Title

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Publication Date

2022-11-01

DOI

10.1016/j.ypmed.2022.107288

Peer reviewed

Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Preventive Medicine 164 (2022) 107288

Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

Parental refusal and hesitancy of vaccinating children against COVID-19: Findings from a nationally representative sample of parents in the U.S.

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ARTICLE INFO

Keywords:
COVID-19
Vaccine
Children
Parents
Discrete choice experiment

ABSTRACT

The uptake rate of COVID−19 vaccines among children remains low in the U.S. This study aims to 1) identify sociodemographic and behavioral factors influencing parental refusal of vaccinating children, and 2) quantify the relative importance of vaccine characteristics in parental hesitancy of vaccinating children. An online survey was conducted from October to November 2021 among a probability-based, representative sample of 1456 parents with children under age 18. The survey included a discrete choice experiment asking parents to choose between two hypothetical COVID-19 vaccine alternatives with varying levels of characteristics in 10 hypothetical scenarios. Logistic regressions were used to estimate parental refusal (refused to choose any vaccine alternatives in all hypothetical scenarios) and random parameter logit regressions were used to estimate parental hesitancy (choice of vaccine alternatives depended on vaccine characteristics) of vaccinating children. About 20% parents refused to vaccinate children. The refusal is predicted by parents' sociodemographic characteristics, political orientation, vaccination status, and parents' and children's previous exposure with COVID-19. Among parents who were willing to consider vaccinating children, the most important vaccine characteristics are risk of severe side effects (31.2% relative importance) and effectiveness (30.7%), followed by protection duration (22.6%), local coverage (9.4%), and hospitalization rate of unvaccinated children (6.1%). Our findings imply that policymakers and public health professionals could develop outreach programs at community level to encourage specific subgroups and focus on vaccination depoliticization. Effectively communicating the low risk of severe side effects and high effectiveness of the vaccines may relieve some of the parental hesitancy.

1. Introduction

As of August 2022, children accounted for 18.4% of all COVID-19 (SARS-CoV-2) cases in the U.S with an overall rate of ~19,000 cases per 100,000 children. (American Academy of Pediatrics, 2022b) Although most children showed milder symptoms compared to adults, some developed serious illnesses such as multiple inflammatory syndrome that require hospitalization or experienced long-lasting clinical symptoms. (Buonsenso et al., 2021; Encinosa et al., 2022; Feldstein et al., 2020; Kim et al., 2020) Outbreaks of COVID-19 in schools and daycare centers also disrupted children's education and social life. (Browne et al., 2021; Patrick et al., 2020; Reimers, 2022).

Vaccination is an effective way to protect against the health effects resulted from COVID-19, including among children. The Centers for Disease Control and Prevention previously recommended that "everyone ages 5 and older get a COVID-19 vaccine" and now expands the recommendation to "everyone 6 months and older". (Centers for Disease Control and Prevention, 2022) According to its records, nearly 94% of 6 month to 4 year olds, 63% of 5–11 year olds, and 31% of 12–17 year olds have not received at least one dose of the vaccines as of August 2022. (American Academy of Pediatrics, 2022a) Parents are the primary decision makers for children's vaccination in the U.S.: 42 states require parental consent before a child receives a COVID-19 vaccine. (Kaiser Family Foundation, 2021) Understanding the factors associated with parental intentions is critical for policies and prevention programs that aim to increase the uptake rate of COVID-19 vaccines among children.

All of the existing studies in the U.S. focus on sociodemographic characteristics, behaviors, and perceptions to predict parental intentions of vaccinating children against COVID-19. A systematic review of 44 studies estimates that the overall proportion of parents intending to vaccinate their children against COVID-19 is 60.1% with a wide range from 25.6% to 92.2%. (Galanis et al., 2022) The common predictors of the intention include sociodemographic characteristics of the parents, age of the children, attitudes of parents regarding vaccination,

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https://doi.org/10.1016/j.ypmed.2022.107288
Received 16 May 2022; Received in revised form 29 September 2022; Accepted 2 October 2022
Available online 10 October 2022

children's and parents' vaccination history, compliance with prevention measures, and trust in public health agencies and personnel. The generalizability of these survey-based studies is usually limited by convenience sampling and/or sampling in specific regions or groups. Studies in the U.S. and other countries assessing adults' preferences for COVID-19 vaccines suggest that vaccine characteristics significantly influence the vaccine uptake among adults. (Craig, 2021; Eshun-Wilson et al., 2021; Kreps and Kriner, 2021; Motta, 2021a; Vasquez and Trudeau, 2021; Zimba et al., 2021) To our knowledge, however, no studies have evaluated the impacts of COVID-19 vaccine characteristics on parental intentions of vaccinating children.

This study aims to identify sociodemographic and behavioral factors influencing parental refusal and quantify the relative importance of vaccine characteristics in parental hesitancy of vaccinating children against COVID-19. We expect to make two contributions. This is among the very few studies in the U.S. that uses a probability-based, representative sample of parents in household population to make the findings generalizable. (Szilagyi et al., 2021) This is the first study in the U.S. and other countries that adopts discrete choice experiments to causally estimate parents' trade-offs between different COVID-19 vaccine characteristics.

2. Methods

2.1. Study design

The study uses a cross-sectional online survey with a discrete choice experiment (DCE) involving hypothetical vaccine choice scenarios to simulate parental intentions of vaccinating their children against COVID-19. DCE is a stated-preference method commonly used to examine preferences for vaccine characteristics. (Borriello et al., 2021; Determann et al., 2014; Hall et al., 2002; Lack et al., 2020; Michaels-Igbokwe et al., 2017) It is particularly appropriate in this study. 1) Because choice scenarios are hypothetical, DCE provides opportunities to examine vaccines that are not yet available in the market or to certain population (such as children under age 5 in the U.S. at the time of interview). 2) DCE can yield causal findings because it estimates within-individual variations in choice scenarios. The study is approved by Human Research Protections Program at University of California San Diego.

2.2. Study sample

A representative sample of parents with children under age 18 in the U.S. household population were recruited from the online panel AmeriSpeak® to complete a 15-min online survey from October 14 to November 22, 2021. Operated by National Opinion Research Center (NORC) at the University of Chicago, AmeriSpeak® is a probability-based, nationally representative online panel of the U.S. household population. The current AmeriSpeak panel consists of 48,900 members residing in over 40,000 households, providing sample coverage of approximately 97% of the U.S. residential population. Households in the AmeriSpeak® panel were randomly selected using area probability and address-based sampling from the NORC National Sample Frame.

This study sample of parents was drawn from the AmeriSpeak® using sampling strata based on age, race/ethnicity, education, and gender. A total of 1473 respondents completed the survey. After removing 17 respondents with incomplete information on key variables, the final analytical sample includes 1456 parents. The sample size in this study is greater than the minimum sample size recommended by Johnson and Orme for this specific DCE design (recommended $n = 100$) as well as over 90% of the DCE studies in healthcare research summarized in de Bekker-Grob et al. (de Bekker-Grob et al., 2015; Johnson and Orme, 2010).

2.3. Discrete choice experiment

The core component of the survey is DCE questions on COVID-19 vaccine choices. We followed the good practices of DCE design recommended by the Task Force. (Bridges et al., 2011) In a series of hypothetical scenarios, we asked each parent to choose a vaccine from two vaccine alternatives for their child (youngest child if more than one child under 18). Parents could also opt out of choosing either vaccine alternative. Each vaccine alternative is characterized by five attributes and their associated levels (eTable 1). The five attributes include 1) effectiveness, 2) duration of protection, 3) local coverage (number of friends and peers vaccinated), 4) risk of severe side effects, and 5) risk of unvaccinated children requiring hospitalization. The attributes were selected based on the review of primary and secondary objectives listed in contemporaneous COVID-19 trials in children and prior research using DCEs to study COVID-19 vaccine preferences in adults. (Ali et al., 2021; Craig, 2021; Eshun-Wilson et al., 2021; Frenck Jr. et al., 2021; Kreps and Kriner, 2021; Motta, 2021a; Vasquez and Trudeau, 2021; Zimba et al., 2021) We did not consider cost in this study because COVID-19 vaccines are free in the U.S.

The three levels associated with effectiveness (95%, 85%, and 75%) were chosen based on efficacy data reported by COVID-19 vaccine trials in children. (Ali et al., 2021; Frenck Jr. et al., 2021) Because research about COVID-19 vaccine protection duration was still in progress, the three levels (6 months, 1 year, and 2 years) were chosen based on data on influenza vaccine and H1N1 vaccine. Prior research suggests that social influence, specifically the vaccination coverage among family and friends, is a strong predictor of vaccine uptake. (Gidengil et al., 2012; Hoogink et al., 2020) We therefore specified three levels of local coverage (3, 6 and 9 out of 10). Three levels associated with risk of severe side effects are none, 1 in a million, and 10 in a million, which reflect no reporting of serious adverse events among children during the trials for Pfizer-BioNTech vaccine. Finally, the two levels associated with risk of unvaccinated children requiring hospitalization include 1 in 1000 and 10 in 1000 unvaccinated children, reflecting that less than 1% of all COVID-19 cases in children required hospitalization at the time of interview.

Because the total number of possible vaccine alternatives is enormous (162), we randomly selected a fraction of vaccine alternatives and combined them into scenarios in five choice blocks. Each respondent was randomly assigned to one DCE block, each with 10 choice scenarios. Each choice scenario includes two vaccine alternatives and an opt-out option and allows overlapped levels for an attribute. Such design is a near optimal design accounting for statistical preciseness given the sample size (D-efficiency 86%).

To ensure data quality, prior to DEC questions we explained the vaccine choices and attributes in lay terms followed by a choice scenario example (eFig. 1). Inattention is a common concern in online surveys, particularly in DCE studies. We therefore added two attention checks. First, we asked the day of the week. Second, we included a test-retest at the end of a DCE block by duplicating a DCE choice scenario randomly selected from the 10 scenarios. Consistent choices in the test-retest could be considered an indicator of stable preferences. Inconsistent choices, however, could be due to learning effects or fatigue; we hence retained them in the main analysis to maximize external validity. (Bateman et al., 2008; Hess et al., 2012) We used sensitivity analyses to assess robustness of our results to attention checks.

2.4. Survey questions

In addition to DCE questions, we also collected the following information on parents and their children (youngest child if more than one child under 18): demographic and psychosocial characteristics, COVID-19 related status and behaviors, and COVID-19 and flu vaccination histories. We also asked parent's political orientation and attitudes towards COVID-19 related policies.

2.5. Outcome measures: refusal and hesitancy

We evaluated parental refusal and hesitancy of vaccinating their children against COVID-19. Consistent with previous literature, we defined parental refusal as a parent refusing to vaccinate children irrespective of vaccine characteristics (i.e., opting for no vaccination in all 10 scenarios) and defined parental hesitancy as a parent's acceptance depending on vaccine characteristics (i.e., choosing a vaccine alternative in at least one DCE scenario). (Schwarzinger et al., 2021).

2.6. Statistical analysis

Counts and percentages are reported on parent- and child-specific characteristics. A logistic regression was used on individual-level observations ($N = 1456$) to estimate the associations between parental refusal and parent- and child-specific characteristics. We also report the percentages of parents refusing vaccines for various reasons.

Among parents who did not refuse, a random parameter logit regression was used on choice-alternative-level observations to model parental hesitancy. Because hesitancy model relies on within-individual variations across DCE scenarios, the predictors only include five vaccine attributes with varying levels. A total of 1160 parents selected a vaccine at least in one of the 10 choice scenarios. Hence, the total number of alternatives for hesitancy analysis is 34,800 (1160*10*3). Compared to traditional conditional logit regression, random parameter logit regression is more flexible by allowing for preference heterogeneity as well as correlation between choice responses drawn from the same individual. It has been commonly used in studies examining vaccine preferences. (Hensher and Greene, 2003) Vaccine effectiveness, local coverage, and hospitalization rate of unvaccinated children were modeled as continuous variables and protection duration and risk of severe side effects were modeled as categorical variables. The decision of specifying continuous vs. categorical variable was made at the DCE design stage and based on the current practices in literature. (Borriello et al., 2021; Determann et al., 2014; Gidengil et al., 2012; Hoogink et al., 2020) All coefficients were specified as normally distributed. Results for effectiveness and local coverage are reported as per 10% increase instead of 1% increase to provide more precision in the estimates.

We calculated the relative importance of vaccine attributes following the previous literature. (Czoli et al., 2016; Hauber et al., 2016) Specifically, we first calculated the range of utility for each attribute as the difference between each attribute's highest and lowest estimated part-worth utility. The relative importance score was then calculated as the range of the particular attribute divided by the sum of all attribute ranges and expressed as a percentage. It should be noted that even though the relative importance scores for all the attributes sum to 100%, it does not imply that the five attributes considered in the study fully account for parents' vaccination decision in reality. Rather, the relative importance reflects the relative impact of the considered attribute on the total utility a parent could receive from a vaccine alternative.

We conducted the following supplementary analyses. 1) Because researchers may have different opinions about whether an attribute should be modeled as continuous or categorical, we report results with all the attributes modeled as categorical. 2) When we launched the survey, only children aged 12–17 were eligible to receive a COVID-19 vaccine. We therefore interacted vaccine attribute levels with a dichotomous variable for older children (12–17) in hesitancy model to detect heterogeneities by child age. 3) We excluded inattentive respondents who failed attention checks in hesitancy model. 4) We report frequencies and percentages of key COVID-19 descriptive variables.

Post-stratification weights provided by NORC were applied to all the statistics to generate nationally representative estimates. Statistical significance was defined as 2-sided $p < .05$. All analyses were performed in Stata/MP 16.1 software.

3. Results

3.1. Descriptive statistics of the sample

Table 1 reports parent and child characteristics. Compared to Census Bureau Current Population Survey in March 2021, our parent sample is representative of the U.S. parent population in terms of gender, race/ethnicity, age, and education (eTable 2).

Table 1
Descriptive Characteristics of the Study Sample, $N = 1456$.

Characteristics	Count (weighted %)
Parents' characteristics	
Gender	
Male	660 (44.8)
Female	796 (55.2)
Race/ethnicity	
Non-Hispanic white	923 (57.1)
Non-Hispanic black	143 (10.8)
Hispanic	270 (21.9)
Non-Hispanic other minority	120 (10.2)
Age	
18–29	160 (11.8)
30–44	931 (57.7)
45+	365 (30.5)
Education	
High school or less	235 (32.3)
Some college/associate degree	568 (25.4)
Bachelor's degree or higher	653 (42.3)
Household income	
<25 k	208 (17.8)
25-50 k	286 (18.1)
50-75 k	278 (19.0)
>75 k	684 (45.2)
Political orientation	
Democratic/democratic leaning	529 (36.4)
Republican/republican leaning	445 (30.1)
Independent/other	482 (33.5)
Occupation	
Essential worker in healthcare	166 (10.5)
Essential worker not in healthcare	519 (35.9)
Not essential worker	771 (53.6)
Ever tested positive for COVID-19 or had COVID-like symptoms	
Yes	695 (44.6)
No	761 (55.4)
COVID-19 vaccination status	
Received at least one dose	995 (66.5)
Not vaccinated	461 (33.5)
Flu vaccination status	
Vaccinated	629 (43.1)
Not vaccinated	827 (56.9)
Children's characteristics	
Gender	
Male	712 (48.9)
Female	709 (48.7)
Non-binary/third gender	6 (0.4)
Prefer not to answer	29 (2.1)
Age	
<5	476 (31.8)
5–11	625 (42.7)
12–17	355 (25.5)
Ever tested positive for COVID-19 or had COVID-like symptoms	
Yes	535 (34.8)
No	921 (65.2)
COVID-19 vaccine was recommended by a health professional	
Yes	359 (25.1)
No	1097 (74.9)
Flu vaccination status	
Vaccinated	670 (45.7)
Not vaccinated	786 (54.3)

3.2. Association between parents' and children's characteristics and parental refusal

Of the 1456 parents, 296 (20.3%) always refused to choose vaccines in all DCE scenarios. Table 2 presents the predictors of parental refusal from the logistic regression. The parents who refused are more likely to be female, non-Hispanic Black, Republican or Republican-leaning, essential worker not in healthcare sector, ever tested positive for COVID-19, having not vaccinated against COVID-19, and having not vaccinated against seasonal flu. The children whose parents refused are more likely to be younger, never tested positive for COVID-19, having not received recommendation of COVID-19 vaccine from a health professional, and having not vaccinated against seasonal flu.

eFigure 2 presents the reasons for parental refusal. The most cited reasons are "worried about long-term health consequences" and "too early to make vaccine decision".

Table 2
Association between Characteristics of Parents and Children and Parental Refusal of Vaccinating Children against COVID-19, N = 1456.

Characteristics	Odds ratio [95% CI]
Parents' characteristics	
Gender	
Male (reference)	1
Female	2.40[a] [1.48 to 3.89]
Race/ethnicity	
Non-Hispanic white (reference)	1
Non-Hispanic black	2.18[a] [1.58 to 3.01]
Hispanic	0.41[a] [0.35 to 0.48]
Non-Hispanic other minority	0.65[a] [0.53 to 0.81]
Age	
18–29 (reference)	1
30–44	0.84 [0.69 to 1.03]
45+	1.11 [0.73 to 1.71]
Education	
High school or less (reference)	1
Some college/associate degree	0.96 [0.57 to 1.63]
Bachelor's degree or higher	0.79 [0.50 to 1.24]
Household income	
<25 k (reference)	1
25-50 k	2.86[a] [2.28 to 3.59]
50-75 k	1.65[b] [1.21 to 2.25]
>75 k	2.44[c] [1.16 to 5.11]
Political orientation	
Democratic/democratic leaning (reference)	1
Republican/republican leaning	5.98[a] [4.74 to 7.55]
Independent/other	2.76[a] [2.40 to 3.17]
Occupation	
Essential worker in healthcare (reference)	1
Essential worker not in healthcare	2.30[a] [1.88 to 2.81]
Not essential worker	1.75 [0.90 to 3.39]
Ever tested positive for COVID-19 or had COVID-like symptoms	
No (reference)	1
Yes	1.35[a] [1.15 to 1.60]
COVID-19 vaccination status	
Received at least one dose (reference)	1
Not vaccinated	6.96[a] [5.12 to 9.46]
Flu vaccination status	
Vaccinated (reference)	1
Not vaccinated	1.83[b] [1.24 to 2.72]
Children's characteristics	
Age	
<5 (reference)	1
5–11	0.83 [0.69 to 1.01]
12–17	0.46[c] [0.23 to 0.93]
Ever tested positive for COVID-19 or had COVID-like symptoms	
No (reference)	1
Yes	0.75[c] [0.58 to 0.98]
COVID-19 vaccine was recommended by a health professional	
No (reference)	1
Yes	0.62[b] [0.46 to 0.83]
Flu vaccination status	
Vaccinated (reference)	1
Not vaccinated	1.41[b] [1.13 to 1.76]
Constant	0.004[a] [0.003 to 0.01]

Notes: [a]p < 0.001, [b]p < 0.01, [c]p < 0.05.

3.3. Association between vaccine characteristics and parental hesitancy

Table 3 reports the influences of vaccine characteristics on parental hesitancy from the random parameter logit model. Of the 1160 parents in the hesitancy model, 768 (66.2%) always chose a vaccine. Parent preference is predicted by higher effectiveness and longer protection duration of the vaccine, greater coverage among peers, lower risk of severe side effects, and lower rate of unvaccinated children getting hospitalized. Most estimated standard deviations are significant, suggesting substantial heterogeneities in preferences.

Figure 1 shows the relative importance of each vaccine attribute. The most important attributes are risk of severe side effects (31.2% relative importance) and effectiveness (30.7%), followed by protection duration (22.6%). Local coverage (9.4%) and hospitalization rate of unvaccinated children (6.1%) are the least important.

3.4. Supplemental analyses

eTable 3 reports results with all the attributes modeled as categorical. The results are comparable to the main analysis that models vaccine effectiveness, local coverage, and hospitalization rate of unvaccinated children as continuous.

Table 3
Association between Vaccine Characteristics and Parental Preferences for Vaccinating their Children against COVID-19, among Parents Who Did Not Consistently Refuse Vaccine Options in DCE Scenarios ($N = 1160$).

Variable	Coefficient [95% CI]	Standard deviation [95% CI]
Effectiveness (per 10%)	0.98[a] [0.87 to 1.09]	0.43[a] [0.33 to 0.52]
Protection duration		
6 months (reference)		
1 year	0.92[a] [0 0.79 to 1.06]	0.01 [−0.07 to 0.09]
2 years	1.44[a] [1.27 to 1.61]	0.62[a] [0.44 to 0.81]
Local coverage (per 10%)	0.10[a] [0.07 to 0.12]	0.14[a] [0.099 to 0.19]
Severe side effects		
None (reference)		
1 in 1000,000	-0.75[a] [−0.89 to −0.61]	0.31 [−0.04 to 0.67]
10 in 1000,000	-1.99[a] [−2.21 to −1.77]	1.04[a] [0.82 to 1.26]
Hospitalization of unvaccinated (per 1%)	-0.43[a] [−0.55 to −0.29]	0.81[a] [0.60 to 1.01]
Constant	4.37[a] [3.33 to 5.40]	2.70[a] [1.99 to 3.42]
No of DCE scenarios	34,800	
Log likelihood	−7881.87	
AIC	15,795.73	
BIC	15,931.05	

Notes: This table presents the results of the Random Parameter Logit model. Standard errors were clustered at the respondent level. [a]$p < 0.001$. The part-worth utilities of continuous attributes are reported as follows: 9.31, 8.33, and 7.35 for the three effectiveness levels (95%, 85%, and 75%, respectively), 0.90, 0.60, 0.30 for the three local coverage levels (90%, 60%, and 30%, respectively), and − 0.04, and − 0.43 for the two levels of hospitalization of unvaccinated (1 in 1000 and 10 in 1000, respectively).

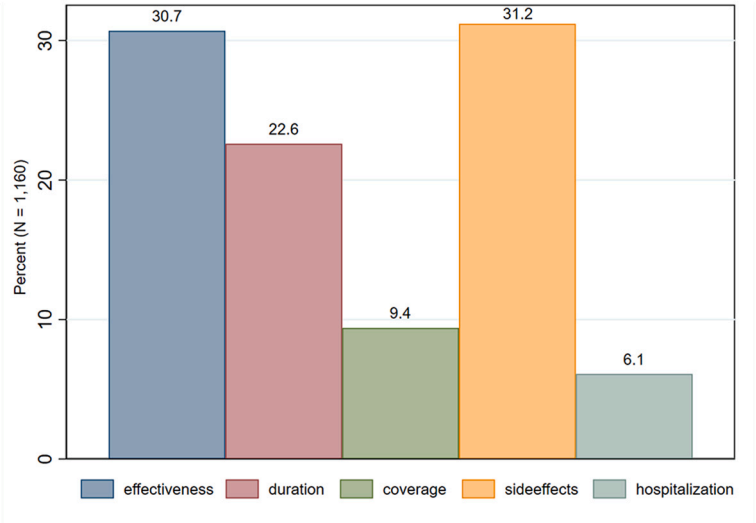

Fig. 1. Relative Importance of Vaccine Attributes in DCE Choices.
Notes: This figure presents the relative weights that parents placed on a particular vaccine attribute. For each attribute, the relative importance (expressed as a percentage) was calculated as the difference between the highest and the lowest estimated parameter of that attribute divided by the sum of all the attribute ranges. The cumulative relative importance adds up to 100%.

eTable 4 reports results from refusal model with interactions between vaccine characteristics and child age group. Heterogeneities in the associations are observed between the two age groups (0–11 vs. 12–17).

The main results of the parental hesitancy model still hold after we excluded respondents who failed the day-of-the-week attention check (1.6% of the sample) (eTable 5) and who failed the test-retest of the selected DCE scenario (23.1% of the respondents) (eTable 6).

eFigures 2–4 illustrate COVID-19 related behaviors and attitudes. The majority of parents (66.5%) had received at least one dose of COVID-19 vaccine and less than a quarter (22.8%) of parents indicated that they have no plan to receive vaccines in the next 12 months (eFigure 2.1). About 75.2% of the parents always or most of the time wore masks (eFigure 2.2). Among the 353 vaccine-eligible children aged 12–17, 61.3% received at least one dose of COVID-19 vaccine and 21.9% of the parents of the unvaccinated children stated that they were unlikely to vaccinate their children in the next 12 months (eFigure 3.1). Over two thirds of the children aged 2 and older always or most of the time wore masks (eFigure 3.2). Greater proportions of parents and children who received at least one dose of COVID-19 vaccines always or most of the time wore masks (eFigure 2.3 and eFigure 3.3).

About 47.1% of the parents disagreed with mandatory COVID-19 vaccination policy for children in schools (eFigure 4). The majority agreed that unvaccinated children should wear masks in schools and that new variants could become more dangerous to children. The majority of parents also worried that social isolation is detrimental for children's mental and physical health.

4. Discussion

This study finds that, after COVID-19 had continued over a year and a half, about 20% of the parents refused to vaccinate their children. Most of the factors that predict parental refusal are also suggested by previous studies. For example, non-Hispanic Black parents have a higher odds of refusal, possibly explained by a lack of trust due to racial inequalities in the healthcare system. (Alfieri et al., 2021; Ferdinand, 2021; Paradies et al., 2015; Rane et al., 2022; Szilagyi et al., 2021; Teasdale et al., 2021a; Teasdale et al., 2021b) The odds of a Republican or Republican-leaning parent refusing to vaccinate their child is almost six times the odds of a Democrat or Democrat-leaning parent doing so. It implies that continued partisan politicization of vaccination efforts undermines the confidence in COVID-19 vaccines. (Motta, 2021b; Rane et al., 2022) Future public health policies should focus on how to depoliticize vaccination. Debus et al. suggests that forming alliances and coalitions beyond political party and ideological lines to share a uniform message about vaccine safety and effectiveness could help. (Debus and Tosun, 2021) Parents' own status of vaccination against COVID-19 and seasonal flu strongly predict their intentions to vaccinate their children. (Rane et al., 2022; Szilagyi et al., 2021; Teasdale et al., 2021a; Teasdale et al., 2021b) Parents of younger children are less likely to consider vaccination. (Szilagyi et al., 2021).

Some predictors of parental refusal in our study are unique. For example, parents are less likely to vaccinate their children if they have tested positive or had COVID-19 like symptoms. It is possible that the concern on the safety of the vaccines outweigh the severity of COVID-19 consequences among these parents who experienced and survived COVID-19 themselves, a survivor bias. Greater efforts should be undertaken to understand and educate this specific group of parents. Another example is vaccine recommendation from a health professional, which is associated with a lower odds of refusal, implying that education and consultation from health professionals may be an effective way of reducing the refusal rate. A survey that specifically sampled vaccine-hesitant parents in the U.S. suggests that effective communication about COVID-19 vaccine among children should start with healthcare professionals. (Rhodes et al., 2020) Public health efforts are recommended to target marginalized groups without strong ties to the standard healthcare infrastructure, who are frequently the most persuadable vaccine refusers.

Among parents whose intentions relied upon vaccine characteristics, the most influential vaccine characteristics are risk of severe side effects and effectiveness. Such results are also revealed in recent research on COVID-19 vaccine preferences in adults. (Craig, 2021; Kreps and Kriner, 2021; Motta, 2021a; Vasquez and Trudeau, 2021) It appears that effectively communicating the low risk of severe side effects and high effectiveness of COVID-19 vaccines for children may relieve some of the parental hesitancy. Parents prefer vaccines that have been received by children's friends and peers. Local policies that encourage vaccine uptake in communities, especially via emphasizing safety and effectiveness, maybe most effective. Future research is encouraged to test different ways of communicating information at community level.

This study has limitations. First, even though DCEs could reasonably predict real-world health behaviors, they may still oversimplify real-life decision scenarios and hence reduce the external validity of the findings. (Quaife et al., 2018) For example, the hypothetical vaccine alternatives do not perfectly match the real vaccines from which parents choose in reality. Some parents already vaccinated their children in reality, so rethinking the decision in hypothetical scenarios may be less practical for them. The hypothetical scenarios do not consider all the constraints

faced by parents, such as lack of access to healthcare, time cost associated with receiving vaccines, or school mandates. Nonetheless, the tradeoff between external and internal validity is a limitation that almost all DCE designs suffer from.

Second, even though the levels of vaccine attributes reflect available findings from vaccine trials and other similar vaccines at the time of interview, they may not match the levels observed today. For example, the duration of vaccine protection seems to vary substantially with evolving virus variants. Similarly, vaccine effectiveness is lower against the new variants, even though still remains highly effective against serious illness. Therefore, generalizing our findings to new COVID-19 variants is somewhat limited.

Third, we did not examine preferences of children, which may differ from their parents. We asked parents to consider their youngest child if they had more than one, which could reduce the representativeness of the child sample. Not all parents in our study were fully or partially responsible for making vaccine decisions for their children.

Fourth, halfway through data collection, children aged 5–11 years became eligible to receive COVID-19 vaccines, which may have influenced parental intentions in this age group. We did not ask children's COVID-19 vaccination status if they were under 12.

Fifth, by design two vaccine choices in the same scenario could have different levels for an attribute. However, such inconsistency may lead to confusions among parents. This could be particularly problematic for local coverage and hospitalization rate of unvaccinated children, which in reality only one level could be possible in the population at a given time. Although such design is frequently used in vaccine literature, it may have confounded the results and could explain the lower relative importance of these two attributes. (Hoogink et al., 2020; Leng et al., 2021; Verelst et al., 2021; Verelst et al., 2018).

Further, self-reported responses may have bias related to social desirability and recall. Lastly, parental intentions may fluctuate over time.

5. Conclusions

Parental refusal and hesitancy are major issues for protecting children against COVID-19. In a nationally representative sample of parents, 20% of the parents refused to consider COVID-19 vaccines for their children. Parental refusal is predicted by parents' sociodemographic characteristics, political orientation, vaccination status, and parents' and children's previous exposure with COVID-19. Parents who were willing to consider vaccinating children perceive risk of severe side effects and effectiveness to be the most important vaccine characteristics. Our findings imply that policymakers and public health professionals could develop outreach programs to encourage specific subgroups and focus on vaccination depoliticization. Effectively communicating the low risk of severe side effects and high effectiveness of the vaccines may relieve some of the parental hesitancy.

Conflict of interest disclosure

Drs. Panchalingam and Shi report no conflict of interest.

Funding/support

Dr. Shi reports grants from the National Institute on Drug Abuse (award numbers R01DA042290 and R01DA049730) during the conduct of the study.

Role of the funder/sponsor

The funding organization had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

CRediT authorship contribution statement

Thadchaigeni Panchalingam: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data curation, Writing – original draft, Visualization. **Yuyan Shi:** Conceptualization, Methodology, Formal analysis, Investigation, Resources, Data curation, Writing – review & editing, Supervision, Project administration, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgement

We thank Harji Charaia for literature review and survey development.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ypmed.2022.107288.

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