Cooperation Behavior and How Parents Decide Whether to Vaccinate Their Children

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1. Introduction

Recent preventable disease outbreaks, such as the Measles outbreak in New York at the beginning of 2019, have refocused public attention on immunization policy. Fauci (2019) suggests that this outbreak, and others, are a direct result of the modern anti-immunization movement with the 111 cases related to the 2014 Disneyland outbreak being just one example [1]. In total there were 17 measles outbreaks in the United States alone [2]. A substantiable proportion of all preventable disease cases occur when parents choose not to immunize eligible children. This reluctance suggests the possibility of a Free Rider Dilemma forming. Parents are electing not to immunize their child yet benefit from protection because those around them continue to. The higher the immunization rate is in a community, the lower the odds an unprotected child comes into contact with a disease. Certain communities have abnormally low immunization rates, which creates the possibility of disease outbreaks. Understanding the social and behavioral contexts that lead to higher parental resistance may yield useful information for counteracting parental resistance.

The purpose of this paper is to analyze parents' willingness to cooperate within groups to predict the role of general, economize behaviors, and weigh social pressures and preferences in parents' immunization decisions. This is done through the use of a Voluntary Contribution Mechanism (VCM) Game. We hypothesize that parents who contribute more to the VCM group account and indicate higher social awareness towards vaccines on the survey will be more likely to immunize their child. People that care about and are influenced by the community's well-being will be less likely to immunize.

We measure social preferences and economic behavior in two ways. First, survey questions are used to measure social network preferences. Second, the VCM game measures parents' free rider economic behavior. These two types of measures inform a model to explain how socioeconomic preferences and economic behavior influence parents' child immunization decisions.

We find immunization resistant parents are not more likely to free ride in the VCM compared to immunizing parents. Rather, the disparity in community donations develops as the contribution becomes more context-specific, ie. immunization decisions, and the group becomes more intimate and health related.

2. Background and Literature Review

In this paper, there are three different subject areas of focus: parents' immunization hesitancy, the demographic and socioeconomic characteristics of these parents, and free-riding hesitancies. We will discuss each of these in further detail before continuing onto the design of the experiment.

2.1 Immunization Hesitancy and Group Decision Process

In 2007 the World Health Organization (WHO) set a public health target rate of 90% immunization. Over the past decade, global child immunization rates have plateaued. The WHO notes international diphtheria, tetanus, and pertussis (DTaP) immunization rates have held constant at a mere 85% since 2010 [3]. In Wyoming there is a dramatic immunization rate variance across communities. While many communities have performed well in immunity metrics, others have some of the lowest immunization rates for the DTaP, Hepatitis A (Hep A), and Measles, Mumps, and Rubella (MMR) vaccines for children aged 19 to 35 months nationally every year. Natrona County, Wyoming has been the center of a Hepatitis A outbreak, one that coincides with below-average Hep A coverage.

National annual influenza immunization rates have failed to increase since 2013. Nationally, 41.1% of children received their influenza immunization by November in 2013, but just 38.8% we immunized by November in 2017. End of influenza season coverage in 2014 was at 58.9%, yet in 2018 it was just 59%. Overall, Wyoming has one of the lowest influenza immunization rates in the country. In the 2016-17 influenza season, only 38.9% of people received their influenza vaccine, the second lowest rate in the country [4]. These immunization rates are well below the Centers for Disease Control's Healthy People 2020 objective of a 70% across-the-board annual influenza protection rate [5].

One major factor that some medical professionals suggest affects parents is reliance on their opinion. They feel parents whom do not trust medical professionals' opinions are the more likely to delay immunizations or avoid them entirely [6]. Researchers find parents may elevate the importance of family opinions when they make such decisions. Hill (2013) confirms that parents who do not immunize tend to be influenced by external factors note inclusive of medical professionals' advice [7]. Present approaches to immunization hesitancy tend to focus on changing parents' perceptions towards healthcare professionals in an attempt to have parents follow the professionals' recommendations.

Subramanian et al. (2002) concluded that those who feel ostracized from a community will trust it less, and in particular, will not conform with community norms [8]. Those with less social trust are more likely not to follow health norms like getting their children immunized [9]. While the research is focused on socioeconomic isolation, results suggest a rural-urban divide. This has been more relevant in developing countries. For example, in rural China there is a significantly higher distrust in health practitioners than in developed China [10].

2.2 Free Riding in Economic Experiments

While to our knowledge a VCM has never been run exclusively for parents, Yoko et al. (2014) studied the possibility of free riding among parents when making immunization decisions for their children by setting up a game which assigned costs to immunization decisions and probabilities of getting ill [11]. In the study, parents' likelihoods to immunize decreased as the rate of those immunized in the game increased [12]. This result occurred independent of the severity of the illness in question. Of note, the parents' communities were kept anonymous.

Isaac and Walker (1998) find group size affects cooperation. The individual contribution is higher in smaller settings because there tends to be increased pressure to cooperate [13]. Applications are twofold. First, smaller groups in the VCM should make higher contributions than larger groups. Second, people in smaller communities should donate more in the game.

Another consideration is the subjects' ability to interpret the game and develop a strategy. Confusion in a game like the VCM is a real problem that needs to be considered [14]. The study found that confusion is lower in later rounds, which can be attributed to learning the game. Confusion declines rapidly in the first couple rounds while the learning tapers off in later rounds, leaving some subjects who never understand the game. This is a serious threat to the integrity of results, and one way to mitigate the effect is by discounting variances in the results in initial rounds and focusing analysis on mid-to-late rounds of the experiment.

This research will help us better understand the factors that influence parents to not immunize their child. More specifically, we analyze the effect of possible Free Riding, and whether parents that immunize are more likely to be Free Riders, and how parents' communities influence their decisions. It can be extremely helpful to future strategies to increase immunization rates, specifically in rural communities.

3. Study Design

3.1 Experiment

Experiments were conducted at four locations across Wyoming in counties with low immunization coverage. The four counties were Park, Sheridan, Albany, and Natrona. All participants were parents with a child between the ages of zero and five at the time of the study. Only one participant was allowed per household. The recruitment process involved combination of recruiting strategies, including a one-time advertisement campaign, random calls to qualifying households, and ads in community message boards. Potential participants were told the study would look at parents' health decision process. To incentivize participation, free childcare services were provided on-site. Each participant was also offered a $100 show-up fee for their opportunity cost and the ability to earn more during the experiment. Each session was held in classroom-style rooms using paper worksheets. All recruitment and data collection processes were approved by the University of Wyoming Institutional Review Board, and all researchers passed human subjects training. The collected data was double-entered and cleaned to limit entry error.

3.2 Study Design and Procedure

At the beginning of the study, all participants were told that they would be participating in three tasks and a survey. We also reinforced that communication of any kind other than to ask the monitor for clarification on directions was prohibited. This was to ensure individuals' answers and strategies were theirs. Participants were told they would receive their payment in cash at the end of the session.

The VCM can be used to measure individual inclinations toward free-riding. The Nash Equilibrium for the game is that both group members donate all their tokens to the group account. However, precedent predicts that contributions in early rounds will be significantly higher than in later rounds [14]. Without the threat of punishment in later rounds, players should distance themselves from the Nash Equilibrium in favor of self-promoting strategies that only have minimal contributions to the group account. Reciprocity is an additional element that is expected within the VCM. Players will continue to contribute to the group account through the last round of the game as long as they expect others to do so as well [15].

In the VCM game participants were endowed with thirteen tokens for each of the eight rounds they played. Every round they were required to decide how much of the endowment to place in private and group accounts. The return on the private account was $ 0.04 per token while the return on the group account was $0.03 per token. With high amounts of dual investment, the group account had the potential to earn more than the private account. Participants wrote down the number of tokens they invested in the group account on their reporting form. Then, they independently decided how many tokens to invest in each account. The monitor collected all forms and redistributed them to another predetermined session participant using a random pairing order in each round. In sessions with an odd number of participants the experiment director added a blank to each round to provide even pairings. As a result, one alternating random player sat out each round. The slip was left blank to minimize the effect it would have on changes in contribution perceptions as the game evolved. At the end of all the rounds, participants added up the money received from tokens in their private and group accounts in each round to arrive at a total received. The participants were paid in cash for their total VCM investments. The table that participants completed during the VCM is provided in Appendix A.

The participants finished by individually filling out their survey. They were reminded talking was only allowed to ask the monitor for clarification. In the surveys, participants were asked about the following: their youngest child's immunization and health history, their general views on immunization in private and community settings, and demographics. For consistency, in-depth immunization questions were only asked about the parent's youngest child. There was an additional section in which parents could report the total number of children in the household and whether those children were up-to-date on their immunizations.

3.3 Experimental Parameters

The following results summarize data from 19 study sessions run over five Saturdays between November 2017 and April 2018. The number of participants per session ranged from five to 16. Table 1 shows the total number of participants in each location.

Table 1: Participation by Location

Location	***Total Population***	***Number of Children Under 5***	***Number of Adult Participants in Study***
Albany County	*38,332*	*1,878*	*58*
Park County	*29,568*	*1,626*	*45*
Natrona County	*79,547*	*5,489*	*48*
Sheridan County	*30,210*	*1,662*	*47*
Total			*198*

Note that all sessions followed the outlined procedure.

4. Model and Methodology

We developed three probit models to test our hypotheses. We estimate the following regressions:

$$\widehat{Y_i} = f(\alpha + \beta\widehat{VCM}_i + \delta N_i + \varepsilon_i) \tag{1}$$

$$\widehat{Y_i} = f(\alpha + \beta \widehat{Social\ Network}_i + \delta N_i + \varepsilon_i) \quad (2)$$

$$\widehat{Y_i} = f(\alpha + \beta \widehat{Community}_i + \delta N_i + \varepsilon_i) \quad (3)$$

Where $\widehat{Y_i}$ is whether a child is immunized, α is the intercept, N_i represents the demographic variables that are controlled in the regressions, and ε_i is the error term. Each regression is run four times in which $\widehat{Y_i}$ uses a different vaccine for each ith child: Influenza, HepA, DTaP, and MMR. The three independent variables across the models include a) contributions to the VCM private and public accounts, b) a question that gauges how community protection weighs into immunization decisions (to evaluate community pressures on a parent), and c) a series of four questions about the immunization views of friends and families (which measure the effect that close relationships have on immunization decisions). The five total questions used from the latter two independent variables are listed in Table 2. The dependent variable is whether or not the child is immunized against a certain disease (e.g., HepA, DTaP, MMR, and influenza).

The demographic characteristics that are controlled for include: distance from the child's healthcare provider, age of the adult, ethnicity, religion of the adult, highest level of education, employment status, and household income.

The VCM data used for the models is derived using a two-step process. First, t tests measuring the contributions in Rounds Three through Eight indicate that individuals' contributions did not vary from round to round at a significant level. Because of this, Principal Component Analysis (PCA) is used to condense the data from each round. Doing so allows for more complete and meaningful data to be inserted in Model 1. PCA is also used to condense the four questions that comprise the Social Network variable. A full list of the survey questions used in the analysis is found in Table 2.

Table 2: Questions Used in Models 2 and 3

Community Question	
**Below are possible things you may consider when making your child's vaccination decisions. Circle the number (where 1= Very Unimportant and 5= Very Important) that best reflects how you feel about the following items when deciding to vaccinate your youngest child.* *	
Reducing the chances contagious diseases are in my community	1 2 3 4 5
Social Network Questions	
Think about your closest friends and family members. Circle the appropriate response based on how important the statements are where 1= Very Unimportant and 5= Very Important	
My friends and family know my children received their influenza immunization.	1 2 3 4 5
My friends and family know my children received their immunizations on schedule	1 2 3 4 5
I know my friends and family immunized their children against influenza	1 2 3 4 5
I know my friends and family immunize their children on schedule	1 2 3 4 5

5. Results

We will now analyze the results of the models and make preliminary observations. First, Table 3 contains summary statistics about the immunization history of the participants.

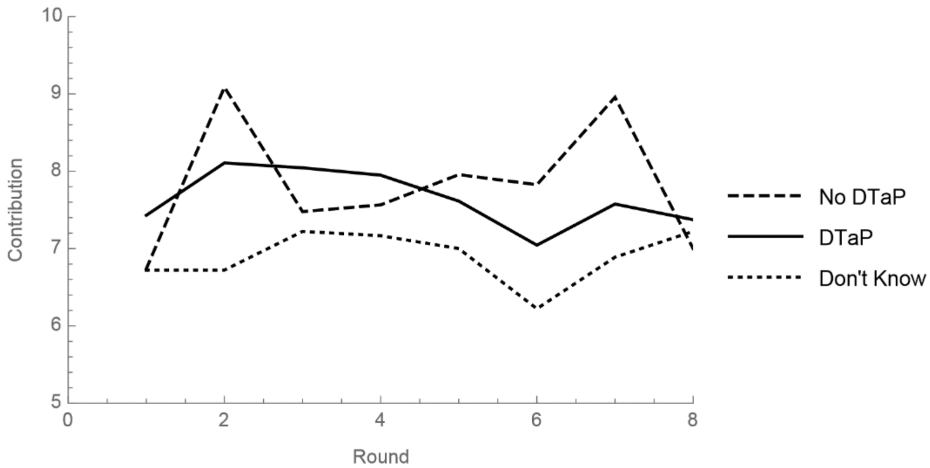
Table 3: Parents' Report of Youngest Child's Immunization Status for each Immunization Option

	Immunized (%)	***Not Immunized (%)***	***Don't Know (%)***	***% Immunized***	***% Not Immunized***	***% Don't Know***
Influenza	123	75	N/A*	62.2%	37.9%	N/A
HepA	140	29	29	70.7%	14.6%	14.6%
MMR	144	30	24	72.7%	15.1%	12.1%
DTaP	157	23	17	79.7%	11.7%	8.6%

*Don't Know was not an option for Influenza
**Don't Know responses were not included in the data analysis

Those that indicated they were not sure whether their child had received a particular vaccine were excluded from the regressions. Results from the VCM game are summarized in Figure 1. The t-tests indicate that the variations between rounds are not significant.

Figure 1: VCM Contribution Results Grouped by DTaP Immunization



Each regression was run four times: once for every dependent variable. Table 4 contains summary statistics for regression results and marginal effects of each regression run. The only variables in Table 4 are the independent variables of interest (VCM, Community, and Social Network) and the dependent variable (the immunizations). The summary statistics from Models 1 through 3 are reported in Appendix B. The complete marginal effects are given in Appendix C. All responses for parents who did not know their youngest child's immunization status were omitted from the models because no relevant conclusions can be made from their behavior.

Table 4: Summary Regression Results

	VCM		***Community***		***Social Network***	
	Regression Results	**Marginal Effects**	**Regression Results**	**Marginal Effects**	**Regression Results**	**Marginal Effects**
Influenza	0.011 (0.048)	-0.018	0.301*** (0.116)	0.069	0.411*** (0.065)	0.131
HepA	-0.026 (0.062)	0.004	0.393*** (0.133)	0.119	0.437*** (0.088)	0.053
DTaP	0.052 (0.061)	0.007	0.148 (0.145)	0.018	0.384*** (0.097)	0.046
MMR	0.043 (0.061)	0.002	0.390***	0.059	0.283*** (0.075)	0.043

Note: * ≥ 90% significant ** ≥ 95% significant *** ≥ 99.9% significant

A clear hierarchy emerges when focusing on VCM, social network, and community variables. Results from the VCM suggest there is no statistically significant relationship between VCM game play and immunization decisions. However, a different conclusion can be ascertained when studying the next two sets of regressions. Both social network and community suggest a clear demarcation between the responses of those who choose to immunize and those that choose not to immunize. We found that for each response level up in the community answers, parents are 6.9% more likely to have their child receive the annual influenza vaccine. Each increase in social network preference makes parents an impressive 13.1% more likely to immunize. While the marginal effect is less for one-time immunization responses, each increase in the social network responses make parents 5.3% more likely to pursue the HepA vaccine for their child.

Our results allow us to observe how players adjust their contributions to society based on who the affected group is and what other players are contributing. Table 5 summarizes the relationship.

Table 5: Changes in Framing of Community Cooperation

	Personal Connection	***Contribution Mechanism***	***Relationship With Imm. Rate***
VCM	Low	Token (unspecified)	None
Community	Low	Vaccine	High
Social Network	High	Vaccine	Very High

As the personal connection grows and the mechanism becomes more specified, the role participants feel they play becomes more dichotomous. In the VCM, there is no significant differentiation between parents who choose to immunize their child and those that elect not to immunize. When the community contribution is a vaccine, there is a significant correlation between community awareness and children immunization. The trend continues through the third row of Table 5. Parents whom align themselves in social circles where the expectation is that all children are immunized are significantly more likely to immunize their child.

6. Discussion

Our findings suggest that the free-riding that Yoko (2014) detected is not differentiable between parents who do and do not immunize their children as a personality trait. Rather, it is a result of opinions of vaccines, which come from external sources.

A secondary result confirms that people who live further away from their medical provider are more likely to not immunize. This confirms that the findings of Subramanian et al. (2002) are relevant in developed nations such as America. One explanation for this is that the personal connection decreases as the parent becomes more isolated, thus decreasing the personal connection between parent and healthcare provider. As such, the influence is lessened, meaning parents are less likely to follow recommendations. Further research is needed to be done to confirm this hypothesis.

We found that many commonalities between those that elect not to immunize their children with the three one-time vaccines used in the study do not stretch to the influenza non-immunizers. Influenza immunization responses indicate decisions may be a matter of habit rather than just philosophy. The best way to increase immunization across all vaccines appears to be to encourage pro-immunization behavior to those in close social networks.

The results of the study will allow medical agencies to re-assess the way they nudge parents toward immunizing their children. Table 5 shows that deviations in community participation only arise when immunization is involved. Campaigns in which vaccines are framed as a generic donation could make strides towards pushing non-immunizers' socioeconomic behavior to what they displayed in the VCM (a behavior that closely matches that of immunizers), or in which grass-roots activism are encouraged could be influential in increasing immunization rates.

Future areas of study could include exactly how these policy recommendations can be implemented. In particular, different framing questions to analyze whether parents can be nudged towards pro-immunization behavior because their social group's norm requires such could confirm the theories proposed in the study. Different framings of immunization information could also yield useful results. Finally, a broader implementation of our study can evaluate whether the results are localized to Wyoming.

Appendix A

				(C)	**(D)**	**(E)**	**(F)**	**(G)**
Period	Endowment	Your Decision		Value of Tokens in Private Account	Number of Group Member’s Tokens in Group Account	Total Number of Tokens in Group Account	Value of Tokens in Group Account	Earnings
		(A) Private Account	**(B)** Group Account	**(C)=0.04 x(A)**		**(E)=(B) +(D)**	**(F) = 0.03 x (E)**	**(G) = (C) + (F)**
1	13							
2	13							
3	13							
4	13							
5	13							
6	13							
7	13							
8	13							

Appendix B

Table A.1: Regression Results Using VCM Results as Primary Independent Variable

	Influenza	***HepA***	***DTaP***	***MMR***
VCM	0.011 (0.048)	-0.026 (0.062)	0.052 (0.061)	0.043 (0.061)
Dist. From Healthcare Provider	-0.018 (0.103)	-0.291*** (0.121)	-0.240** (0.118)	-0.240** (0.119)
Age of Adult	-0.014 (0.015)	0.061** (0.026)	0.011 (0.022)	0.023 (0.021)
Race	-0.086 (0.448)	0.713 (0.478)	1.042** (0.479)	0.817* (0.476)
Religion	0.130 (0.309)	0.292 (0.398)	0.138 (0.451)	-0.001 (0.372)
Highest Level of Education	0.000 (0.056)	-0.163** (0.078)	-0.056 (0.080)	-0.124 (0.076)
Employment Status	0.021 (0.064)	-0.037 (0.081)	0.008 (0.088)	-0.066 (0.080)
Household Income	0.134 (0.131)	0.188 (0.167)	0.338* (0.180)	0.342** (0.166)
Constant	0.475 (0.729)	-0.378 (0.927)	-0.303 (0.947)	0.078 (0.878)

Note: * ≥ 90% significant ** ≥ 95% significant *** ≥ 99.9% significant

Table A.2: Regression Results Using Social Network Results as Primary Independent Variable

	Influenza	***HepA***	***DTaP***	***MMR***
Social Network	0.411*** (0.065)	0.437*** (0.088)	0.384*** (0.097)	0.283*** (0.075)
Dist. From Healthcare Provider	0.039 (0.113)	-0.279** (0.137)	-0.274** (0.140)	-0.217* (0.125)
Age of Adult	-0.026 (0.017)	0.086*** (0.033)	0.006 (0.268)	0.022 (0.024)
Race	-0.088 (0.461)	0.947* (0.522)	1.176** (0.509)	0.846* (0.491)
Religion	-0.102 (0.349)	0.111 (0.456)	-0.036 (0.530)	-0.238 (0.399)
Highest Level of Education	0.019 (0.061)	-0.203** (0.091)	-0.065 (0.092)	-0.135* (0.082)
Employment Status	-0.035 (0.072)	-0.071 (0.091)	-0.029 (0.096)	-0.116 (0.086)
Household Income	0.215 (0.150)	0.208 (0.193)	0.460** (0.205)	0.413** (0.181)
Constant	0.732 (0.787)	-0.723 (1.054)	-0.132 (1.023)	0.234 (0.922)

Note: * ≥ 90% significant ** ≥ 95% significant *** ≥ 99.9% significant

Table A.3: Regression Results Using Community Results as Primary Independent Variable

	Influenza	***HepA***	***DTaP***	***MMR***
Community	0.301*** (0.116)	0.393*** (0.133)	0.148 (0.145)	0.390*** (0.129)
Dist. From Healthcare Provider	0.003 (0.105)	-0.272** (0.123)	-0.286** (0.127)	-0.231* (0.122)
Age of Adult	-0.011 0.015	0.067*** (0.265)	0.013 (0.023)	0.026 (0.022)
Race	-0.059 (0.452)	0.852* (0.490)	1.003** (0.474)	0.088* (0.483)
Religion	0.131 (0.310)	0.274 (0.409)	0.121 (0.449)	-0.037 (0.380)
Highest Level of Education	0.010 (0.056)	-0.135* (0.079)	-0.053 (0.080)	-0.103 (0.077)
Employment Status	0.003 (0.065)	-0.055 (0.168)	-0.004 (0.089)	-0.100 (0.083)
Household Income	0.085 (0.132)	0.109 (0.168)	0.307* (0.182)	0.275 (0.169)
Constant	-0.924 (0.918)	-2.405** (1.188)	-0.883 (1.156)	-1.734 (1.107)

Note: * ≥ 90% significant ** ≥ 95% significant *** ≥ 99.9% significant

Appendix C

Table B.1: Marginal Effects Using VCM Results as Primary Independent Variable

	Influenza	***HepA***	***DTaP***	***MMR***
VCM	-0.018	0.004	0.007	0.002
Dist. From Healthcare Provider	-0.037	-0.089	-0.074	-0.073
Age of Adult	-0.003	0.007	0.008	0.004
Race	0.000	0.011	0.006	0.017
Religion	0.008	0.004	0.018	-0.009
Highest Level of Education	0.009	-0.006	-0.005	0.008
Employment Status	0.0100202	-0.02	0.015	0.012
Household Income	0.023	0.103	0.077	0.062

Table B.2: Marginal Effects Using Social Network Results as Primary Independent Variable

	Influenza	***HepA***	***DTaP***	***MMR***
Social Network	0.131	0.053	0.046	0.043
Dist. From Healthcare Provider	-0.009	-0.078	-0.062	-0.063
Age of Adult	-0.004	0.007	0.009	0.004
Race	0.009	0.024	0.031	0.011
Religion	0.007	0.019	0.010	-0.007
Highest Level of Education	0.008	-0.007	-0.010	0.007
Employment Status	-0.012	-0.033	0.008	0.006
Household Income	0.042	0.109	0.080	0.065

Table B.3: Marginal Effects Using Community Results as Primary Independent Variable

	Influenza	***HepA***	***DTaP***	***MMR***
Community	0.069	0.119	0.018	0.059
Dist. From Healthcare Provider	-0.029	-0.083	-0.074	-0.069
Age of Adult	0.002	0.011	0.009	0.006
Race	0.007	0.022	0.035	0.018
Religion	-0.008	0.019	0.007	0.025
Highest Level of Education	0.011	0.000	-0.006	0.009
Employment Status	0.009	-0.026	0.014	0.010
Household Income	0.020	0.089	0.073	0.056

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