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Health Behavior and Outlooks in an Altered Microbial Diversity: Changes in Parental Attitudes on ‘Building Immunity’ Throughout the COVID-19 Pandemic

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Health Behavior and Outlooks in an Altered Microbial Diversity: Changes in Parental Attitudes on 'Building Immunity' Throughout the COVID-19 Pandemic

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By

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Abstract

The Covid-19 Pandemic in a short amount of time put into action disease control measures. Current literature has sought to address the long-term effects of sanitization efforts and social isolation on the diversity of the microbiome and the future of infectious diseases. Microbes – microorganisms such as bacteria, protozoa, algae, fungi, and viruses – inhabit the natural environment and human microbiome with our immune system, playing an essential role in immune regulation. The interplay between humans and microbes forms early immune development that has impacted parents' attitudes toward microbes shown through their participation in Covid-19 preventative health practices. Using the National Immunization Survey Child COVID Module (NIS-CCM), this study evaluated telephone interview responses from parents and guardians of children aged 5-17 years and collected information on their outlooks to represent trends in vaccination status and intent and other health behavioral indicators. Using R Studio, a comparison of the child vaccination status with 9 factors –child age range, adult vaccination status, previous conditions/vaccinations, school vaccination requirements, vaccination confidence, vaccination hesitancy, covid concern, and vaccination accessibility – was visualized where a chi-squared test was performed to evaluate the distribution of the categorical variables. The statistical analysis of the compared categorical variables found them not significant. While this study did not find a statistically significant association, the call to action is still being echoed by microbiologists for different methods of disease transmission that take into account microbial diversity.

Keywords: Covid-19, vaccines, hygiene hypothesis, infectious diseases, microbial exposure, socialization, preventative measures, children, schooling and daycare

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Acknowledgments

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Introduction

The global Covid-19 health crisis drastically impacted how we lived our lives in a short amount of time. Overnight, people were advised to follow disease control measures to reduce potential exposures, changing hygienic practices and social and environmental interactions. With the advancement of scientific knowledge and government interventions to protect public health, the burden of infectious diseases seemed like a thing of the past since most disease outbreaks were contained and the last pandemic comparable to Covid-19 was the 1918 Flu pandemic (22). There are still many unanswered questions on whether Covid-19's emergence is a painful lesson of the negative feedback from controlling microbial threats or if infectious diseases are re-emerging as a threat. However, now more than ever, the relationship between humans and microbes is being re-evaluated.

Microbiome: Historical and Evolutionary Process

The way humans intervene to control infectious diseases doesn't happen in a vacuum. We live among microbes, thus any action has a ripple effect with broader implications for nature as a whole. Historically, western science has treated nature as being stagnant without the consideration of the creation of environments where the evolutionary potential of microbes to "[mutate, adapt, and migrate] that enable pathogens to proliferate or nonpathogens to acquire virulence" (23). With current preventative measures, we have tried to amp up our defense systems against microbes. Microbes, or microorganisms, are organisms that can only be seen through a microscope (41). They form a part of nature and include living organisms – such as bacteria, protozoa, algae, and fungi – or non-living – such as viruses. To humans and animals, they are essential but pose a threat when they're pathogenic to humans. Ichinohe et al. found how commensal microbiota composition is important in the immunity regulation of the respiratory mucosa by proper activation of inflammasomes, which are part of the innate immune system that is responsible for the activation of inflammatory responses (28). This showed just how essential microbes are to immune responses, which brings attention to altering the balance in which microbiota has existed. The co-evolution of humans and microbes is a historical process that has been affected by the drastic changes in human lifestyles with denser populations and globalized economic and social networks (23). In the expansions of transportation technologies and human movements, patterns of infectious diseases can be traced because human health is globally interdependent and inseparable from the well-being of the planet itself.

Germs and history have a distinctive relationship where they have influenced each other: germs as a historical byproduct and history as being impacted by endemic and epidemic diseases. The toll of morbidity and mortality of infectious diseases led to human intervention. Humans exist in a distinct disease pool with microbes essential and disease-causing to humans, but have learned to make the environments we inhabit unfit for microbes that cause us harm. Efforts to control infectious diseases ranged “from public health reforms and the so-called hygiene revolution, to chemical controls and biomedical interventions like antibiotics, vaccines, and improvements to patient care” (23). The sanitary or hygiene revolution refers to the time period after several severe cholera epidemics led to policies and actions being implemented to ensure safe drinking water, sanitary disposal of human and animal waste, and hygienic food handling (22). This historical context is important to understand the progression of behaviors to where our microbial relationship stands.

Currently, we are facing uncertain times where we aren't really sure how to find a healthy balance in our relationship with microbes. Living the COVID-19 pandemic experience has led to a heightened sense of awareness of how we interact with infectious diseases. To prevent the spread of COVID-19, local governments enforced lockdowns and quarantines because the main form of spread was through direct contact with an infectious person, thus any form of social interaction was pathologized, especially in the beginning stages of the Covid-19 pandemic where we could not trace who was infected and how it was being spread. The default public health measure was to quarantine infected individuals, but with limitations of testing availability, it was only certain that the virus was highly transmissible in any social situation. Alongside this, the pandemic also called for hygienic behavior changes. For example, face masks were being used to prevent respiratory virus transmission after studies provided evidence of their protective value, but a review released on the effectiveness of mask-wearing found a "high risk of bias in the trials, variation in outcome measurement, and relatively low adherence with the interventions during the studies" (34, 30).

The emergence of Covid-19 can be understood as a paradox of progress in technological advancement where there is an increased understanding of human health, but such understanding can cause an imbalance in the dynamic nature of microbes, causing negative feedback. Before Covid-19, there was a reliance on established preventative measures (such as sanitary conditions, vaccinations, antibiotics, etc.) that provided immunity, even leading to the eradication of the smallpox virus. The negative feedback, including antibiotic resistance and climate change's ecological disruption, have a connection to biological disturbances. Pre-pandemic literature was exploring the changes in lifestyle and environment, along with rapid urbanization, have all contributed to changes in our exposure to essential microbes.

Behaviors associated with the pandemic were debated as being public imperative and/or public duty. This is all to say that our actions were a point of emphasis because social behaviors and actions could result in infection with a highly transmissible virus. The new norm from the pandemic was increased personal sterilization such as masking, physical distancing, and hand sanitizing that intersected with a long conversation about how to manage microbial diversity while evading infectious diseases. The long-term biological and social outcomes of the pandemic lie in further research on how the consequences of how COVID-19 disease and prevention measures have added to the previous discourse of normalized processes and practices that impacted microbial diversity such as " increased urbanization; overuse of antibiotics and other medications; birth and infant feeding practices; intensified hygienic practices that disinfect bodies, homes, and workplaces; reduced diversity in global diets (especially declining intake of dietary fiber and increased consumption of processed foods); and widespread use of tobacco, alcohol, and other drugs" (27). Often hygiene has been synonymized with sterilization practices, especially when it came to Covid-19 disinfection, having the consequences of altered microbial functionality, as explored in Vandegrift et al 2017 (53). Particularly, a review of hand hygiene noted how most evidence suggests skin microbiome as being likely to directly benefit the host and only rarely displaying pathogenicity, thus washing your hands would clean them but by reducing the microbial load which is not pathogenic organisms (53). The CDC recommends "staff and children in schools and early care and education (ECE) programs healthy is cleaning hands at key times with soap and water for at least 20 seconds or using an alcohol-based hand sanitizer with at least 60% alcohol if soap and water are not readily available" citing that it can result in less gastrointestinal and respiratory illness and fewer missed school or program days (10). The germ theory of disease shaped our understanding of microbes by stating transmission of pathogens was through direct contact, therefore hand hygiene is thought to be a practice rooted in cleanliness and the maintenance of good health. This goes along with the conversation of the hygiene hypothesis – "the idea that individuals who are exposed to a variety of microbes (i.e., germs) in childhood build better immunity" – can provide a contrasting context to the mentality behind sanitization practices that reduce our microbial exposure in an effort to reduce infectious diseases to humans (48). The hygiene hypothesis has been reconsidered and has called to action the collective social understanding of the relation of hygiene in the prevention of infectious diseases, instead proposing a "risk assessment approach (targeted hygiene) [to provide] a framework for maximizing protection against pathogen exposure while allowing spread of essential microbes" (4).

The control of our microbial adversaries is linked to a threshold of sanitization and exposure to microbes. The human imprint on the environment due to the population number, density, and connectivity led to the response and adaptation of microbes and the importance of understanding how health has become globalized. The different environments in which interactions with microbes mainly occur in public spaces, which has brought private habits to the forefront. Health decisions come from the "wide range of public health, medical, and other changes [that] have occurred over the past century such as clean water and food, sanitation, antibiotics, and vaccines, all of which are likely to have resulted in significant alterations in microbial exposure and infection in the community" (5). The binary thinking in public health and health care has simplified microbes by treating them as good or bad, not taking into account the influences on overall microbial loss and the inability for reinoculation. Individual behaviors of controlling diseases have led to a rising "concern among some microbiologists, for the last decade or so, [about] the collateral damage of excessive sanitizing and use of antibiotics [to the balance of] microbes that we spent thousands of years evolving with" (21). The nature of the microbiome is affected by the biosocial processes of loss of diversity in nature. The emergence of diseases are "combinations of predictability and unpredictability, of structure and chance, of pattern and contingency, [that lie] in the very nature of infectious diseases," where chances of replication and mutations happen while trying to provide immunity (23). Altered microbial functionality is a reflection of the existing inequalities of youth, elderly, poor, and chronically ill populations. In this study, we will be focusing on how parents perceive their children's exposure to microbes in the context of the hygiene hypothesis and Covid-19.

The long-term effects of COVID-19 infection on the early life microbiome are a significant unresolved issue. Although there is minimal infant and child mortality from COVID-19, it is uncertain how asymptomatic carriage affects microbiota exposure (17). The changes in sanitary practices during the previous century have significantly decreased the death rate from infectious illnesses. However, the convergence of historical hygiene practices and current COVID-19 pandemic control approaches may have detrimental effects on the microbiome and thus, human health over a variety of periods, and shifting the course of human evolution may potentially shift. Currently, a 2022 study has shown decreases in IgG levels in children and adults that could lead to vulnerability to infections (56).

Socialization: Early Life Immunity

Understanding the development of the early life "critical window" for microbiota development is relevant to the progression of how we interact with our environment. Medical sociology can offer a perspective on studying health, illness, and disease in the contexts of nature, operation, and the use of the medical system as important areas of scholarship and human social activity (44). Early socialization is when children's immunity is in development, and their defense systems are being actively built (39). In this study, I will be looking at the decisions that parents make in managing their children's health by engaging in preventative health behaviors during Covid-19. The Covid-19 Pandemic highlighted the decisions on whether or not people were taking protective measures. SARS-CoV-2 has shown its potential to mutate into many variants with a pool of unvaccinated individuals serving as a reservoir for the virus to grow and multiply, thus increasing the likelihood that new variations will grow (19). Microbial exposures happen in every interaction and social setting: “households, day nurseries, rural environments, farms and places of work” (5). In children, the hygiene hypothesis is thought to be hurting the diversity of the human microbiome and our early immune development.

The Covid-19 pandemic caused rapid changes to public health and shined a spotlight on individual behaviors that followed the CDC-recommended preventative measures. Our microbiota was already undergoing so many ecological alterations with globalization that change the environments through means of climate change, transportation, etc. Measures taken to control COVID-19 -- such as physical separation, social bubbles, reduced travel, and border closures -- have all disrupted the social interactions and patterns of movement linked to microbial transfer and possibly had a significant effect on human microbiomes (17). These preventative measures impacted the overall exposure to microbes in childhood, which has given rise to the concern of long-term effects that could mean a heightened susceptibility to infectious diseases, such as common communicable diseases. Infant exposure to "normal" environmental microorganisms might be decreased at home by increased sanitization measures and fewer interactions with others, as well as parents falling behind on their child’s regular vaccine schedule to avoid the healthcare system in fear of potential exposure and/or overwhelming the demand for care. Socialization is an integral part of immunoregulation and interaction with environments. In the context of the hygiene hypothesis, socialization provides a foundation for a relationship between diverse microbial exposure and hygiene existing within a sphere of public spaces and private habits that is treated as a public imperative and personal duty.

The Tucson Children's Respiratory Study investigated the association between infections (such as the common cold) and daycare attendance, given the likelihood of increased exposure would give the expected outcome of infection helping in the long run – hygiene hypothesis (5). However, the results were inconsistent, thus there was no evident protective effect at an older age with children who got more frequent infections (of the common cold in this case) at a younger age due to being in large daycare facilities with circumstances that led to more microbial exposure and infection. In a review, childcare settings infections – such as frequent respiratory and gastrointestinal illness – were explored as places of central social interactions/behaviors, including mobility, where microbial transmission occurs (12). UNICEF statistics show children under 5 are especially vulnerable to infectious diseases like malaria, pneumonia, diarrhea, HIV, and tuberculosis, specifically, they were responsible for 30 percent of global deaths among children under the age of 5 in 2019 (11). The social settings in which children often interact are seen as harborers of infectious diseases.

It is important to note the role of family and community in influencing ideologies and behaviors health and hygiene behaviors. The risk assessment through which people saw their potential pathogenic exposure was a key factor in their decision to participate in institutionally recommended health protective measures to control COVID-19. In the beginning stages of the pandemic, the long-term effects of a Covid-19 infection on children were unknown with the news reporting potential risks of children developing Multisystem Inflammatory Syndrome-Child (MIS-C) (42). Alongside, the direct and indirect effects on children's well-being; the long-term social, economic, and health effects of the pandemic.

The implication of the pandemic was socio-medical due to the drastic changes of social isolation for children meant that they missed out on formative socialization.

Children's own experiences and understandings of health and illness have started to become an emerging area of interest as the scholarship for the sociology of childhood grows (6, 13, 14, 15, 37). Recently, the emphasis in childhood sociology studies changed from viewing children as immature becomings on the verge of adulthood to viewing children as beings and as capable actors with their own sense of social agency, not just impacted by but actively shaping their social environment and social reality (6, 39). Child agency is a contested concept in the sociology of childhood being understood as complex and multifaceted. Studying children's experiences and strategies for managing health and wellness in daily life entails awareness of them as social agents and as collaborators in the construction of their social worlds. Adults may not be aware of how children are interpreting health-related information and applying it to their own life, but children actively participate in managing their diseases, health risks, and interacts with healthcare providers; as well as having an active role in their family's health situation through promoting health knowledge (38, 49). There are sites of health practices considered to be of importance to children's health, including early-year childcare settings, school (the classroom and playground), the family home, and wider public space.

Parental authority still exists in meeting the children's needs in regard to health, development, and physical safety, as well as being affected by the health condition of their children as "parents of children who attend a childcare facility… have an increased risk of acquiring infections such as CMV, parvovirus B19, HAV, and infectious diarrhea" (12). This becomes particularly interesting when considering the spaces where children experience formative socialization are places where they experience exposure to infectious diseases, thus microbes.

Socialization provides a foundation for a relationship between diverse microbial exposure and hygiene existing within a sphere of public spaces and private habits. It is treated as much as a public imperative as it is a personal duty. The control of our microbial adversaries is linked to a threshold for sanitization and exposure to microbes through diffusing control of diseases in an environment of rapid development. The human imprint on the environment due to the population number, density, and connectivity led to the response and adaptation of microbes and the importance of understanding how health has become globalized. In the Covid-19 pandemic specifically, the disruptions in healthcare access and utilization, childcare, and education due to the Covid-19 pandemic quarantine was transitioned to remote means to limit the spread of Covid-19. Interaction with peers is essential to the emotional and social well-being of children, which made the sudden restrictions of societal distancing have consequences (50, 33, 29, 57).

Medical sociology can serve as an interdisciplinary perspective to understand the health-related phenomena behind the increasing biological phenomenon of understanding the microbiome by viewing its impact on the immunological development of children (24). The social and health systems for children need to be fundamentally transformed because of this pandemic with disaster preparedness for child-serving systems that prioritize higher value and better-integrated care for future generations (55).

Vaccinations: Health Preventative Behaviors

Senate Bill (SB) 277 is a bill that eliminated all nonmedical exemptions – such as personal belief exemptions that offered a loophole – to school vaccination requirements (7, 35). Vaccinations can be used as a measure of how people opt for health behaviors. Many people believe that childhood vaccinations have a significant impact on preventing disease, although there are still some concerns about their effectiveness and safety. The public perception rate of childhood immunizations -- among which include measles, mumps, and rubella vaccination -- receives high marks in a Pew Research study from most adults worldwide with 17 out of 20 for its preventative health benefits (40). Depicted in *Figure 1* is the Californian Public Health approach to advertise staying up to date on immunizations with a record or if not, then the child cannot enroll in school (35). It served as a promotional guide for the immunization requirements of children before starting school or childcare.

Figure 1. An infographic of the Shots For School campaign from the Division of Communicable Disease Control of the Center for Infectious Diseases program (35).

The negative effects of not opting into health protective measures, such as remaining unvaccinated, where the virus finds opportunities for variants to emerge by using the unvaccinated pool of individuals as a reservoir to continue growing and multiplying (19). Parental vaccine refusal and hesitance are emerging issues posing a threat to public health, especially with exemptions being a possibility in some states. Vaccine-preventable diseases thrive in under-immune and unimmunized populations (35). Childhood immunization rates have a level to maintain herd immunity and prevent outbreaks, which is why it is important to address parental knowledge and attitudes toward vaccination. Parental education and understanding of vaccines and their safety have been a focus of healthcare professionals. After the implementation of Senate Bill 277 (SB277), 92% of parents had fully vaccinated children with around 44% having felt hesitant about childhood vaccinations (35, 1). While parents may have compliance with SB277, concerns and misconceptions remain about vaccines and public health authorities (26, 54). A review showed how studies assessing the Covid-19 vaccine effectiveness found insufficient evidence to support a difference between vaccines and placebo in relation to adverse effects (20, 42, 54).

The pandemic has presented an interesting collision between the evolution of our microbiome and our long-term process of sanitization, which both have been gaining recognition in significance. In the context of a global pandemic, social isolation and frequent sanitization offer a unique and unprecedented opportunity to explore human-microbiome interactions with ecological and environmental changes. The current literature addresses the microbiome as a historical and evolutionary process, socialization as the main source of agency in health and exposure for children, and vaccines as essential to communal immunity. Existing literature offers a historical perspective on the human microbiome in relation to health behaviors and risk assessment, but there is limited research on how Covid-19 control measures interact and impact the microbial composition since its outbreak was so recent. From this standpoint, there is a need to examine the existing knowledge about how the human microbiome affected the emergence of Covid-19. By pointing to the interconnection of the two, we gain valuable insights and highlight critical issues that need to be addressed simultaneously by researchers in the fields of biological and social sciences, as well as by public health authorities. In this study, we will examine the interplay between sanitization and a dynamic microbiome in the context of the Covid-19 pandemic, particularly the impact on the developing immune systems of children who have experienced a disruption in formative microbial exposure due to social quarantine measures and heightened sanitization practices. This will be done by viewing how parents' attitudes have changed in the concept of building immunity since the start of the Covid-19 pandemic.

Methods

In order to address this question, I am going to be using the National Immunization Survey Child Covid Module (NIS-CCM), a data set from the Center for Disease Control & Prevention Data Catalog. The dataset from the NIS-CCM was conducted by the CDC via telephone interviews using a random-digit-dialed sample of cell telephone numbers. Responses from parents and guardians of children aged 5-17 years were collected to represent trends in vaccination status and intent and other health behavioral indicators. The CDC created this module to collect information on Covid-19 vaccine confidence to supplement vaccine administration data. I am going to be using the variable of Child Vaccination Status/Intent and cross-examining them with the following 8 categories: Adult Vaccination Status, Previous Conditions or Vaccinations, School Vaccination Requirements, Vaccination Confidence, Vaccination Hesitancy, Covid Concern, Vaccination Accessibility. The observational unit of my study is the Children, the explanatory variable is the Child's Vaccination Status, and the response variable is the seven categories of health behaviors/perceptions.

Child Vaccination Status/Intent (n = 9232) measured the latest Covid-19 vaccine that the child has received or intends to receive. Adult Vaccination Status (n = 975) measured the latest Covid-19 vaccine that the adult or guardian has received or intends to receive. Both variables had responses measured by: vaccinated (~1 dose), definitely will get an updated bivalent booster, definitely will get vaccinated, probably or definitely will not get vaccinated, probably will get an updated bivalent booster or unsure, probably will not or definitely will not get an updated bivalent booster, received first booster dose, received updated bivalent booster dose, unvaccinated, and probably will get vaccinated or are unsure.

School Vaccination Requirements (n = 927) measured if the child's school requires Covid-19 vaccination for in-person classes. The responses were measured by the indicators: not applicable, no, yes.

Previous Conditions or Vaccinations (n = 1967) accounted for the factors of if the child ever had Covid-19 disease, if the child ever received an HPV vaccine (among 13 to 17-year-olds only), if the child ever received a meningococcal vaccine (among 13 to 17-year-olds only), and if the child ever received a Tap vaccine (among 13 to 17-year-olds only). With the responses: yes or no.

Vaccination Confidence (n = 1311) accounted for the factors of the parent/guardian's confidence in Covid-19 vaccine safety for their child, and the parent/guardian's confidence that the Covid-19 vaccine is important to protect their child from Covid-19. With the responses being: a little or not at all important, somewhat or not at all safe, somewhat or very important, and very or completely safe.

Vaccination Hesitancy (n = 1209) was the parent/guardian's hesitancy about childhood vaccines with the responses: not at all hesitant, not that hesitant, somewhat hesitant, and very hesitant.

Covid Concern (n = 656) refers to the concern about the respondent's child getting COVID-19 disease with the responses: a little or not at all concerned, and very or moderately concerned.

Vaccination Accessibility (n = 623) refers to the difficulty the parent/guardian perceived getting their child a COVID-19 vaccination, which was measured with the responses: not at all or a little difficult, and somewhat or very difficult.

For the NIS-CCM data, I used R Studio to graph and run a Chi-Squared test to measure the statistical significance of the data sets because I was comparing the distribution of two categorical variables to each other. This data focuses on vaccination status as a reflection of health-protective behaviors against Covid-19 infection, while focusing on the vaccine behaviors/perceptions by asking questions about intentions. I use the responses to the vaccine behaviors/perceptions categories in the data in conjunction with the respondent's child vaccination status to construct an indicator for whether a higher vaccination status indicates health-protective behaviors and perceptions, thus higher child vaccines mean: more adult vaccinations, higher school requirements, higher Covid-19 infection concern, lower vaccine hesitancy, high vaccine confidence, lower vaccine accessibility difficulty.

Results

I used 8 health behavior/perception variables to compare to Child's Vaccination Status. Through running a Chi-squared test in R Studio, I was able to compare the distribution of the Child's Vaccination Status (a categorical variable) with the distribution of the seven health behavior/perception categorical variables in my dataset. The seven categories of health behavior/perception are Adult Vaccination Status, School Vaccination Requirements, Vaccination Confidence, Vaccination Hesitancy, Covid Concern, Previous Conditions or Vaccinations, and Vaccination Accessibility.

The intention of the child to get the next-in-line vaccine is the category with the most responses (Figure 2). For Child Vaccination Status (n = 9232) based on Age Rage, the results are non-significant, p = 1.00, X-squared = 2.23, df = 12 and, therefore, we fail to reject the null hypothesis and conclude that there is no association between vaccination status for children and the vaccination status of the parent/guardian. While there may be a visual pattern, we cannot prove that this is not due to chance since our statistical tests were not significant.

For Adult Vaccination Status (n = 975), the results are non-significant, p = 0.31, X-squared = 20.4, df = 18 and, therefore, we fail to reject the null hypothesis and conclude that there is no association between vaccination status for children and the vaccination status of the parent/guardian (Figure 3).

For School Vaccination Requirements (n = 927), the results are non-significant, p = 1.00, X-squared = 0.24, df = 12 and, therefore, we fail to reject the null hypothesis and conclude that there is no association between vaccination status for children and the immunization requirements for school (Figure 4).

For Vaccination Confidence (n = 1311), the results are non-significant, p = 1.00, X-squared = 0.02, df = 18 and, therefore, we fail to reject the null hypothesis and conclude that there is no association between vaccination status for children and the vaccine confidence of parents/guardians cannot be proven that it is not due to chance (Figure 5).

For Vaccination Hesitancy (n = 1209), the results are non-significant, p = 1.00, X-squared = 0.003, df = 15 and, therefore, we fail to reject the null hypothesis and conclude that there is no association between vaccination status for children and the vaccine hesitancy that parents/guardians cannot be proven that it is not due to chance (Figure 6). The number of people that answered the questionnaire interview question is visually bigger than the other child vaccine status but has an even distribution of the vaccine hesitancy responses.

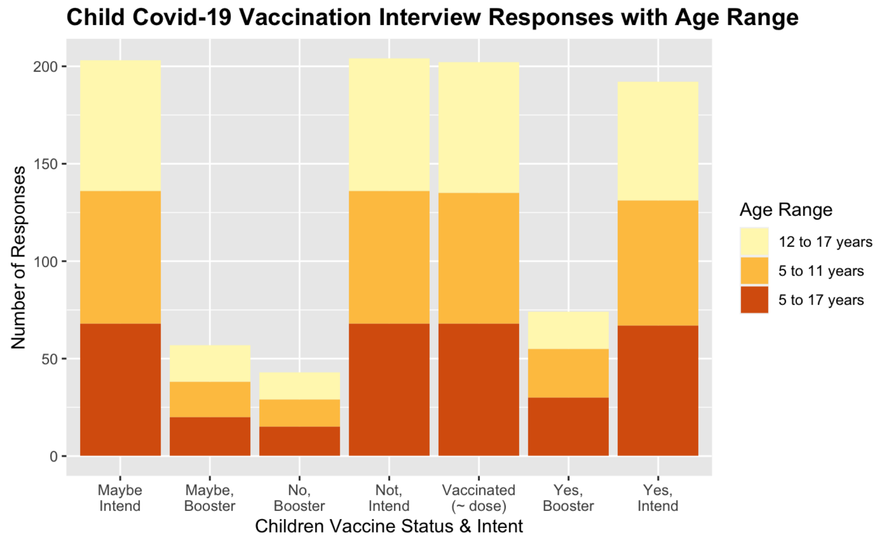
For Previous Conditions/Vaccinations (n = 1967), the results are non-significant, p = 1.00, X-squared = 0.34, df = 7 and, therefore, we fail to reject the null hypothesis and conclude that there is no association between vaccination status for children and the previous conditions/vaccinations that the children received (Figure 7). It cannot be proven that it is not due to chance. The number of people that answered the questionnaire interview question was higher when answering if they've ever had Covid-19 disease, but we still see that halfway split on the distribution of the vaccination and infection history interview responses.

For Vaccine Accessibility (n = 623), the results are non-significant, p = 1.00, X-squared = 0.02, df = 6 and, therefore, we fail to reject the null hypothesis and conclude that there is no association between vaccination status for children and the difficulty to get a child vaccinated (Figure 8). It cannot be proven that it is not due to chance. There is still that halfway split in the percent distribution of the vaccine accessibility interview responses.

For Covid Concern (n = 656), the results are non-significant, p = 1.00, X-squared = 0, df = 6 and, therefore, we fail to reject the null hypothesis and conclude that there is no association between vaccination status for children and the difficulty to get a child vaccinated (Figure 9). It cannot be proven that it is not due to chance. There is still that halfway split in the percent distribution of the vaccine accessibility interview responses. We have an X-squared equaling zero, which means that all the observed values in all the cells are exactly equal to their expected values

In Figure 10, there are a series of box plots, a method of displaying five numerical summary values of data: the minimum, first quartile, median, third quartile, and maximum. This shows the distribution of the numerical data in terms of locality, spread, and skewness. The box plots display the weighted average of the health behaviors/perceptions categories. Most notable is the Child Vaccination Weighted Average Figure 10a which weighed the data of parents with intentions to get their children more updated vaccines than what they had.

Figure Appendices



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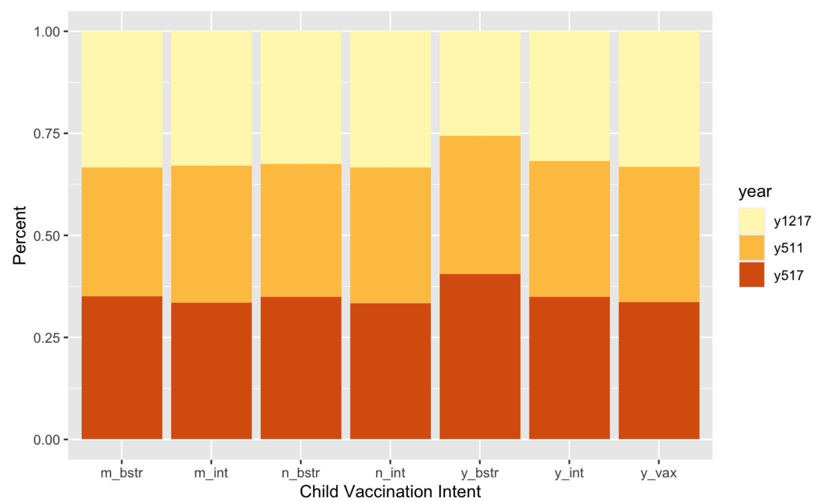
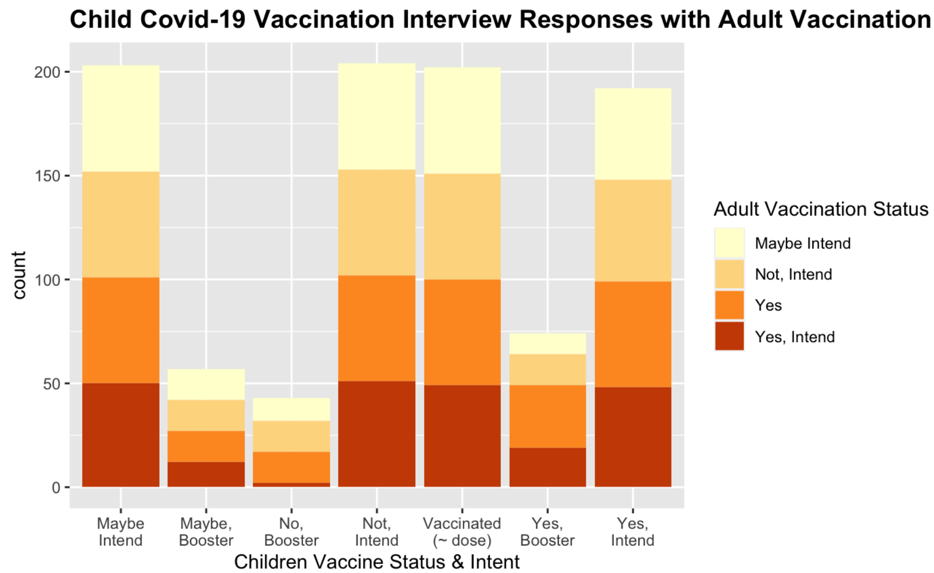


(b)

Figure 2. (a) A bar plot visualizes the overall Number of Interview Responses to the Child's Vaccination Status (n = 9232) with their Age Rage. (b) A segmented bar plot visualizing the Percent of Child Vaccination Status (n = 9232) with Age Range (Chi-Squared, p = 1.00, X-squared = 2.23, df = 12)



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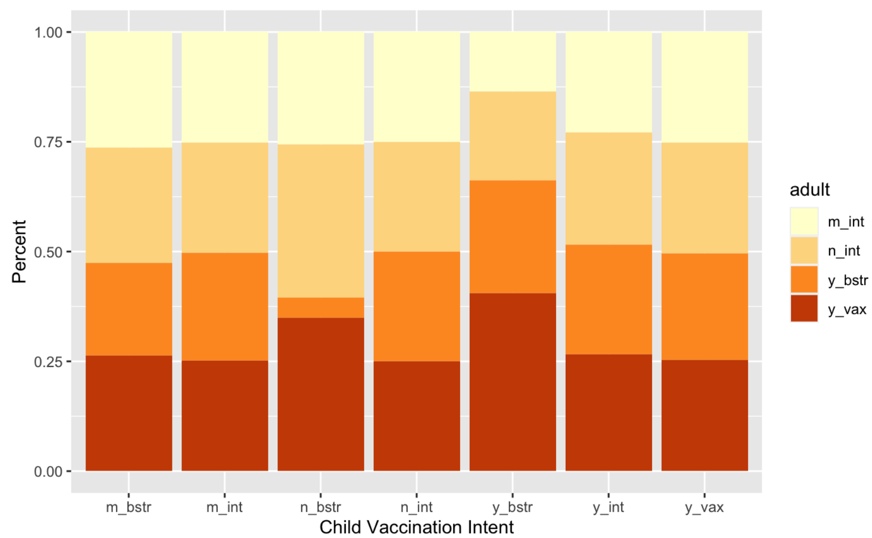
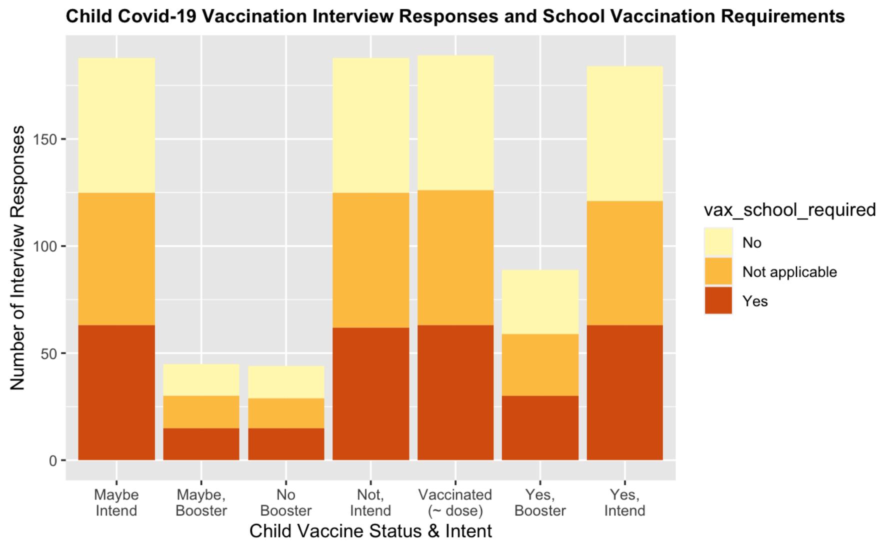


(b)

Figure 3. (a) A bar plot visualizing the overall Number of Interview Responses to the Child's Vaccination Status with their Adult Vaccination Status (n = 975). (b) A segmented bar plot visualizing the Percent of Child Vaccination Status with Adult Vaccination Status (Chi-Squared, $p = 0.31$, X-squared = 20.4, df = 18).



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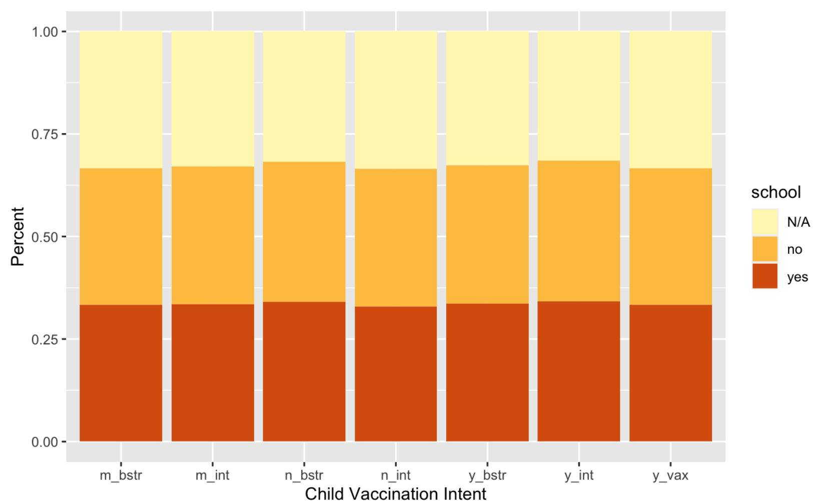
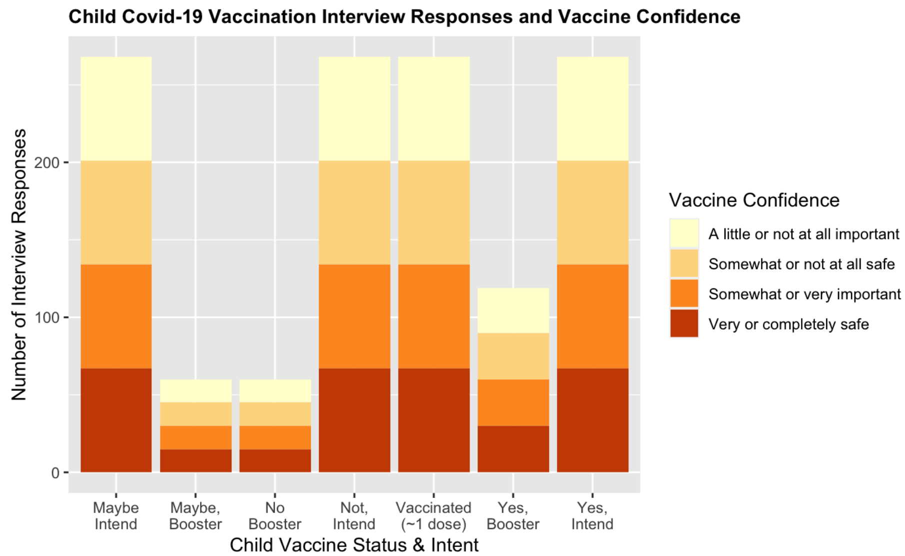


(b)

Figure 4. (a) A bar plot visualizing the overall Number of Interview Responses to the Child's Vaccination Status with School Vaccination Requirements (n = 927). (b) A segmented bar plot visualizing the Percent of Child Vaccination Status with School Vaccination Requirements (Chi-Squared, p = 1.00, X-squared = 0.24, df = 12).



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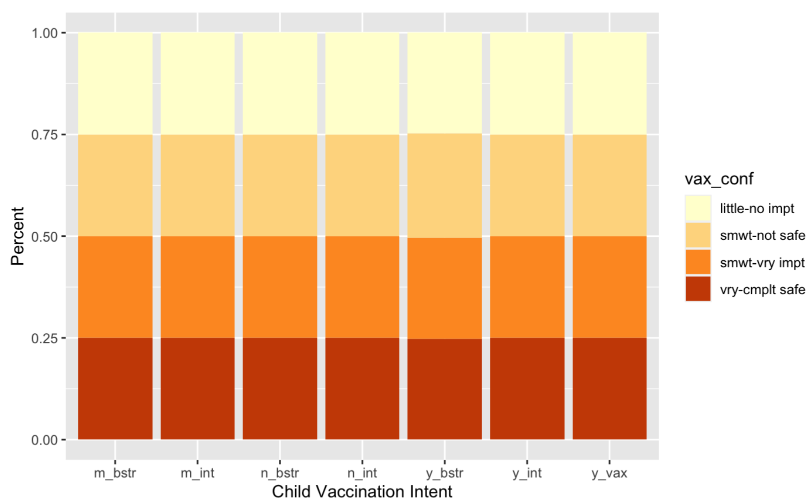
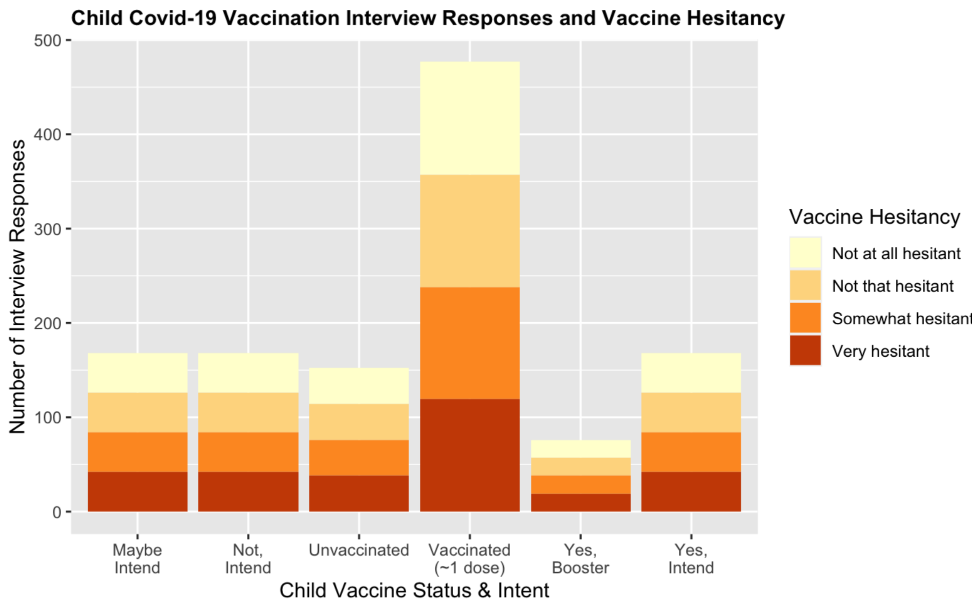


(b)

Figure 5. (a) A bar plot visualizing the overall Number of Interview Responses to the Child's Vaccination Status with Vaccine Confidence (n = 1311). (b) A segmented bar plot visualizing the Percent of Child Vaccination Status with Vaccine Confidence (Chi-Squared, $p = 1.00$, X-squared = 0.02, df = 18).



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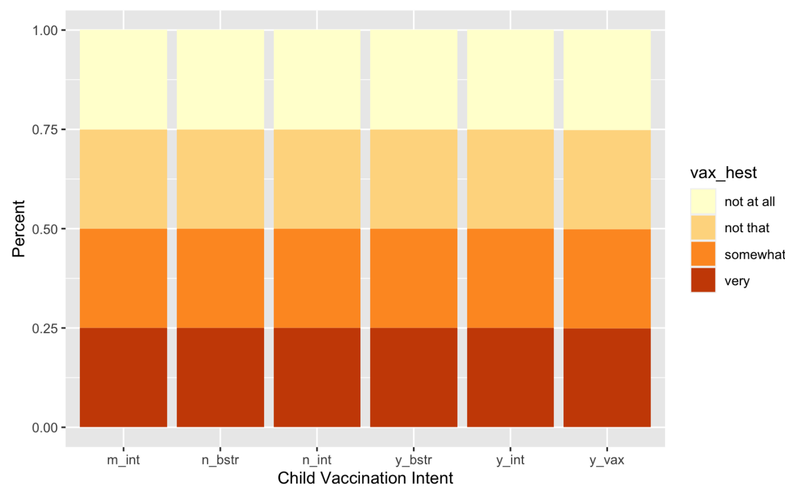
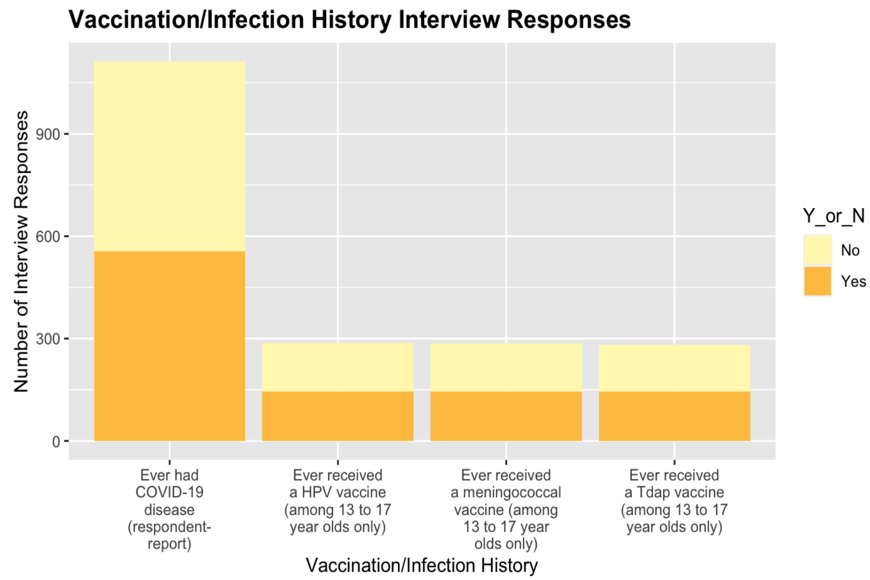


(b)

Figure 6. (a) A bar plot visualizing the overall Number of Interview Responses to the Child's Vaccination Status with Vaccine Hesitancy (n = 1209). (b) A segmented bar plot visualizing the Percent of Child Vaccination Status with Vaccine Hesitancy (Chi-Squared, p = 1.00, X-squared = 0.003, df = 15).



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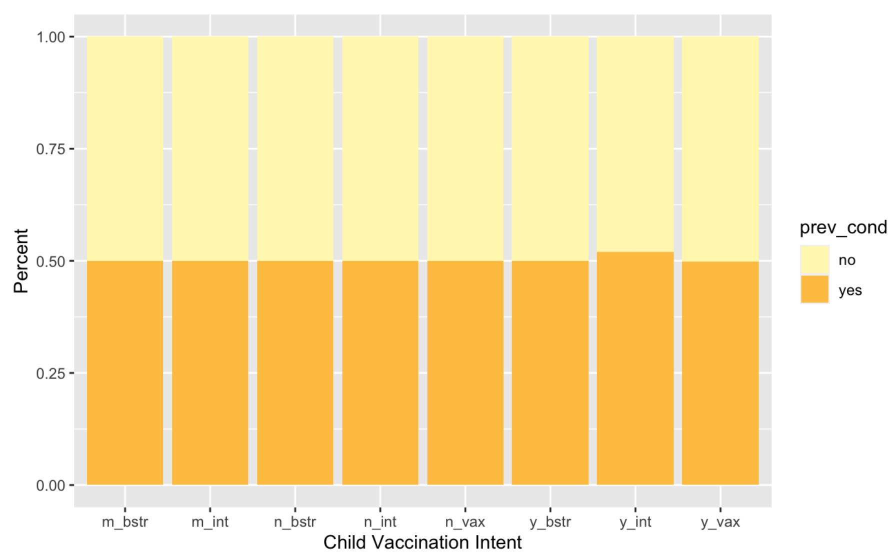
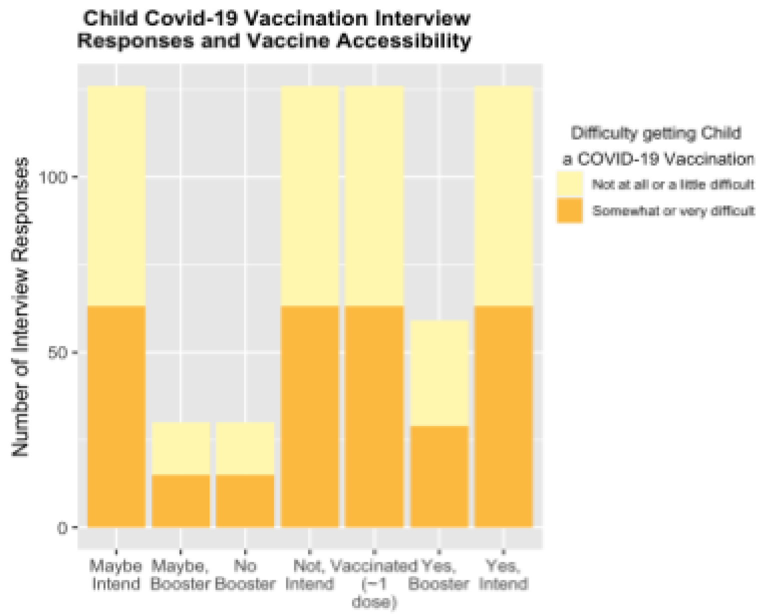


(b)

Figure 7. (a) A bar plot visualizing the overall Number of Interview Responses to the Child's Vaccination Status with Previous Conditions/Vaccinations (n = 1967). (b) A segmented bar plot visualizing the Percent of Child Vaccination Status with Previous Conditions/Vaccinations (Chi-Squared, $p = 1.00$, X-squared = 0.34, df = 7).



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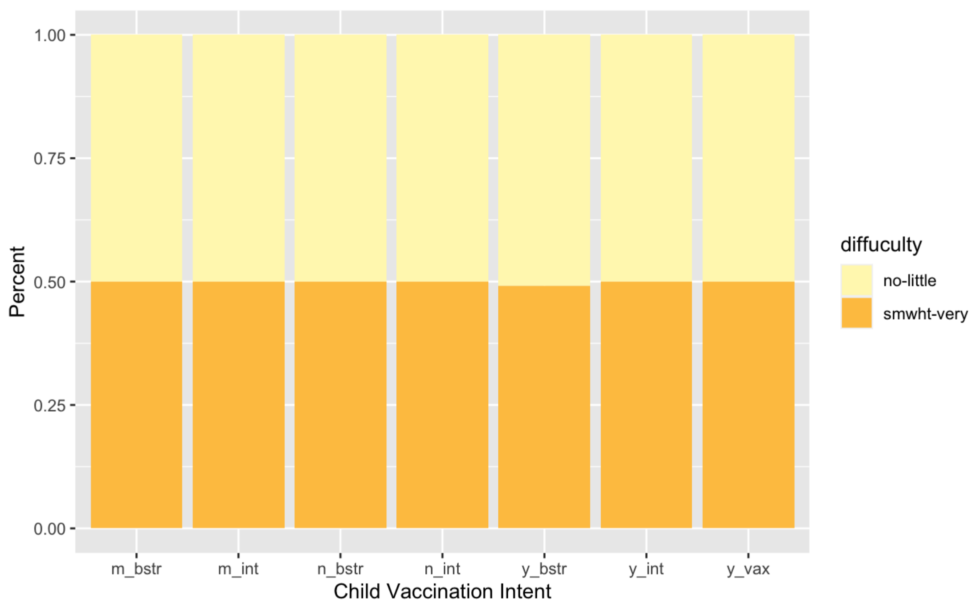
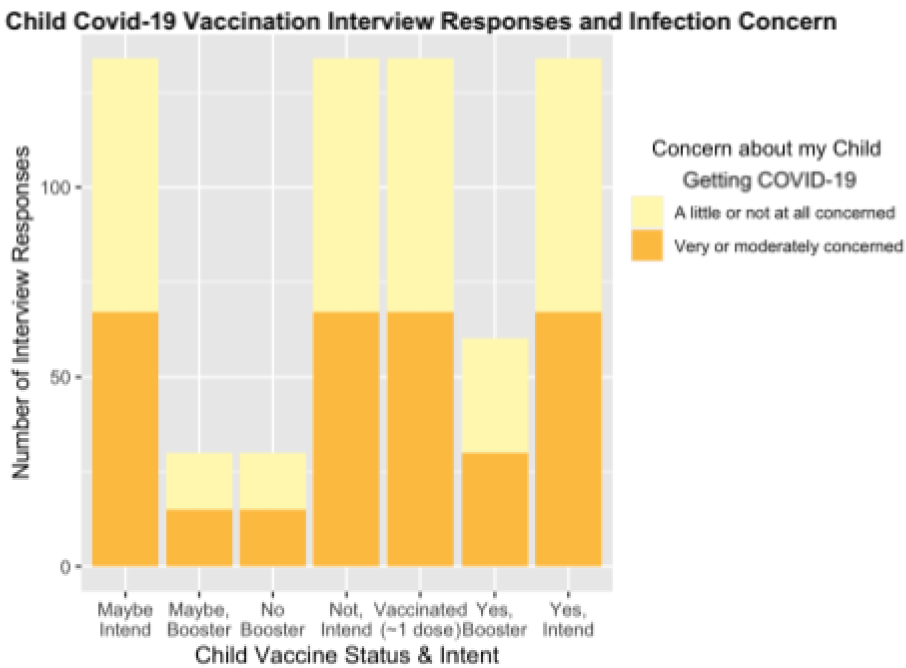


(b)

Figure 8. (a) A bar plot visualizing the overall Number of Interview Responses to the Child's Vaccination Status with Vaccine Accessibility Difficulty (n = 623). (b) A segmented bar plot visualizing the Percent of Child Vaccination Status with Vaccine Accessibility Difficulty (Chi-Squared, p = 1.00, X-squared = 0.02, df = 6).



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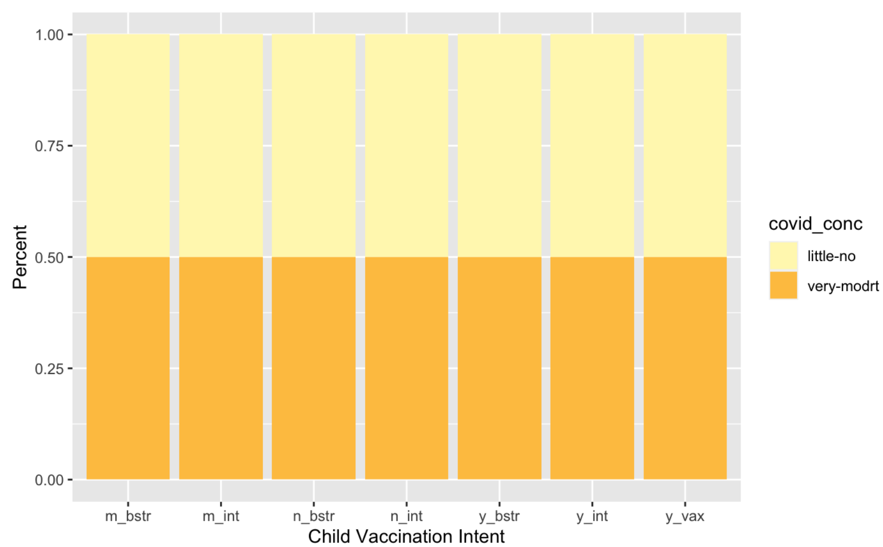

(b)

Figure 9. (a) A bar plot visualizing the overall Number of Interview Responses to the Child's Vaccination Status with Covid-19 Infection Concerns (n = 656). (b) A segmented bar plot visualizing the Percent of Child's Vaccination Status with Covid-19 Infection Concern (Chi-Squared, p = 1.00, X-squared = 0, df = 6).

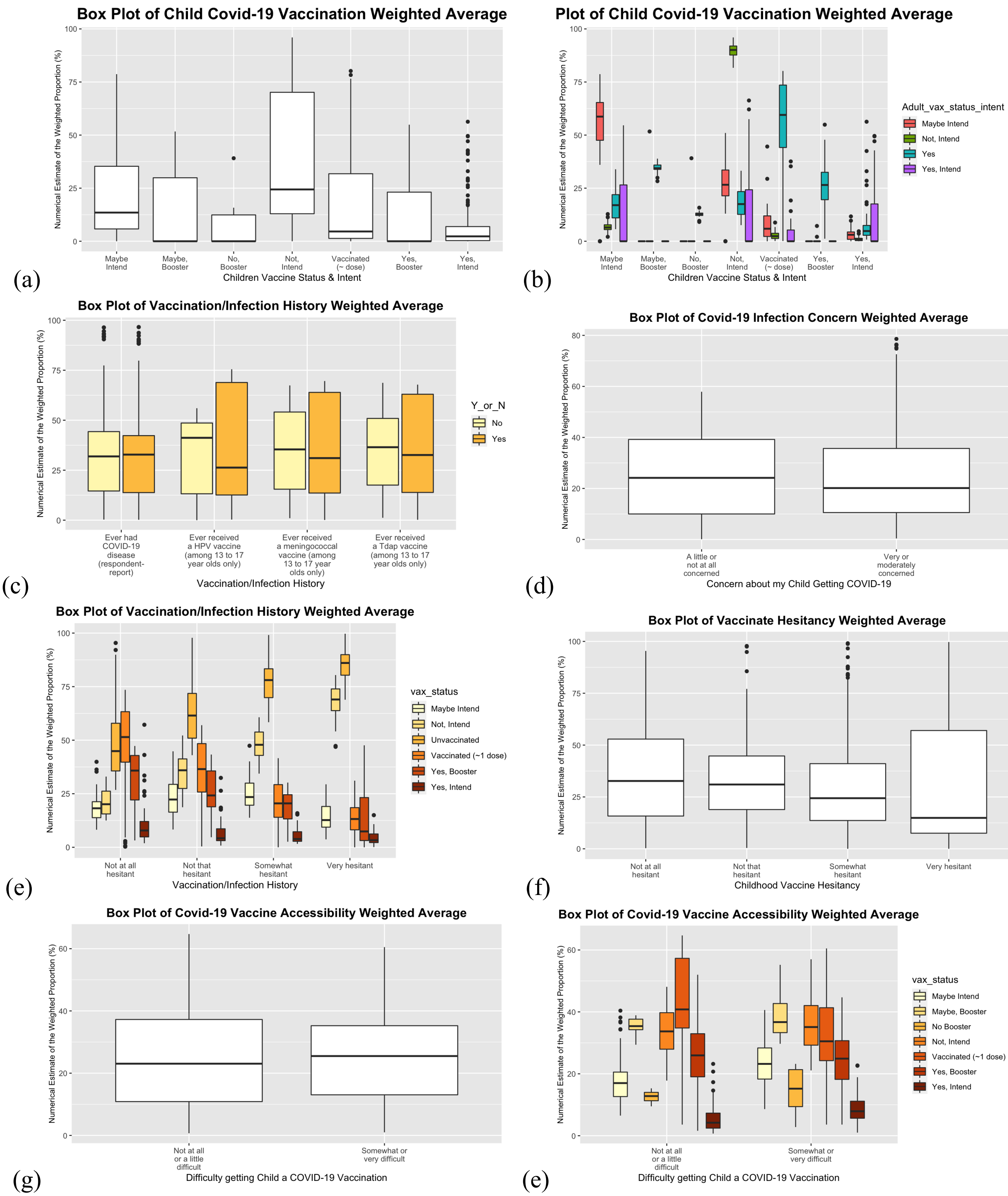

Figure 10. Eight bar plots visualizing the distribution of the weighted proportion in different health behaviors/perceptions categories.

Discussion

I ran a chi-squared statistical analysis to see if my data would be statistically significant. The way it functions is by predicting the probability of observations as expected to find a relationship between two categorical variables, assuming the null hypothesis to be true. In Figures 2, 4, 5, 6, 7, 8, 9, and 10 the X-squared observed was equal to or close to 1, meaning there was no difference between the observed and expected data set and could not reject the null hypotheses. Adult vaccination status and the vaccination status of children had a high X-squared statistic (Figure 3, X-squared = 20.4). When a larger chi-squared value is observed, the greater the probability of a significant difference is observed between the two categories of data in consideration, but given that its p-value was not significant, we could not use this difference as a way to accept the null hypothesis.

The p-value represents the probability of the occurrence of a given event. Treating the data as if in the population from which this sample was randomly drawn the null hypothesis was true, it was getting a test statistic at least as extreme as the one we got in a sample the size of the one we have. The statistical tests of Figures 1-10 observed p values higher than 0.05 meaning that the trends I was observing were non-significant, which could be interpreted in two ways. On one hand, the data set could be an unlikely sample and further research might be needed to provide further support that the null hypothesis can not be proven true. On the other hand, the data set could have been low probability because the null hypothesis was incorrectly stated, thus trying to support it being true, the framing was wrong. This data set was provided by National Center for Immunization and Respiratory Diseases (NCIRD) created on November 29, 2021, and last updated on March 16, 2023. It was made open to the public, but they did not offer any insights into its collection other than through telephone interviews using a random-digit-dialed sample of cell telephone numbers. My study's statistical analysis indicated that the results were not significant, therefore the null hypothesis could not be ruled out by the data alone. This could happen due to a number of things including a limited sample size, measurement error, or the lack of a real impact on the population under investigation. These limitations can interfere with the ability to support the null hypothesis as not happening due to chance. Another limitation would be considering the type of people to pick up the phone and answer questions to the CDC could not really include the working class who would be working during the same hours that the CDC surveyors would be conducting their study.

In Figures 1-10, there is a notable even distribution of the responses that could indicate in the data collection process, the CDC might have been looking to hit a certain quota of responses and not necessarily a reflection of the answers received. The US has grown increasingly divided because of the Covid-19 pandemic, which could explain the vast range and unusual distribution of the responses. The public's perception of the government's Covid-19 outbreak handling showed 77% of Americans felt the outbreak further divided the country (40). Alongside this, the opinions came directly from parents/guardians that as discussed previously, reduce children to being products of their environment, when scholarship has explored children actively shaping their own and their families' social environment and health knowledge (6, 38, 39, 49). In Figure 2, the parent/guardian response of intentions in getting their child their next sequential vaccine is higher than other vaccine intentions, which suggests the openness to health protective behaviors. The risk assessment that parents perceive influences their decision on whether or not they perceive pathogenic exposure as a threat. These are important in this immunological stage of development for children. Further research needs to be addressed in the early life "critical window" for microbiota intervention if researchers intend to use these health protective behaviors that became frequent during the pandemic (such as social isolation and sanitization) to prevent immunological dysregulation due to changes in the daily levels of microbe exposure (51).

It is crucial to remember that an insignificant finding of this study does not imply that there is no influence or connection between the variables under investigation. It simply indicates that there was insufficient support for the alternative hypothesis in the data. There could be further studies that ask microbiome and hygiene hypothesis-specific questions that could solve the drawbacks of this study and deepen the investigation of children's immunoregulation as research subjects. Focusing on a specific region rather than nationwide where the public health protocols and the pandemic response weren't so polarizing would because would allow us to further understand the attitudes and perceptions of the microbiome.

It is important that this topic be continued to be explored in the biosocial sciences as microbial diversity is continuously affected by sanitation and rapidly changing environments. Despite the rapid disruption that COVID-19 has already brought throughout the planet, it serves as a reminder of the important part that microbes play in every area of our lives since we live in a microbial world. This pandemic offers a unique chance to study the complex interactions between a pathogenic organism, the microbiome, and their combined effects on health and disease. This study has presented an opportunity to be able to improve existing pandemic response and control approaches by remaining vigilant on long-term alterations to the microbiome before and during the Covid-19 pandemic. With the guidance of these developments in concepts and procedures, we will be prepared in being able to handle any pandemics in the future.

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Dataset Citation:

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