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Vaccine Literacy and Hesitancy Among Parents and Legal Guardians of Elementary School-Aged Children in Two Northern Indiana Cities

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Abstract

Parental refusal of childhood vaccines is a growing public health concern. Numerous reasons exist for this refusal, including religious, personal, and philosophical beliefs, and safety concerns. However, parental refusal of childhood vaccines is not simply an individualized problem for the family; this impacts herd immunity and affects the entire community. To improve vaccination rates among the pediatric population, understanding the thought process and decision-making behind parental opposition and refusal of vaccinations is essential. Using a survey developed to assess attitudes towards recommended childhood vaccines and the COVID-19 vaccine, this study examined the association between vaccine literacy and hesitancy among parents and legal guardians of elementary school-aged children in two northern Indiana cities. Responses were analyzed using Chi-squared tests on "R-4.1.1" software. Significant associations were found between COVID-19 hesitancy and vaccine literacy, and resistance towards all vaccines and vaccine literacy. No associations were found between hesitancy towards all vaccines and vaccine literacy, or hesitancy and literacy among different income and education brackets. Our results suggest that vaccine education may lessen vaccine hesitancy among parents and may be an essential factor in improving vaccination rates among the pediatric population.

Keywords: Vaccine literacy; vaccine hesitancy; immunity; beliefs; COVID-19 vaccine

Introduction

Vaccines have been and remain one of the most profound advancements in medical science. They are potent tools that bolster immune defenses, protecting individuals from debilitating diseases and often saving lives. The significance of vaccines extends beyond personal well-being, contributing to collective (herd) immunity within communities. By achieving high vaccination rates, we create a shield that guards vulnerable populations and reduces the spread of infectious diseases. Vaccines represent a cornerstone of public health efforts and a testament to our capacity to prevent and control potentially devastating illnesses. The recent SARS-CoV-2 pandemic has raised concerns regarding vaccine participation and immunity. Similar to discussions surrounding mask usage, SARS-CoV-2 vaccines have been discussed in the context of the safety and convenience of the individual rather than the importance of herd immunity and protecting immunosuppressed individuals [1]. These discussions are consistent with the observed rise in vaccine hesitancy and non-medical vaccine exemption trends in the U.S. [2]. This increase in vaccine hesitancy is concerning, as shown by an analysis of

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the 2018 measles epidemic in New York, which demonstrated that a vaccination rate of 79.5% was insufficient to guarantee herd immunity [1].

Vaccine hesitancy refers to delayed acceptance or refusal of vaccination despite the availability of vaccination services [3]. It covers a broad range of concerns regarding acceptance, including refusal of some vaccines and acceptance of others, delaying of vaccination, and acceptance of vaccination with some uncertainty. Thus, hesitancy encompasses a continuum ranging from individuals who accept all vaccinations without question to those who completely refuse them, with the hesitant individuals existing as a heterogenous population in between [3,4]. Furthermore, hesitancy refers to a behavioral phenomenon that is specific to vaccines and contexts, and is influenced by a number of factors including trusts and beliefs about vaccine efficacy, safety, and availability [3]. Understanding the factors that motivate or disincentivize individuals from getting immunized is crucial to maintain public health [5]. For example, some individuals may lack awareness about the safety and effectiveness of vaccines, or they may not fully comprehend the importance of population-wide participation in order to protect the entire community. Others may feel pressured to question scientific and medical consensus regarding vaccinations [6]. By recognizing and addressing these factors, efforts can be made to encourage individuals and communities to get vaccinated.

Several studies have attempted to shed light on factors that may contribute to vaccine resistance and hesitancy [7]. Researchers have developed survey instruments to examine potential correlations between vaccine hesitancy and political affiliations [8] and parents' beliefs about immunizations [4]. Examination of responses from focus groups has revealed that some parents object to vaccines due to fewer cases of vaccine-preventable diseases (VPDs) in the U.S. Some parents feel that vaccine-induced immunity is unnatural and express a lack of trust in expert opinions [4].

Other factors include philosophical beliefs, religious beliefs, and safety concerns [9]. As the prevalence of VPDs has decreased, the number of groups opposing vaccines on religious and philosophical grounds has increased, and this opposition is fundamental, unrelated to safety concerns. Historical examples, such as establishment of the Anti-Vaccination League in London in 1853, illustrate widespread objections to vaccination laws [10]. Religious objections to vaccines, as described by Lynnfield and Daum (2014), are often related to the origins of vaccines [9]. For example, Catholics may be concerned about vaccines derived from cell lines of aborted fetuses, while Jewish and Muslim individuals may be concerned about the porcine constituents in certain vaccines. Representatives from these religious denominations have typically advocated for vaccines, explaining that that those seeking to be immunized are not responsible for the abortions and that the porcine components undergo sufficient alteration during vaccine development. However, individual members within these denominations may still feel differently and choose not to vaccinate [9].

Surveys have proven to be valuable tools for examining the relationship between health literacy and utilization of medical services [11,12], as well as for investigating the factors associated with vaccine resistance and hesitancy. For example, Wang et al. (2018) conducted a survey to explore parents' opinions on vaccines following a scandal and their "vaccine literacy," or their knowledge of vaccines [13]. Based on current literature, vaccine literacy is defined as the extent of people's capacity to obtain and understand information regarding vaccination and related services [14,15]. While it is similar to health literacy in that it encompasses the knowledge, motivation, and competencies of an individual or the community to obtain, understand and apply information about vaccines, vaccination programs and immunization in making decisions for health care, disease prevention and health promotion [16–18], vaccine literacy incorporates distinct motivations about vaccines and vaccinations. Wang et al. (2018) found that parents with better vaccine literacy were more likely to trust vaccines [13]. Furthermore, these findings present an interesting question: if vaccine literacy is negatively correlated with vaccine hesitancy, increasing the public's understanding of vaccines could increase vaccine participation and help eliminate harmful diseases [19]. Vaccine literacy has been proposed to influence vaccination acceptance and therefore could be useful in addressing vaccine hesitancy [20]. Recent studies on potential correlations between vaccine literacy and hesitancy have produced conflicting results. One study conducted in urban and rural communities in India found a positive association between maternal health literacy and childhood vaccination with diphtheria-tetanus-pertussis (DTP3) [14]. In contrast, a different study conducted in Israel found a negative association between parental critical and communicative health literacy and compliance with vaccinations [19]. More research is needed to truly uncover whether these results are due to differences in other demographic factors or simply due to a lack of association between vaccine hesitancy and literacy.

This study aimed to examine the association between vaccine literacy and hesitancy in parents and legal guardians of elementary school-aged children residing within the periphery of South Bend and Fort Wayne, two cities located in northern Indiana. Due to the conflicting results described previously, we had no prediction whether an association would exist. The annual summary data from National Notifiable Diseases Surveillance System (NNDSS) of the Centers for Disease Control and Prevention (CDC) showed an overall reduced number of cases of vaccine preventable diseases in children aged <5 years in Indiana for 2020 compared to

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2019 (data accessed through https://wonder.cdc.gov/nndss-annual-summary.html). We did, however, predict that those parents who filed for vaccine exemptions, and were thus vaccine hesitant or resistant (refused vaccination for reasons other than an illness or allergy), would be the minority. Our prediction was based on the survey data from the Centers for Disease Control and Prevention (CDC) that estimated only 2.2% of kindergartners in Indiana were unvaccinated during the 2019-2020 school year [22].

Materials and Methods

A 25-question, anonymous survey was utilized to collect data from participating parents or legal guardians of elementary-age students in South Bend and Fort Wayne, Indiana, between September 23, 2021, to January 9, 2022. The survey questionnaire (Fig. A1-A2, see Appendix section) included questions regarding demographics (adapted from Evans, 2015) [23], child vaccination status, and parental understanding of vaccines. The survey was made available in English and Spanish for the bilingual population. Physical and electronic copies of flyers with QR codes linked to the survey were sent by principals and directors to parents and legal guardians at a public elementary school, private school, Early Childhood Development Center, and bilingual community center in South Bend, as well as two private schools in Fort Wayne, Indiana. Flyers were also posted on the parent Facebook pages for a private and a public school in South Bend, Indiana. Additionally, the survey was advertised by the Saint Mary's College Vaccine Ambassadors team while tabling on campus and at COVID-19 and influenza vaccine clinics at a local church in South Bend, Indiana. The survey was completed anonymously online. An informed consent was collected from each participant at the beginning of the survey. To be included in data analysis, participants had to answer "yes" to the first question, indicating they understood and agreed to the informed consent guidelines. If interested, participants could provide an email address to be entered in a drawing for a gift card, as an incentive for completing the survey. These email addresses were stored separately from the data and deleted after the drawing took place. This survey was approved by the institutional review board of Saint Mary's College (approval date: April 20, 2021).

For data analysis, a schematic approach was adopted with modifications from previous studies with similarly related objectives [13,19,23,24]. Participants were sorted into one of four groups according to their responses to the vaccine hesitancy and literacy questions (Figures 1 and 2). For example, the participant could be vaccine literate and unhesitant, vaccine literate and hesitant, vaccine illiterate and unhesitant, and vaccine illiterate and hesitant. Participants who answered at least three literacy questions correctly were considered "literate" and participants who answered at least two literacy questions incorrectly were considered "illiterate." Participants who left literacy questions blank or answered "prefer not to say," and therefore did not answer either at least three questions correctly or at least two questions incorrectly, were considered neither vaccine literate nor illiterate and were not included in the statistical analysis. In this study, vaccine hesitancy is defined as the delay of vaccination to a later time, and vaccine rejection or resistance is defined as the refusal of vaccination, assuming the refusal is not medically related [24]. Participants who answered "yes" to Question 11 ("Have you chosen not to vaccinate your child(ren) 'for reasons other than an illness or allergy?'" [4], and therefore deemed "resistant", were excluded from the hesitancy tests to prevent these participants from being included in the "unhesitant" group. Potential associations were analyzed with Chi-squared tests utilizing the "R-4.1.1" statistical software at a 95% confidence interval (https://cran.r-project.org/bin/windows/base/old/4.1.1/) [25]. The first Chi-Squared analysis examined hesitancy towards all vaccines and vaccine literacy. Hesitancy was assessed through Question 13 ["Did you choose to delay any of your child's vaccinations?" [4], and vaccine literacy was assessed using Questions 15 (Do you feel vaccines could harm your child? If you answered "yes," why do you think so?"), 16 ["Do you feel that there are better ways to build up your child's immunity, including them getting the diseases themselves? Please specify." [4], 18 ("Do you think you understand how vaccines work to build immunity?"), and 20 ("Do you think vaccinating your child will protect other children in the community?").

The second Chi-squared analysis examined COVID-19 vaccine hesitancy and vaccine literacy. COVID-19 vaccine hesitancy was assessed through Questions 17 ("Do you plan to get (one of the) COVID-19 vaccine shots for your children when they become available? Why do you feel that way?") and 23 ("Do you feel that the COVID-19 vaccine should be required for children to go to school?"), and vaccine literacy was assessed through Questions 15, 16, 18, and 20. Participants were asked if they planned to get their children vaccinated for COVID-19 when vaccines became available because children in this age group were not yet eligible for the vaccine when data collection began. The third Chi-squared analysis examined resistance towards all vaccines and vaccine literacy. Resistance was assessed through Question 11 ["Have you chosen not to vaccinate your child(ren) 'for reasons other than an illness or allergy?'" [4]], and vaccine literacy was assessed through Questions 15, 16, 18, and 20. Additional Chi-squared analyses were conducted to examine associations between hesitancy towards all vaccines and vaccine literacy in terms of participants' income and education levels. Participants were placed into income and education brackets based on their answers to Questions 7 ("What is your annual income?") and 8 ("What is the highest level of education you have received?"), respectively.

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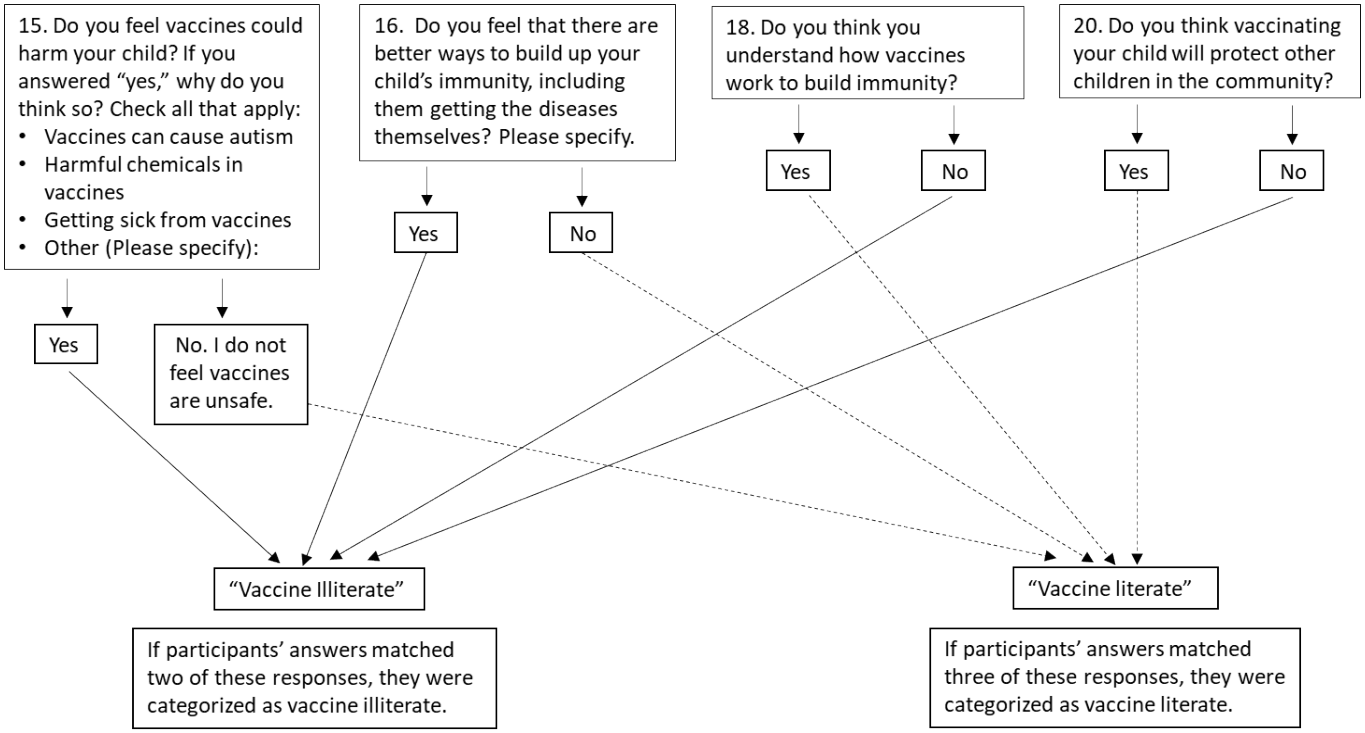

Figure 1: Flowchart for determining vaccine literacy

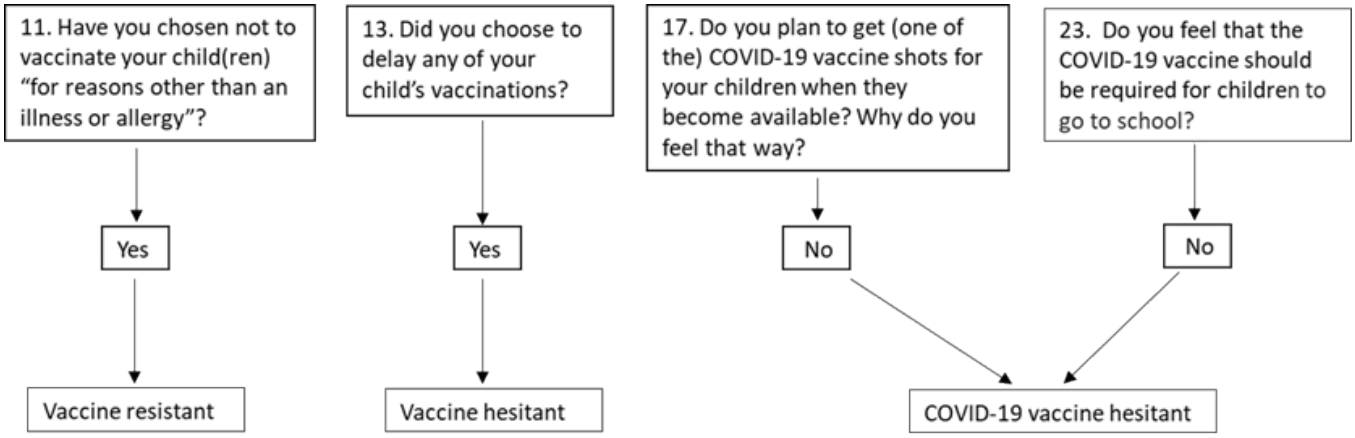

Figure 2: Flowchart for determining vaccine hesitancy

Results

A total of 115 responses were collected. Of the 115 participants who responded, 107 answered "I agree to participate" to Question 1 and were included in the statistical analysis. Demographics of the sampled population are shown in Table 1. The number of participating parents was sufficient to analyze the data, considering the high rate of vaccination coverage of >97% of kindergarteners in the sampled population [22]. Eighty-nine of the total responses were completed by mothers (Table 1). If participants identified with more than one race, they were only categorized as "mixed race" to avoid counting participants more than once.

Eighty-eight participants were unresistant and answered either "yes" or "no" to Question 13 ("Did you choose to delay any of your child's vaccinations?") [4] and were therefore "hesitant" or "unhesitant" towards all vaccines. 84 of these individuals also answered either at least three of the vaccine literacy questions correctly or answered at least two of the vaccine literacy questions incorrectly and were included in the first Chi-squared test. The remaining four were neither vaccine literate nor vaccine illiterate (Figure 3). Although the majority of literate individuals were not hesitant, no significant association between vaccine literacy and vaccine hesitancy was found (P>.05). Sixty-seven participants were

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unresistant and answered either "yes" for both Questions 17 ("Do you plan to get (one of the) COVID-19 vaccine shots for your children when they be-come available?") and 23 ("Do you feel that the COVID-19 vaccine should be required for children to go to school?") or "no" for both Questions 17 and 23 and were included in the second Chi-squared test which examined an association between vaccine literacy and vaccine hesitancy towards the COVID-19 vaccine (Figure 3). A significant association was observed between vaccine literacy and vaccine hesitancy towards the COVID-19 vaccine (P<.001). Vaccine literate parents were more likely than vaccine illiterate parents to be unhesitant to COVID-19 vaccination. 11 people said "yes" to Question 17 and "no" to Question 23, indicating they intended to immunize their child for COVID-19 but did not think the COVID-19 vaccine should be required for school. None of the participants said "no" to Question 17 and "yes" to Question 23 (Figure 3).

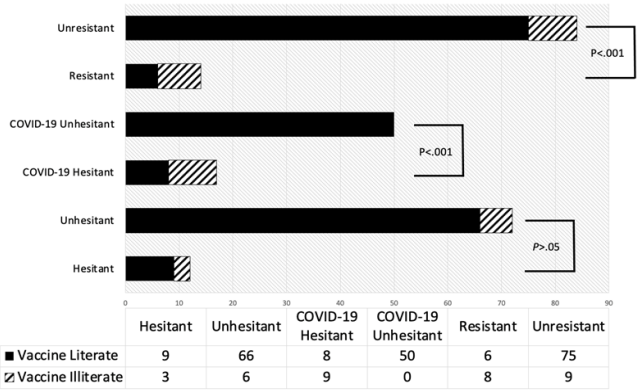
Table 1: Characteristics of the survey participants

Characteristic	N (%)*
Relationship to Child	
Mother	89 (83.2)
Father	16 (15.0)
Grandparent	1 (0.9)
Marital Status	
Married	85 (79.4)
Single	9 (8.4)
With Partner	7 (6.5)
Separated	1 (0.9)
Race/Ethnicity	
White	87 (81.3)
Hispanic or Latino	8 (7.5)
Mixed-race	4 (3.7)
Asian or South Asian	3 (2.8)
Black or African American	2 (1.9)
Age	
21-30 years	9 (8.4)
31-40 years	54 (50.4)
41-50 years	38 (35.5)
51 years or older	5 (4.6)
Religious Status	
Catholic Christian	54 (50.5)
Protestant Christian	19 (17.8)
Unaffiliated	12 (11.2)
Agnostic	7 (6.3)
Atheist	4 (3.7)
Other ("Christian-Anglican," "Christian," "Brethren Christian")	3 (2.8)
Non-protestant Christian (e.g. Mormon, Jehovah's Witness)	2 (1.9)
Orthodox Christian	1 (0.9)
Buddhist	1 (0.9)
Hindu	1 (0.9)
Annual Income	
Under $10,000	2 (1.9)
$10,000-$29,999	9 (8.4)
$30,000-$49,999	17 (15.9)
$50,000-$69,999	16 (15.0)
$70,000-$89,999	6 (5.6)
$90,000-$109,999	7 (6.5)
$110,000-$149,999	17 (15.9)
$150,000 or more	12 (11.2)
I am a full-time parent	11 (10.3)
Education	
GED	2 (1.9)
High school diploma	4 (3.7)
Some college	15 (14.0)
Associate's degree	9 (8.4)
Bachelor's degree	41 (38.3)
Master's degree	18 (16.8)
Doctoral degree (MD, PhD, PsyD, JD, etc.)	17 (15.9)
Child's School	
Public	48 (44.9%)
Private	55 (51.4%)

*Percentage of total (N= 107 for all characteristics).

The third Chi-squared test examined vaccine resistance and vaccine literacy. Ninety-eight participants were either vaccine literate or illiterate and answered either "yes" or "no" to Question 11 ("Have you chosen not to vaccinate your child(ren) 'for reasons other than an illness or allergy?") [4]. Seventy-five participants were unresistant and vaccine literate, six were resistant and vaccine literate, nine were unresistant and vaccine illiterate, and eight were resistant and vaccine illiterate (Figure 3). A significant association was found between vaccine literacy and vaccine resistance (P<.001). Vaccine literate parents were more likely than vaccine illiterate parents to be unresistant to vaccination. Of the unresistant participants who were either vaccine literate or vaccine illiterate, more participants were hesitant towards the COVID-19 vaccine than were hesitant towards vaccines in general (Figure 3). Fifteen participants were "COVID-19 vaccine hesitant" but were not hesitant or resistant toward vaccines. For example, a participant answered "no" to Question 13 ("Did you choose to delay any of your child's vaccinations?"), but said they were "only nervous about the COVID-19 vaccine" and did not plan on getting this vaccine for their child. Another participant underlined this difference by stating, "for COVID-19 there are better ways to build up immunity."

Vaccine hesitancy and vaccine literacy were compared at different income and education levels to determine if different associations existed between the two variables at different levels. Seventy-seven participants who were unresistant and answered Question 7 (What is your annual income?) were sorted into four income subgroups (Figure 4). Chi-squared tests revealed no significant associations for any of the groups (P>.05). It was not possible to calculate a p-value for the less



	Hesitant	Unhesitant	COVID-19 Hesitant	COVID-19 Unhesitant	Resistant	Unresistant
■ Vaccine Literate	9	66	8	50	6	75
▨ Vaccine Illiterate	3	6	9	0	8	9

Figure 3: Comparison of vaccine literacy, hesitancy, and resistance in the sampled population

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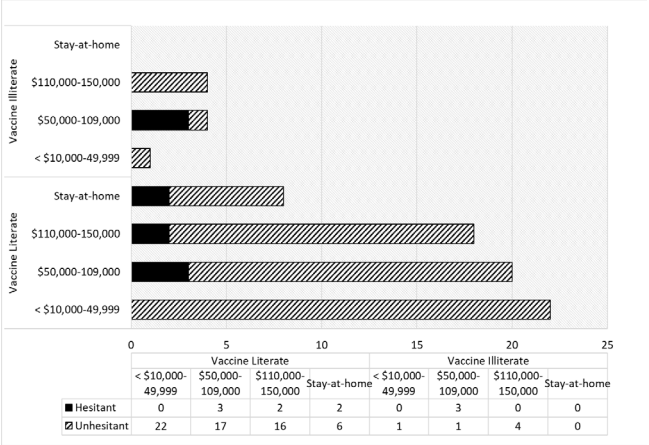
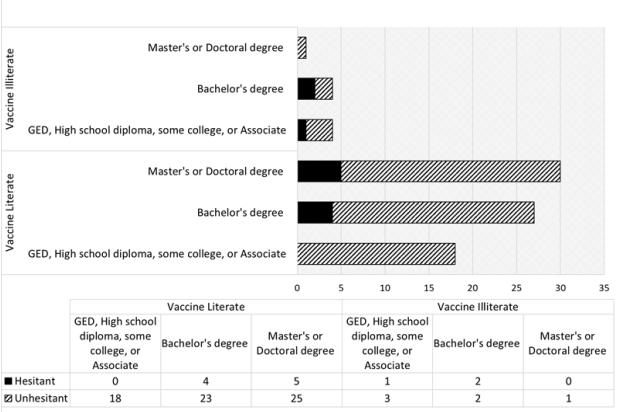
than $10,000-49,9999 group because there were no hesitant individuals in this category. Additionally, it was not possible to calculate a p-value for the stay-at-home parents because there were no vaccine illiterate participants in this category (Figure 4).

Eighty-four participants who were unresistant and answered Question 8 (What is the highest level of education you have received) were sorted into three educational subgroups: 1) GED, high school diploma, some college, or an associate degree, 2) bachelor's degree, and 3) master's or a doctoral degree (Figure 5). Chi-squared tests revealed no significant associations for these groups (P>.05).



	Vaccine Literate				Vaccine Illiterate			
	< $10,000-49,999	$50,000-109,000	$110,000-150,000	Stay-at-home	< $10,000-49,999	$50,000-109,000	$110,000-150,000	Stay-at-home
Hesitant	0	3	2	2	0	3	0	0
Unhesitant	22	17	16	6	1	1	4	0

Figure 4: Comparison of vaccine literacy and hesitancy towards all vaccines in participants in different annual income groups



	Vaccine Literate			Vaccine Illiterate		
	GED, High school diploma, some college, or Associate	Bachelor's degree	Master's or Doctoral degree	GED, High school diploma, some college, or Associate	Bachelor's degree	Master's or Doctoral degree
Hesitant	0	4	5	1	2	0
Unhesitant	18	23	25	3	2	1

Figure 5: Comparison of vaccine literacy and hesitancy towards all vaccines in different education levels

Discussion

Researchers have speculated that high health literacy correlates with low vaccine hesitancy. However, a low level of communicative health literacy has been found to increase the likelihood of childhood vaccination [19]. It should be noted that "health literacy" refers to basic health knowledge relating to a variety of health decisions whereas "vaccine literacy" specifically refers to knowledge about vaccines and information that combats anti-vaccine sentiments [12,15–18]. Individuals with high health literacy that understand the basic principles of health and wellness may not necessarily understand the importance of vaccines or vaccine mechanisms. This underscores the importance of investigating a possible association between participants' vaccine literacy and hesitancy [26]. The participant population comprised a significantly higher number of mothers compared to fathers, legal guardians, and grandparent combined (83.2% compared to 15.9%, respectively). This is supported by previous findings by Opel et al. (2011) [4]. Furthermore, participants predominantly identified as white compared to any other ethnicity, which is not fully unexpected considering the overwhelmingly non-Hispanic (91.8%) population in the area, with the majority being white and white in combination (77.3%) and a smaller Hispanic or Latino minority (8.2%) [27]. Both aspects could have influenced the results of this study.

Questions 15, 16, 18, and 20 evaluated the participants' vaccine literacy. For Question 15 ("Do you feel vaccines could harm your child?"), "I do not feel vaccines are unsafe" indicated vaccine literacy, with the understanding that the child had no allergies or medical conditions where temporary post-vaccine symptoms would be dangerous [e.g., fever-induced seizures [28]]. Question 16 ("Do you feel that there are better ways to build up your child's immunity, including them getting the diseases themselves?") was used to assess if the participant understood the information obtained on how vaccines work and applied the information to make health-related decisions for their children [19], a "no" indicated vaccine literacy. Almost all routinely used vaccines, including those used for vaccinating children, induce high immunoglobulin levels and T-cell responses, thereby strengthening their humoral and cellular immunity and inducing immune memory against future infections [29,30]. Moreover, studies have shown that vaccinated children may have a reduced risk of other unconnected infections [31,32]. Therefore, vaccines are generally a safer and medically recommended option. For both Questions 18 ("Do you think you understand how vaccines work to build immunity?") and 20 ("Do you think vaccinating your child will protect other children in the community?"), "yes" indicated vaccine literacy. However, Question 18 was subjective, and it is plausible that some participants mistook their understanding of vaccines. Participants were identified as vaccine literate if they answered at least three of the four literacy questions correctly and "illiterate" if they answered at least two of the three questions incorrectly.

It is widely accepted that vaccine hesitancy rates can differ depending on the vaccine [33]. Therefore, determining if vaccine literacy is correlated with higher vaccination rates is especially relevant during a pandemic. The significant associations between vaccine literacy and COVID-19 vaccine

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hesitancy, and vaccine literacy and resistance towards all vaccines indicate that vaccine literate participants are significantly less likely to be hesitant towards the COVID-19 vaccine or resistant toward all vaccines. However, the null hypothesis, that no significant association exists between vaccine literacy and vaccine hesitancy towards all vaccines, was supported. The significant association between vaccine literacy and COVID-19 vaccine hesitancy is consistent with the findings of Johri et al. (2015) and Wang et al. (2018) but differs from the findings of Aharon et al. (2016) [13,19,21]. There are various possible explanations for this, one being that the assessment by Aharon et al. focused on psychological factors influencing vaccine literacy. Using the Vaccine Health Literacy Scale adapted from Ishikawa et al. (2008), Aharon et al. asked participants whether they searched for and understood information on vaccines but did not ask questions that evaluated this understanding [19,34]. They did not, for example, ask participants if they were worried about vaccines causing autism. It would therefore be possible for participants to find inaccurate sources on vaccines and score well on this test without being vaccine literate. Participants would be more likely to undertake research autonomously if they felt the need to make decisions based either on their own intuition or to question the scientific consensus without advice from their healthcare provider [6]. Additionally, vaccine hesitant or vaccine resistant parents who communicate with their child's healthcare provider are more likely to change their minds and vaccinate their children [35]. These findings suggest that if parents' decision-making regarding childhood vaccination does not include their child's healthcare provider, they are more likely to be vaccine hesitant as well as vaccine illiterate [35].

While surveys are a relatively easy means of gathering and quantifying data from large populations, biases can still exist [36]. Results may be skewed by coverage errors, sampling errors, nonresponse errors, or measurement errors [37]. Coverage errors occur when the sample group is not diverse enough to represent the population. Sampling errors occur when not all members of the sample group are surveyed. Nonresponse errors occur when not all members of the sample group respond. Measurement errors occur when participants feel they cannot answer honestly or completely [37]. Additionally, studies examining self-reported vaccine acceptance can be subject to biases regarding the individuals' responses including cognitive and social desirability biases [38,39] and thus, may not represent actual vaccination behavior. Therefore, the observations cannot guarantee that vaccination rates will actually correspond with vaccine acceptance. In future surveys, the questions can be revised to minimize the potential for miscommunications. For example, the phrase "but eventually got them vaccinated" could be added to the end of Question 13 (Did you choose to delay any of your child's vaccination) to more clearly separate vaccine hesitant and not resistant participants. The metrics used to determine vaccine literacy can be edited to prevent participants from answering one question correctly and being considered literate. It would be wise to revise the subjective Question 18 (Do you think you understand how vaccines work to build immunity) and instead require correct answers for Questions 15, 16, and 20. Additional questions on knowledge about vaccines can be added to the questionnaire to make the assessment of vaccine literacy more comprehensive. It would be interesting to examine any associations between vaccine literacy and hesitancy toward all vaccines, COVID-19 vaccine hesitancy, and resistance toward vaccines with a larger and more diverse sample size. As the majority of participants in this study were white mothers, it is necessary to expand this study to determine if these trends are seen in more diverse samples. The results of this study indicate that education and teaching about the importance of vaccines for individual, community, and population health may lessen vaccine hesitancy among parents and may be an important factor in improving vaccination rates among the pediatric population.

Studies have shown that socioeconomic status is a determinant of health disparities [40], and individual income, educational level, race/ethnicity, perceived township safety, and access to healthcare substantially affect vaccination rates [40–45]. Poorer self-rated health status and lower educational levels as well as certain ethnic backgrounds have been linked with poor preventive health behaviors leading to lower vaccination rates [45]. Understanding the associations among these determining factors will be helpful in developing strategies to address vaccine hesitancy, for example, targeted educational campaigns to increase health literacy in the population. A community that is health-literate can analyze the social determinants of health, mobilize resources to address these variables, and effectively advocate for structural changes that will enhance the quality of life for its members [46].

Conclusion

Vaccination is an incredibly important medical advancement that has provided protection against many life-threatening diseases. Many vaccines have worked so well that there are fewer physical manifestations of the danger, and some parents are uncertain as to how badly their children need these preventive measures [35]. Some individuals think that VPDs have been eliminated and are now more likely to delay or refuse vaccines. Furthermore, religious, personal, and philosophical beliefs and safety concerns have influenced perceptions of vaccines and decisions about whether to get vaccinated or vaccinate children. Refusal of vaccines can eventually lessen herd immunity and put everyone at risk. This study examined a potential association between vaccine literacy and vaccine hesitancy. Our results revealed significant

associations between COVID-19 hesitancy and vaccine literacy and resistance towards all vaccines and vaccine literacy. No significant association was found between hesitancy towards all vaccines and vaccine literacy. Also, no significant associations were found between hesitancy and literacy in the different income and education brackets. Our results suggest that increasing vaccine education and individuals' understanding of the importance of vaccines for both personal health and community well-being can reduce hesitancy and enhance the likelihood of receiving recommended vaccinations.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author Contributions

MC and RLK conceived and designed the study topic and conducted the survey. MC, RLK and CRL analysed the data, wrote, and reviewed the paper. All authors agree to be equally accountable for the content of the work.

Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of Saint Mary's College (Date of approval: April 20, 2021). Informed consent was obtained from all participants included in the study.

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Appendix

Demographics

2. What is your relationship to this child?

Please choose one

- Mother
- Father
- Grandparent
- Legal guardian
- Prefer not to say

3. What is your current marital status?

- Single
- Married
- With Partner
- Divorced
- Widowed
- Separated
- Other (Please specify): _____
- Prefer not to say

4. What ethnicity do you identify as? (please mark all that apply)

- American Indian or Alaska Native
- Asian or South Asian
- Black or African American
- Pacific Islander
- Hispanic or Latino
- Native Hawaiian or Other Pacific Islander
- White
- Middle Eastern
- Mixed-race
- Other (Please specify): _____
- Prefer not to say

5. What is your age?

- 18-20 years
- 21-30 years
- 31-40 years
- 41-50 years
- 51 years or older
- Prefer not to say

6. Religious Status

- Agnostic
- Atheist
- Buddhist
- Catholic Christian
- Hindu
- Jewish
- Muslim
- Non-protestant Christian (e.g. Mormon, Jehovah's Witness)
- Orthodox Christian
- Protestant Christian
- Unaffiliated
- Other (Please specify): _____
- Prefer not to say

7. What is your annual income?

- Under $10,000
- $10,000-$29,999
- $30,000-$49,999
- $50,000-$69,999
- $70,000-$89,999
- $90,000-$109,999
- $110,000-$149,999
- $150,000 or more
- I am a full-time parent
- Prefer not to say

8. What is the highest level of education you have received?

- GED
- High school diploma
- Some college
- Associate's degree
- Bachelor's degree
- Master's degree
- Doctoral degree (MD, PhD, PsyD, JD, etc.)
- Other (Please specify): _____
- Prefer not to say

9. Does your child(ren) go to a public or private school?

- Public
- Private
- Prefer not to say

10. Is your child(ren)'s school outside of city limits?

- Yes
- No
- I don't know
- Prefer not to say

Vaccine Status

11. Have you chosen **not** to vaccinate your child(ren) "for reasons other than an illness or allergy"?

- Yes
- No
- Prefer not to say

12. How did you make the decision to vaccinate your child?

- I made the decision
- My spouse made the decision
- My spouse/partner and I made the decision together
- I took a health professional's advice
- Other (Please specify): _____
- Prefer not to say

13. Did you choose to delay any of your child's vaccinations?

- Yes
- No
- Prefer not to say

14. If you chose not to get a vaccine for your child, which exemption did you choose to file under and why?

- Diagnosed medical condition such as latex allergy that could be triggered by vaccine
- Religious Exemption
- Did not file for exemption
- Prefer not to say

Why? _____

Figure A1: Vaccine literacy survey questionnaire that was used to record demographic information and assess participants' vaccine literacy and vaccine hesitancy. Questions 2-14.

Note: The questionnaire consisted of a of total 25 questions. Question 1 was the consent form, question 24 asked participants if they wanted to participate in the gift card drawing, and question 25 asked participants to provide an email address for the gift card drawing. These questions have not been included.

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Vaccine safety perceptions

15. Do you feel vaccines could harm your child? If you answered "yes," why do you think so? Check all that apply:
    - Vaccines can cause autism
    - Harmful chemicals in vaccines
    - Getting sick from vaccines
    - I do not feel vaccines are unsafe
    - Other (Please specify): _____
    - Prefer not to say
16. Do you feel that there are better ways to build up your child's immunity, including them getting the diseases themselves? Please specify.
    - Yes: __
    - No:__
    - Prefer not to say
17. Do you plan to get (one of the) COVID-19 vaccine shots for your children when they become available? Why do you feel that way?
    - Yes: __
    - No:__
    - Prefer not to say

Understanding of vaccine mechanisms

18. Do you think you understand how vaccines work to build immunity?
    - Yes: __
    - No:__
    - Prefer not to say
19. Do you think your decision to vaccinate your child affects other parents'/legal guardians' decisions in the community?
    - Yes, because:_____
    - No, because:_____
    - Prefer not to say
20. Do you think vaccinating your child will protect other children in the community?
    - Yes
    - No
    - Prefer not to say
21. Would information from research by scientists change your decision to vaccinate your child?
    - Would not change my answer
    - Would help me decide to vaccinate
    - Would help me decide not to vaccinate
    - I don't know if my answer would change
    - Prefer not to say
22. Would information from a medical doctor or nurse change your decision to vaccinate your child?
    - Would not change my answer
    - Would help me decide to vaccinate
    - Would help me decide not to vaccinate
    - I don't know if my answer would change
    - Prefer not to say
23. Do you feel that the COVID-19 vaccine should be required for children to go to school?
    - Yes: __
    - No:__
    - Prefer not to say

Figure A2: Vaccine literacy survey questionnaire contd. Questions 15-23.