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Cost-Effectiveness of a Social Media Campaign to Promote COVID-19 Vaccination in Nigeria

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Abstract

Background: Vaccine hesitancy has increased in recent decades internationally, which set up a critical barrier to rapid deployment of novel vaccines against infection with COVID-19.

Objective: This study used a quasi-experimental design to evaluate the cost-effectiveness of a quasi-experimental social media intervention to reduce COVID-19 vaccine hesitancy implemented in Nigeria in 2022.

Methods: The intervention targeted healthcare providers and adults from the general population who were users of a specific social media platform. We used published estimates from a quasi-experimental evaluation of the campaign's effectiveness compared to the status quo assigned across 6 intervention states and 31 comparison states over a 10-month period. We estimated the cost-effectiveness of the campaign in terms of cost ($2022) per person vaccinated using a decision-tree analysis and probabilistic sensitivity analysis.

Results: The social media campaign resulted in 58.3 million impressions and 1.87 million people reached for a total societal cost of $1.15 million, or $0.613 per person reached. The campaign led to a 1.57 (95% Uncertainty Interval (UI): 0.337, 2.87) percentage point increase in the proportion of those vaccinated against COVID-19 among those reached by the social media campaign compared to those in comparison states. This resulted in an incremental cost-effectiveness ratio of $54.70 (95% UI: $20.90, $163) per person vaccinated.

Conclusions: A social media-based campaign to address COVID-19 vaccine hesitancy in six states in Nigeria resulted in an increase in vaccination rates. The cost-effectiveness of the campaign compared to no campaign is comparable to other campaigns promoting COVID-19 vaccine uptake and is 1-8% of the estimated cost per life year saved by vaccination against COVID-19 in low and middle-income countries. Investing in social media campaigns would likely be a cost-effective approach to increase vaccine uptake and save lives. Clinical Trial: Pan African Clinical Trial Registry: PACTR202310811597445

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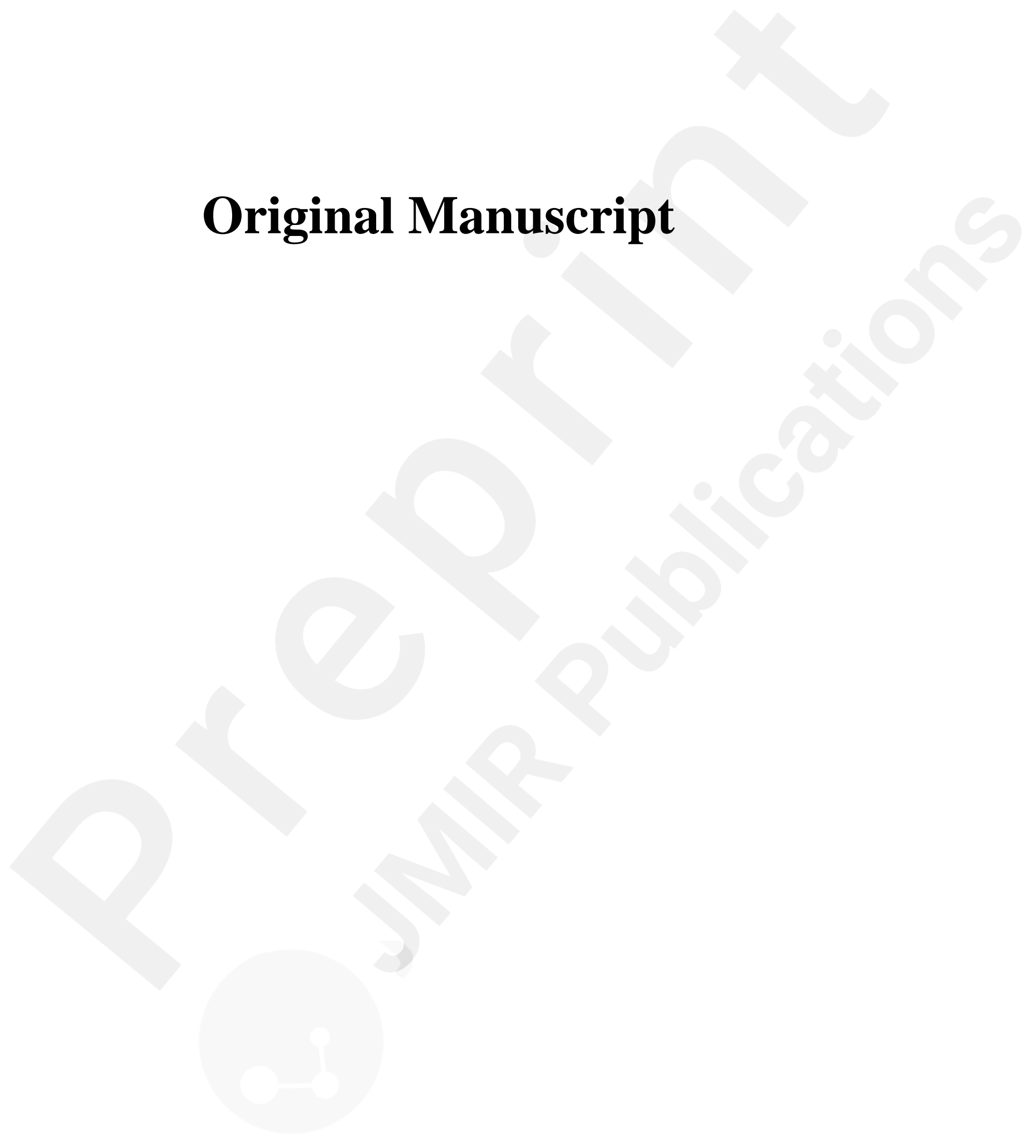

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Compliance with Ethical Standards

Conflict of Interest: The authors declare that they have no conflict of interest.

Ethical Approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This evaluation was approved by the George Washington University Institutional Review Board as well as the National Health Research Ethics Committee (NHREC) in Nigeria.

Informed Consent: Participants provided consent through a social media chat interface

Open Science Transparency Statement: This natural experiment design study is 1) not registered in a clinical trial database and 2) does not have a pre-registered analysis plan. 3) Data are available from the authors upon request and are not available in a data repository. The cost-effectiveness analysis in this study was performed using a visual editor 4) without the development of analytic code or 5) other materials.

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Abstract

Background: Vaccine hesitancy has increased in recent decades internationally, which set up a critical barrier to rapid deployment of novel vaccines against infection with COVID-19.

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INTRODUCTION

The COVID-19 pandemic led to the death of 15-20 million people globally through 2021.[1,2] In response to this threat, governments and private companies demonstrated high capacity for innovation; the rapid development and testing of multiple effective vaccines stands out as critical success.[3] The pandemic also highlighted ongoing systemic failures in global and national public health systems, including limited capacity for surveillance, communication, and distribution of preventive materials and services.[4] These failures exacerbated existing health inequities within and between countries.

The potential impact of the successful development, manufacture, and distribution of effective vaccines was not fully realized due to the public health system's inability to communicate the safety and benefit of the new vaccines in the context of widespread mis- and disinformation about the pandemic and the public health response. Building on well-established anti-vaccine movements, COVID-19 vaccine hesitancy emerged as a major barrier to the control of the pandemic. In the United States, 70% of the total population completed the primary vaccination series, but only 18% received a booster for new virus variants (CDC). While 70% of the global population had received at least one dose of a COVID-19 vaccine, only 31% of those living in low-income countries received at least one dose (KFF tracker).

In the years prior to the COVID-19 pandemic, researchers were evaluating the potential use of social media communication campaigns to address vaccine misinformation and increase vaccine uptake. Previous vaccine promotion campaigns addressing vaccine hesitancy mostly targeted a narrow set of vaccines (e.g. Influenza and HPV in high-income countries and diphtheria, tetanus, pertussis, and polio in mid and low-income countries).[5] Reviews of a broader selection of health promotion campaigns on social media found limited or mixed evidence of reported or observed behavior changes (i.e. high engagement) and more reports of interaction with posts and/or changes in knowledge and attitudes (i.e. low to medium engagement).[6,7]

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With this promising, but limited research base and accompanied by calls for development of theoretically and practice-based social marketing strategies,[8] funders and public health organizations rapidly implemented social media campaigns to promote vaccine uptake. Initial evaluations of these efforts have been positive, leading the public health community to consider whether and how to invest in a sustainable public health social media communications infrastructure.

We evaluated the cost-effectiveness of a targeted social media campaign to promote vaccination against COVID-19 among healthcare providers and other adults in their social environment in Nigeria in 2022. In this analysis, we aimed to evaluate the cost of implementing a social-influencer based social media campaign and to estimate the value of the campaign in terms of cost per person vaccinated, which can be compared to other campaigns targeted vaccine uptake.

METHODS

The prospective economic analysis plan was included in the overall analysis plan submitted to the funder and has not been published elsewhere. This project followed the guidelines of the Second Panel on Cost-Effectiveness in Health and Medicine and the reporting guidelines from the Consolidated Health Economic Evaluation Standards (CHEERS 2022) checklist.[9,10] The data used in the model synthesis were collected from 2021 to 2022. The analysis was completed in 2023.

This evaluation was approved by [blinded] Institutional Review Board as well as the National Health Research Ethics Committee (NHREC) in Nigeria. Participants provided consent through a social media chat interface. Data are available from the authors upon request.

Intervention Description

The current cost-effectiveness analysis is based on the implementation and quasi-experimental evaluation of a 10-month social media campaign promoting vaccination against COVID-19 in Nigeria among healthcare workers and those in their social networks in 2022.[11] The campaign was

designed and implemented by a team of designers and local organizations and delivered through Facebook and Instagram. The campaign included pro-vaccination social norms and vaccine hesitancy reduction messages delivered by social influencers (e.g. local celebrities, healthcare providers, and religious and business leaders). The campaign theory of change was based on the theory of Diffusion of Innovations, Social Norms Theory, and the Motivation, Opportunity, and Ability (MOA) framework.[12-14]

Study Population and Setting

The intervention was implemented in six states in Nigeria (Anambra, Bauchi, Lagos, Niger, Rivers, or Sokoto) with participants in the control condition recruited from the federal district and all other states. Participants were eligible if they were 18 years or older, had a Facebook account, and received a recruitment advertisement for this study through their Facebook account. While people in low and middle-income (LMIC) countries generally have higher vaccine acceptance than those in high-income countries. Nigeria faced vaccine availability and other challenges that may impact vaccine hesitancy differently than in higher-income settings, including perceptions that safety and efficacy have not been adequately evaluated in the setting.[15-17]

Cost Evaluation

We used the standard microcosting approach, for which we evaluated all component costs of the intervention instead of using a global project budget. Microcosting includes three main steps: 1) Identification; 2) Measurement; and 3) Valuation. To identify resources used, we prospectively developed a thick description of the intervention activities and identified necessary resources for each activity. Resources were measured and valued using actual reported expenditures from implementing partners and reported or estimated opportunity costs for the non-budgeted time from implementing partners, influencer organizations, and participants. Direct costs were all reported in

$US by the implementing partners and were adjusted for inflation to 2022 dollars. Opportunity costs accrued in Nigeria were estimated in 2022 Nigerian naira. Nigerian currency was converted to purchasing power parities (PPP) with total costs reported in 2022 $PPP, which is equivalent to 2022 $US. Costs were converted in 2023. As we did not assess health or economic benefits of vaccination, we did not include opportunity costs of individuals or direct healthcare sector costs for receipt of the vaccine.

Intervention Reach

The intervention included 245 distinct advertising campaigns implemented on the Facebook social media platform. For each of these campaigns, the platform reported the total number of unique individuals receiving campaign messages (reach), the total impressions, and a range of engagement metrics for each of these campaigns. Because we did not have access to the total unique individuals reached across all campaigns, we estimated reach based on the largest reported reach across all campaigns. Due to a lack of data on the degree of overlap within a targeted campaign, we based our reach estimate on a conservative assumption that there is complete audience overlap across campaigns.

Cost-Effectiveness Analysis

We used a societal and payer perspective, which captures both the budgetary costs of implementing a similar campaign in the future and the opportunity costs of implementing partners and individuals engaging with campaign messages. The comparator was the status quo, which was chosen based on the intervention design and effect estimate. The time horizon for the study was one year to capture planning and implementation; we did not have capacity to model longer-term health and cost effects following a change in vaccination rates. We did not discount costs or benefits over the 1-year time horizon.

Outcome Measurement

The primary outcome for this study is vaccination against COVID-19. The incremental effect of exposure to the advertising campaign was estimated from a survey of 10,965 participants who were users on the Facebook social media platform. Surveys were fielded to the same cohort in with baseline data collection during the period December 1 to December 31, 2021, midline data collection during the period March 1-April 30, 2022, and endline data collection during the period October 1-October 4, 2022. Exposure was based on state of residence with the intervention implemented in 6 states (Anambra, Bauchi, Lagos, Niger, Rivers, and Sokoto) and control participants recruited from all other states in Nigeria.

Participants were recruited through a social media-based research platform called Virtual Lab (https://vlab.digital/). Recruitment was stratified by whether participants were healthcare providers, with the goal of recruiting 50% of the sample from the healthcare provider community. Participants were compensated with 400 naira (~$1) for completion of the 40-item survey implemented through Facebook Messenger (FM) chat function. COVID-19 vaccination uptake was measured with a single question “Have you received a COVID-19 vaccine?”

The effect of the intervention was estimated with a linear regression model predicting vaccination status at the midpoint and final survey. The primary independent variable in each model was exposure to the intervention. Adjusted models included the following control variables: age group, gender, education, religion, and occupation. We used clustered standard errors to account for nesting within state of residence. Additional detail on the evaluation of the intervention on vaccine uptake are reported elsewhere.[11]

We estimated the reach of the campaign in the intervention states based on the impressions reported by the social media platform Facebook. Impressions are defined as an individual user’s exposure to specific content on the platform that may or may not result in active engagement such as

liking, commenting, or following the account that disseminated or originated the content.[18] Impressions have been shown to account for most of the information exposure on social media, to have low correlation with active engagement, or “expression,” and to be independently correlated with user-reported influence of a given information source.[18]

Uncertainty Analyses

We conducted a probabilistic sensitivity analysis by sampling from the distributions of all parameters with measured uncertainty (Table 1). We included the following scenario analysis: the use of the effect estimate from the second follow-up period from the same study. We did not evaluate heterogeneity of the intervention effect or distributional effects of the intervention. Decision-tree models and the probabilistic sensitivity analysis were conducted using TreeAge Pro 2023 R2.0 (TreeAge Software, LLC).

RESULTS

The campaign generated 58,255,000 total impressions across 245 distinct advertising campaigns, which on the Meta platform include one or more sets of individual ads. Distinct campaigns were run to allow the intervention to best measure and optimize performance against advertising objectives. The mean reach (unique individuals generating 1 or more impressions) per campaign was 100,000 (min: 1,000; max: 1,873,000). Based on an assumption that there is complete overlap across distinct advertising campaigns, the intervention reached 1,873,000 unique individuals.

We summarize intervention costs by activity category in Table 2. Due to the use of marketing labor in the United States and the United Kingdom as well as dollar-denominated contracts with partners in Nigeria, the payer costs accounted for 93% of the total societal costs, even though the paid hours to implement the project were 14% of the total person-time included in the societal perspective.

Across both the control and intervention sample, 64.5% (6,198/9607) of participants were already vaccinated at baseline. After excluding these participants, 20% of the sample was estimated to be in the persuadable middle, or 57% of those who had not already been vaccinated and were otherwise eligible (excluding those based on eligible age, duplicate ID, and missing baseline data). In a previous study, we estimated that the intervention led to a 7.8 percentage point increase (95% UI: 1.68, 14.2) in vaccine uptake controlling for demographic variables among those in the persuadable middle.

In the primary analysis, we estimated that the incremental cost of the intervention per person reached was $0.63 and the incremental percentage point increase in vaccination prevalence was 0.0157 (95% UI: 0.00337, 0.0287). This resulted in an incremental cost effectiveness ratio of $54.70 (95% UI: $20.90, $163), which means that it cost $54.70 more than the status quo (or doing nothing) for every additional vaccination compared to the status quo.

In scenario analysis 1, we used the effect estimate from the 2nd follow-up of the same study as the primary analysis. In this scenario, the larger increase in vaccinations per person (0.0221 vs. 0.0157) compared to the no intervention condition reduced the incremental cost-effectiveness ratio almost in half ($29.60 (95% UI: negative, $180) (Table 3). The uncertainty interval includes 0 due to the smaller sample at the 2nd follow-up and resulting marginally significant coefficient reported in the evaluation study. We found that using this estimate resulted in 3% of all model iterations having a negative effect.

DISCUSSION

In this cost-effectiveness analysis of a social media campaign promoting vaccination against COVID-19 among healthcare workers and adults in their social environment in Nigeria in 2022, we found that the intervention increased vaccination rates among the target audience at a cost in line with similar efforts in the field.

Incremental cost-effectiveness estimates of media campaigns promoting vaccine uptake vary substantially. Based on an analysis of attitude changes as a result of social media campaigns run by 174 public health organizations during the COVID-19 pandemic and another study linking attitudes to vaccination outcomes, Athey et al. estimated that the campaigns cost $5.68 per person vaccinated.[19] The Athey et al. study only incorporated the cost of advertising, which accounted for only 12% of the total costs of running and participating in the campaign in our study. This suggests that our estimate of $54.70 is likely consistent with the Athey et al. analysis (which would cost $48 per person vaccinated assuming a similar cost structure) and highlights the importance of incorporating as many relevant costs as feasible when presenting the cost-effectiveness of social media campaigns.

Because there is no willingness-to-pay threshold for the cost of an incremental person vaccinated, it may be useful to integrate the findings from this study with others that have measured the cost per life year saved or cost per disability-adjusted or quality-adjusted life year. A study estimating health benefits and donor costs for increase COVID-19 vaccination rates in 91 low- and middle-income countries found that spending on vaccination would cost between $670/year of life saved (YLS) and $7820/YLS depending on the level of vaccination achieved.[20] The authors noted that the cost per YLS for COVID-19 vaccination is similar to the cost for antiretrovirals therapy for human immunodeficiency virus under the President's Emergency Plan for AIDS Relief (PEPFAR) PEPFAR, which they estimated at $4310/YLS using the total budget and life years saved from PEPFAR 2004-2013.[19] The cost per person vaccinated in this study ($54.70) is between 1% and 8% of the estimated cost per life year saved by vaccination against COVID-19 in 91 low and middle-income countries.[20] To further contextualize the value of the social media campaign evaluated here, vaccination against COVID-19 in lower-middle income countries was estimated to prevent 20.39 deaths per 10,000 people vaccinated; each death from COVID-19 was separately estimated to lead to 16 years of life lost.[21,22] This means that for each person vaccinated there is an average 0.0326

(20.39x16/10000) years of life lost prevented. Based on estimates of the variable cost of vaccination delivery after roll-out of a national campaign ($10 for the vaccine and $2.46 for delivery) and the cost of promotion from this study ($54.70), the marginal cost for each vaccination delivered would be $67.16, leading to an estimate of $2,060 per year of life lost averted.

Much of the work to prepare and launch this specific campaign to increase COVID-19 vaccine uptake could support other public health communications campaigns in Nigeria and potentially other countries. Moving the intervention to scale, such as all 37 states instead of the 6 in the intervention arm of this intervention, would spread fixed costs across a much larger population and reduce the cost per person vaccinated substantially. Goulborne and Yanovitzky argue that the COVID-19 pandemic has clarified the role of health communications infrastructure as a social determinant of health and that public health organizations will need to invest in hyperlocal health communication capacity across populations to address health inequities.[23] They suggest training and providing ongoing technical support to trusted intermediaries is one approach to providing hyperlocal health communication at scale. The intervention evaluated in the current study did implement the COVID-19 vaccine promotion social media campaign with 12 local health organizations and 10 other local influencers. The involvement of local influencers to shape and deliver health messages was considered an essential component of the campaign. This approach could limit the degree to which the intervention could be scaled at a lower marginal cost.

A primary limitation of this cost-effectiveness analysis is that we were not able to obtain a specific estimate of the total unique individuals run by the intervention on the Meta platform. To be conservative, we estimated the total intervention reach of 1.87 million unique users based on the reach of the largest single campaign and not the 24.5 million reached if we summed over the reported reach estimates for all campaigns. Our estimated $0.61 per person reached by the campaign would instead be $0.05, shifting the cost per vaccination from $54.70 to $2.98. This order of magnitude difference in the cost-effectiveness of the intervention emphasizes the importance of understanding

how social media reach metrics are reported and how studies estimating the same cost-effectiveness outcomes (e.g. cost per person vaccinated against COVID-19) are using these metrics in their work. The lack of comparability across studies may be further compounded when studies only use active engagement or expression as a measure of campaign reach.[18]

The extent of competing social media and other communications campaigns promoting vaccination against COVID-19 as well as the high levels of mis- and disinformation about the pandemic and the vaccines on the same social media platforms created another limitation. The incremental effect of the intervention campaigns on the message environment was lower than they would be in a non-pandemic context. We were not able to assess any competing or synergistic effects of the campaign due to variation in individual or community media environments nor were we able to evaluate how the campaign interacted with other public health campaigns on the same platform or across channels.

We used a self-reported measure of vaccination, which could potentially overestimate the effect of the intervention. Stephenson et al. reported that from a sample of about 2,000 patients with both self-reported and recorded COVID-19 vaccination status in a hospital setting, the self-reported and recorded vaccination status agreed for 95% of participants.[24] While we use existing studies on the cost-effectiveness of vaccination in similar settings,[20] we did not directly estimate how the campaign affected health outcomes, which may vary based on, among other factors, the vaccination level in the community, underlying demography and health status of the population, type of vaccine used, and healthcare system cost and effectiveness. Incorporating these factors within evaluation of new health communication and other strategies is likely infeasible for most interventions but could be accomplished by partnering with modeling groups that do address these factors or through sustained support of modeling consortia that could share modeling capacity more rapidly during future pandemics.[25]

CONCLUSION

We found that a local influencer-based social media campaign implemented in six states in Nigeria during the COVID-19 pandemic increased COVID-19 vaccination rates among those exposed to the campaign. The campaign demonstrated comparable cost-effectiveness to other COVID-19 campaigns when accounting for differences in cost data included across studies. When combined with existing estimates of the effect of vaccination against COVID-19 on mortality and years of life lost per death due to COVID-19, this intervention achieved a lower cost per year of life lost averted ($2,060) than debated, but recognized thresholds of 3 times national GDP per year of life lost averted.[26] Boosting the reach of vaccination efforts through influencer-based social media campaigns such as the one implemented in this study is likely to be a cost-effective approach to save lives.

Role of the Funder: The study was funded by the Bill & Melinda Gates Foundation (INV-033413). We also state that the project officer who was an employee of the funder at the time this project was initiated, Dr. Sohail Agha, participated in discussions about the study design and data collection. At the time of this manuscript preparation, Dr. Agha was no longer with the funder. Dr. Agha did participate in the development of the manuscript as noted in the CRediT Statement.

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Table 1. Summary of Inputs

Variable	**Point Estimate (95% UI)**	**Distribution (parameters)**
Target population already vaccinated at start of campaign (%)	64.5 (63.5, 65.5)	Binomial (0.645, 9607)
Persuadable middle population among those unvaccinated (%)	56.7 (55.1, 58.3)	Binomial (0.567, 3409)
Percentage point increase in vaccination status due to treatment among persuadable middle	7.8 (1.68, 14.2)	Normal (0.078, .032)
Campaign Reach	1,870,000	N/A
Average engagement time per media impression (seconds)	1.7	N/A
Total Campaign Impressions	58,300,000	N/A
Total Cost ($)	1,150,000	N/A
Cost per person reached ($)	0.613	N/A
Sensitivity and Scenario Analyses		
Scenario 1: Percentage point increase in vaccination status due to treatment among persuadable middle using 2nd follow-up	11.0 (-0.00337, 0.225)	Normal (0.10952, 0.0580377)

All currency in US$2022. UI: Uncertainty Interval

Table 2. Intervention Cost by Activity

	Payer	**Societal**
Government Liaison	73,400	73,400
Monitoring and Evaluation	98,300	98,300
Campaign Development	360,000	360,000
Advertising Expenditure	102,000	102,000
Advertising Campaign Implementation	134,000	134,000
Stakeholder Management	293,000	293,000
Participant Engagement with Advertising	-	77,700
Influencer Campaign Implementation	-	7,520
Total	**1,060,000**	**1,150,000**

All currency in US$2022. May not sum due to rounding.

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Table 3. Cost-Effectiveness Results

	Mean (95% Uncertainty Interval)
Incremental Cost per Person Reached ($)	0.613 (0.613, 0.613)
Incremental COVID-19 Vaccination per Person	0.0157 (0.00337, 0.0287)
Incremental Cost-Effectiveness Ratio ($/vaccination)	54.70 (20.90, 163)
Scenario 1: Incremental COVID-19 Vaccination per Person	0.0221 (-0.000649, 0.0452) [a]
Scenario 1: Incremental Cost-Effectiveness Ratio ($/vaccination)	29.60 (negative, 180)[b]

All currency in US$2022.

[a]For Scenario 1, we used an alternative estimate of the effectiveness of the intervention from the second follow-up period of the same intervention used for the primary analysis. [b]3% of model iterations were negative.

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