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Financial incentives and COVID-19 vaccinations: evidence from a conditional cash transfer program

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Financial incentives and COVID-19 vaccinations: evidence from a conditional cash transfer program

ABSTRACT

This paper investigates the effects of a nationwide conditional cash transfer program aimed at increasing COVID-19 vaccine uptake in Slovakia. Due to relatively low vaccination rates and overcrowding of hospitals during the COVID-19 pandemic, Slovak government decided to offer € 200 and € 300 cash transfers to individuals older than 60 years, conditional on taking any of the available vaccines at the time. The eligibility requirements result in a sharp discontinuity in treatment assignment at the age threshold. Our results suggest that the program significantly increased vaccination rates in the population. However, overall costs related to the intervention do not appear to outweigh the benefits.

KEYWORDS: health policy; financial incentives; conditional cash transfers; regression discontinuity; COVID-19; vaccination

JEL CLASSIFICATION: D78, H41, I18

Finančné stimuly a očkovanie proti COVID-19: dôkazy z programu podmieneného peňažného transferu

ABSTRAKT

Tento článok skúma účinky celonárodného programu podmienených peňažných transferov zameraného na zvýšenie COVID-19 na Slovensku. Vzhľadom na relatívne nízku zaočkovanosť a preplnenosť nemocníc počas pandémie COVID-19 sa slovenská vláda rozhodla ponúknuť jednotlivcom peňažné transfery vo výške 200 a 300 eur starším ako 60 rokov, podmienené prijatím niektorej z vtedy dostupných vakcín. Oprávnenosť požiadavky vedie k prudkému prerušeniu prideľovania liečby na vekovej hranici. Naše výsledky naznačujú, že program významne zvýšil mieru očkovania v populácii. Celkové náklady súvisiace s intervenciou sa nezdá, že by prevažovali nad prínosmi.

KĽÚČOVÉ SLOVÁ: zdravotná politika; finančné stimuly; podmienené peňažné prevody; regresná diskontinuita; COVID-19, očkovanie
JEL KLASICIFIKÁCIA: D78, H41, I18

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1 Introduction

Vaccine hesitancy has been outlined as one of the top threats to global health alongside climate change according to a statement by the World Health Organization (WHO) in 2019. Studies such as Figueiredo et al. (2020) note that confidence in the importance, safety, and effectiveness of vaccines fell between 2015–2019 in many countries around the world, including developed countries such as South Korea and Poland. Somewhat surprisingly, European countries were considered as being among the least vaccine confident, with France being mentioned as the most sceptical (Karafillakis et al., 2022). However, only a few would expect that the topic of large-scale immunization programs and vaccine hesitancy will come to the center of policy debate only a short while after WHO's statement. Outbreak of the COVID-19 pandemic in early 2020 hastened efforts to create effective vaccine against the disease, with the first vaccines being conditionally approved and authorized only a few months later. Despite the fact that the vaccines have been subsidized and offered to citizens in the European Union (EU) free of charge, many countries faced problems with uptake due to low confidence in safety or effectiveness.

This was also the case in Slovakia. According to a nationwide representative poll conducted in December 2020, only a third of population indicated willingness to get vaccinated against COVID-19. As of December 2021, only 49% of the population was vaccinated with at least one dose. Over the course of the pandemic, reluctance to immunization was likely one of the most significant drivers of a significant overcrowding of hospitals with severe cases requiring intensive care. Health care system in the country reached its capacity limit several times, with the number of concurrent hospital admissions peaking as high as 3 600. In order to combat low vaccination rates among high-risk groups, in October 2021 Slovak government introduced a conditional cash transfer (CCT) scheme "*Vakcinačný bonus*"[2], offering €200 and €300 cash transfers to individuals who were at least 60 years of age as of December 31, 2021, conditional on having been vaccinated against COVID-19 and the number of doses. Nearly 847 000 individuals became eligible for the transfer, with total costs amounting to €245 million.

Conditional cash transfers have long been used to reduce poverty, increase human capital and incentivize targeted behavior. According to human capital theory (Grossman, 2000), individuals will invest in health if the expected private benefit exceeds the cost. Thus, a decision to not take a vaccine as a preventive measure can be interpreted as disutility from vaccination (including fear of negative side effects), discounting due to time preferences or expected mortality, or low valuation of life. The presence of externalities means that individuals weighing their private costs and benefits of vaccination and ignoring the social benefits will result in socially suboptimal vaccination rates. There is also a potential moral hazard problem—while it may be socially efficient to vaccinate, individuals may neglect this preventive measure because they do not incur the full costs of treatment in case they fall ill due to insurance. A simple theoretical framework by Kremer and Glennerster (2011) suggests that insurance providers (or government) may wish to subsidize the vaccination or even mandate it. The latter, as experience shows, is often problematic legally. Therefore, a more feasible solution may be offsetting the disutility from vaccination by means of CCT.

There is a substantial literature showing the effectiveness of CCT programs on uptake of immunization, mostly focused on randomized control trial (RCT) evaluation. For example, Banerjee et al. (2010) study immunisation coverage of children in 134 Indian villages using clustered RCT, evaluating immunisation campaigns with and without financial incentives. Their findings suggest that modest incentives such as one kilogram of dried beans have a positive effect on immunisation in settings with very low immunisation rates. Salinas-Rodríguez and Manrique-Espinoza (2013) analyze effects of a Mexican CCT program Oportunidades on vaccination coverage in older Mexican people. Using a cross-sectional survey data on a matched sample of

2. "Vaccination bonus".

4 628 individuals, the authors report that the Oportunidades program significantly increased vaccinations for a complete schedule by 5.5%, for influenza by 6.9%, for pneumococcal infections by 7.2% and for tetanus by 6.6%. Kusuma et al. (2017) evaluate large-scale RCT with CCTs on child vaccination rates in Indonesia, with a sample of over 4 000 children under two years old. After two years of implementation, their difference-in-differences estimates show that the program significantly increases child vaccination rates for all basic vaccine types by up to 30%.

Evidence concerning the effectiveness of financial incentives on COVID-19 vaccination rates where respondents surveyed and offered hypothetical rewards is somewhat mixed. For example, Sprengholz et al. (2021) randomly offered hypothetical financial rewards for receiving vaccine ranging from €20–€200 to 1 349 participants of a German survey. Their results reveal that none of the rewards were associated with a higher willingness to vaccinate. Contrary to their findings, a study by Robertson et al. (2021) offered \$1000, \$1500, \$2000 hypothetical financial incentive or a no-incentive condition to a sample of 1 000 American adults. In this particular experiment, a financial incentive yields an increase of 8 percentage points in vaccine uptake relative to the no-incentive scenario. The authors also conclude that the size of the cash transfer does not dramatically affect uptake rates.

Studies on uptake of COVID-19 vaccination where conditional cash transfers were offered are relatively scarce. Campos-Mercade et al. (2021) evaluate a RCT in Sweden with 8 286 participants, where the effect of a small cash reward (around US \$24), was compared with the effect of several behavioral nudges. Their results suggest that the monetary incentive had the power to increase participation by about 4 percentage points, while behavioral nudges and reminders also had a small positive effect. Wong et al. (2022) exploit a quasi-experimental incentive program that offered a \$25 cash card to adults who received their first dose of COVID-19 vaccine in select clinics within four counties in North Carolina. The authors analyze the effects of the program using a difference-in-differences approach within a competing-risk hazard rate framework. Clinics participating in the intervention reported an increase in vaccination rates by 46.2%, while remaining clinics in the counties experienced a 9.5% decline. As a part of of a survey, 41% of vaccine recipients indicated that the cash card was an important reason for vaccination. Jacobson et al. (2022) evaluate outcomes of a RCT on a sample of 2 701 Medicaid patients in California, where participants were assigned either to behavioral nudges, or \$10 or \$50 financial incentives for vaccination. The authors conclude that none of the interventions increased vaccination rates.

Several states in the US also initiated conditional cash lotteries (CCL) during the pandemic. Barber and West (2022) study effects of Ohio's Vax-A-Million CCL initiative, the first CCL targeting COVID-19 vaccinations. Forming a synthetic control from other states, their findings reveal that CCL increased the vaccinated share of state population by 1.5% (0.7 percentage points), costing \$68 per person persuaded to vaccinate. Furthermore, the authors also claim that the lottery prevented at least one infection for every six vaccinations that the lottery had successfully encouraged.

To our knowledge, the Slovak CCT program encouraging vaccination among the elderly is unique and therefore our analysis contributes to the literature in several respects. First, it is a large-scale nationwide program in a developed country, affecting more than 840 000 individuals, amounting to nearly one-sixth of the whole population. The majority of the CCT literature on immunisation focuses on uptake in children in developing countries, while evidence from the adult population in developed countries is lacking. Second, the financial incentives are substantially larger than in previous studies, where only modest amounts of cash was offered to participants. The conditional transfer amounts to almost a quarter of the average monthly wage in Slovakia and to nearly 60% of the average monthly retirement pension. Finally, the design of the program and availability of administrative data allows us to exploit a sharp discontinuity at the eligibility cut-off, allowing us to construct credible estimates of the program impacts. Combined with administrative data about mortality and hospitalizations related to COVID-19, we are also able to use the estimates to quantify the benefits of the program.

Our findings suggest that the cash transfers lead to a statistically significant increase in uptake of COVID-19 vaccines among the targeted population for all three vaccine doses, most notably for the third dose. Despite the increased vaccination rates, the program exceeds the cost-effectiveness threshold only if we assume constant effect of the program for everyone over 60 years of age and only for nudging unvaccinated individuals to take the first dose. Under a more realistic scenario where the effect diminishes with age, none of the interventions are cost-effective. We also explore potential correlates of the estimated treatment effect, which varies substantially across districts. Higher median income, life expectancy and prior vaccination rates, as well as higher share of Roma, Hungarian and female population are all associated with lower treatment effects.

The rest of the paper is organized as follows: section two describes the institutional setting and the data, section three outlines the econometric methodology, section four presents the main results, while section five presents the results from cost-benefit analysis. Section six explores heterogeneity of the estimated treatment effect, section seven provides discussion and section eight closes with concluding remarks.

2 Institutional setting and data

Slovakia is an European country with about 5.5 million inhabitants of whom about half a million live in the capital Bratislava. Health care in Slovakia is based on universal coverage, with the compulsory insurance package covering nearly all treatments, both inpatient, primary and secondary care as well as prescription medications. Thus, COVID-19 vaccination was offered to everyone with permanent or temporary residency free of charge. Despite that, the uptake of vaccines was relatively low when compared to the rest of the EU. Figure 1 plots the vaccination rates across EU countries. In Slovakia, only 49% of the total population was vaccinated as of December 2021, compared to the EU average of 66% at the time.

The CCT program was announced on November 26, 2021 by the Ministry of Finance. Everyone aged 60 years or more as of December 31, 2021 was eligible for the cash transfer. The eligibility criteria were designed in such a way that people who got vaccinated before the announcement were eligible for the transfer, unless they became eligible for another dose during the period when the policy was in place. The amount of the transfer was determined by the following criteria, which reflect the time interval required between different doses[3]:

- 300€ for those taking a third (booster) dose by January 31, 2022.
- 200€ for those taking a second dose between June 30, 2021 and January 31, 2022.
- 200€ for those taking a first dose between November 26, 2021 and January 31, 2022.
- 200€ for those taking a one-shot vaccine between November 26, 2021 and January 31, 2022 and taking a booster dose by March 15, 2022.

When the program was initially announced, the deadline for receiving vaccination was set to December 31, 2021. However, on December 30, 2021 the government decided to extend the deadline until the end of January 2022. The cash was automatically transferred to everyone fulfilling the criteria based on administrative data, without the need to apply. In total, 846 985 individuals fulfilled the criteria, at a total cost of nearly €245 million. Table 1 summarizes the costs for each category of the program. Clearly, the highest amount of cash transfers is concentrated within the 753 354 recipients of the third dose, amounting to a total of €226

3. 1 month between first and second dose, 6 months between second and third dose.

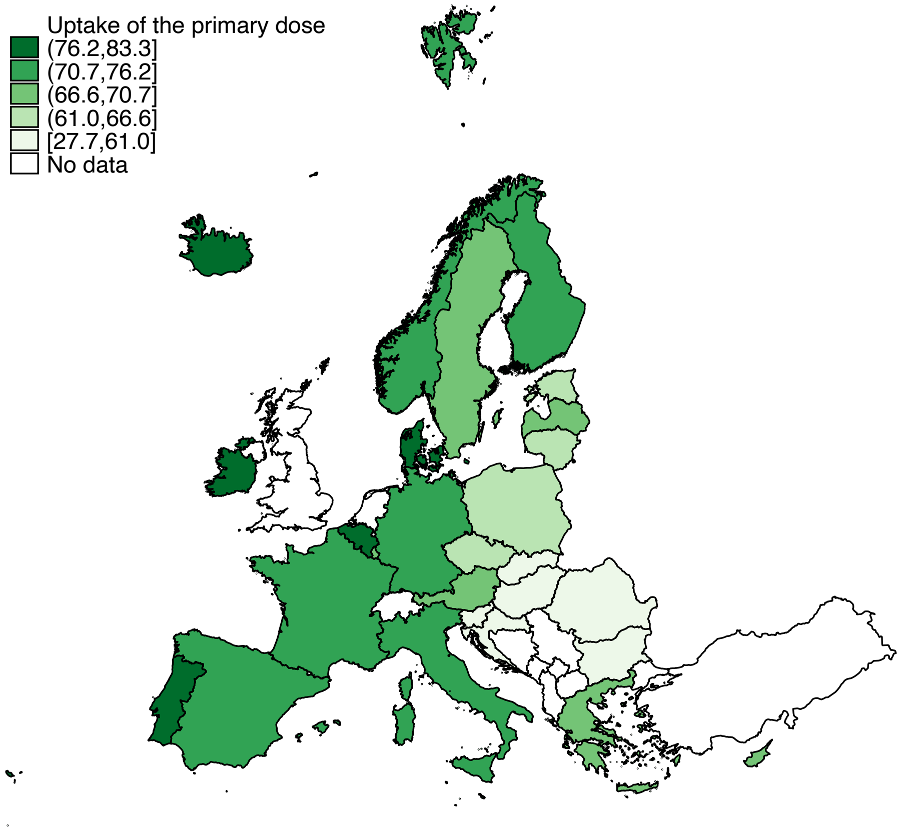


Figure 1: Vaccination Rates Across European Union

Notes: Uptake of the primary dose as a percentage of total population. Data as of December 2021 by European Centre for Disease Control and Prevention.

Table 1: Costs of the Vaccination Bonus Program

Dose	Cash transfer (€)	No. of recipients	Costs (€)
Third dose	300	753 354	226 006 200
Second dose	200	53 210	10 641 945
First dose	200	38 969	7 793 855
One-shot vaccine	200	1 452	290 400

Notes: Based on internal data from the Ministry of Finance.

million. The remaining doses have a significantly lower share of recipients, which can be partly explained by the fact that the vast majority of the vaccinated population already received both doses of the vaccine and was therefore eligible for the third dose. Total costs for the second dose amount to more than €10.6 million, distributed among 53 210 recipients. The intervention for the first dose attracted 38 969 recipients, amounting to nearly €7.8 million. The €200 cash transfer was also offered for a one-shot vaccine, persuading 1 452 recipients for a total cost of €290 400.

Information about vaccination, mortality and hospitalizations used in the following sections of the paper to estimate the social benefits of vaccination against COVID-19 is extracted from administrative data maintained by the National Health Information Center of Slovakia (NHIC). NHIC administers several national health registries, including a claim database on all health expenditure reimbursements. Nationwide registration system for COVID-19 vaccination was maintained by the NHIC, where all relevant information such as individual's personal identification number, birth date, provider of the vaccination, type of the vaccine as well as the exact date when the vaccine was administered were recorded.

3 Set-up of the analysis

Eligibility criteria for the vaccination bonus program form a sharp cut-off, allowing us to use regression discontinuity design (RD) to estimate the causal effects of the program on vaccine uptake. RD designs exploit the idea that assignment to the treatment is determined by the value of a predictor being on either side of a fixed threshold, which is usually based on administrative decisions. This association is assumed to be smooth and therefore any discontinuity of the outcome conditional on the predictor is interpreted as evidence of causal effect of the treatment (Imbens and Lemieux, 2008). More formally, in a sharp discontinuity design, the assignment W_i is a deterministic function of the forcing variable X: $W_i = 1\{X_i \geqslant c\}$. All individuals with the forcing variable less than c are not eligible for the treatment and form the control group, while those with forcing variable at least c form the treatment group. In the sharp RD design, the discontinuity in the conditional expectation of the outcome given the covariate uncovers the causal effect of the treatment:

$$\lim_{x \downarrow c} E[Y_i \mid X_i] - \lim_{x \uparrow c} E[Y_i \mid X_i = x]$$

The average causal effect of the treatment at the discontinuity point c is then:

$$\delta = E[Y_i(1) - Y_i(0) \mid X_i = c]$$

The sharp RD requires that the forcing variable is continuous around the cut-off point, and individuals are unable to manipulate the treatment assignment. Since the eligibility criteria are based on birth date, it is impossible to increase chances for inclusion in the program. Given that the assignment to the control and treatment groups is not randomized as in RCTs, it is required that individuals around the cut-off are similar in their observed and unobserved characteristics. While this assumption is practically untestable, it is plausible to expect that individuals born within a narrow window around the cut-off are similar and therefore the assignment is as good as random.

The continuity assumption around cut-off also implies that there are no competing policies occurring upon reaching the age of 60 years. A potential threat would be retirement, since exit from the labour force is likely accompanied by a decrease in disposable income, possibly increasing the motivation to accept cash transfers. Statutory retirement age in Slovakia for individuals born in 1961 (i.e. those just reaching the age of 60 at the time) was 63 years for men and 62 years for women. Thus, retirement should not bias our estimated treatment effects. We are also not aware of any other policy coinciding with the CCT program.

We estimate the effects of the program separately for each dose and using only the subset of the population eligible for that dose during the period under consideration[4] using a local linear regression:

$$Y_i = \alpha + \delta W_i + \gamma_0(X_i - c) + \gamma_1 W_i(X_i - c) + \epsilon_i \tag{1}$$

where Y_i is a binary indicator denoting whether the individual was vaccinated or not. Furthermore, we use optimal bandwidth choice methods and local polynomial RD estimators with robust bias-corrected confidence intervals and inference procedures developed by Calonico et al. (2018) and Calonico et al. (2019). We observe the exact date of birth in our data, hence the distance from cut-off is calculated in days. The results are summarized in the following section.

4. When estimating the effect for the first dose, we exclude people, who received their first dose prior to November 26, 2021. When estimating the effect for the second dose, we exclude people who received their second dose prior to June 30, 2021 and their first dose prior to November 26, 2021.

Table 2: Estimates of the Vaccination Bonus Program on Vaccine Uptake

Variable	(1)	(2)	(3)
Panel A. First dose			
Treatment effect (δ)	0.023	0.027	0.032
	(0.002)***	(0.003)***	(0.006)***
Observations	263 019	263 019	263 019
Panel B. Second dose			
Treatment effect (δ)	0.026	0.038	0.047
	(0.010)**	(0.014)**	(0.018)**
Observations	29 625	29 625	29 625
Panel C. Third dose			
Treatment effect (δ)	0.190	0.166	0.171
	(0.002)***	(0.003)***	(0.004)***
Observations	688 457	688 457	688 457

Notes: Robust standard errors in parentheses. Estimation sample is restricted to age 50–70.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

4 Results

Table 2 summarizes results from regressions. Column (1) presents results from a local linear regression, while column (2) presents estimates from a quadratic specification. Finally, column (3) presents estimates with data-driven bandwidth selection, where the point estimator is based on local linear regression and local quadratic regression is used to construct the bias correction. We also display the vaccination rates around the eligibility cut-off for the cash transfer for both control and treated groups graphically in figure 2.

Figure 2A plots the vaccination rates for those eligible for the first dose between November 26, 2021–January 31, 2022. Results show that roughly 7.2 out of 100 eligible individuals were vaccinated in the control group. In contrast, almost 10.5 out of 100 eligible individuals were vaccinated in the treatment group. Thus, the clear jump in the vaccination rate around the cut-off corresponds to approximately 3.3 percentage points increase. This result is also confirmed by estimates from regressions explaining the probability to get vaccinated, suggesting that the estimated treatment effect ranges from 2.3–3.2 percentage points depending on the specification. Assuming a constant effect of the intervention beyond age 60 from our preferred specification in column (3), this translates to 14 801 nudged individuals. In a scenario with a linear decrease of the effect up to age 80, this would equal 7 081 nudged individuals. All calculations for respective doses and scenarios are summarized in tables 5 and 6. Taking these results to the full population, this corresponds to 0.54% and 0.25% increase in overall first dose vaccination rates for the constant effect and decreasing effect scenarios respectively.

Figure 2B display the vaccination rates for those eligible for the second dose between November 26, 2021–January 31, 2022. Unlike for the first dose, the treatment effect around the cut-off is less prominent for the second dose. Within the control group, 75 out of 100 eligible individuals were vaccinated. In the treatment group, 78 out of 100 were vaccinated during the program, corresponding to roughly 2.5 percentage points increase. However, compared to the first dose, the effect does not seem as robust, clearly decreasing further away from the cut-off. Estimates from regressions presented in panel B of table 2 suggest a statistically significant effect on the uptake of the second dose ranging between 2.6–4.7 percentage points. This translates to 1 124 and 567 nudged individuals or an increase in overall vaccination rates for the second dose of 0.04% and 0.02% under the constant effect and decreasing effect scenario respectively.

Table 3: Estimates of the Vaccination Bonus Program on Vaccine Uptake—Placebo Intervention

Variable	(1)	(2)	(3)
Panel A. First dose			
Treatment effect (δ)	0.004	0.005	−0004
	(0.004)	(0.006)	(0.008)
Observations	89 451	89 451	89 451
Panel B. Second dose			
Treatment effect (δ)	0.006	0.052	0.065
	(0.024)	(0.036)	(0.043)
Observations	5 410	5 410	5 410
Panel C. Third dose			
Treatment effect (δ)	0.003	0.006	0.013
	(0.004)	(0.006)	(0.009)
Observations	140 557	140 557	140 557

Notes: Robust standard errors in parentheses. The estimation sample is restricted to age 60–63.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The largest treatment effect is observed with the third (booster) dose, plotted in figure 2C. Around 65 individuals out of 100 in the control group were vaccinated, compared to 82 out of 100 in the treatment group. This significant jump in vaccination rate around the cut-off corresponds to roughly 17 percentage points increase. Similarly, as with the first dose, the effect seems fairly robust and consistent across the plotted age window. The estimated treatment effect from regressions presented in panel C of table 2 is statistically significant and ranges from 17.1–19.0 percentage points depending on specification. This corresponds to 97 172 individuals nudged and increase of 7.2% in overall vaccination rates for the third dose under the constant effect scenario, or 55 216 individuals and 4.0% increase in vaccination rates in the decreasing effect scenario.

4.1 Sensitivity analysis

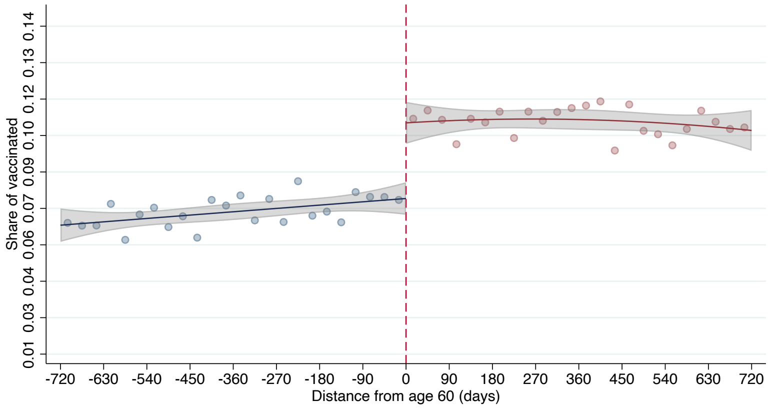
In order to test the assumption that the increase in vaccination rates presented in table 2 occurs due to the effect of the CCT program, we also estimate a placebo intervention occurring at age 62. This should rule out possible effects due to age trends, or any potential contamination of the treatment effect due to early retirement. Table 3 summarizes the results.

All specifications displayed in columns (1)–(3) are the same as in the main estimates, with the exception being that the estimation sample is restricted to age 60–63. As it can be seen, none of the estimated coefficients is different from zero, which is reassuring. Since there is no effect observed for the fictional policy at the age of 62, which is also the statutory age or retirement for females, it is unlikely that the main effect of the CCT program would be contaminated by individuals potentially eligible for early retirement before the statutory age.[5]

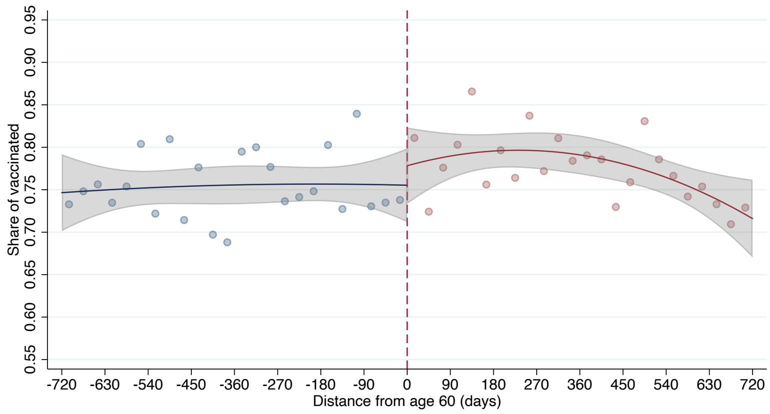
5 Cost-benefit analysis

The following section presents cost-benefit analysis based on the estimates from the RD regressions. Studies analyzing cost-effectiveness of vaccine rollout such as Mar et al. (2024) model the dynamics of the COVID-19 pandemic for the counterfactual scenario based on compartmental epidemiological models. While

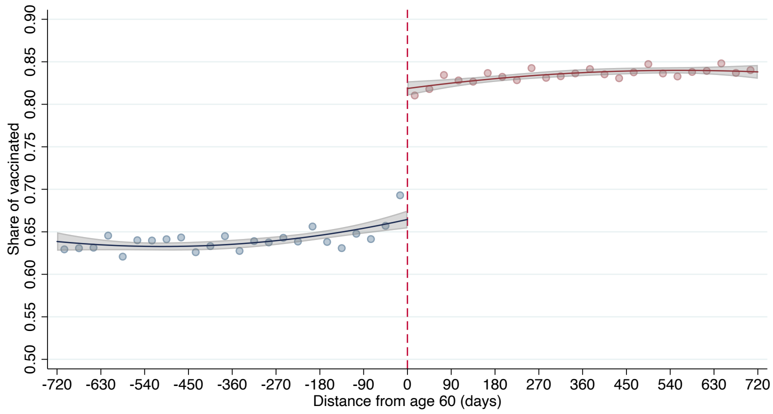
5. While early retirement is possible under certain conditions in Slovakia, it is rather uncommon. According to data from the Social Security Administration, only 0.86% of 1 387 282 pensions paid in 2021 was under the early retirement scheme.



A: First Dose



B: Second Dose



C: Third Dose

Figure 2: Vaccination Rates in Eligible Population

Notes: Shaded areas show 95% confidence intervals. Based on bin width of 30 days.

such models are well established and relatively straightforward to parameterise, they do not easily account for individual variability and complex interactions. Agent-based models such as Groves-Kirkby et al. (2023) were developed to address these issues, at the cost of computational intensity and parametrization resulting from complex interventions and interactions between agents. Our cost-benefit analysis presents a simpler, more straightforward approach to assess the impact of the cash transfer program, focusing on the value of life-years saved and hospitalization costs averted.

Since the eligible population is known, we are able to calculate the total share of individuals nudged by the intervention based on the estimated treatment effect. We consider two scenarios: one where the effect of the program is constant beyond age 60 and the second scenario where the estimated effect diminishes up to age 80 beyond which it becomes zero. The second scenario reflects the fact that the willingness to vaccinate likely increases with age due to higher risk of complications in case of COVID-19 infection. In other words, it is very likely that older individuals would be more motivated to vaccinate and less responsive to financial incentives.

The most tangible benefit associated with COVID-19 vaccination is a significantly lower risk of hospitalization and death. We calculate the costs related to COVID-19 hospitalizations based on an administrative dataset of all COVID-19 hospital admissions in Slovakia between January 1, 2022 and June 1, 2022. The data are reported to the NHIC by insurance companies and contain detailed information about hospital admissions such as admission and discharge diagnosis, length of stay as well as total of hospital charges. The dataset is linked to the vaccination data, allowing us to calculate costs separately for age groups and vaccination status. Expected probabilities of hospitalization or death are calculated based on incidence rates during the same period.[6] Our calculation of costs and benefits associated with the program relies on an assumption that the increase in vaccination rates would not have a significant impact on virus transmission rates. We believe that this is a reasonable assumption, since studies of household transmission such as Lyngse et al. (2022) show that the difference in infectiousness between vaccinated and unvaccinated for the most prevalent virus variant during the first quarter of 2022 is rather small.[7]

Costs related to premature death due to COVID-19 are based on discounted quality-adjusted life years (dQALY). The willingness to pay (WTP) for one year of life is implicitly set in Slovakia by a decree which specifies the cost-effectiveness threshold for reimbursing newly approved drugs in the Slovak health care system, defined as 35 times the average monthly wage, equal to €39 655.[8] The value is multiplied by the expected remaining life years for each age group from life tables published by the Slovak Statistical Office, discounted to the present value using a rate of 3.5%. Calculation of dQALY is based on life expectancy to quality-adjusted life expectancy ratio adjusted to COVID-19 following Briggs et al. (2021), assuming standardized mortality ratio equal to one. Table 4 summarizes the expected costs of COVID-19 to the individual for each age-group-dose combination and the incremental expected benefit of vaccination calculated as the reduction in expected cost of the disease.

All probabilities for hospitalisation and death are as expected, i.e. they decrease with each additional dose of the vaccine. The risk of hospitalisation and death between unvaccinated and those vaccinated with a first dose is rather small for the 60-69 age group, but becomes more apparent for older age cohorts. Those aged 70-79 and vaccinated only with the first dose of the vaccine have nearly 25% lower probability of being

6. Incidence rate is calculated as number of events during the observed time period, i.e. number of hospitalizations or deaths by vaccination status in the respective age group, divided by average population during the same period. Average population by vaccination status is calculated based on weekly average in each respective group. Deaths related to COVID-19 are based on data from the national death registry, which includes all deaths with a respective diagnosis code as a cause of death. All deaths with suspected COVID-19 as a cause had to be confirmed with autopsy.

7. The study used whole-genome sequencing to analyze virus samples of more than 50 000 individuals in Denmark, finding that for the Omicron BA.1 variant, unvaccinated household members had an odds ratio for infectiousness of 0.98 compared to the reference category of fully-vaccinated, while those having a booster dose had an odds ratio of 0.82.

8. The threshold is based on the average monthly wage reported by the Statistical Office of the Slovak Republic two years before the current calendar year. In 2020, the average monthly wage was equal to €1 133.

Table 4: Expected Costs and Benefits per Person

Age group	Prob. of hosp. (%)	Costs of hosp. (€)	Prob. of death (%)	Expected cost (€)	Expected benefit
Panel A. Unvaccinated					
60–69	0.66	1 466	0.40	1 691	
70–79	1.52	1 391	1.22	3 553	
80+	3.18	1 389	2.97	4 640	
Panel B. First dose					
60–69	0.65	1 304	0.36	1 522	170
70–79	1.16	1 260	0.66	1 928	1 625
80+	2.33	1 546	0.90	1 424	3 216
Panel C. Second dose					
60–69	0.48	1 485	0.10	427	1 094
70–79	1.22	1 388	0.34	1 001	927
80+	1.95	1 392	0.52	831	593
Panel D. Third dose					
60–69	0.14	1 389	0.01	44	383
70–79	0.34	1 423	0.03	92	909
80+	0.88	1 354	0.09	151	681

Notes: Based on the following dQALY values: 60–69: 10.6, 70–79: 7.3, 80+: 3.9. Cost for one year of life assumed to be equal to 39 655€.

hospitalised compared to unvaccinated in the same group. Those aged 80 and more and vaccinated only with the first dose are almost 70% less likely to die compared to unvaccinated. The disparity of risks between unvaccinated and vaccinated population becomes even more apparent with each additional dose. Individuals aged 80 or more having two doses of the vaccine are roughly 80% less likely to die compared to unvaccinated, while those having also the third booster shot are nearly 97% less likely to die compared to unvaccinated in the same age group.

Expected costs of COVID-19 per person in the respective age-dose groups are calculated as follows:

$$c_{d,g} = \left(p^H_{d,g} \times €^H_{d,g}\right) + \left(p^D_{d,g} \times \text{dQALY}_d \times \text{WTP}\right) \quad (2)$$

where $c_{d,g}$ denotes the expected cost of COVID-19 for people with a given vaccination status and number of doses in a given age-group, $p^H_{d,g}$ denotes the probability of hospitalisation, $€^H_{d,g}$ denotes the average cost per hospitalisation and $p^D_{d,g}$ denotes the probability of death, for $d \in \{0, 1, 2, 3\}$ and $g \in \{60\text{–}69, 70\text{–}79, 80+\}$. The expected benefit $b_{d,g}$ is then calculated as the difference between the expected costs and expected costs of having one dose less: $b_{d,g} = c_{d-1,g} - c_{d,g}$.

The last column of Table 4 shows the incremental expected benefit of vaccination to the individual resulting from reducing the expected cost of COVID-19 with each successive dose. The incremental expected benefit was highest for the first dose for those above 70 years of age. For people in the 60-69 years age group the second dose had the largest incremental benefit. Even so, the third dose still offered large incremental benefit to all age groups studied.

5.1 Constant effect of the program

Table 5 summarizes the total costs and benefits separately for each dose-age group, assuming a constant effect for everyone aged 60 years or more. The total expected benefit is calculated as a product of the expected individual benefit per each dose-age group from table 4 and the number of nudged individuals:

$B_{d,g} = b_{d,g} \times n_{d,g}$. The number of nudged individuals is calculated by multiplying the total number of eligible individuals in the respective age group by the estimated RD coefficient from column (3) of table 2. For example, the expected first dose benefits for the 60–69 age group are equal to $170 \times 7\,330 =$ €1.25 million.

The results suggest that the cash transfer for nudging unvaccinated individuals to take the first dose appears to be the only cost-effective intervention. Total benefits for the first dose are equal to €18.28 million, while the total costs of the program (including also cost of the vaccine) amount to €8.24 million. The highest cost-benefit ratio is concentrated among the oldest age group. Despite the fact that the RD estimates showed a statistically significant increase in vaccine uptake for for the second and third dose, the cost-benefit ratios are substantially below the cost-effectiveness threshold. For the second dose, the ratio is equal to 0.09–0.10, while for the third dose it ranges between 0.19–0.31 across age groups. Overall, the total benefits of the program for all vaccine doses amount to nearly €74 million, while total costs reached €247.83 million, resulting in a cost-effectiveness ratio of 0.30.

Table 5: Total Costs and Benefits of the Vaccination Program—Constant Effect

Age group	No. of nudged	Total benefits (mil. €)	Total costs (mil. €)	Benefit-cost ratio
Panel A. First dose				
60–69	7 330	1.25	4.59	0.31
70–79	4 399	7.15	2.48	2.88
80+	3 072	9.88	1.16	8.52
Total	14 801	18.28	8.24	2.22
Panel B. Second dose				
60–69	589	0.64	6.21	0.10
70–79	337	0.31	3.09	0.10
80+	198	0.12	1.38	0.09
Total	1 124	1.07	10.68	0.10
Panel C. Third dose				
60–69	59 536	22.80	119.31	0.19
70–79	27 173	24.70	80.65	0.31
80+	10 463	7.13	28.96	0.25
Total	97 172	54.63	228.92	0.24
Panel D. All doses				
First dose 60+	14 801	18.28	8.24	2.22
Second dose 60+	1 124	1.07	10.68	0.10
Third dose 60+	97 172	54.63	228.92	0.24
Total	113 096	73.98	247.83	0.30

Notes: Total costs also include the cost of the vaccine equal to €30 for each nudged person.

5.2 Diminishing effect of the program

The results presented in this section take into account the possibility that the nudging effect of the cash transfer may decrease with age, due to the fact that older individuals face a higher risk of severe disease and death and hence are more likely to undergo vaccination even without cash transfers. This scenario assumes that the estimated effect from the RD regressions linearly decreases up to age of 80, where it reaches zero. This effectively decreases the number of nudged individuals compared to the constant effect scenario. Table 6 summarizes the resulting total costs and benefits. Compared to the constant effect of the programme, none of the vaccine doses now exceed the cost-benefit threshold. For the first dose, the total benefit decreases by slightly more than €15 million. The resulting cost-benefit ratio is equal to 0.40, compared to 2.22 in the constant scenario. For the second and third dose, the benefits decrease by €0.46 and €28.88 million, shrinking the cost-effectiveness ratio to 0.06 and 0.11 respectively. Total benefits for the whole program decrease to €29.53 million, lowering the benefit cost ratio to 0.12.

5.3 Sensitivity analysis

In this section we relax some simplifying assumptions made in the previous sections when calculating the discounted quality-adjusted life years for each dose-age group. Firstly, in previous sections we calculated the life expectancy for each age group as a simple average of life expectancies for each annual cohort within that particular age group. However, these simple averages may not reflect the actual age distribution of nudged individuals. To address this issue, we apply weights to life expectancy of each annual cohort within a particular age group according to the actual number of nudged individuals of that age per each dose and scenario. This results in different dQALY values for the constant and particularly the diminishing effect scenario, as well as for each vaccine dose.

Secondly, even with these improved dQALY values the calculation of the expected incremental benefit of each dose should reflect the possibility that for a given age group the age structure of individuals nudged to receive a given dose may not be the same as the age structure of individuals nudged to receive one dose less. In other words the second group may not be a good counterfactual for the first. Therefore in Appendix A table A1, we calculate the cost of COVID-19 under the counterfactual scenario of having one dose less using the dQALY value for the population nudged by the dose under consideration. Formally equation 2 under the counterfactual scenario becomes:

$$c_{d-1,g} = \left(p^H_{d-1,g} \times c^H_{d-1,g}\right) + \left(p^D_{d-1,g} \times \text{dQALY}_{d,g} \times \text{WTP}\right) \tag{3}$$

For example, the incremental expected benefit of the second dose is calculated as a difference between expected costs of COVID-19 for individuals with only one dose (€447) and individuals with two doses (€1 593) where the costs associated to having only the first dose of vaccine are based on weighted dQALY values reflecting the nudged population of the second dose.[9]

The total costs and benefits for each vaccine dose are summarized in table A2 for constant effect and in table A3 for diminishing effect of the program. Clearly, reweighting of dQALY values does not have a significant impact on the total costs and benefits under either scenario. The benefit of the first dose under the constant effect scenario remains nearly the same at €18.27 million, while the benefit of the second dose increases slightly from €1.07 to €1.11 million. Third dose benefits also increase by a small margin, from €54.63 to €57.03 million. The total benefit for all vaccine doses slightly increases from €73.98 to €76.41 million. Similar modest increases of calculated benefits can be seen under the diminishing effect scenario. The resulting benefit-cost ratios remain similar to those presented in the previous sections.

6 Correlates of the treatment effect

The response to financial incentives for vaccination against COVID-19 may vary significantly across different demographic and socioeconomic groups. A variety of factors, such as economic status, health status, and personal beliefs related to vaccines, may influence individuals' responses to these incentives. To better understand these differences, we examine potential correlates of the estimated treatment effect by leveraging residence data within our primary estimation sample. This allows us to estimate our main specification from

9. $0.0065 \times 1\,304 + 0.0036 \times 11.1 \times 39\,655 = 1\,593$

Table 6: Total Costs and Benefits of the Vaccination Program—Diminishing Effect

Age group	No. of nudged	Total benefits (mil. €)	Total costs (mil. €)	Benefit-cost ratio
Panel A. First dose				
60–69	5 727	0.97	4.51	0.21
70–79	1 354	2.20	2.39	0.92
Total	7 081	3.17	8.01	0.40
Panel B. Second dose				
60–69	464	0.51	6.21	0.08
70–79	104	0.10	3.08	0.03
Total	567	0.61	10.66	0.06
Panel C. Third dose				
60–69	46 466	17.80	119.19	0.15
70–79	8 749	7.95	79.89	0.10
Total	55 216	25.75	227.66	0.11
Panel D. All doses				
First dose 60+	7 081	3.17	8.01	0.40
Second dose 60+	567	0.61	10.66	0.06
Third dose 60+	55 216	25.75	227.66	0.11
Total	62 864	29.53	246.33	0.12

Notes: Totals for each dose include cash transfers for 60+ age group. Total costs also include cost of the vaccine equal to €30 for each nudged person.

equation 1 separately for each of 79 districts in Slovakia. We focus specifically on the uptake of the third dose of the vaccine.

Figure 3 plots the estimated treatment effect across districts.[10] As it can be seen, there is a substantial geographical variation in response to the cash transfers offered. The effect ranges from 8 percentage points to almost 29 percentage points in some areas. Districts in the western part of the country situated around the capital city Bratislava (BA I–BA V) exhibit lower values of the treatment effect. This area is also the richest part of the country, with the volume of regional GDP representing 28% of the national GDP. The regional GDP per capita of the Bratislava region is equal €41 193, almost two times higher than the national average. High-income areas are likely also correlated with more educated population, as well as with better attitudes

10. Results from per-district regressions are summarized in table A4.

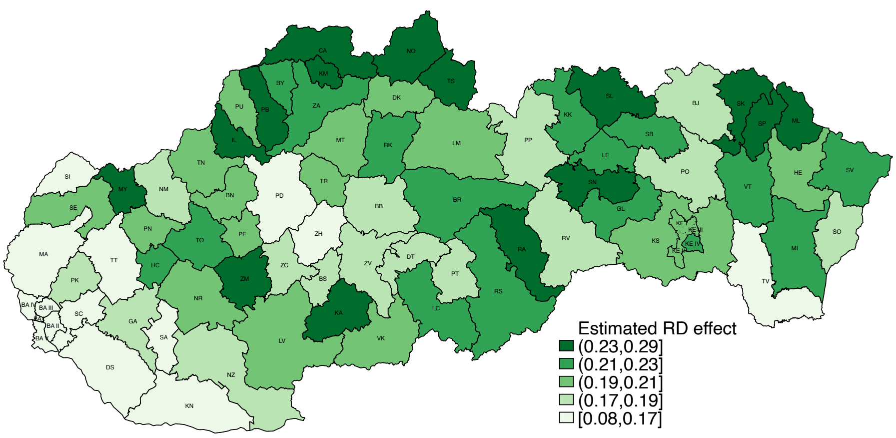


Figure 3: Estimated Treatment Effect for the Third Dose by District

towards health. Thus, one may hypothesize that a higher share of individuals would get vaccinated irrespective of the financial rewards offered. On the contrary, poorer regions situated in the northern or eastern part of the country display substantially higher values of the treatment effect.

We select several proxies possibly explaining the variation: median income to capture economic status and population density as a proxy for remoteness of the area. For health status, we include life expectancy at birth, Charlson index, COVID-19 mortality per 10 000 inhabitants and average yearly health care utilization. We also include vaccination rate prior to the start of the program. For demographic characteristics, share of population with secondary and university education is included, as well as share of female population above age 50 and more. To capture ethnic status, shares of the two largest ethnic groups in Slovakia are included—Hungarian and Roma. Finally, we also include information from a nationwide representative survey about beliefs and opinions related to the COVID-19 pandemic, conducted between July 2021–December 2021. Beliefs about vaccination may be shaped not only by socioeconomic and demographic factors, but also by cultural and political influences, and these also significantly influence the effectiveness of incentives. For instance, in districts where there is more scepticism or misinformation about vaccination, incentives may be less effective or require higher amounts to change attitudes. More specifically, we select average responses to the questions where respondents had to indicate how strongly they feel threatened by the current pandemic, how they conform to the containment measures and what is their trust towards the current government and health care system. Finally, as proxies for vaccine hesitancy, we also include share of individuals indicating their refusal to get vaccinated and share of individuals indicating reasons such as "vaccines are more harmful than the virus", or "I do not trust pharmaceutical companies" for refusal of the vaccine. Detailed definitions of the variables, data sources and information about the survey is presented in Appendix B.

We follow Belloni and Chernozhukov (2013) and Finkelstein et al. (2016) and estimate the correlates by using adaptive Lasso regression, with a penalty chosen by 10-fold cross-validation to minimize the mean squared error. The variables selected by Lasso are then used in a standard OLS regression to obtain coefficients and standard errors. All covariates are standardized to have a mean 0 and a standard deviation of 1. The results are summarized in figure 4. The left panel displays results from bivariate OLS regressions for each coefficient, while the right panel displays coefficients from OLS where Lasso selects variables.

The results show higher median income, higher population density, higher life expectancy, higher vaccination rate, higher share of Hungarian population and higher share of university-educated are associated with significantly lower treatment effects. This may reflect the above-mentioned hypothesis that individuals living in richer regions, in more densely-populated areas will undergo vaccination irrespective of the financial rewards, since it reduces risks associated with COVID. It is also perhaps not surprising that regions with higher life expectancy and already high vaccination rates are associated with lower treatment effect. Turning to the opinion survey about the pandemic, districts with higher share of individuals refusing vaccine and with higher share of conspiracy beliefs about vaccines are associated with higher treatment effect. Post-Lasso OLS regression suggests that median income, life expectancy and vaccination rate remain significant. Higher mortality rates from COVID-19 are associated with higher values of treatment effect. From demographic characteristics, share of Roma and share of female population is not significant in the bivariate OLS, but is selected by Lasso and becomes significant in multivariate OLS, together with share of Hungarian population. Lower response in districts with higher share of Roma people may be explained by the fact that this ethnic group has a very low health care utilization in general, resulting from worse access to health care and general attitudes toward health. The vast majority of Roma people in Slovakia lives in segregated rural communities, often in abject poverty. Thus, the design of the policy may not be efficient in reaching these marginalized groups and increasing vaccination, despite substantial cash offers. Overall, the variables selected by Lasso explain almost 66% of variation of the estimated treatment effects across districts in the multivariate OLS.

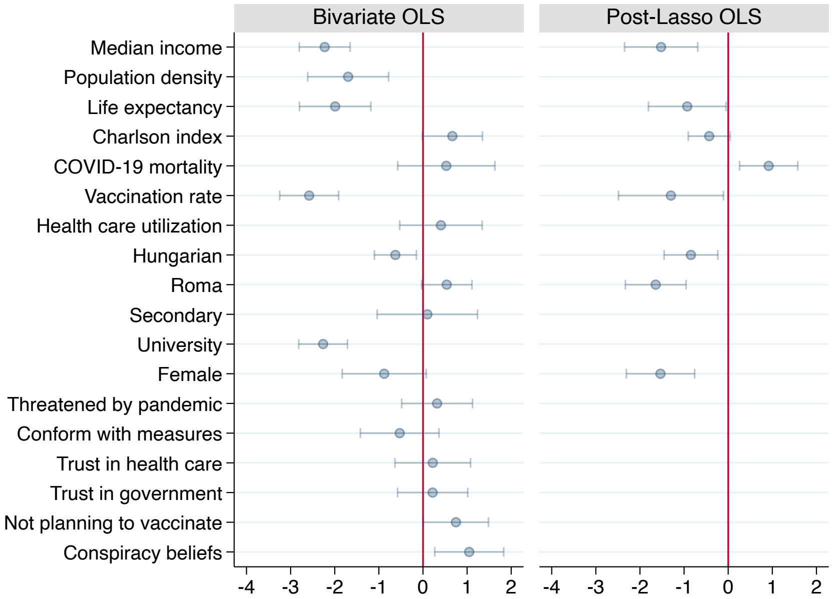


Figure 4: Correlates of the Estimated Treatment Effects

Notes: Horizontal bars show 95% confidence intervals. All covariates standardized to have mean 0 and standard deviation 1.

7 Discussion

In the empirical analysis presented in the previous sections of the paper, we show that the Slovak nationwide program offering conditional cash transfers increased vaccination rates among the targeted group of seniors for all three doses of vaccine. Our results provide clear evidence that financial incentives can work. However, the Slovak policy was very expensive and despite the increase in vaccination rates, its overall costs do not appear to outweigh the benefits. This raises the question of whether the amount of cash transfer was appropriate.

Our estimates for the uptake of the first dose are comparable to the study by Campos-Mercade et al. (2021), where unvaccinated participants of a RCT in Sweden were offered a small cash reward of around US $24 for receiving the first dose of COVID-19 vaccine. Their findings suggest that the cash reward increased vaccine uptake by 4 percentage points. Estimates from our RD regressions indicate a similar increase of 3.2 percentage points for the recipients of the first-dose cash transfer. Evidence from an online experiment conducted by Klüver et al. (2021), where respondents were asked about hypothetical financial remuneration for receiving a vaccine is also pointing in a similar direction. The authors conclude that a €50 incentive is associated with a 5 percentage points increase in willingness to vaccinate. It is therefore reasonable to ask whether it would be possible to achieve similar results with a substantially smaller cash transfer in the Slovak context. Assuming a €20 cash transfer for the first dose, the total costs for the intervention would decrease to €1.17 million. This would increase the benefit-cost ratio to 2.71 in the more realistic, diminishing effect scenario, assuming unchanged effect of the scheme on vaccination rates.

However, it is also worth noting that there is a substantial difference (3.2 percentage points versus 17.1) in response to the cash transfer between unvaccinated, compared to those who already had a full, two-dose course of the vaccine. Despite the fact that the cash transfer for the booster dose was €100 higher, it appears that it is easier to nudge to take one extra dose, than it is to persuade potentially vaccine-hesitant individuals.

The Slovak government could have significantly reduced the cost of the scheme, if it limited the conditional cash transfer to those seniors, who were vaccinated after November 26, 2021, that is after the policy was announced. It bears emphasis, however, that such a policy would be widely seen as unfair, penalizing those, who were responsible and up to date with their vaccinations. Such a policy would also create moral hazard, by dissuading people from getting vaccinated in future pandemics and encouraging them to wait for the government to announce a similar scheme. The Slovak policy thus nicely illustrates the trade-off between cost-effectiveness and fairness inherent in such incentive schemes.

8 Conclusions

Vaccine hesitancy during the COVID-19 pandemic forced policy makers in many countries to offer various incentives to increase vaccination rates. These include lotteries, vouchers, pre-paid cards, access to amusement parks as well as conditional cash transfers. More often than not, these efforts were designed without reliable evidence on the effectiveness of such interventions. Nonetheless, it is clear from a relatively limited empirical evidence that incentives as low as $20–$25 may be effective.

This paper analyzes an unique nationwide intervention from Slovakia, where the government decided to offer cash transfers ranging from €200–€300 to everyone aged 60 or more conditional on getting vaccinated. Compared to other similar programs, financial benefits offered to Slovak citizens were substantially larger, while also targeting more than 840 000 individuals. The design of the program and use of individual-level administrative data allowed us to evaluate its effects on vaccine uptake, as well as associated costs and benefits.

Our results suggest that the €200 cash transfer for taking the first dose of vaccine increased the vaccination rates by 3.2 percentage points at the cut-off. Expected individual benefit for the first dose ranges from €170–€3 216 for the 60–69 and 80+ age groups respectively. Overall, this translates to 7 081–14 801 nudged individuals. Cash transfers for the second dose nudged 567–1 124 individuals and increased the share of vaccinated by 4.7 percentage points, achieving per person benefits of €1 094 for 60–69 age group, €927 for 70–79 and €593 for those older than 80 years. The largest €300 cash transfer for the third dose resulted in the highest increase of 17.1 percentage points, persuading between 55 216–97 172 individuals. Compared to having only two doses of vaccine, this translates to a per-person benefit of €383, €909 and €681 for the respective age groups.

Despite the expected per-person benefits associated with each dose, the Slovak CCT program does not appear to have been cost-effective. The benefit-cost threshold is only exceeded for the first dose, assuming a constant effect of the intervention for everyone aged 60 or more. For all other doses and scenarios, costs of the program substantially exceeded the benefits. The total benefit-cost ratios for the whole program are equal to 0.30 and 0.12 under the constant and diminishing effect scenarios respectively. Weighting of life expectancy according to the age distribution of nudged individuals has no effects on overall conclusions. Considering the benefit-cost ratios and the fact that a similar increase in vaccination rates was achieved with a substantially smaller financial rewards in other experiments, our results also serve as a caution for policymakers. As in all areas of public expenditure, more is not always better.

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Appendix A

Subsection A.1 Additional tables for sensitivity analysis

Table A1: Expected Costs and Benefits per Person—Sensitivity Analysis

				Constant effect				Diminishing effect			
Age group	Prob. of hosp. (%)	Costs of hosp. (€)	Prob. of death (%)	dQALY	Expected cost (€)	Expected counterfact. cost (€)	Expected benefit	dQALY	Expected cost (€)	Expected counterfact. cost (€)	Expected benefit
Panel A. Unvaccinated											
60–69	0.66	1 466	0.40	11.0	1 755			11.2	1 786		
70–79	1.52	1 391	1.22	7.5	3 648			7.9	3 843		
80+	3.18	1 389	2.97	3.8	4 522						
Panel B. First dose											
60–69	0.65	1 304	0.36	11.0	1 578	1 593	177	11.2	1 607	1 621	179
70–79	1.16	1 260	0.66	7.5	1 980	1 980	1 668	7.9	2 085	2 085	1 758
80+	2.33	1 546	0.90	3.8	1 388	1 460	3 134				
Panel C. Second dose											
60–69	0.48	1 485	0.10	11.1	447	443	1 146	11.3	455	451	1 166
70–79	1.22	1 388	0.34	7.5	1 028	1 042	952	7.9	1 082	1 096	1 003
80+	1.95	1 392	0.52	4.0	852	893	608				
Panel D. Third dose											
60–69	0.14	1 389	0.01	11.0	46		397	11.2	46		405
70–79	0.34	1 423	0.03	7.6	95		947	8.0	100		996
80+	0.88	1 354	0.09	4.2	161		732				

Notes: Cost for one year of life assumed to be equal to 39 655€.

Table A2: Total Costs and Benefits of the Vaccination Program—Constant Effect Sensitivity Analysis

Age group	No. of nudged	Total benefits (mil. €)	Total costs (mil. €)	Benefit-cost ratio
Panel A. First dose				
60–69	7 330	1.30	4.59	0.28
70–79	4 399	7.34	2.48	2.96
80+	3 072	9.63	1.16	8.30
Total	14 801	18.27	8.23	2.22
Panel B. Second dose				
60–69	589	0.67	6.21	0.11
70–79	337	0.32	3.09	0.10
80+	198	0.12	1.38	0.09
Total	1 124	1.11	10.68	0.10
Panel C. Third dose				
60–69	59 536	23.64	119.31	0.20
70–79	27 173	25.73	80.65	0.32
80+	10 463	7.66	28.96	0.26
Total	97 172	57.03	228.92	0.25
Panel D. All doses				
First dose 60+	14 801	18.27	8.01	0.44
Second dose 60+	1 124	1.11	10.66	0.06
Third dose 60+	97 172	57.03	228.92	0.52
Total	113 096	76.41	247.83	0.31

Notes: Totals for each dose include cash transfers for 80+ age group. Total costs also include cost of the vaccine equal to 30€ for each nudged person.

Table A3: Total Costs and Benefits of the Vaccination Program—Diminishing Effect Sensitivity Analysis

Age group	No. of nudged	Total benefits (mil. €)	Total costs (mil. €)	Benefit-cost ratio
Panel A. First dose				
60–69	5 727	1.03	4.51	0.23
70–79	1 354	2.38	2.39	1.00
Total	7 081	3.41	8.01	0.43
Panel B. Second dose				
60–69	464	0.54	6.21	0.09
70–79	104	0.10	3.08	0.03
Total	567	0.64	10.66	0.06
Panel C. Third dose				
60–69	46 466	18.82	119.19	0.16
70–79	8 749	8.71	79.89	0.11
Total	55 216	27.53	227.66	0.12
Panel D. All doses				
First dose 60+	7 081	3.41	8.01	0.43
Second dose 60+	567	0.64	10.66	0.06
Third dose 60+	55 216	27.53	227.66	0.12
Total	62 864	32.64	246.33	0.13

Notes: Totals for each dose include cash transfers for 80+ age group. Total costs also include cost of the vaccine equal to 30€ for each nudged person.

Appendix B

Subsection B.1 Definition of variables for correlates of the treatment effect

- **Demographics**
  All variables based on data from the 2021 census, reported by the Slovak Statistical Office.
  - Secondary: share of inhabitants with only secondary education.
  - University: share of inhabitants with university education.
  - Female: share of female population above age 50.
  - Roma: share of Roma population.
  - Hungarian: share of Hungarian population.
- **Health**
  - Life expectancy: life expectancy at birth, reported by the Slovak Statistical Office.
  - Charlson index: average Charlson index in year 2019, calculated from individual-level health care utilization claims data reported to the NHIC and Ministry of Health. Based on an algorithm by Bannay et al. (2016). The index is based on year 2019 due to disruptions in delivery of health care during the pandemic, which could possibly skew occurrence of diagnoses, procedures and hospitalizations used for calculation of the index.
  - COVID-19 mortality: mortality on COVID-19 per 10 000 inhabitants until the start of the program, based on data from the national death registry.
  - Health care utilization: average yearly health care utilization in year 2019, based on individual-level claims data reported to the Ministry of Health. Includes accrued costs for all health care procedures covered by the mandatory health care insurance. Slovak health care system is based on universal coverage, where all inpatient and outpatient costs, including specialist ambulatory care and prescription medication is covered.
  - Vaccination rate: vaccination rate as of November 2021, reported by the National Health Information Center.
- **Survey data**
  Online survey conducted by the Department of Sociology, Slovak Academy of Sciences between July–November 2021. Based on a representative sample ($n = 3000$) according to the following socio-demographic characteristics: gender, age, region, education, size of municipality. The survey monitors public opinions about the disease, consent and compliance with quarantine measures, changes in behavior during the epidemic, and approval of government procedures. Several questions are also devoted to plans to get vaccinated against the COVID-19 disease and factors that would change the decision (not) to get vaccinated. Opinions on mandatory vaccination and agreement with conspiracy theories about the coronavirus epidemic are also determined. All variables coded as an average of responses per each district, unless otherwise noted.
  - Threatened by pandemic: on a scale of 1–10, indicate whether you're feeling threatened by the current pandemic. 1 = I don't feel threatened, 10 = I am feeling quite threatened.
  - Conform with measures: on a scale of 1–10, indicate whether you conform with containment measures to stop spreading of the virus. 1 = I don't conform with the measures at all, 10 = I thoroughly conform with the measures.

– Trust in health care: on a scale of 1–11, indicate your trust in the health care system in relationship to the current pandemic. 1 = I completely trust, 11 = I do not trust at all.

– Trust in government: on a scale of 1–11, indicate your trust in the current government in relationship to the current pandemic. 1 = I completely trust, 11 = I do not trust at all.

– Not planning to vaccinate: Indicate whether you're planning to vaccinate against COVID-19. The resulting variable is coded as a share of individuals indicating refusal to get vaccinated.

– Conspiracy beliefs: those indicating their refusal to get vaccinated had to indicate their reasons in a follow-up question. Possible answers were listed as follows:

  1. Any vaccine can cause bigger problems than the virus itself
  2. I don't trust pharmaceutical companies
  3. I don't think that the vaccine can help against the virus
  4. I can't get vaccinated due to a underlying health condition
  5. The virus is not as harmful as they are try to tell us
  6. I can't choose a vaccine which I would like
  7. The pandemic is on a decline, it is no longer necessary
  8. Other

  The resulting variable is coded as a share of individuals indicating refusal to get vaccinated.

Table A4: RD Effect by District

District	Treatment effect (δ)	SE
Banská Bystrica (BB)	0.177	(0.014)***
Banská Štiavnica (BS)	0.187	(0.036)***
Bardejov (BJ)	0.181	(0.018)***
Bratislava I (BA I)	0.082	(0.021)***
Bratislava II (BA II)	0.120	(0.013)***
Bratislava III (BA III)	0.123	(0.017)***
Bratislava IV (BA IV)	0.132	(0.014)***
Bratislava V (BA V)	0.132	(0.013)***
Brezno (BR)	0.214	(0.020)***
Bytča (BY)	0.227	(0.028)***
Bánovce nad Bebravou (BN)	0.199	(0.025)***
Čadca (CA)	0.275	(0.018)***
Detva (DT)	0.183	(0.044)***
Dolný Kubín (DK)	0.202	(0.023)***
Dunajská Streda (DS)	0.169	(0.012)***
Galanta (GA)	0.183	(0.014)***
Gelnica (GL)	0.217	(0.031)***
Hlohovec (HC)	0.226	(0.023)***
Humenné (HE)	0.194	(0.019)***
Ilava (IL)	0.248	(0.020)***
Kežmarok (KK)	0.213	(0.020)***

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District	Treatment effect (δ)	SE
Komárno (KN)	0.168	(0.013)***
Košice I (KE I)	0.166	(0.012)***
Košice II (KE II)	0.181	(0.025)***
Košice III (KE III)	0.193	(0.093)*
Košice IV (KE IV)	0.218	(0.031)***
Košice-okolie (KS)	0.208	(0.014)***
Krupina (KA)	0.271	(0.034)***
Kysucké Nové Mesto (KM)	0.264	(0.030)***
Levice (LV)	0.204	(0.014)***
Levoča (LE)	0.212	(0.028)***
Liptovský Mikuláš (LM)	0.195	(0.017)***
Lučenec (LC)	0.215	(0.019)***
Malacky (MA)	0.153	(0.018)***
Martin (MT)	0.208	(0.015)***
Medzilaborce (ML)	0.277	(0.049)***
Michalovce (MI)	0.226	(0.016)***
Myjava (MY)	0.229	(0.026)***
Nitra (NR)	0.203	(0.011)***
Nové Mesto nad Váhom (NM)	0.179	(0.019)***
Nové Zámky (NZ)	0.176	(0.012)***
Námestovo (NO)	0.292	(0.021)***
Partizánske (PE)	0.204	(0.024)***
Pezinok (PK)	0.177	(0.017)***
Piešťany (PN)	0.198	(0.019)***
Poltár (PT)	0.189	(0.038)***
Poprad (PP)	0.190	(0.015)***
Považská Bystrica (PB)	0.246	(0.019)***
Prešov (PO)	0.174	(0.011)***
Prievidza (PD)	0.154	(0.013)***
Púchov (PU)	0.209	(0.024)***
Revúca (RA)	0.263	(0.027)***
Rimavská Sobota (RS)	0.221	(0.019)***
Rožňava (RV)	0.177	(0.021)***
Ružomberok (RK)	0.227	(0.020)***
Sabinov (SB)	0.224	(0.021)***
Senec (SC)	0.128	(0.016)***
Senica (SE)	0.197	(0.019)***
Skalica (SI)	0.146	(0.021)***
Snina (SV)	0.225	(0.023)***
Sobrance (SO)	0.191	(0.033)***
Spišská Nová Ves (SN)	0.232	(0.017)***

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Table A4—Continued From Previous Page

District	Treatment effect (δ)	SE
Stará Ľubovňa (SL)	0.233	(0.023)***
Stropkov (SP)	0.232	(0.036)***
Svidník (SK)	0.231	(0.030)***
Šaľa (SA)	0.164	(0.018)***
Topoľčany (TO)	0.214	(0.019)***
Trebišov (TV)	0.170	(0.016)***
Trenčín (TN)	0.206	(0.014)***
Trnava (TT)	0.159	(0.012)***
Turčianske Teplice (TR)	0.205	(0.036)***
Tvrdošín (TS)	0.250	(0.030)***
Veľký Krtíš (VK)	0.204	(0.024)***
Vranov nad Topľou (VT)	0.211	(0.019)***
Zlaté Moravce (ZM)	0.238	(0.024)***
Zvolen (ZV)	0.178	(0.016)***
Žarnovica (ZC)	0.192	(0.030)***
Žiar nad Hronom (ZH)	0.149	(0.022)***
Žilina (ZA)	0.216	(0.012)***

Notes: Robust standard errors in parentheses. Estimation sample is restricted to age 50–70.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$