalent gain. Thus, people are more willing to take on risk to avoid a loss, and are less risk-seeking when pursuing gain (Kahneman & Tversky, 1979: 268). Reference dependence follows on from loss aversion and suggests that people define gains and losses relative to a reference point (Tversky & Kahneman, 1991: 1039). People are also subject to regret avoidance, where there is a significant emotional cost attached to regret and people make decisions to avoid regretting alternative decisions in the future (Bailey & Kinerson, 2005).

A regret lottery takes advantage of these three principles by entering all participants into a lottery and the winner can claims the prize contingent on some condition. If this condition is not met, a new winner is selected. By entering all participants, people's reference point is shifted to "I have a chance at winning the lottery". However, if a person is not eligible to claim the prize because he does not meet the required condition, he feels he has lost out. He is more likely to try and meet the condition to minimise the pain of this loss. Additionally, he will want to avoid the regret that would come from having missed the opportunity to claim the prize. Several empirical papers investigate how "regret lotteries" can improve health behaviours. Humphrey, Small, Jensen, Volpp, Asch, Zhu & Troxel (2019) analysed the effect of a daily regret lottery on cholesterol-lowering, and heart medication adherence, and found that the treatment group better adhered to their medication regime than the control group. In a different study, Husain, Diaz, Schwartz, Parsons, Burg, Davidson & Kronish (2019) found that implementing a weekly electronic regret lottery increased adherence to a self-monitoring study protocol.

Some states in America have run regret lotteries to encourage people to get vaccinated against COVID-19. An unpublished paper by Thaler *et al* evaluates the effect of regret lotteries in Philadelphia (Gandhi, Milkman, Ellis, Graci, Gromet, Mobarak, Buttenheim, Duckworth, Pope, Stanford, Thaler & Volpp, 2021). The authors did not find convincing evidence that the regret lotteries significantly increased first-dose vaccination rates for the treatment groups[7]. Similarly disappointing results were found for a COVID-19 vaccine lottery in Ohio (Walkey, Law & Bosch, 2021). To the best of my knowledge, there have been no studies on COVID-19 vaccine lotteries in South Africa[8] - a gap which this experiment is intended to fill. This experiment would also contribute to the empirical literature on lotteries as public health interventions and the integration of behavioural economics into public policy.

[7]The authors acknowledge that there were some design flaws in the experiment that could be clouding the results.

[8]It should be noted, however, that First National Bank is running a COVID-19 vaccine lottery for FNB customers, with total cash prizes amounting to R18 million

3. The South African Context

A report by the National Lotteries Commission (2019) on lottery habits shows that 35% of South Africans[9] participated in lottery activities in 2018 (National Lotteries Commission, 2019: 78–79). This high participation rate supports the implementation of a vaccine lottery in South Africa, as there is evidence of "demand" for lotteries. The average amount spent on lottery activities was R156 per month, with average monthly lottery winnings amounting to R110. A rational agent would not buy lottery tickets due to the negative expected value (−R46). Yet people still play the lotto, which suggests that South Africans may not be rational, and behavioural economic insights are applicable[10].

Johnson & Johnson (J&J), Pfizer and AstraZeneca are all approved COVID-19 vaccines in South Africa (South African Health Products Regulatory Authority, 2021) and citizens have to register on the EVID portal before receiving a vaccine. Some vaccines require more than one dose. For this experiment, *fully vaccinated* refers to an individual who has had the maximum required doses of any vaccine. *Vaccinated* refers to an individual who has had 1 shot of any vaccine. According to the Department of Health (2021b), 34% of South Africans are vaccinated, while 25% are fully vaccinated. These low numbers indicate that an intervention is necessary to improve vaccination rates if South Africa wants to achieve herd immunity. Table 3.1 below gives a breakdown of vaccination rates.

Province	Total Adults Vaccinated	Adult Population	Percentage Vaccinated
Eastern Cape	1 603 045	4 099 543	39%
Free State	735 696	1 914 521	38%
Gauteng	3 523 373	11 311 326	31%
KwaZulu-Natal	2 170 526	7 219 795	30%
Limpopo	1 437 846	3 695 801	39%
Mpumalanga	831 759	3 039 520	27%
North West	835 206	2 693 247	31%
Northern Cape	290 962	847 545	34%
Western Cape	2 141 933	4 976 903	43%
Total	13 570 346	39 798 201	34%

Table 3.1: Vaccination Statistics

[9] Based on a sample of 3,090 households randomly distributed across the country.

[10] The gross revenue from gambling activities, excluding the National Lottery, amounted to R32.7 billion for the 2019 financial year (National Gambling Board, 2020: 3). This represents 0.64% of South Africa's 2019 nominal GDP (R5.1 trillion) (Statistics South Africa, 2020: 8), which suggests that gambling is a lucrative market in South Africa and a lotto device could be an appropriate tool for incentivising behaviour.

4. Experiment Design

4.1. Sample

The sample used in this experiment will be the same sample used for the Coronavirus Rapid Mobile Survey (NIDS-CRAM)[11] (Ingle, 2021). There have been five waves of NIDS-CRAM surveys, with wave 5 comprising 5,862 people[12] (Ingle, 2021: 14). Wave 3 comprised 8,157 potential participants, of which 6,130 were interviewed. For this experiment, the 8,157 people from wave 3 will be contacted and asked to participate in wave 6. We can expect between 5,500-6,200 people to participate, given the previous attrition rates in NIDS-CRAM.

A conservative sample size of 5,500 and a vaccination proportion of 34%, leaves 3630 eligible participants for the study[13]. This sample will be split into 4 groups of equal size (907), and randomised such that each group has a similar distribution of participants in terms of age, race, health status and gender, as proposed by Duflo, Glennerster & Kremer (2007)[14]. One group is randomly chosen to be the control group, and the other 3 groups are randomly allocated to different lottery treatments. There will be 1 lottery a month for each treatment group, which will run for three months. There will be 9 lotteries in total, with 3 lotteries every month. Lottery winners receive a cash prize of R1,000,000.

4.2. Treatment Groups

For the first treatment group, if an individual has received a vaccination shot within a given month, she will be entered into that month's vaccine lottery. At the end of the month, a winner is randomly selected; winners are privately contacted and receive a cash prize[15]. The second lottery is a regret lottery. Every individual in the group is entered into a monthly lottery but an individual may only claim her prize if she has been vaccinated in that month. At month end, a winner is randomly drawn. If the winner has been vaccinated, she will be privately notified and receives a cash prize. If the winner has not been vaccinated, she will receive a "regret message" stating that she would have won the cash prize if she had been vaccinated; and a new winner is drawn from the lottery.

The final treatment is a "referral lottery". An individual is entered into the monthly lottery if 2 conditions are met: he is vaccinated, and he refers a friend to get vaccinated and the friend gets vaccinated. Both the individual from the treatment group and his friend are entered into the lottery. At the end of the month, a winner is selected, and once he and his referral partner are verified to

[11]NIDS-CRAM was created to build a representative data set of the South African population to inform decision-making for the pandemic

[12]Suveyed over April to May 2021

[13]Since we are interested in unvaccinated individuals

[14]This randomisation serves to ensure groups are comparable, and eliminate bias in treatment assignments.

[15]Once it is verified that the winner has indeed been vaccinated.

be vaccinated, he will be notified. An individual can refer more than one friend to be vaccinated in any given month. However, only individuals from the treatment group can refer friends[16]. Group 3 participants may not refer any person in the control group or in group 1 or group 2 (to avoid contamination).

Whenever a lottery is won, it will be announced via SMS to all participants in the relevant treatment group. The amount of the lottery prize and the winner's province will also be included in the SMS[17]. Group 2's SMS will include a reminder that only vaccinated individuals are eligible to win the lottery. Group 3's SMS will include a reminder that participants can refer as many friends as they like to be eligible for the following month's lottery. All SMS's will end with: "Thank you for vaccinating and keeping our country safe!" as one final nudge to encourage/guilt participants to vaccinate.

Table 4.1 summarises the different treatments arms.

Group	Treatment
Control	No lottery
Group 1	Individual is entered into a lottery once they are vaccinated
Group 2	Everyone in the group is entered into a lottery; only vaccinated individuals can claim the prize
Group 3	Individual is entered if she is vaccinated and refers a friend, who gets vaccinated

Table 4.1: Treatment Summary

4.3. Theory of Change

The decisions and actions associated with getting vaccinated appear deceptively simple but are the result of a complex series of behaviours (Brewer, Chapman, Rothman, Leask & Kempe, 2017: 154). To design an intervention to increase vaccinations, we need to understand who would be affected by the intervention. There are two groups for whom any treatment is irrelevant: people who would always choose to get vaccinated, and those who would never get vaccinated. We are interested in identifying a group who would not get vaccinated without intervention but with treatment would get vaccinated. It is plausible that a standard lottery intervention would be appealing to risk-on individuals (Björkman Nyqvist, Corno, Walque & Svensson, 2018) and could convince them to vaccinate. Even though the vaccine is free in South Africa, poorer individuals may still be reluctant to incur the frictional costs of getting vaccinated (such as transport costs). A lottery intervention could compensate for such costs and incentivise vaccination, especially if such individuals overweight small probabilities (see 2).

[16] i.e. people outside of group 3 will not be entered into the lottery for referring others to get vaccinated

[17] This serves as a reminder of how large the cash prize is, and including the winner's province makes winning seem more tangible

If there are individuals who are willing to get vaccinated but procrastinate (e.g. naïve hyperbolic discounters), a lottery deadline could help overcome the procrastination problem. Additionally, a lottery could solve the herd immunity free-riding problem. A regret lottery (treatment 2) would incentivise vaccination among individuals who experience reference dependence, loss aversion and regret avoidance. We would expect vaccination rates to be higher under treatment 2 compared to treatment 1 since a regret lottery has all the same qualities of a standard lottery, and additional incentives.

Treatment 3 uses aligned incentives[18] and social pressure to encourage vaccinations. Both the friend and the referring individual get a payoff from being vaccinated because of the lottery entry. However, neither can enter the lottery without the other getting vaccinated, which creates the pressure for each to get vaccinated as soon as possible to avoid disappointing the other. Vaccination incentives are now also a function of the social preferences of group 3 and their friends. It is reasonable to assume that the introduction of a lottery would not deter someone from getting vaccinated, who would have got vaccinated otherwise. Thus, we would expect to see higher vaccination rates for all three treatment groups compared to the control group.

5. Treatment and Data

The two main partner institutions for this field experiment would be the Department of Health, and the CRAM team[19]. Vaccine data is collected by health professionals at the designated vaccination sites. The EVDS captures a vaccinee's personal information[20] as well as the vaccine date and details. The only additional information needed for the experiment is the name, ID number, and phone number of the referring individual (under treatment 3). The person receiving the vaccine is responsible for supplying these details to the vaccine administrator. The agent who collected the information of the winning person from group 3's lottery will receive R10,000. This is an incentive for healthcare workers to correctly capture referral details.

The other data collection mechanism occurs through the NIDS-CRAM survey (Spaull, Posel, Wills, Makaluza, Daniels, Burger, Burger, Berg, Ranchhod, Ingle, Brophy & Carel, 2021). Two extra questions will be added to the original survey: "How often do you buy lotto tickets?" and "How often do you participate in gambling activities?". An additional survey section is needed to record the personal information of the referred friends for group 3. This acts as a second check for the referral informa-

[18] I like to think of treatment 3 as a positive-sum pyramid scheme

[19] The CRAM project is supported by the Department of Planning Monitoring and Evaluation (DPME), the Research on Socioeconomic Policy (RESEP) group at Stellenbosch University, and the Southern Africa Labour and Development Research Unit (SALDRU) at UCT.

[20] Names, Identity Number, medical aid details, residential address, email address, phone numbers, employment details, professional category, and health status.

tion collected by healthcare workers. It is assumed that the marginal cost of adding this section and the two questions to the survey is negligible. This experiment is designed to harness existing data collecting processes to reduce costs and exploit the existing NIDS-CRAM time series data.

Funding for the experiment would need to cover: R9,000,000 for the cash prizes, the admin fees associated with the SMS program and award disbursement, and R30,000 for incentive fees for the people who capture the winner's information from group 3's lottery. Potential funding sources include the COVID-19 Africa Rapid Grant Fund administered by the NRF, government funding, and private donors such as the Allan & Gill Gray Philanthropy.

6. Pre-analysis Plan

First, a balance test should be employed to check that randomisation was successful. If the F-test is not significant, then we know that the covariates cannot be used to predict the treatment status, and we can conclude that the covariates are balanced among treatment groups and the sample has been randomised. To estimate the average treatment effect, an OLS regression would be run with the outcome variable as the number of first-dose vaccinations. The exogenous variables would include a dummy variable for each of the treatment groups (which takes a value of 1 for the treatment group and 0 otherwise) and a vector of covariates to control for gender, age, health, income and education (this information is captured in the NIDS-CRAM questionnaire). If the coefficients of the dummy variables are positive and statistically significant, we can infer that a lottery treatment improved vaccine uptake. A second OLS model could include a control variable for how risk-seeking an individual is, using the answers to the lottery and gambling questions as a proxy for people's risk preferences. Interaction effects of the covariates with the dummy variables could be included for a more comprehensive understanding of how lottery incentives work for different individuals. For all of the regressions, the standard robustness checks should be applied.

A difference-in-difference regression approach could also be taken, comparing monthly vaccinations per 100 individuals over time in the control group, with the monthly per-100 vaccinations for each of the treatment groups. Alternatively, a logit model could be used, where the outcome variable is 1 if an individual is vaccinated and 0 otherwise; the exogenous variables would include dummies for the different treatment groups and a vector of covariates. For each model, it should be assessed whether the estimates (and subgroup heterogeneity) are consistent with the theory of change. Since most people are subject to loss aversion and the other behavioural biases that drive the success of vaccine lotteries, it stands to reason that the results of the empirical analysis have external validity. Although, this makes no normative assessment of whether vaccine lotteries are the most efficient use of funding for incentivising vaccination.

7. Conclusion

The behavioural literature and empirical studies show that lotteries can be an effective method to incentivise vaccine take-up, and South Africans appear to be well-primed for such a health intervention. This field experiment is designed to test this hypothesis.

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