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Longitudinal parental perception of COVID-19 vaccines for children in a multi-site, cohort study

Patrick Rivers, MPP[1], **Cynthia Porter, MS**[1], **Lindsay B. LeClair, MS**[2], **Zuha Jeddy, MPH**[2], **Ashley L. Fowlkes, ScD**[3], **Julie Mayo Lamberte, MSPH**[3], **Katherine Herder, MPH**[1], **Madeleine Smith, BS**[6], **Ramona Rai, MPH**[2], **Lauren Grant, MS**[3], **Kurt T. Hegmann, MD**[6], **Krystal Jovel, MA**[1], **Molly Vaughan, PhD**[2], **Clare Mathenge, BS**[2], **Andrew L. Phillips, MD**[6], **Sana Khan, PhD**[1], **Amadea Britton, MD**[3], **Tamara Pilishvili, PhD**[3], **Jefferey L. Burgess, PhD**[1], **Gabriella Newes-Adeyi, PhD**[2], **Manjusha Gaglani, MD**[4], **Alberto Caban-Martinez, DO**[5], **Sarang Yoon, DO**[6], **Karen Lutrick, PhD (SR)**[1] **PROTECT network**

[(1)]University of Arizona, Tucson, Arizona

[(2)]Abt Associates

[(3)]Centers for Disease Control and Prevention

[(4)]Baylor University

[(5)]University of Miami

[(6)]Utah University

Abstract

Objectives: Pediatric COVID-19 vaccine hesitancy and uptake is not well understood. Among parents of a prospective cohort of children aged 6 months to 17 years, we assessed COVID-19 vaccine knowledge, attitudes, and practices (KAP), and uptake over 15 months.

Methods: The PROTECT study collected sociodemographic characteristics of children at enrollment and COVID-19 vaccination data and parental KAPs quarterly. Univariable and multivariable logistic regression models were used to test the effect of KAPs on vaccine uptake; McNemar's test for paired samples was used to evaluate KAP change over time.

Results: A total of 2,837 children were enrolled, with more than half (61%) vaccinated by October 2022. Positive parental beliefs about vaccine safety and effectiveness strongly predicted vaccine uptake among children aged 5-11 years (aOR 13.1, 95% CI 8.5-20.4 and aOR 6.4, 95% CI 4.3-9.6, respectively) and children aged 12+ years (aOR 7.0, 95% CI 3.8-13.0 and aOR 8.9, 95% CI 4.4-18.0). Compared to enrollment, at follow-up parents (of vaccinated and unvaccinated

Corresponding author: Patrick Rivers, Department of Family and Community Medicine, University of Arizona, 655 N. Alvernon Way, Tucson, AZ 85712, privers@arizona.edu.

Disclosures

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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children) reported higher self-assessed vaccine knowledge, but more negative beliefs towards vaccine safety, effectiveness, and trust in government. Parents unlikely to vaccinate their children at enrollment reported more positive beliefs on vaccine knowledge, safety, and effectiveness at follow-up.

Conclusion: The PROTECT cohort allows for an examination of factors driving vaccine uptake and how beliefs about COVID-19 and the COVID-19 vaccines change over time. Findings of the current analysis suggest that these beliefs change over time and policies aiming to increase vaccine uptake should focus on vaccine safety and effectiveness.

Background

Despite recommendations from the Centers for Disease Control and Prevention's (CDC) Advisory Committee on Immunization Practices for all youth aged 6 months and older to receive COVID-19 vaccines,[1-3] vaccination rates remain relatively low. Less than 10% of children 6 months to 4 years, 39% of children aged 5-11 years, and 72% of children aged 12-17 years had received at least one dose of a COVID-19 vaccine as of March 2023.[4] There is a burgeoning literature on the knowledge, attitudes, and practices (KAP) of adults relating to COVID-19 vaccines[5-9] and their relationship to vaccine uptake; however, data for pediatric populations are limited.[10] KAP data have been previously utilized to understand COVID-19 vaccine uptake and acceptance over time among adults.[6,11]

Parental hesitation of routine childhood immunizations have been linked to religious exemption, concerns about vaccine safety, and social determinants of health – such as race/ethnicity and education.[5,12,13] Misconceptions about the safety of COVID-19 vaccines as well as concerns about vaccines in general have also been identified as barriers to uptake of COVID-19 vaccines.[14] COVID-19 vaccine hesitancy may also be linked to the general antivaccine movement,[12] and individual political views.[15] Unvaccinated parents have broadly reported an unwillingness to vaccinate their children, especially those less than 5 years of age, with nearly half of parents reporting they will definitely not vaccinate their young children, and one-quarter to one-third undecided.[16-18] Additional research is required to better understand COVID-19 vaccine hesitancy among parents, how vaccine perceptions evolve over time, and vaccine uptake among pediatric populations.[10]

An examination of the KAPs of parents as they relate to their children can help elucidate factors associated with COVID-19 vaccine acceptability and uptake. Using data collected through prospective cohorts of children and their parents, we examined parental COVID-19 vaccine KAPs as predictors of vaccine uptake in children and assessed individual-level change in KAP responses over 15 months.

Methods

Study design and population:

The Pediatric Research Observing Trends and Exposures in COVID-19 Timelines (PROTECT) study is a prospective cohort of children aged 6 months to 17 years initiated July 2021 in Arizona, Florida, Texas, and Utah in both rural and urban sites; for this analysis, we used data collected through October 13, 2022.[19] PROTECT is a companion

study to the HEROES-RECOVER study, two cohorts of frontline workers aged ≥18 years: the Arizona Healthcare, Emergency Response, and Other Essential Workers Surveillance (HEROES) study and the Research on the Epidemiology of SARS-CoV-2 in Essential Response Personnel (RECOVER) study.[20,21] PROTECT recruitment included the children of HEROES-RECOVER participants and from the community. Community recruitment strategies included radio and social media advertisements, outreach at local events, and phone banking. Parents (or legal guardians) provided informed consent and children aged 7 to 17 years provided assent for study participation. This study protocol was reviewed and approved by the Abt Associates Institutional Review Board (IRB) (which serves as the single IRB of record for the Florida, Texas, and Utah sites and CDC), by the University of Arizona IRB for the Arizona site, and CDC.

Data Collection

Upon enrollment, parents reported their child's sociodemographic information (e.g., household income, race/ethnicity, and gender), SARS-CoV-2 infection history, and medical history (e.g., medical insurance, vaccinations, medical conditions, and daily medication use).

Parents' intention to vaccinate their children with COVID-19 vaccine and KAPs were assessed through a series of questions about knowledge, attitudes towards the safety and effectiveness, trust in government information, intent to vaccinate, and perceived risk of COVID-19 infection without receiving the COVID-19 vaccine (Supplement). Responses at enrollment were considered baseline and questions were readministered every 90 days to assess change.

COVID-19 vaccination status was collected at enrollment if the child was eligible to receive the vaccine. Parents of children enrolled before they were eligible to receive the vaccine were asked as soon as the child became eligible (COVID-19 vaccines in children were approved by the U.S Food and Drug Administration under Emergency Use Authorization on: December 11, 2020 for children aged ≥16 years;[22] May 10, 2021 for children aged 12-15 years;[23] October 29, 2021 for children aged 5-11 years;[24] and June 17, 2022 for children aged 6 months to 4 years).[25] Parents continued to receive surveys about their child's initial series of COVID-19 vaccines until the series was completed. Vaccination was verified by parent-submitted vaccination cards, electronic medical records, or State Immunization Information Systems, as available.

Analysis

The first outcome was COVID-19 vaccine uptake, defined as the proportion of children who had received at least one COVID-19 vaccine dose at the time of analysis (October 13, 2022). Vaccine intention was derived using child's vaccination status at enrollment and parents' response to, "What are the chances that [child's first name] will get a COVID-19 vaccination?" Using responses on an 8-point Likert scale, children were grouped into three intention categories based upon parent responses and the child's vaccination status at time of enrollment: 1) *Reluctant*, defined as answers of "almost zero chance" or "very small chance," and unvaccinated; 2) *Undecided*, defined as answers of "small chance," "do not know," or "moderate chance" and unvaccinated, or 3) *Likely*, defined as answers of "large

chance," "very large chance," or "almost certain," or vaccinated at the time of enrollment. Intention categories were established based on information provided at enrollment to allow comparison over time (outcome 2).

Likert scores for each KAP question were condensed into three categories, with responses greater than the midpoint indicating positive associations, midpoint responses indicating neutral associations without direction, and responses below the midpoint indicating negative associations.

Statistical analysis

General study participant sociodemographic characteristics (age category, sex, race, and ethnicity), recruitment site, previous SARS-CoV-2 infection, parent insurance status, and household annual income were stratified by child's vaccination status and then further broken down by vaccine intention group, with Pearson's chi-squared tests used to determine differences within each group. Statistical significance was based on p-values < 0.05.

For the first objective, continuous measurements were expressed as means and standard deviations. Counts and percentages were used for categorical variables. Univariable and multivariable logistic regression models with robust standard errors[26] clustered at the household-level were used to test the effect of each KAP on vaccine uptake. Multivariable models were stratified by age group to account for differences in the timing of vaccine availability and adjusted for sociodemographic characteristics (sex, age, race, ethnicity, and household income of the participant), recruitment site, parent health insurance status, and SARS-CoV-2 infection prior to study enrollment as covariates. Statistical significance was based on 95% confidence intervals.

To assess changes in KAP responses over time, all parents who completed KAP questions at enrollment and 9-month follow-up were included. McNemar's test for paired samples was used to evaluate the proportion individuals whose KAP responses between enrollment and 9-month assessments changed from negative/neutral to positive (positive change) or from positive to negative/neutral (negative change). For parents with multiple children enrolled in the study, stratified random sampling was used to select one child from each household. Differences in KAP responses were examined within households to ensure the validity of the sampling method. Analyses were stratified by vaccine intention at baseline and vaccination status at follow-up. Statistical significance was based on p-values <0.05.

All statistical analyses were completed using SAS (version 9.4; SAS Institute Cary NC).

Results

Participant Characteristics

July 2021 to October 2022, 2,834 children from 1,712 households, an average of 1.6 children per household, (Figure 1) were enrolled in PROTECT; including 511 children (18%) aged 6 months-4 years, 1,529 (53%) aged 5-11 years, 610 (22%) aged 12-15 years, and 184 (7%) aged 16-17 years (Table 1). Nearly half were male (n=1,363, 48%), 58% (n=1,503) were non-Hispanic White, 30% (n=771) were Hispanic, and 67%

(n=1,910) resided in Arizona. Only 17% (n=464) reported a SARS-CoV-2 infection prior to enrollment.

Overall, 1,717 (61%) were vaccinated with at least one dose of a COVID-19 vaccine by the time of analysis (Table 1). Unvaccinated children were more frequently non-Hispanic Black or Hispanic or Other, uninsured, in a home with lower household annual income, or in Texas or Florida; unvaccinated children were also more likely to have reported a SARS-CoV-2 infection prior to enrollment (all $p<0.001$).

Parents of 2,709 children answered questions at enrollment about intention to vaccinate their children. Of this, 73% (n=1,970) were likely to vaccinate their child and 82% (n=1,625) of their children had received at least one dose of a COVID-19 vaccine by the time of analysis in October 2022 (Table 2). Of the 415 (15%) parents undecided about vaccinating their child at enrollment, 20% (n=84) had received at least one dose at follow-up and only 8 (2%) of the 324 (12%) parents unlikely to vaccinate their child were vaccinated.

Among children of parents likely to vaccinate at enrollment, children residing in Texas, Florida, and Utah, or in a household with a lower income, with children aged <5 years, uninsured, or non-Hispanic Black and Hispanic were less frequently vaccinated ($p<0.001$). Similarly, children of parents likely to vaccinate at enrollment, but who reported a SARS-CoV-2 infection prior to enrollment, were more likely to be unvaccinated at time of analysis ($p=0.02$).

KAP as predictor for vaccine uptake

In adjusted models, beliefs regarding vaccine safety, vaccine effectiveness, trust in government information about the vaccine, and chances of getting sick without the vaccine strongly predicted vaccine uptake in children aged 5 years and older. Parents of children aged 12 and older with positive beliefs towards COVID-19 vaccine safety were 7 times more likely to vaccinate their child (aOR 7.0, 95% CI 3.8-13.0) compared to parents responding neutrally and nearly 9 times more likely if reporting positive beliefs about COVID-19 vaccine effectiveness (aOR 8.9, 95% CI 4.4-18.0, Table 3a). Parents of children in this group who believed their child had higher chances of getting sick without a COVID-19 vaccine were over 8 times more likely to vaccinate their child (aOR 8.4, 95% CI 4.0-17.7) compared to parents responding neutrally, and nearly 5 times more likely if reporting more trust in government information about the COVID-19 vaccines (aOR 4.7, 95% CI 2.6-8.6).

Parents of children aged 5-11 years with positive beliefs in COVID-19 vaccine safety were 13 times more likely to vaccinate their child (aOR 13.1, 95% CI 8.5-20.4, Table 3b) than parents responding neutrally, and more than 6 times more likely to vaccinate their child if reporting positively about COVID-19 vaccine effectiveness (aOR 6.4, 95% CI 4.3-9.6). Parents of children in this age group who believed their child had higher chances of getting sick without a COVID-19 vaccine were 3 times more likely to vaccinate their child (aOR 3.0, 95% CI 1.9-4.6) compared to parents responding neutrally, and over 7 times more likely if reporting more trust in government information about the COVID-19 vaccines (aOR 7.4, 95% CI 4.7-11.9). Parents of children in this group were twice as likely to vaccinate

their child if they reported positively about their vaccine knowledge compared to parents responding neutrally (aOR 2.1, 95% CI 1.4-3.1).

A smaller number of vaccinated individuals in the under 5 years group led to model convergence issues, though similar trends held in the unadjusted models for both negative and positive KAPs (Table 3c).

Individual-level change in KAPs over time

A total of 1,134 PROTECT parents completed both enrollment and 9-month follow-up surveys and were included in the individual-level change over time analysis (Figure 2). One hundred and eighteen (17%) parents of children who were vaccinated and 57 (15%) parents of unvaccinated children changed responses regarding COVID-19 vaccine knowledge from a negative response at enrollment to a positive response at follow up ($p<0.0001$, and $p=0.02$ respectively) (Table 4a). A larger proportion of parents changed from a positive response at enrollment to negative at follow up regarding COVID-19 vaccine effectiveness among vaccinated (n=312, 44%, $p<0.001$) and unvaccinated (n=87, 23%, $p=0.001$) children. About a quarter of parents of vaccinated (n=175, 25%) and unvaccinated (n=85, 23%) children with positive responses at enrollment toward trust in government information about COVID-19 vaccines changed to negative at follow up ($p<0.001$). One hundred and thirty-one (19%) parents of vaccinated children also changed from a positive response at enrollment to a negative response at 9 months reporting their views about COVID-19 vaccine safety ($p=0.003$).

When analyzing the changes in KAPs from enrollment to the 9-month follow-up by vaccine intention group, a significant percentage of parents unlikely to vaccinate their children changed from a negative response at enrollment to a positive response at follow up, including 25 (20%) responding positively towards COVID-19 vaccine knowledge ($p=0.03$), 19 (16%) towards COVID-19 vaccine safety ($p=0.007$), and 27 (22%) towards COVID-19 vaccine effectiveness ($p=0.004$) (Table 4b). Among parents undecided about vaccination, 28 (17%) changed from providing negative responses at enrollment to positive responses at follow up to questions on COVID-19 vaccine knowledge ($p=0.005$) and 30 (18%) changed to positive responses on COVID-19 vaccine safety ($p=0.002$); however, 32 (20%) parents changed from providing positive responses at enrollment to negative at follow up on questions regarding trust in government information about COVID-19 vaccines ($p=0.011$). Parents likely to vaccinate their children changed from negative at enrollment to positive at follow up on COVID-19 vaccine knowledge (n=134, 16%, $p<0.001$), but a larger proportion changed from positive at enrollment to negative at follow up on COVID-19 vaccine safety (n=172, 21%), COVID-19 vaccine effectiveness (n=369, 45%), and trust in government information about COVID-19 vaccines (n=213, 27%, all $p<0.001$).

Discussion

The prospective nature of the PROTECT cohort enabled investigation of vaccine perception and uptake across a wide geographical area and the shifting nature of beliefs between July 2021 and October 2022, throughout youth vaccine availability. Children who were uninsured or had a lower household annual income were less likely to have received a vaccination. The

cohort was more vaccinated than the general population in all age groups, though children in younger age groups were less likely to be vaccinated. These broad sociodemographic and age trends match those found in the general population.[27] Children who experienced a SARS-CoV-2 infection prior to enrollment were also less likely to receive a vaccination, which is consistent with other findings,[28,29] and may be due to a belief in a protective effect or immunity from the previous infection. Even amongst parents likely to vaccinate their children, children under 5 years of age were less likely to be vaccinated, which may be partially explained by the shorter duration of availability.

After adjusting for sex, race/ethnicity, health insurance, household income, prior SARS-CoV-2 positivity, and site, favorable KAPs predicted vaccination. Vaccine effectiveness, vaccine safety, chances of getting sick without vaccination, and trust in government information about the vaccine were significant predictors for parents of children aged 5-11 and 12 and older. In parents of the older group, beliefs around vaccine effectiveness were the strongest predictor of child vaccination, with vaccine safety being the strongest in parents of those 5-11. These trends align with findings of parents of children <5 in this cohort.[30] Other studies have previously found vaccine intention in parents for their children to be associated with different sociodemographic factors and medical history, including parent vaccination status, though the number of studies has been limited, and their findings have been inconsistent.[31-34]

Vaccine perceptions among parents changed over the 15-month observation period. Parents who were likely to vaccinate their children felt more knowledgeable about COVID-19 vaccines 9 months post-enrollment compared to enrollment, but their beliefs about vaccine safety and effectiveness, and their level of trust in government information about the vaccines became more negative. Undecided parents were more positive about vaccine knowledge and vaccine safety, but trusted government information about the vaccines less. On the other hand, parents who were unlikely to vaccinate their child reported increased vaccine knowledge and more positive views on vaccine safety and vaccine effectiveness after 9 months.

This broad shift from more positive to negative over time may be due to most enrollment surveys being completed before the Omicron waves of COVID-19 in the United States, while most 9-month follow-up surveys were completed afterwards. It would seem likely the high rates of infection in child and adult populations would lead to more negative beliefs in several of these KAPs (e.g. beliefs relating to effectiveness and trust in government information about the vaccines), even among parents of vaccinated children. It is notable, though, that the general change from positive to negative responses in the likely to vaccinate group did not appear to significantly slow vaccine uptake, and the broad change to more positive associations in the unlikely to vaccinate group suggest some positive change. Therefore, increasing the likelihood of vaccination may be possible over time even among parents who had no intention of vaccinating their children when enrolled in PROTECT.

This study is subject to several limitations. First, due to enrollment and follow-up survey timing being tied to when a participant enrolled, and the fact that the follow-up surveys are not administered cross-sectionally to the entire cohort at the same time, it is difficult to draw

clear conclusions about cohort-level changes over time. Secondly, some parents may have interpreted the different KAP response options (e.g., a little knowledge, or somewhat safe, or very effective) differently. Third, because approximately two-thirds of the cohort came from Arizona, there may be somewhat limited generalizability, though the other sites span a wide geographical area. In addition, the study population of families willing to complete weekly nasal swabs and complete 9 months or more of follow-up may not be generalizable to the entire population. Fourth, KAP responses for children less than 5 years of age were relatively sparse due in part to the timing of vaccine availability and time enrolled in the study, which limited the ability to examine predictors of vaccine uptake accounting for potential confounders. Finally, the surveys do not capture parents' precise reasons for changes in KAPs over time, and further investigation would be warranted to elucidate why some KAPs may change over time.

Conclusion

The PROTECT cohort allows for useful examinations of the factors driving vaccine uptake and how beliefs about COVID-19 and the COVID-19 vaccines change over time. Our findings suggest that many of these beliefs do change over time and policies aiming to increase vaccine uptake should focus on reinforcing messaging around the safety profiles of the vaccines and their effectiveness.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations

PROTECT	Pediatric Research Observing Trends and Exposures in COVID-19 Timelines
HEROES	Arizona Healthcare, Emergency Response, and Other Essential Workers Surveillance
RECOVER	Research on the Epidemiology of SARS-CoV-2 in Essential Response Personnel
KAP	knowledge, attitudes, and practices
IRB	Institutional Review Board

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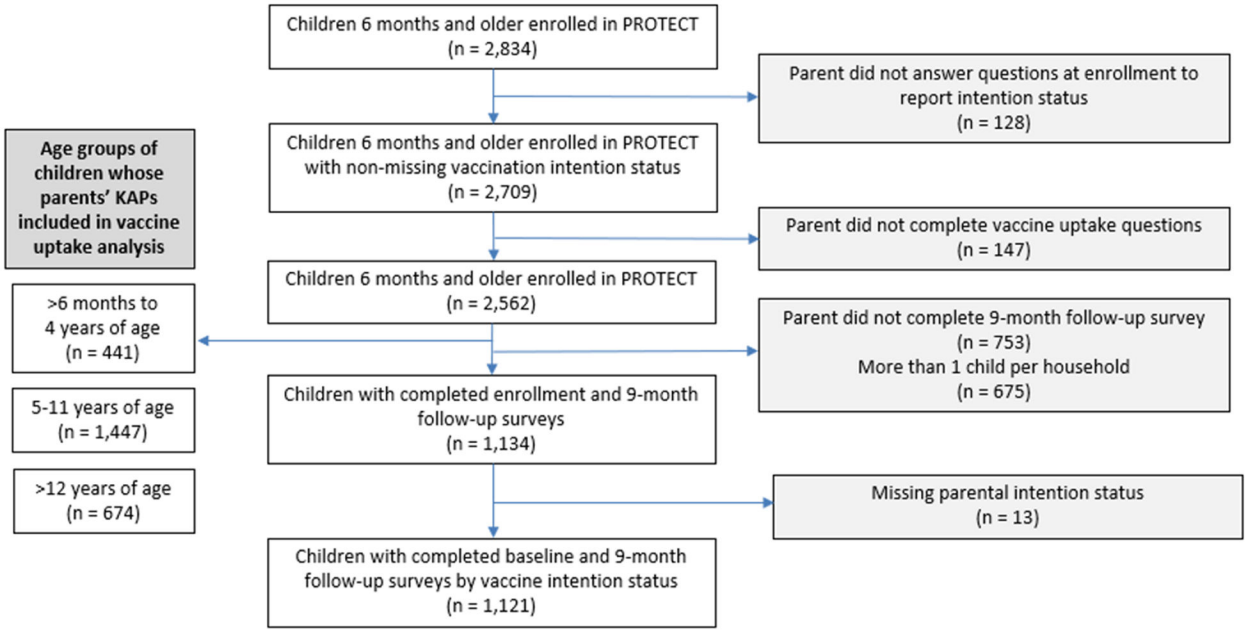

Figure 1.

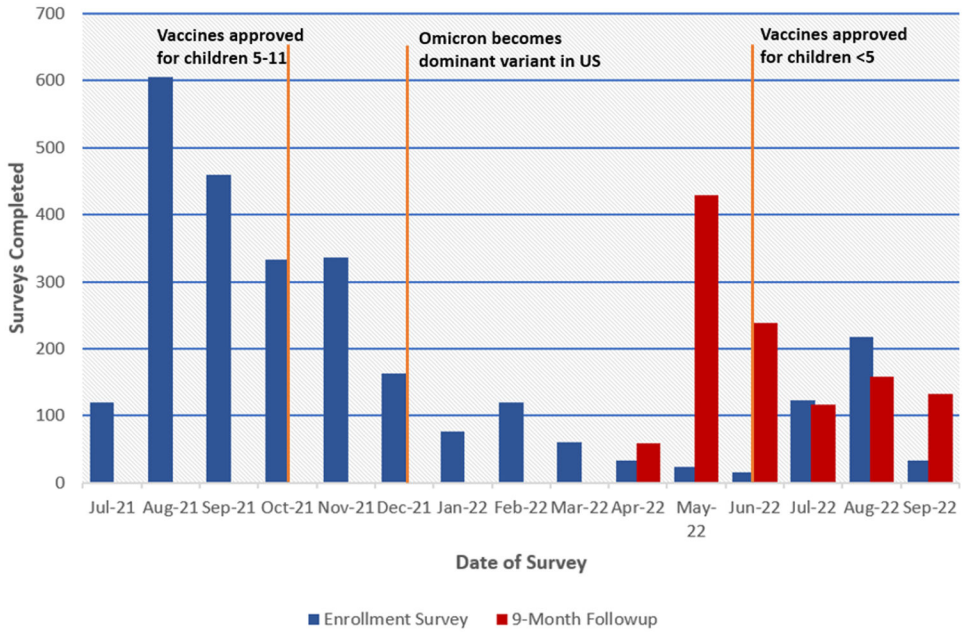

Figure 2.

Distribution of completed enrollment and 9-month follow-up parental KAP surveys in the PROTECT cohort by date, July 2021-September 2022

Table 1.

Characteristics of children aged 6 months and older in PROTECT[a], July 2021 to October 2022, stratified by COVID-19 vaccination status (n=2834)

Characteristic	Vaccinated[b] (n = 1717)		Unvaccinated (n = 1117)			Total (n = 2834)	
	No.	Row %	No.	Row %	*p-value* [c]	No.	Col %
Recruitment site					**<0.001** *		
Tucson, AZ	920	72.5	349	27.5		1269	44.8
Phoenix, AZ	267	70.1	114	29.9		381	13.4
Other AZ sites	155	59.6	105	40.4		260	9.2
BSWH,[d] TX	85	39.4	131	60.6		216	7.6
Salt Lake City, UT	156	54.3	131	45.7		287	10.1
Miami, FL	134	31.8	287	68.2		421	14.9
Age at Enrollment					**0.321**		
<5 years	145	28.4	366	71.6		511	18.0
5-11 years	1023	66.9	506	33.1		1529	53.4
12+ years	549	69.1	245	30.9		794	28.6
Sex [e]					**<0.001** *		
Male	832	61.0	530	39.0		1362	48.1
Female	861	63.6	492	36.4		1353	47.7
Missing	24	19.8	95	80.2		119	4.2
Race/Ethnicity					**<0.001** *		
NH White[f]	1004	66.8	499	33.2		1503	53.07.5
NH Black	29	38.2	47	61.8		76	2.7
NH Asian	53	69.7	23	30.3		76	2.7
Hispanic	431	55.9	340	44.1		771	27.2
Other	131	68.9	59	31.1		190	6.7
Missing	69	31.7	149	68.3		218	7.6
SARS-CoV-2 Infection Prior to Enrollment					**<0.001** *		
Yes	248	53.4	216	46.6		464	16.6
No	1469	62.8	865	37.2		2327	83.4
Parent Insured					**<0.001** *		
Yes	1644	64.8	893	35.2		2537	89.5
No	45	28.8	111	71.2		156	5.5
Missing	28	19.9	113	80.1		141	5.0
Household Annual Income					**<0.001** *		
$0-49,999	121	39.5	185	60.5		306	10.8
$50,000-$99,999	383	55.5	307	44.5		690	24.3
$100,000- $149,999	437	70.3	185	29.7		622	21.9
$150,000+	608	73.3	222	26.7		830	29.2

Characteristic	Vaccinated[b] (n = 1717)		Unvaccinated (n = 1117)			Total (n = 2834)	
	No.	Row %	No.	Row %	*p-value* [c]	No.	Col %
Missing	168	43.5	218	56.5		386	13.6

[*] Denotes statistically significant p-value

[a] PROTECT = Pediatric Research Observing Trends and Exposures in COVID-19 Timelines

[b] Child received at least one dose of a COVID-19 vaccine

[c] Pearson's chi-squared test used to generate p-values

[d] Baylor Scott & White Hospital

[e] Assigned at birth

[f] NH = Non-Hispanic

Table 2.

Characteristics of children in PROTECT, July 2021 to October 2022, aged 6 months and older, stratified by parental intention to vaccinate at enrollment and child's vaccination status at follow-up (n=2709)

	Unlikely to vaccinate child (n = 324)		Undecided (n = 415)			Likely to vaccinate child (n=1970)			Total[a] (n=2709)
Characteristic	**Vaccinated[b] (n = 8)**	**Unvaccinated (n = 316)**	**Vaccinated[b] (n = 84)**	**Unvaccinated (n = 331)**	***p-value*** [c]	**Vaccinated[b] (n = 1625)**	**Unvaccinated (n=345)**	***p-value*** [c]	
	No. (Col %)	**No. (Col %)**	**No. (Col %)**	**No. (Col %)**		**No. (Col %)**	**No. (Col %)**		**No. (Col %)**
Recruitment Site					*0.001			*<0.001	
Tucson, AZ	1 (12.5)	92 (29.1)	38 (45.2)	83 (25.1)		881 (54.2)	128 (37.1)		1225 (45.2)
Phoenix, AZ	1 (12.5)	34 (10.8)	21 (25.0)	35 (10.6)		245 (15.1)	34 (9.9)		371 (13.7)
Other areas in AZ	2 (25.0)	39 (12.3)	5 (6.0)	36 (10.9)		148 (9.1)	22 (6.4)		252 (9.3)
BSWH, TX	0 (0.0)	43 (13.6)	8 (9.5)	44 (13.3)		77 (4.7)	39 (11.3)		211 (1.8)
Salt Lake City, UT	1 (12.5)	31 (13.0)	4 (4.8)	41 (12.4)		151 (9.3)	56 (16.2)		284 (10.5)
Miami, FL	3 (37.5)	77 (24.4)	8 (9.5)	92 (27.8)		123 (7.6)	63 (18.3)		366 (13.5)
Age					0.711			*0.001	
<5 years	0 (0.0)	53 (16.8)	4 (4.8)	95 (28.7)		141 (8.7)	182 (52.8)		475 (17.5)
5-11 years	4 (50.0)	170 (53.8)	55 (65.5)	151 (45.6)		964 (59.3)	131 (38.0)		1475 (54.4)
12+ years	4 (50.0)	93 (29.4)	25 (29.8)	85 (25.7)		520 (32.0)	32 (9.3)		759 (29.9)
Sex [d]					0.782			0.599	
Male	6 (75.0)	170 (53.8)	40 (47.6)	167 (50.5)		786 (48.4)	177 (51.3)		1346 (49.7)
Female	2 (25.0)	145 (45.9)	44 (52.4)	163 (49.2)		815 (50.2)	166 (48.1)		1335 (49.3)
Refused	0 (0.0)	1 (0.3)	0 (0.0)	1 (0.3)		24 (1.5)	0 (0.0)		28 (1.0)
Race/Ethnicity					0.285			*0.0001	
NH White[e]	2 (25.0)	182 (57.6)	39 (46.4)	158 (47.7)		963 (59.3)	154 (44.6)		1500 (57.9)
NH Black	0 (0.0)	18 (5.7)	3 (3.6)	14 (4.2)		26 (1.6)	11 (3.2)		72 (2.8)
NH Asian	0 (0.0)	5 (1.6)	2 (2.4)	11 (3.3)		51 (3.1)	7 (2.0)		76 (2.9)
Hispanic	3 (37.5)	83 (26.3)	28 (33.3)	117 (35.3)		400 (24.6)	122 (35.4)		753 (29.1)
Other	0 (0.0)	10 (3.2)	8 (9.5)	12 (3.6)		123 (7.6)	35 (10.1)		189 (7.3)
Previous COVID-19 Infection					0.055			*0.020	
Yes	2 (25.0)	70 (22.2)	10 (11.9)	70 (21.1)		236 (14.5)	67 (19.4)		456 (16.9)

Characteristic	Unlikely to vaccinate child (n = 324)		Undecided (n = 415)			Likely to vaccinate child (n=1970)			Total[a] (n=2709)
	Vaccinated[b] (n = 8)	Unvaccinated (n = 316)	Vaccinated[b] (n = 84)	Unvaccinated (n = 331)	*p-value* [c]	Vaccinated[b] (n = 1625)	Unvaccinated (n=345)	*p-value* [c]	
	No. (Col %)	No. (Col %)	No. (Col %)	No. (Col %)		No. (Col %)	No. (Col %)		No. (Col %)
No	6 (75.0)	246 (77.8)	74 (88.1)	261 (78.9)		1382 (85.1)	275 (79.7)		2246 (83.1)
Parent Insured					*0.006			*<0.001	
Yes	7 (87.5)	288 (91.1)	82 (97.6)	280 (84.6)		1555 (95.7)	303 (87.8)		2515 (92.8)
No	0 (0.0)	22 (7.0)	2 (2.4)	45 (13.6)		43 (2.6)	34 (9.9)		146 (5.4)
Missing	1 (12.5)	6 (1.9)	0 (0.0)	6 (1.8)		27 (1.7)	8 (2.3)		48 (1.8)
Household Annual Income					0.362			*<0.001	
$0-$49,999	1 (12.5)	48 (15.2)	12 (14.3)	66 (19.9)		108 (6.6)	59 (17.1)		294 (12.1)
$50,000- $99,999	1 (12.5)	126 (39.9)	23 (27.4)	105 (31.7)		359 (22.1)	72 (20.9)		686 (28.3)
$100,000- $149,999	2 (25.0)	57 (18.0)	18 (21.4)	52 (15.7)		417 (25.7)	72 (20.9)		618 (25.5)
$150,000+	3 (37.5)	56 (17.7)	20 (23.8)	68 (20.5)		585 (36.0)	95 (27.5)		829 (34.2)

a. Children with missing vaccine intention group not included

b. Child received at least one dose of the vaccine by 6-month follow-up

c. Differences in characteristic distributions between unvaccinated and vaccinated children within the undecided and likely intention group evaluated using Pearson's chi-square tests. P-values not calculated for the unlikely intention group given the sparse cells

d. Assigned at birth

e. NH = Non-Hispanic

Table 3a.

Knowledge, attitudes, and practices (KAPs) at enrollment of parents of children ages 12+ in the PROTECT cohort as predictors of vaccine uptake at 9-month follow-up July 2021 to October 2022 (n=674)

	Unadjusted		Adjusted[a]	
	OR	**95% CI**	**OR**	**95% CI**
Chances of getting sick without vaccine				
Large to almost certain	6.93*	3.87-12.41	8.37*	3.97-17.67
Moderate chance	REF	REF	REF	REF
Small to almost zero	0.22*	0.12-0.39	0.23*	0.10-0.50
Vaccine knowledge				
A lot to a great deal	1.58*	1.03-2.44	1.26	0.74-2.13
Some	REF	REF	REF	REF
A little to nothing at all	0.83	0.49-1.39	1.34	0.70-2.57
Vaccine safety				
Extremely safe or very safe	7.13*	4.32-11.76	7.02*	3.78-13.01
Somewhat safe	REF	REF	REF	REF
Not too safe or not at all safe	0.08*	0.03-0.19	0.04*	0.01-0.15
Vaccine effectiveness				
Extremely effective or very effective	7.75*	4.63-12.97	8.90*	4.39-18.04
Somewhat effective	REF	REF	REF	REF
Not too effective or not at all effective	0.18*	0.09-0.36	0.17*	0.07-0.41
Trust in government information about the vaccine				
Strongly or mildly agree	7.20*	4.28-12.12	4.74*	2.61-8.61
Neutral	REF	REF	REF	REF
Strongly or mildly disagree	0.51*	0.30-0.87	0.34*	0.18-0.67

[a] Adjusted for age, sex, race/ethnicity, health insurance, household income, prior COVID-19 positivity, and site

* Statistically significant

Table 3b.

Knowledge, attitudes, and practices (KAPs) at enrollment of parents of children ages 5-11 in the PROTECT cohort as predictors of vaccine uptake at 9-month follow-up, July 2021 to October 2022 (n=1447)

	Unadjusted		Adjusted[b]	
	OR	**95% CI**	**OR**	**95% CI**
Chances of getting sick without vaccine				
Large to almost certain	3.96*	2.74-5.72	2.98*	1.92-4.63
Moderate chance	REF	REF	REF	REF
Small to almost zero	0.45*	0.31-0.64	0.41*	0.26-0.63
Vaccine knowledge				
A lot to a great deal	2.18*	1.54-3.09	2.06*	1.37-3.09
Some	REF	REF	REF	REF
A little to nothing at alla	0.55*	0.39-0.78	0.75	0.49-1.13
Vaccine safety				
Extremely safe or very safe	11.25*	7.81-16.20	13.14*	8.47-20.40
Somewhat safe	REF	REF	REF	REF
Not too safe or not at all safe	0.08*	0.03-0.21	0.07*	0.02-0.24
Vaccine effectiveness				
Extremely effective or very effective	8.05*	5.67-11.45	6.43*	4.30-9.63
Somewhat effective	REF	REF	REF	REF
Not too effective or not at all effective	0.07*	0.03-0.18	0.04*	0.01-0.15
Trust in government information about the vaccine				
Strongly or mildly agree	8.43*	5.75-12.34	7.43*	4.65-11.88
Neutral	REF	REF	REF	REF
Strongly or mildly disagree	1.44	0.92-2.23	1.59	0.95-2.65

[a] Child received at least one dose of COVID-19 vaccine by October 2022

[b] Adjusted for age, sex, race/ethnicity, health insurance, household income, prior COVID-19 positivity, and site

* Statistically significant.

Table 3c.

Knowledge, attitudes, and practices (KAPs) at enrollment of parents of children ages < 5 years in the PROTECT cohort as predictors of vaccine uptake at 9-month follow-up, July 2021 to October 2022 (n=441)[b]

	Unadjusted	
	OR	**95% CI**
Chances of getting sick without vaccine		
Large to almost certain	2.90*	1.84-4.59
Moderate chance	REF	REF
Small to almost zero	0.51*	0.28-0.91
Vaccine knowledge		
A lot to a great deal	1.68*	1.05-2.68
Some	REF	REF
A little to nothing at all	0.41*	0.28-0.72
Vaccine safety		
Extremely safe or very safe	6.26*	3.65-10.75
Somewhat safe	REF	REF
Not too safe or not at all safe	N/A	N/A
Vaccine effectiveness		
Extremely effective or very effective	3.26*	2.07-5.16
Somewhat effective	REF	REF
Not too effective or not at all effective	N/A	N/A
Trust in government information about the vaccine		
Strongly or mildly agree	7.31*	3.68-14.53
Neutral	REF	REF
Strongly or mildly disagree	3.27*	1.37-7.83

[a] Child received at least one dose of COVID-19 vaccine by October 2022

[b] Adjusted model failed to converge due to cell sparseness, so is omitted

* Statistically significant.

Table 4a.

Change in parental knowledge, attitude, and practice (KAP) responses of parents in regards to vaccination of their children in the PROTECT cohort during July 2021 to October 2022 by vaccine status from baseline to 9-month follow-up surveys[a] (n=1134)

	Vaccinated				Unvaccinated			
n, (% of sample) at 9 months	710 (62.6)				424 (37.4)			
KAP Responses at 9 months	**n**	**n (%) Change: Neg to Pos[b]**	**n (%) Change: Pos to Neg[c]**	**p-value[d]**	**n**	**n (%) Change: Neg to Pos**	**n (%) Change: Pos to Neg**	**p-value**
Chances of Getting Sick Without Vaccine	463	90 (19.4)	83 (17.9)	0.648	359	24 (6.7)	40 (11.2)	0.059
Vaccine Knowledge	707	118 (16.7)	42 (5.9)	<.0001*	381	57 (15.0)	33 (8.7)	0.015*
Vaccine Safety	700	78 (11.4)	131 (18.7)	0.003*	371	40 (10.8)	57 (15.4)	0.104
Vaccine Effectiveness	706	35 (5.0)	312 (44.2)	<0.001*	377	43 (11.4)	87 (23.1)	0.001*
Trust in Government information about the vaccine	695	66 (9.5)	175 (25.2)	<.0001*	367	45 (12.3)	85 (23.2)	0.0006*

a. Responses included if parents had completed KAP questions for both enrollment and 9-month follow-up surveys.

b. Number of parents (percentage of responses) who changed from negative/neutral KAP response to positive KAP response at follow-up.

c. Number of parents (percentage of responses) who changed from positive KAP response to negative/neutral KAP response at follow-up.

d. P-value from Mcnemar's exact test of matched pairs. H_0: Proportion of parents who changed from positive KAP response to negative/neutral KAP response is the same as the proportion of parents who changed from negative/neutral KAP response to positive KAP response at follow-up.

*Indicates statistically significant p-value

Table 4b.

Change in parental knowledge, attitude, and practice responses of parents regarding vaccination of their children in the PROTECT cohort during July 2021 to October 2022 by vaccine intention from baseline to 9-month follow-up surveys[a] (n=1121)

	Unlikely to vaccinate				Undecided				Likely to vaccinate			
n, % of sample at 9 months	125 (11.2)				168 (15.0)				828 (73.9)			
KAP Responses at 9 months	**n**	**n (%) Change Neg to Pos[b]**	**n (%) Change Pos to Neg[c]**	**p-value[d]**	**n**	**n (%) Change Neg to Pos**	**n (%) Change Pos to Neg**	**p-value**	**n**	**n (%) Change Neg to Pos**	**n (%) Change Pos to Neg**	**p-value**
Chances of Getting Sick Without Vaccine	117	5 (4.3)	105 (62.5)	0.99	147	17 (11.6)	14 (9.5)	0.720	576	94 (16.3)	109 (28.9)	0.326
Vaccine Knowledge	123	25 (20.3)	11 (17.7)	0.029*	165	28 (17.0)	7 (4.2)	0.005*	827	134 (16.2)	55 (6.7)	<0.001*
Vaccine Safety	118	19 (16.1)	5 (4.2)	0.007*	164	30 (18.3)	7 (4.3)	0.002*	816	76 (9.3)	172 (21.1)	<0.001*
Vaccine Effectiveness	122	27 (22.1)	9 (7.4)	0.004*	165	22 (13.3)	32 (19.4)	0.220	824	32 (3.9)	369 (44.5)	<0.001*
Trust in Government information about the vaccine	121	25 (20.7)	16 (13.2)	0.211	162	14 (8.6)	32 (19.8)	0.011*	808	74 (9.2)	213 (26.7)	<.0001*

[a] Responses included if parents had completed KAP questions for both enrollment and 9-month follow-up surveys.

[b] Number of parents (percentage of responses) who changed from negative/neutral KAP response to positive KAP response at follow-up.

[c] Number of parents (percentage of responses) who changed from positive KAP response to negative/neutral KAP response at follow-up.

[d] P-value from Mcnemar's exact test of matched pairs. H_0: Proportion of parents who changed from positive KAP response to negative/neutral KAP response is the same as the proportion of parents who changed from negative/neutral KAP response to positive KAP response at follow-up.

* Indicates statistically significant p-value