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 could be critical tools in subduing COVID-19. For example, Aldila, Samiadji, Simorangkir, Khosnaw & Shahzad (2021) find COVID-19 vaccines to be effective in Jakarta, Indonesia. Leaders of 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. Burger, Maughan-Brown, Köhler, English & Tameris (2021) compiled a report, based on data from wave 5 of the NIDS-CRAM survey, and find that that around 20% of South Africans are concerned that COVID-19 vaccines are not safe. The report concluded that a significant portion of South Africans still have to be convinced to take the vaccine[3] (Burger, Maughan-Brown, Köhler, English & Tameris, 2021). 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 incentives. Section 3 elaborates on the South African context. Section 4 describes the design of the experiment

[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)

and outlines the three types of treatment groups. Section 5 discusses how the treatment will be administered and the data collection process. Section 6 gives a pre-analysis plan, and the final section (7) concludes.

2. Behavioural Economics and Health Incentives

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). While neoclassical economics assumes that people are perfectly rational agents, behavioural economics relaxes this assumption and uses psychology and economic theory to create more realistic models of human decision-making (Rabin, 2002). As Khaneman and Tversky show, 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, which is a key insight from the seminal work by Kahneman & Tversky (1979: 286) on prospect theory. Due to this nonlinear probability weighting, an individual overestimates her chances of winning a lottery. Björkman Nyqvist, Corno, Walque & Svensson (2018) ran an experiment in Lesotho, where participants were entered into a financial lottery and they could win a cash prize if they tested negative for sexually transmitted infections. In spite of the fact that the lottery had low expected payments, HIV incidence

[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.

decreased by 21.4% over two years as a result 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 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 in order 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 but the winner can only claim 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 is losing the chance to claim the prize. He is more likely to try and meet the condition in order 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. Every day, members of the treatment group chose a two-digit number. If a participant's number matched at least one digit of the randomly drawn lottery number, she was eligible to win a cash prize. However, she could only claim her winnings if she had taken her relevant prescribed medication the previous day. The results show 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 attempted to run regret lotteries to encourage people to get vaccinated against COVID-19. An unpublished paper by Thaler *et al* evaluates the effect of weekly regret lotteries in Philadelphia (Gandhi, Milkman, Ellis, Graci, Gromet, Mobarak, Buttenheim, Duckworth, Pope, Stanford, Thaler & Volpp, 2021). After giving away $400,000 in cash prizes to residents, 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 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.

3. The South African Context

An integrated report by National Lotteries Commission (2019) on the lottery habits shows that around 35% of South Africans[9] participated in lottery activities in the year preceding the study (National Lotteries Commission, 2019: 78–79). This suggests that a significant amount of South Africans engage in lotteries, which supports the implementation of a vaccine lottery, as there is evidence of "demand" for lotteries. The average amount spent on lottery activities was R156 per month, whereas the average monthly winnings of lottery schemes was R110. A rational economic agent would recognize that the expected value for playing lotteries is negative (−R46) and not buy lottery tickets. The fact that people still play the lotto despite a negative expected value 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). COVID-19 vaccines are available free of charge, but citizens have to register on the EVID portal before receiving their dose[11]. The J&J vaccine only requires 1 dose; the Pfizer and AstraZeneca vaccines require two doses each. 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 the breakdown of vaccination rates.

[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
[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.
[11] Due to supply constraints, vaccines were rolled out in phases and are currently available to individuals over the age of 18 only.

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

4. Experiment Design

4.1. Sample

The sample used will be the same sample used for the Coronavirus Rapid Mobile Survey (NIDS-CRAM). NIDS-CRAM was created in response to the pandemic as a way to build a representative data set of the South African population to inform decision-making (Ingle, 2021). Thus far, there have been five waves of NIDS-CRAM surveys, with wave 5 comprising a sample of 5,862 people being surveyed during April to May 2021 (Ingle, 2021: 14). Wave 3 comprised 8,157 potential participants, of which 6,130 were interviewed. For this field experiment, the 8,157 people from Wave 3 will be contacted and asked to participate. We can expect between 5,500 -6,200 people to participate, given the previous rates of attrition in NIDS-CRAM.

If we assume a conservative sample size of 5,500 and a vaccination proportion of 34%, then there will be 3630 eligible participants for the study, since we are interested in unvaccinated individuals. 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). This randomisation serves to ensure groups are comparable, and eliminate bias in treatment assignments. One group is randomly chosen to be the control group, where individuals will not be entered into any vaccine lottery. The other 3 groups are randomly allocated to different lottery treatments, which are explained below (4.2). There will be 1 lottery a month for each treatment group, which will run (in parallel) 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 from the lottery pool. Once it is verified that the winner has been vaccinated, she will be privately contacted and will receive a cash prize. 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 from the lottery pool. 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.

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 sample 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 be vaccinated, he will be privately informed. An individual can refer more than friend to be vaccinated in any given month. However, only individuals from the treatment group can refer friends (i.e. people outside of group 3 will not be entered into the lottery for referring others to get vaccinated). 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. This serves as a reminder of how large the cash prize is, and including the winner's province makes winning seem more tangible. 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 (regardless of extra incentives), 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 (as explained in section 2).

If there are individuals who are willing to get vaccinated but procrastinate (e.g. naïve hyperbolic discounters), a lottery deadline could increase the utility of getting the vaccine earlier enough to overcome the procrastination problem. Additionally, if there are South Africans who are not opposed to the vaccine but expect to free-ride on herd immunity, an incentive in the form of a lottery could way them to get vaccinated. As discussed in the literature review, a regret lottery (treatment 2) would incentivise individuals who are experience reference dependence, loss aversion and regret avoidance to get vaccinated. 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[12] 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

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

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[13]. Vaccine data is collected by health professionals at pharmacies, clinics and other vaccination sites around South Africa. The EVDS captures a vaccinee's personal information[14] 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 (from treatment group 3). The person receiving the vaccine is responsible for supplying these details to the vaccine administrator. An SMS will be sent to the friend and the referring individual, asking each to confirm that the referal details are correct. 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 information collected by the healthcare worker. 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 donors such as the Allan & Gill Gray Philanthropy, FEM Education Foundation, and the Michael & Susan Dell Foundation who sponsor the CRAM project.

[13] 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.

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

6. Pre-analysis plan

Regression discontinuity design

- a pre-analysis plan of the empirical analysis that will be performed on the data.

https://jamanetwork.com/journals/jama/fullarticle/2781792 - method for analysis

7. Conclusion

If the experiment results provide enough evidence that a vaccine lottery is effective, the EVDS nudge is to rollout to whole country and possible

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