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The Influence of Dietary Factors on Child Food Allergies

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Abstract

Objective: Solid food introduction guidelines were recently amended to suggest that earlier introduction of peanuts is associated with a decreased prevalence of peanut allergies in high-risk children. This study aimed to determine whether there is a relationship between timing of introduction to the eight most common food allergens and the development of a food allergy.

Methods: A total of 177 biological mothers of school-aged New Hampshire children completed the survey, but some were excluded due to answering <50% of the survey or not consenting to participate in the study. This left data on 101 participants, and the number of participants then varied between the various food allergens.

Results: Out of the 22 children with a milk allergy, 10 children were introduced to milk when they were less than 12 months old and 12 children were introduced at or after one year old. Fifty-nine percent of those introduced before 12 months of age developed a milk allergy, while only 17% of those introduced at or past 12 months developed a milk allergy ($p = 0.00$). Out of the 55 participants that developed a peanut/tree nut allergy, 12 were introduced to peanuts/tree nuts before the age of 12 months, and 43 introduced after. This means that 63% of those introduced before a year developed an allergy, while only 33% introduced later developed an allergy ($p = 0.01$). Although not significant, the results for egg, wheat, and peanut also demonstrated that earlier introduction may be associated with an increased risk of an allergy to that food. When only one child per family was considered, to exclude genetic confounders, the only significant value was for a milk allergy, in which 64% of children introduced before 12 months developed a food allergy, while only 18% of children introduced at or after 12 months developed one ($p = 0.00$). Results were similar even after the exclusion of child one and two.

Conclusion: The results of this study concur with the recommendation of introducing milk after one year, but do not support earlier introduction to other food allergens in the general population.

Introduction

The prevalence of childhood food allergies has drastically increased over the years and does not seem to be coming to a plateau, yet the exact cause of food allergy development remains unknown. The prevalence of food allergies increased from 3.4% of all United States (U.S.) children in 1997 to 5.1% of children by 2011.[1] In 2015, the Centers for Disease Control and Prevention surveyed families throughout the U.S. to discover that approximately 4.2 million children throughout the nation had been diagnosed with one or more food allergies.[2] Food allergies and food intolerances are both reactions that consist of similar symptoms appearing after eating certain foods. This research study focuses solely on food allergies, which are reactions involving an immune response, as opposed to just a sensitivity to a food.[3] Although quite a variety of foods can cause allergic reactions, there are eight food allergens that cause most of the allergic reactions found in our nation. The eight most common food allergens are peanuts, tree nuts, milk, eggs, wheat, soy, fish, and shellfish.[4]

The first recorded instance of a food allergy was documented by Franz Hamburger, a German scientist, in 1901.[5] The allergy was diagnosed by an infant's reaction to its first feeding of cow's milk, which resulted in severe stomach upset and failure to thrive over time. In the years to follow, scientists created various tests to diagnose food allergies, and these tests have been improved upon ever since. Today, allergists begin the diagnosis of a food allergy by collecting a family history of food allergies along with a detailed history of allergic symptoms in the individual, such as whether or not they experience hives.[6] If there is a genetic history of food allergies present, the doctor will typically follow up with a blood test that looks for immunoglobulin E (IgE) antibodies and/or a skin prick test. If the tests provide positive results, then allergists will typically conduct an oral food challenge test in which the patient will

consume the food in small amounts multiple times over a series of hours while in the safety of the allergist's office. Reactions to the food such as edema or hives results in the official positive food allergy diagnosis.

In a normal non-allergic situation, the human body does not recognize food as a harmful substance. In individuals with food allergies, the immune system identifies certain foods as being harmful or dangerous to the body.[7] This recognition elicits hyperactivity by the immune system, causing a release of IgE antibodies upon first introduction to the food. These antibodies then recognize the food the next time that it is consumed. This causes an immediate production and release of histamine, triggering the allergic response. Allergic responses range in severity from person to person and may even change each time the food is consumed. Some of the more minor reactions may include tingling/itching in or around the mouth, eczema or a skin reaction, swelling around the mouth area, wheezing, gastrointestinal symptoms, and dizziness. The most severe reaction is anaphylaxis, a life-threatening reaction due to constriction of the airway/throat that causes the inability to breathe, a drastic decrease in blood pressure, and an increased heart rate that can result in a loss of consciousness. Immediate treatment with an epinephrine injection, also known as an "epi pen", is necessary to stop the anaphylaxis before it ultimately results in death.[8] Because of the severity and potential dangers involved in allergic reactions, it is important that there are guidelines for parents to be able to follow to help prevent food allergy development and keep their children safe.

In the year 2000, the American Academy of Pediatrics (AAP) released a recommendation that infants at high risk of having a food allergy (infants with other atopic diseases and allergies such as eczema and/or egg allergy) should be introduced to certain solid foods at different points in their life depending on the food.[9] Specifically, they recommended the introduction of solid

foods that are typically non-allergenic such as rice cereal at six months old, dairy at one year, eggs at two years, and nuts/fish at three years old. At the time, it was deemed unnecessary to avoid potential allergens while pregnant, with the exception of the recommendation to exclude peanuts if that seemed to be a high risk potential allergen to the unborn infant. Eight years after those recommendations were released, the National Institute of Allergy and Infectious Diseases (NIAID) began drafting new recommendations. In 2010, they released the recommendation to introduce solid foods earlier rather than later, as long as the child was between four to six months of age and anaphylaxis was not an issue with other foods/beverages prior.[10] These guidelines were accepted by the AAP as well. The NIAID added an amendment to their guidelines in 2017, which provided the strong recommendation that high-risk infants should be introduced to peanuts between the ages of four to six months old, after skin prick testing is completed.[11] The amended guidelines also stated that infants with mild-to-moderate atopic diseases should be introduced to peanuts at six months, while those without any eczema/allergies can be introduced to peanuts whenever the family decides that the child is ready. However, the child should be at least four months of age and demonstrate developmental signs of preparedness to tolerate solid food consumption.

The main reason that the NIAID changed their recommendation guidelines was because of the Learning Early About Peanut allergy (LEAP) study, published in February of 2015.[12] This study examined the relationship between timing of peanut introduction and the development of a peanut allergy. High-risk children between the ages of 4 and 11 months were randomly assigned into two separate groups. The parents of the children in group one began introducing peanut butter or other baby-safe peanut foods immediately, at least three times per week until the child reached age five. In group two, peanuts were withheld until the study was completed at age five.

Results from 530 remaining subjects showed an 80% lower incidence of a peanut allergy by age five in group one compared to group two, demonstrating a potentially protective effect of earlier introduction.

Researchers used the LEAP cohort to complete a follow-up study in which they asked all participants to avoid peanut consumption for the full year following the trial.[13] Over 500 of the participants completed the follow-up, and were tested again for a peanut allergy. Results showed a 74% lower incidence of peanut allergy in those that had introduced peanuts earlier on in the primary study, again demonstrating the potentially protective effect of earlier introduction to peanuts.

Other research on potential food allergy causes are sparse. In addition, some only target one or two variables that may contribute to the development of allergies, as opposed to considering multiple variables all at once. In a 2004 retrospective cohort study of 8,600 Jewish children, DuToit et al. determined that the significant increase of peanut allergy prevalence in the United Kingdom (UK) as compared to Israel could potentially be due to the fact that Israeli infants consume more peanuts in the first year of life than those in the UK.[14] This study identified later introduction as a potential cause of childhood food allergy.

In a more recent study of 1,303 infants called the Enquiring About Tolerance (EAT) Study, Perkin et al. chose an experimental group of children that were introduced to six common food allergens at three months old alongside breastfeeding, and a control group that was solely breastfed for six months.[15] The goal of this study was to ensure that it was in fact possible to introduce six allergenic foods alongside breastfeeding. Researchers faced some difficulty with compliance from participants, but overall decided that it was possible to introduce the food allergens to their children alongside breastfeeding. In combination, the studies suggest that

introducing allergens earlier in life is possible and may result in a decreased prevalence of food allergy due to a built-up tolerance to foods.

It is important to note that most of the existing research has focused primarily on the topic of peanut allergies. Studies regarding the other seven of the eight top food allergies are lacking. This specific research study was designed with the eight most common food allergens in mind so that it was more inclusive of the most common food allergies having an impact on U.S. children. Therefore, the data can be extrapolated to a wider audience and can give a better guide as to when to introduce various foods to children, not just concerning the introduction of peanuts.

The purpose of this study was to investigate the potential relationships between dietary factors and childhood food allergies in school-age New Hampshire children, with the hopes of adding new information to the existing body of research. The study aimed at factors that may have been previously considered in separate studies or on fewer allergenic foods in order to fill in the gaps in the current research that were previously mentioned. The specific factors targeted in this survey were maternal demographics, breastfeeding length, formula information, introduction to solid foods, food consumption during pregnancy, food consumption while breastfeeding, maternal food allergies, and the age at which the eight most common food allergens were introduced to the child. This study hypothesizes that later introduction to each of the top eight food allergens would correlate with an increase in the prevalence of each individual food allergy.

Methods

This research study was conducted between February 23, 2017 to May 8, 2017 with the approval of the University of New Hampshire's Institutional Review Board, which reviewed all

parts of the study protocol and the reasoning behind the study completion. Participants for the study were recruited through an email that was distributed throughout both public and private New Hampshire school systems at the discretion of the school administrations (see Appendix A). The email stated the purpose of the study, the specific population being targeted, and provided a link to the anonymous Qualtrics online survey. A Microsoft Word format of the Qualtrics survey may be referred to in Appendix B. Out of the 123 school systems that received the email, 24 school administration systems agreed to send out the email which asked parents to fill out the survey. This included both large and small school systems, and it was asked that the lead school supervisor/superintendent send out the email to all of the elementary schools in their school system. The target population for participation in this survey was originally intended to be based solely on biological mothers of children with one or more food allergies, but even those who did not have a child with allergies still completed the survey. Although not the original intention, results from both types of mothers were kept and included as potential valid survey results to then allow for comparison between children with and without food allergies.

The 18-question survey was developed after reviewing past food allergy surveys, and determining the gap in knowledge from prior research. Demographic questions were derived from typical government-created websites. Comparing these past studies helped to determine the best categories to choose that would be most representative of the participant pool of this study. Other questions surrounding dietary patterns and familial allergies followed the demographic information, although these questions were not analyzed in this study. For the allergy questions, each of the top eight food allergens were listed individually in a chart so that participants would answer each question with a different answer for each separate food allergen (see Appendix B). This was to avoid the issue that on allergen, such as peanuts, may have been introduced before

the child reached one year of age, while milk may have been introduced much later. The chart contained questions that were not analyzed in this study as well, such as the mother's allergies and whether or not the mother consumed each food while pregnant and/or breastfeeding. After full development of the survey, a panel of three experienced nutrition professionals reviewed the survey and provided their recommendations and suggestions for changes.

At the start of the survey, participants first had the option of choosing to decline or consent to participating in the research study. Those included in the study were biological mothers of children in New Hampshire School systems, as it was stated in the email that was sent out to parents. In order to keep the sample size above 100 participants, all survey results were considered as a part of the data even if the children did not have food allergies. The only instances in which data were excluded from the study were if the participant declined the consent to participate question or if they filled out less than 50% of the survey questions (solely the demographic information). This left a remaining 101 participants. In the chart-formatted question where the top eight food allergies were analyzed separately, some parents only filled out their answers for certain foods. Because of this, there is a different population size for each question in the survey, and participants that left an answer blank were excluded from *that* specific food question when it was analyzed.

The demographic characteristics of the included participants are demonstrated by Table 1, as analyzed by Qualtrics. The majority (n = 97, 96.04%) of participants were White and most were college graduates with a Bachelor's degree or higher (n = 71, 70.29%). The most common household income was over $150,000 per year (n = 27, 26.73%), followed closely by $100,000-149,000 (n = 21, 20.79%). This means that slightly less than half of our study population made over $100,000 per year, which is nearly double the average U.S. median household income.[16]

These factors limit the population that these results can be extrapolated for because the majority were White with higher level education and a high household income.

After the demographics were analyzed in Qualtrics, data were then exported into Excel for conversion into codes for SPSS. In SPSS, output variables were recoded so that they could then be analyzed using the chi-squared method on the software, with statistical significance being considered if $p \leq 0.05$. Results were displayed in both tables and bar charts, but were then combined into two tables, Table 2 and Table 3.

Results

The results of this survey contradicted much of the current existing research as far as suggesting that introduction earlier in life may have a protective effect against the development of food allergies. When analyzing the data, the only statistically significant results ($p \leq 0.05$) were for the introduction of milk and the introduction of peanuts/tree nuts combined. The results were formatted in a way that would allow us to compare the age groups to determine whether or not there was a difference in the relationship to food allergy depending on the age of introduction.

Table 2 displays the results of children one through three. Out of the 22 children that developed a milk allergy, 10 children were introduced to milk when they were younger than 12 months old. This means that 10/17 (59%) of those who were introduced to milk before 12 months of age developed an allergy to it. Twelve children (17% of the 60 children introduced at or after one year) were introduced to milk past the age of one year ($p = 0.00$). This demonstrates that later introduction beyond the first year of life may be beneficial in preventing food allergies. However, out of the 55 participants that developed a peanut/tree nut allergy, 12 were introduced

to nuts before one year of age while 43 of the children were introduced at or after one year of age. In this case, participants were less likely to develop a peanut/tree nut allergy if they were introduced after one year old, as demonstrated by 63% of children introduced earlier developing allergies compared to 33% who were introduced later ($p = 0.01$).

Although not statistically significant, the results for egg, wheat, and peanuts separately also demonstrated the same pattern of earlier introduction being associated with an increased prevalence of an allergy to that food. Twenty-three percent of children introduced to egg before 12 months developed an egg allergy, while only 20% of those introduced at or after one year developed the allergy ($p = 0.81$). These percentages were so close that they cannot be taken as meaningful to base an opinion or recommendation from. Comparing wheat results, 16% of those introduced before 12 months developed an allergy, while only 14% of the later children did ($p = 0.81$). Similar results were shown for peanuts as well, with the percentages of children with allergies being 57% and 37%, respectively by age of introduction ($p = 0.16$).

Table 3 shows the results of the survey when only one child per family was considered in order to remove the potential for genetic factors as a confounder in the results. The only significant value in these results was with milk allergy, demonstrating that 64% of children introduced before 12 months developed a food allergy, while only 18% of children introduced at or after 12 months developed an allergy to milk ($p = 0.00$). Although all other results for all children and just child one was not statistically significant, they all demonstrated a higher percentage of children developing a food allergy if they were introduced to the food prior to 12 months of age. This suggests that genetics likely did not play a role in the results that included all children.

Discussion

Using a survey-based study, we were able to collect food allergy data on elementary school-aged children from schools throughout the state of New Hampshire. After analysis, the peanut/tree nut combined results were different than the results that former studies have demonstrated. Our study showed that 63% of children that were introduced to peanuts/tree nuts before the age of one developed a peanut allergy, while only 33% of those introduced after age one developed an allergy ($p = 0.01$). The results found in this study suggested that there may be a link between the early introduction of peanuts/tree nuts and the increased chance of developing an allergy to them, while other studies showed that earlier introduction was related to a decreased risk of developing food allergies.[12-14] The most plausible explanation for the difference in results is the fact that this specific survey was not just inquiring about children that were at increased risk for developing a food allergy. Previous studies, specifically the LEAP study, only included high-risk children and included confirmation by a doctor that the children were indeed at an increased risk for developing a food allergy. Our survey was inclusive of all children with or without skin conditions and with or without food allergies, so it better represents the general population consisting of both high-risk and normal-risk children.

However, the results of our study showing that later milk introduction may be correlated with a decreased percentage of children with milk allergies does coincide with the recommendation to wait to introduce cow's milk to children until they are at least one year old.[9] With milk, 59% of those introduced before 12 months of age developed a milk allergy, while only 17% of those introduce at or past 12 months developed one ($p = 0.00$). These results can also be backed up by the science behind later introduction of cow's milk.[17] Cow's milk contains a higher concentration of protein than human milk or baby formulas, which is harder for infants

to digest until they have reached complete development of their stomachs and the enzymes in their intestines. The protein and mineral content of cow's milk can also cause damage to kidneys of a baby because they are still not mature enough to handle such a large renal load until one year old. Although cow's milk has high concentrations of some minerals, it also lacks iron which babies need in order to grow properly. Thus, introducing cow's milk too soon can even result in iron deficiency anemia if the infant is not consuming enough iron-rich foods, as most infants do not at that age. This makes human milk or formula necessary, followed by the introduction of iron-rich foods such as iron-fortified rice cereal. Once infants reach one year of age, their growth rate slows down slightly, causing a decrease in their iron needs, and the kidneys/digestive tract are prepared to digest and absorb the nutrients that cow's milk has to offer, so cow's milk can then be introduced.

Although other data that we collected were not statistically significant, all results showed the same pattern as the combined peanut/tree nut and milk results, suggesting that earlier introduction may be related to an increased risk of developing an allergy to that food in the general population. Since research is lacking in all other allergenic foods besides peanuts, it is difficult to compare our egg and wheat results to any existing studies. However, Poole et al. conducted a study on wheat allergies, which tested 1,612 children between birth and five years old for wheat allergies and then compared questionnaires about the timing of wheat introduction.[18] Results showed that, out of the 16 children (1% of the total sample) that had a wheat allergy, the majority of them had been introduced to wheat after the age of six months rather than before. It is important to note that, although results are opposite between this study and our research, both studies had a very small sample size of children with wheat allergies. Our study also included a larger age range since the two age categories were <12 months or ≥12

months, so it is possible that our results may have been different if the age groupings were changed to before or after six months instead of 12.

In another study published in 2010, Nwaru et al. investigated the same relationship as we did in our study, but with other foods.[19] Two of the foods, egg and wheat, were included in both studies. Their results demonstrated that later introduction of wheat beyond six months of age and later introduction of eggs beyond 10.5 months of age resulted in an increased risk of developing an allergy to each food, which again shows different results than our survey. Koplin et al. published a study solely on eggs, which demonstrated that introducing egg between 10-12 months was associated with a 60% increased risk of developing an egg allergy (95% CI, 1.0-2.6) and after 12 months was associated with a 240% increased risk (95% CI, 1.8-6.5) when compared to the development of allergies in a population that introduced eggs between four to six months of age.[20] Children in this study were at higher risk than the average population, and it is also important to mention that the recommendations at the time were to introduce solids either after six months or after 10 months. These factors may have skewed the data and resulted in more children being introduced after those ages, increasing the number of allergenic children in each of those age categories. This study was comprehensive in its allergy testing because it included skin prick tests and then confirmation by an oral food challenge to determine whether or not the child truly had a food allergy. This is something that should be noted for future research studies on allergens, because it was an important part of their procedure.

Research cannot be done without limitations. For this research project, the biggest limitation involved the limited ability to extrapolate the results to a wide variety of people. The demographic data demonstrated that the majority of the participants were White, college graduates, and nearly half of them had an average household income of over $100,000 per year.

Likely not without coincidence, that is the exact type of population where food allergies are more commonly discovered. Because of the limited diversity of this sample, the results of this research may not apply to those in a lower economic class, of a different race, or not living in the northeastern U.S. Another limitation was the survey itself, due to the difficulties with its wording and format. Because the survey had many open-ended questions, this left some of the answers open to interpretation by the participants, demonstrating that some did not understand the questions being asked. Answers that did not match the question or did not seem logical were excluded to prevent skewing the data if results were entirely not possible, such as an allergy being discovered in a child that was over 200 months old (16 years, which is likely not a food allergy). Such a high age provided as an answer to this question could have been due to a participant typing error or a misunderstanding of what the question was asking. The formatting could have been improved for the chart section as well because participants left areas of the chart blank that were necessary in order to answer the hypothesis, so their data could not be used either.

In general, a larger sample size would have been more beneficial because some of the specific foods, such as wheat, had only been answered by 11 people. If there were a larger sample size, it is possible that the results may have been entirely different just due to the fact that more people were surveyed and the sample size for each food allergen would have been larger. A larger sample size would also have allowed us to stratify the age categories differently. With our results, we only compared introduction of the allergens before or after one year old, but more results may have allowed us to stratify by introduction in every four-month interval since birth. Results may have been different if that were the case because perhaps, hypothetically, there may have been an increased risk of an allergy when a food was introduced between 0-4 months, but a

decreased risk if it was introduced between 4-6 months of age. Being able to stratify into more than two age categories would have improved the results significantly as far as specificity of the timing of introduction.

It is also important to note that this study had the potential to be skewed by memory bias. Parents were surveyed about their child's eating habits when the child was around one year of age. However, the survey was sent out to elementary schools where children are typically at least five years old. This could have contributed to parents being unable to remember the exact age where each solid food was introduced, and they could have even gotten confused between their children if they had multiple children. Self-reporting in general may be less reliable than other methods, but surveying about previous food introduction can only be completed through this method.

Another factor that could have caused skewed data is that fact that the survey did not require that the parents provide documentation of the allergist's verification that the child had a true food allergy. Some parents answered the survey question for wheat and wrote the word "Celiac" in one of the answers, which demonstrates that the general population may get confused between intolerances and allergies even though the survey specifically stated that an allergist diagnosis was preferred. Finally, genetics may be a confounder for food allergies. This is why there is a separate table that only includes the results of one child per family (Table 3) in addition to Table 2 which includes siblings. However, eliminating the other children in each family lowered the sample size of each allergen even further, which contributed to less statistically significant results. There was also not a significant difference between percentages after child two and three were excluded from the results, so it can be assumed that the potential genetic component did not play a role in the results of this survey.

In the future, it would be more beneficial to survey parents of children that are in child care centers where the maximum age of their children would currently be less than five instead of the minimum age being five, as it was in the elementary schools that we surveyed. Results may also be different if more geographic areas were included, such as surveying multiple states throughout the country. This would also result in increased participation, which would increase the power of the results and the ability to extrapolate the data to a more diverse population as well as providing more specific age categories to stratify the results. It also would be beneficial to have a survey question that asks about the child's atopy to determine their risk for developing an allergen so that the data could then be stratified based on child risk level, as well as an additional section in which the documentation of a food allergy diagnosis is requested.

Conclusion

The results of this survey add to the existing body of research on food allergies and even provide new information on food allergies that have not been included in previous studies. The results of this survey supported the recommendation that milk should be introduced after one year of life by demonstrating a higher percentage of children developing a milk allergy when introduced before one year of age. The results did not support the recommendation that all other allergenic foods should be introduced to children earlier than one year of age. The current study found that milk, nut, and peanut allergy prevalence were higher in the children when these foods were introduced at a younger age. This raises the question of whether or not early introduction of allergenic foods is protective over the general, non-high-risk population as compared to other studies of high-risk populations. However, more research is still needed because there is

conflicting evidence surrounding the best time to introduce potentially allergenic foods to children.

Table 1: Demographics of the Population, N = 101			
#	**Answer**	**%**	**N**
Race			
1	American Indian or Alaskan Native	0.00%	0
2	Black or African American	1.98%	2
3	Asian/Pacific Islander	0.00%	0
4	White	96.04%	97
5	Hispanic	1.98%	2
6	Other	0.00%	0
7	Prefer not to answer	0.00%	0
	Total	100%	101
Education			
1	Grade school	1.98%	2
2	Some high school	0.00%	0
3	High school graduate or GED	3.96%	4
4	Some college, no degree	7.92%	8
5	Trade of vocation degree	2.97%	3
6	Associate's degree	12.87%	13
7	College graduate	31.68%	32
8	Master's degree	24.75%	25
9	Professional degree	8.91%	9
10	Doctorate degree	4.95%	5
11	Prefer not to answer	0.00%	0
	Total	100%	101
Annual Household Income			
1	Less than $15,000	0.99%	1
2	$15,000 to $24,999	2.97%	3
3	$25,000 to $34,999	1.98%	2
4	$35,000 to $49,999	9.90%	10
5	$50,000 to $74,999	11.88%	12
6	$75,000 to $99,999	14.85%	15
7	$100,000 to $149,999	20.79%	21
8	$150,000 or more	26.73%	27
9	Prefer not to answer	9.90%	10
10	Total	100%	101

Table 2: Child 1-3 Results					
	<12 months	N <12 months	≥12 months	N ≥12 months	Significance (significant when P ≤ 0.05)
Milk Allergy	10 (59%)	N = 17	12 (17%)	N = 72	P = 0.00
Egg Allergy	5 (23%)	N = 22	12 (20%)	N = 59	P = 0.81
Wheat Allergy	6 (16%)	N = 38	5 (14%)	N = 36	P = 0.82
Peanut Allergy	8 (57%)	N = 14	26 (37%)	N = 70	P = 0.16
Nut Allergy (P + T)	12 (63%)	N = 19	43 (33%)	N = 132	P = 0.01
*Soy, Fish, Shellfish, and Tree Nuts not shown due to small sample size *Percentages denote the percent of the population that introduced the food in that specific age group					

Table 3: Child 1 Results					
	<12 months	N<12 months	≥12 months	N ≥12 months	Significance (significant when P ≤ 0.05)
Milk Allergy	9 (64%)	N = 14	8 (18%)	N = 45	P = 0.00
Egg Allergy	5 (31%)	N = 16	8 (20%)	N = 40	P = 0.37
Peanut Allergy	6 (60%)	N = 10	19 (40%)	N = 48	P = 0.24
*Soy, Fish, Shellfish, Wheat, and Tree Nuts not shown due to small sample size *Percentages denote the percent of the population that introduced the food in that specific age group					

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Appendix A. Email Requesting Participation

Dear Superintendent:

My name is Jessica Shaw, and I am an undergraduate Dietetics student at the University of New Hampshire. I am currently conducting research for my senior honors thesis: The Influence of Dietary Factors on Child Food Allergies. I am emailing you in hopes that it would be possible to send out an email blast to all of the parents in your school system, so that I will be able to gain participants for the research survey. If possible, could you please send out the email below with the survey link? I would be happy to answer any questions you may have regarding this project.

Thank you,

Jessica Shaw

Dear Parent/Guardian(s):

My name is Jessica Shaw, and I am an undergraduate Dietetics student at the University of New Hampshire. I am currently conducting research for my senior honors thesis: The Influence of Dietary Factors on Child Food Allergies. I am using an anonymous online survey to collect data from **biological mothers of one or more children that have food allergies**, in hopes of finding common factors that may contribute to food allergies. If you have approximately 30 minutes to complete this survey, it would be greatly appreciated:
https://unh.az1.qualtrics.com/SE/?SID=SV_29xiuiMKivHneYJ.

There is a consent form at the beginning of the survey, followed by 13 questions. If you have any questions, please feel free to email me at jas2004@wildcats.unh.edu.

Thank you,

Jessica Shaw

Appendix B. Microsoft Word Format of Qualtrics Survey

RESEARCHER AND TITLE OF STUDY?

My name is Jessica Shaw and I am an undergraduate Dietetics student at the University of New Hampshire. The study is: The Influence of Dietary Factors on Child Food Allergies.

WHAT IS THE PURPOSE OF THIS FORM?

This consent form describes the research study and helps you to decide if you want to participate. It provides important information about what you will be asked to do in the study, about the risks and benefits of participating in the study, and about your rights as a research participant. You should:

- Read the information in this document carefully.
- Ask the research personnel any questions, particularly if you do not understand something.
- Not agree to participate in the survey until all your questions have been answered by the researcher, or until you are sure that you want to participate.
- Understand that your participation in this study involves you taking a survey that will take no longer than 30 minutes.

WHAT IS THE PURPOSE OF THIS STUDY?

The purpose of this survey is to determine what dietary factors may have an influence on child food allergies. There are expected to be approximately 100 participants in this study. Participants must be mothers of children who have a food allergy, also known as an immune reaction that occurs soon after eating a certain food, as diagnosed by a physician (Mayo Clinic 2014).

WHAT DOES YOUR PARTICIPATION IN THIS STUDY INVOLVE?

You will be asked to complete the following online survey, which should take no longer than 30 minutes to complete. Some questions require selecting an answer from a menu of options, while others require a very brief typed response.

WHAT ARE THE POSSIBLE RISKS OF PARTICIPATING IN THIS STUDY?

Participation in this study is expected to be at no risk to you.

WHAT ARE THE POSSIBLE BENEFITS OF PARTICIPATING IN THIS STUDY?

The anonymous results of this research will be compiled into a Senior Honors Thesis: The Influence of Dietary Factors on Child Food Allergies to benefit future research in this topic area.

WILL YOU RECEIVE ANY COMPENSATION FOR PARTICIPATING IN THIS STUDY?

There will be no compensation for completing this survey.

DO YOU HAVE TO TAKE PART IN THIS STUDY?

Taking part in this study is completely voluntary. You may choose not to take part at all. If you agree to participate, you may refuse to answer any question. If you decide not to participate, you will not be penalized or lose any benefits for which you would otherwise qualify.

CAN YOU WITHDRAW FROM THIS STUDY?

If you agree to participate in this study and you then change your mind, you may stop participating at any time. If you decide to stop participating at any time, you will not be penalized.

HOW WILL THE CONFIDENTIALITY OF YOUR RECORDS BE PROTECTED?

I plan to maintain the confidentiality of all data and records associated with your participation in this research. There are, however, rare instances when I may be required to share personally-identifiable information with the following:

- Officials at the University of New Hampshire,
- The sponsor(s), or
- Regulatory and oversight government agencies.

Further, any communication via the internet poses minimal risk of a breach of confidentiality. To help protect the confidentiality of your information, data will be collected anonymously without mention of names, addresses, and/or phone numbers. Those with access to the data include myself and Dr. Ruth Reilly (faculty advisor). Data will be reported in a group format, without connection to any personal information that would allow the data to be linked back to an individual person. The results may be used in reports, presentations, future research, and publications.

WHOM TO CONTACT IF YOU HAVE QUESTIONS ABOUT THIS STUDY

If you have any questions pertaining to the research you can contact Jessica Shaw, jas2004@wildcats.unh.edu to discuss them.

If you have questions about your rights as a research subject you can contact Dr. Julie Simpson in UNH Research Integrity Services, 603/862-2003 or Julie.simpson@unh.edu to discuss them.

- ○ Click here if you consent to participate in the research study.
- ○ Click here if you decline to participate in the research study.

1. What is your race?
   _____ American Indian or Alaskan Native
   _____Black or African American
   _____Asian/Pacific Islander
   _____White
   _____Hispanic
   _____Other
   _____Prefer not to answer

2. What is the highest education level you have attained?
   _____ Grade school
   _____ Some high school
   _____ High school graduate or GED
   _____ Some college, no degree
   _____ Trade of vocation degree
   _____ Associate's degree
   _____ College graduate
   _____ Master's degree
   _____ Professional degree
   _____ Doctorate
   _____Prefer not to answer

3. What is your household yearly income? Please include all income sources.
   _____ Less than $15,000
   _____ $15,000 to $24,999
   _____ $25,000 to $34,999
   _____ $35,000 to $49,999
   _____ $50,000 to $74,999
   _____ $75,000 to $99,999
   _____ $100,000 to $149,999
   _____ $150,000 or more
   _____Prefer not to answer

4. How many children do you have with **food allergies**? _____

From this point forward, each child **with a food allergy, as diagnosed by their doctor,** will be given a number: Child 1, Child 2, Child 3, etc. Please answer the questions accordingly, **only** for the number of children with a food allergy.

5. How old were you when you gave birth to Child 1?
   _____ Under 18 years
   _____18 to 24 years
   _____25 to 34 years
   _____35 to 44 years
   _____45 years or older

6. How old were you when you gave birth to Child 2?
   _____ Under 18 years
   _____18 to 24 years
   _____25 to 34 years
   _____35 to 44 years
   _____45 years or older

7. How old were you when you gave birth to Child 3?
   _____ Under 18 years
   _____18 to 24 years

_____25 to 34 years
_____35 to 44 years
_____45 years or older

8. Did you breastfeed your child? Child 1: Yes or No Child 2: Yes or No or N/A Child 3: Yes or No or N/A

9. If yes, for how long (in months)? Child 1: _____ Child 2: _____ Child 3:_____

10. Did you also provide your child with formula while breastfeeding? If so, what brand was used with each child?
_____Child 1: Yes or No or N/A Name(s) of Formula(s)_____
_____Child 2: Yes or No or N/A Name(s) of Formula(s) _____
_____Child 3: Yes or No or N/A Name(s) of Formula(s) _____

11. At what age did you introduce solid foods to your child?
Child 1:_____ Child 2:_____ Child 3: _____

12. What was the first solid food you introduced to your child?
Child 1:_____ Child 2:_____ Child 3: _____

13. The following questions are in a table format. Please answer each question according to the child number above each table. If not applicable, please leave blank.

Child 1:

Food Allergen	Which of these foods did you eat while pregnant with Child 1?	Which of these foods did you eat while breastfeeding Child 1?	Age of the child when each food was introduced	Age of child when allergy appeared (in months) to each food	Allergic reaction symptoms	Do you (mother) have an allergy to these foods?
Milk						
Eggs						
Peanuts						
Tree nuts						
Soy						
Wheat						
Fish						
Shellfish						
Other						

Child 2:

Food Allergen	Which of these foods did you eat while pregnant with Child 2?	Which of these foods did you eat while breastfeeding Child 2?	Age of the child when each food was introduced	Age of child when allergy appeared (in months) to each food	Allergic reaction symptoms	Do you (mother) have an allergy to these foods?
Milk						
Eggs						
Peanuts						
Tree nuts						
Soy						
Wheat						
Fish						
Shellfish						
Other						

Child 3:

Food Allergen	Which of these foods did you eat while pregnant with Child 3?	Which of these foods did you eat while breastfeeding Child 3?	Age of the child when each food was introduced	Age of child when allergy appeared (in months) to each food	Allergic reaction symptoms	Do you (mother) have an allergy to these foods?
Milk						
Eggs						
Peanuts						
Tree nuts						
Soy						
Wheat						
Fish						
Shellfish						
Other						