

**NUTRIENT INTAKE AND MEAL-TIME BEHAVIOR OF CHILDREN WITH  
AUTISM SPECTRUM DISORDER**

by

Jaimie Lillian Lafferty

A thesis submitted to the Faculty of the University of Delaware in partial fulfillment  
of the requirements for the degree of a Master of Science in Human Nutrition

Spring 2020

© 2019 Jaimie Lillian Lafferty  
All Rights Reserved

**NUTRIENT INTAKE AND MEAL-TIME BEHAVIOR OF  
CHILDREN WITH AUTISM SPECTRUM DISORDER**

by

Jaimie Lillian Lafferty

Approved: \_\_\_\_\_  
Jillian C. Trabulsi, Ph.D.  
Professor in charge of thesis on behalf of the Advisory Committee

Approved: \_\_\_\_\_  
P. Michael Peterson, Ed.D.  
Chair of the Department of Behavioral Health and Nutrition

Approved: \_\_\_\_\_  
Kathleen S. Matt, Ph.D.  
Dean of the College of Health Sciences

Approved: \_\_\_\_\_  
Douglas J. Doren, Ph.D.  
Interim Vice Provost for Graduate and Professional Education and Dean  
of the Graduate College

## **ACKNOWLEDGMENTS**

I would like to thank my advisor and mentor, Dr. Jillian Trabulsi, for all her help and support throughout my graduate degree. She truly has been an inspiration for me since the beginning of my college education at UD through her work as both a researcher and an instructor. She was a true driving force who supported my interest in pursuing an advanced degree years ago as a young undergraduate student. I feel fortunate to have the opportunity to work with her and learn from her and appreciate the skillset she has helped me build over the course of my graduate career. I would also like to thank my thesis committee members, Drs. Shannon Robson and Sean Healy for their time, guidance, and invaluable expertise. Lastly, I would like to thank my friends and family for all their encouragement and support throughout this process.

## TABLE OF CONTENTS

LIST OF TABLES .....	vi
ABSTRACT.....	vii
Chapter	
1 INTRODUCTION .....	1
2 LITERATURE REVIEW .....	3
2.1 Autism Spectrum Disorder .....	3
2.2 Autism Spectrum Disorder and Feeding Problems.....	4
2.3 Mealtime Behaviors in Children with Autism Spectrum Disorder.....	5
2.4 Autism Spectrum Disorder and Nutrient Intake .....	6
3 AIMS .....	8
4 METHODS .....	10
4.1 Subjects .....	10
4.2 Study Visit Procedures .....	10
4.3 Anthropometric Measurements .....	11
4.4 Child Demography and Medical History .....	11
4.5 Behavioral Pediatric Feeding Assessment Scale .....	11
4.6 3-Day Diet Record .....	12
4.7 Data Analysis and Statistics .....	13
5 RESULTS .....	15
5.1 Parent and Child Characteristics.....	15
5.2 Nutrient Intake.....	15
5.3 Behavioral Pediatrics Feeding Assessment Scale and Nutrient Intake...	16
6 DISCUSSION AND CONCLUSION .....	18
REFERENCES .....	22

Appendix

A	TABLES.....	29
B	IRB APPROVAL LETTER.....	43

## LIST OF TABLES

Table 1.	Participant Demographics .....	29
Table 2.	Macronutrient and Micronutrient Intake .....	30
Table 3.	Macronutrient Distribution Ranges (AMDR) .....	31
Table 4.	Micronutrient Intake Compared to the Dietary Reference Intakes (DRI) .....	32
Table 5.	BPFAS Child and Parent Frequency and Problem Scores .....	33
Table 6.	Correlations between BPFAS Scores and Micronutrient Intake .....	34

## **ABSTRACT**

Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by challenges in social communication and relationships, as well as restricted, repetitive patterns of behavior, interests and/or activities diagnosed in early childhood. Feeding and mealtime challenges, such as delayed self-feeding skills, food selectivity or aversions, and prolonged meal duration, occur more frequently in children with ASD compared to children with neurotypical development (ND). Children with ASD have also been reported to have deficits in intake of several essential vitamins and minerals. The purpose of this study was to examine association between nutrient intake and mealtime behaviors in children with ASD compared to children with ND.

The data presented in this thesis are part of a larger, ongoing study entitled “Parental Stress, Parental Feeding Styles and Child Nutrient Intake Among Families of Young Children with Autism Spectrum Disorder”. Parents of children at least three years old but less than seven years old, with ASD and with ND, were recruited to participate in this cross-sectional, observational study. Participants attended one study visit at the Energy Balance and Nutrition Laboratory at the University of Delaware or a mutually agreed upon location, to complete questionnaires related to parental feeding styles, feeding practices, child mealtime behaviors, parental stress, and adaptive behaviors (only for children with ASD). Child diet intake was assessed by

three-day diet records and converted to nutrient intake data using Nutrition Data Software for Research (NDS-R).

To date, a total of 30 subjects (10 children with ASD, 20 children with ND) have completed the study. Given the present sample size and the ongoing nature of the study, the following results are considered preliminary. There were no statistically significant differences in child or parent demographic characteristics between children with ASD and children with ND. With respect to diet and nutrient intake, there were no statistically significant differences in macronutrient or micronutrient intake between children with ASD and children with ND. Meal-time behavior scores (mean $\pm$ SD) were higher for children with ASD compared to children with ND: child meal-time behavior frequency (children with ASD: 57.90 $\pm$ 11.4 versus children with ND: 46.10 $\pm$ 7.8;  $p=0.011$ ), child meal-time problems (children with ASD: 7.30 $\pm$ 5.9 versus children with ND: 2.62 $\pm$ 3.1;  $p=0.031$ ), and parent feeling/strategies (children with ASD 3.20 $\pm$ 3.0, children with ND: 0.55 $\pm$ 1.14,  $p=0.015$ ). With respect to associations between nutrient intake and meal-time behaviors, an inverse relationship was observed between vitamin C intake and child behavior frequency and parent feelings/strategies frequency scores in children with ASD ( $r= -0.632$  and  $r= -0.634$ , respectively;  $p<0.05$ ), but not in children with ND. These results are preliminary; enrollment is ongoing, and the study aims will be re-evaluated upon study completion.

## **Chapter 1**

### **INTRODUCTION**

Autism spectrum disorder (ASD) is neurodevelopmental disability.<sup>1</sup>

Symptoms present in early childhood and can be challenging for parents. According to the Centers for Disease Control and Prevention (CDC), since the year 2000, the prevalence of ASD has increased from 1 in 150 children to 1 in 54<sup>2</sup> Research has shown that children can be reliably and validly diagnosed with ASD as early as two years of age, however the average age at diagnosis is approximately four years. ASD is four times more common in male children compared to female children.<sup>2</sup>

Children with ASD have been found to have lower intake of key nutrients compared to children without ASD.<sup>3-9</sup> In addition to poor nutrient intake, the incidence of overweight and obesity in children with ASD is greater than children with neurotypical development (ND),<sup>10-15</sup> which in turn puts children with ASD at risk for other comorbidities such as lipid disorders and metabolic syndrome.<sup>16</sup>

Feeding problems at mealtimes in children with ASD occur much more frequently than in children with ND.<sup>17-26</sup> Some of the common feeding problems in children with ASD include not chewing food, lack of appropriate for age self-feeding, eating inadequate amounts, and prolonged meal times.<sup>3</sup> Food selectivity and food aversions may also occur which may be a result of sensory issues.<sup>4,27</sup> Studies have

explored feeding problems in children with ND<sup>28,29</sup> as well as children with ASD,<sup>30,31</sup> but few have simultaneously evaluated feeding problems and nutrient intake.

Research evaluating the dietary intake and mealtime behaviors of children with ASD is limited. To our knowledge, only Castro et al., 2016, investigated such issues simultaneously.<sup>31</sup> In this study of male, school-age (4 to 16 years of age; mean age of 10 years) children with ASD and age-matched control children, those with ASD were found to have a higher energy intake, limited food repertoire, and inadequate intakes of calcium, iron, pantothenic acid, folate, and vitamin C compared to age-matched control children. Mealtime behavior scores were also higher for children with ASD, indicating more challenges at mealtimes; however, the relationship between mealtime behavior scores and nutrient intake was not examined.<sup>31</sup>

The results presented in this thesis are part of a larger, ongoing study of “Parental Stress, Parental Feeding Styles, and Child Nutrient Intake Among Families of Young Children with Autism Spectrum Disorder”. The purpose of this thesis is to evaluate the nutrient intake, mealtime behaviors, and the relationship between these factors in preschool-aged children with ASD and children with ND.

## **Chapter 2**

### **LITERATURE REVIEW**

#### **2.1 Autism Spectrum Disorder**

Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by social interaction and communication impairments, and restricted, repetitive patterns of behavior or interests that present early in the developmental period that lead to clinically significant impairment in social, occupational or other important areas of functioning.<sup>32</sup> For the diagnosis of ASD, these impairments must not be able to be explained by an intellectual disability (intellectual developmental disorder) or a global developmental delay.<sup>32</sup> The prevalence of ASD has increased from 1 in 150 children to 1 in 59 since the year 2000.<sup>2</sup> Individuals with ASD often struggle with social-emotional interactions and with nonverbal communications in social situations; they also have difficulties with developing, maintaining, and understanding relationships. In earlier versions of the Diagnostic and Statistical Manual of Mental Disorders (DSM) - 4, ASD was one of four ASD-related disorders: ASD, Asperger's disorder, childhood disintegrative disorder, or pervasive developmental disorder not otherwise specified.<sup>33</sup> However there was a lack of consistency with these diagnoses across different treatment centers, therefore the most recent edition of the DSM-5 identifies all of these disorders under one umbrella; a singular ASD diagnosis was established to recognize the variability of symptoms of individuals and acknowledge that these symptoms fall on a continuum.<sup>33</sup> Severity of ASD is determined based on the level of impairments in social communication and level of restricted repetitive behaviors.<sup>34</sup> Children with ASD frequently have co-occurring conditions such as

medical or genetic conditions, other neurodevelopmental conditions, impairments in language, and/or ADHD.<sup>35</sup> While there is no cure for ASD, the use of behavior-focused therapies early in life has been shown to improve outcomes of children with ASD.<sup>36</sup>

## **2.2 Autism Spectrum Disorder and Feeding Problems**

Children with ASD often experience feeding problems, food aversion, and food selectivity due to sensory issues, which in turn can affect their ability to consume foods with specific textures. Feeding problems have been described as not chewing food, lack of appropriate for age self-feeding, not communicating when hungry, stressful mealtimes, eating inadequate amounts, and prolonged meal times.<sup>3</sup> Food aversions may include avoidance of specific foods based on texture, color, smell, or temperature.<sup>4,27</sup> Food selectivity is a term that has been used to indicate food refusal, a limited variety of foods consumed, and high consumption of single foods.<sup>4,27</sup> In a study of 53 children with ASD and 58 children with ND aged 3-11 years, children with ASD refused 41.7% of total foods offered, compared to children with ND who refused 18.9% of total foods.<sup>4</sup> In another study of 56 children with intellectual disabilities (ID) aged three to eight years, 68% of whom had a probable diagnosis of ASD based on the Autism Spectrum Rating Scale, children with ASD had the highest rate of overall food refusal (34.6%) compared to those with ID without probable ASD (22.5%) and children with ND (15.9%).<sup>27</sup> Moreover, children with ID and possible ASD had the highest rates of refusal of fruits and vegetables consumed (50.4%)

compared to those with ID without possible ASD (34.1%) and children with ND (29.6%). Finally, a study of 25 children with ASD and 30 children with ND aged four to six years, found that children with ASD had significantly greater food fussiness when compared to children with ND.<sup>37</sup> Among the 25 children with ASD, 10 children were identified as having atypical oral sensory sensitivity and had the highest rates of food avoidance behaviors, such as neophobia, food fussiness, and greater emotional undereating. Overall, children with ASD compared to children with ND are more likely to have issues with food selectivity and food avoidance behaviors. Furthermore, those with ASD with atypical oral sensitivities are more likely to experience feeding problems.

### **2.3 Mealtime Behaviors in Children with Autism Spectrum Disorder**

Children with ASD are often labeled “picky eaters” and have been found to have more problematic mealtime behaviors compared to children with ND.<sup>37-39</sup> Picky eating has various definitions and may include the limited variety<sup>5</sup> or quantity of the foods consumed by the child,<sup>39</sup> limited vegetable intake,<sup>4</sup> and include selectivity and resistance to trying new foods due to specific textures and colors.<sup>39</sup> This population has also been found to have significantly poorer self-feeding skills.<sup>38</sup> Crist et al developed the Behavioral Pediatric Feeding Assessment Score (BPFAS) to help quantify the frequency and number of mealtime problems and it has been validated in several populations,<sup>40</sup> including children with ASD.<sup>30,31</sup> Studies that have used the BPFAS have reported that parents of children with ASD overall reported more feeding-related difficulties with their child based on scores compared to parents of

children with ND<sup>30</sup> and all questions related to food acceptance were a concern for parents.<sup>31</sup> Children with ASD are five times more likely to experience a feeding problem compared to their peers with ND, according to a meta-analysis of 17 studies evaluating feeding problems and nutrient intake in children with ASD.<sup>7</sup> As a result, children with ASD are at increased risk for developing nutritional deficiencies.<sup>3-9</sup>

#### **2.4 Autism Spectrum Disorder and Nutrient Intake**

Behavioral problems, including picky eating, resistance to new foods, and limited food variety, are common mealtime behaviors in children with ASD that may be problematic in reducing the variety of foods consumed by this population, ultimately affecting the overall nutritional quality of their diet. Focusing on the preschool and school-age years, compared to children with ND, children with ASD have been found to have inadequate intakes of protein, calcium, phosphorus, vitamin D, vitamin A, vitamin K, vitamin C, vitamin B12, potassium, zinc, and fiber.<sup>3-6</sup>

Children with ASD are also at increased risk for overweight and obesity compared to children with ND<sup>10-15</sup> and have been found to have higher waist circumference and waist-to-height ratios compared to children with ND.<sup>37</sup> In a study of 5,053 children ages 2 to 17 years with ASD, the prevalence of overweight and obesity was 33.6% and 18%, respectively.<sup>13</sup> The prevalence of obesity in children with ASD is similar to the US population; 18.5% of children 2-19 years old in the United States (U.S.) are obese.<sup>41</sup> However children with ASD have a higher prevalence of overweight compared to the US population; 16.6% of U.S. children 2-19 years of age

are overweight.<sup>41</sup> A similar prevalence of overweight and obesity have been found in other studies of children with ASD.<sup>10,12,14,15,25,26</sup> Overweight and obesity are of concern as it increases the risk of high blood pressure, type II diabetes, respiratory and joint problems, and psychological problems such as low self-esteem, anxiety and depression, and social problems such as bullying.<sup>16</sup>

## Chapter 3

### AIMS

The overarching purpose of this cross-sectional study is to examine the relationships among nutrient intake, parental feeding styles, and parent stress in children with autism spectrum disorder (ASD). This thesis will focus specifically on the relationship between nutrient intake and mealtime behaviors in children with ASD and children with neurotypical development (ND).

**AIM 1:** Evaluate the nutrient intake of children with ASD compared to children with ND. Based on previous research in children with ASD,<sup>3-6</sup> we hypothesized that children with ASD would have insufficient intakes of key vitamins such as vitamin A, B<sub>12</sub>, C, D, and K, and minerals such as calcium, iron, potassium, phosphorus and zinc as compared to children with ND.

**AIM 2:** Evaluate mealtime behaviors in children with ASD compared to children with ND. Given children with ASD tend to have feeding difficulties and are often reported as picky eaters,<sup>4,5,27,37-39</sup> we hypothesis that parents of children with ASD will score their children higher on meal time difficult behaviors compared to parents of children with ND.

**AIM 3:** Evaluate the association between the dietary intake of key nutrients and the mealtime behaviors in children with ASD and children with ND. Given children with ND who are classified as ‘picky eaters’ have lower intake of key

nutrients,<sup>37-39</sup> we hypothesize an inverse association between mealtime behavior scores and intake of key nutrients will be found in children with ASD and children with ND.

## **Chapter 4**

### **METHODS**

#### **4.1 Subjects**

This study is ongoing and continuing to enroll subjects. Subjects are recruited from the greater Newark area via flyers shared on Facebook, Craigslist, local ASD groups (e.g. Brandywine Center for Autism), Head Start programs, and in physician offices at the A.I. DuPont/Nemours Hospital for Children and greater Newark area.

#### **4.2 Study Visit Procedures**

Participants are screened, either over the phone or in person, to determine eligibility. The study consists of one study visit to the Energy Balance and Nutrition Lab (EBNL) at the University of Delaware or an in-person visit at a mutually agreed upon location. Prior to the visit, participants are mailed/emailed a copy of the informed consent and child assent forms to allow for thorough review prior to the in-person visit. During the first study visit, after informed consent and child assent are completed, anthropometry, child demography and medical history and the Behavioral Pediatric Feeding Assessment Scale are completed. Immediately following the visit, a 3-day diet record of the child's food and beverage intake is completed by the parent.

### **4.3 Anthropometric Measurements**

Anthropometric measurements assessed during the study visit include height, weight, and waist circumference. Height is measured using a stadiometer accurate to the nearest 0.1 centimeters. Weight is measured using a digital scale accurate to the nearest 0.1 kilogram. Waist circumference is measured using a non-elastic tape measure accurate to 0.1 centimeters. All measurements are taken twice, and the average value is used in data analysis.

### **4.4 Child Demography and Medical History**

The demographic questionnaire includes questions on the parent/child race and ethnicity, parent education, the number of individuals living in the household, and the total household income. Data regarding the child's medical diagnosis(es), medication(s) use, supplement use, use of a special diet(s), and a description of foods their child refuses to consume (if any) are collected.

### **4.5 Behavioral Pediatric Feeding Assessment Scale**

The Behavioral Pediatric Feeding Assessment Scale (BPFAS) is a 35-item questionnaire used to assess mealtime behaviors in children.<sup>28</sup> The first 25 items describe the child's behavior and ask the parent to rate the frequency of the behavior ("child behavior: frequency") and indicate if the behavior is a problem or not ("child behavior: problem"). Child behavior: frequency is rated on a Likert scale (1= never through 5=always) and "child behavior: problem" is rated on a dichotomous scale

(0=no, 1=yes). The “child behavior: frequency” score is the sum of the Likert scale score for the first 25 questions on the questionnaire and as such the possible score ranges from 25 to 125. The “child behavior: problem” score is the sum of the dichotomous problem behavior score for the first 25 questions on the questionnaire and as such the possible score ranges from 0 to 25. The last 10 questions ask about the parent’s feeling/strategies surrounding child eating problems and mealtime solutions. The parent is prompted to rate the frequency of the feelings/strategies (“parent feelings/strategies: frequency”) on a Likert scale (1= never through 5=always) and is also asked to rate if the emotion is a problem or not (“parent feelings/strategies: problem”) on a dichotomous scale (0=no, 1=yes). The “parent feelings/strategies: frequency” score is the sum of the Likert scales score for questions 26-35 and as such the possible score ranges from 10 to 50. The “parent feelings/strategies: problem” score is the sum of the dichotomous problem behavior score for questions 26-35 and as such the possible score ranges from 0-10. Higher scores indicate greater feeding behaviors and/or problems.<sup>28</sup> This questionnaire has been validated in both children with ND<sup>28,29</sup> and in preschool-aged children<sup>30</sup> and adolescents with ASD.<sup>30,31</sup>

#### **4.6 3-Day Diet Record**

A three-day diet record to capture the child’s food and beverage consumption is completed by the parent for three non-consecutive days, two weekdays and one weekend day.<sup>42</sup> Data on food and beverage intake is converted to nutrient intake using the Nutrient Data Systems software for Research (NDSR; Minneapolis, MN).

#### **4.7 Data Analysis and Statistics**

Variables were assessed for normality. Continuous variables are reported as means (standard deviations), or if not normally distributed, as median and interquartile range. Categorical variables are reported as frequency and percentage. Dependent variables of interest include the following: nutrient intake (specifically energy, fat, protein, carbohydrate, calcium, iron, vitamin D and vitamin C intake), and mealtime behavior scores from the BPFAS.

To assess Aim 1 (evaluate the nutrient intake of children with ASD compared to children with ND), descriptive statistics were used to summarize macronutrient and micronutrient intake (mean $\pm$ SD, median) for each group (children with ASD and children with ND). Next, intake of each key nutrient was compared to the estimated average requirement (EAR) and recommended dietary allowance (RDA), or adequate intake (AI), for that nutrient to determine the percentage of children meeting or not meeting the EAR/RDA or AI; differences in the percent of children meeting these standards was compared between groups using a Fisher's exact test.

To assess Aim 2 (evaluate mealtime behaviors in children with ASD compared to children with ND), child behavior: frequency, child behavior: problem, parent feelings/strategies: frequency, parent feelings/strategies: problem scores were computed for children with ASD and for children with TD (mean  $\pm$  standard deviation). Differences in scores between children with ASD and children with ND were assessed via Students t-test or Mann-Whitney U-test for data not normally distributed.

To assess Aim 3 (evaluate the association between the dietary intake of key nutrients and the mealtime behaviors in children with ASD compared to children with ND), we assessed the association between the percent of the RDA/AI met for each key nutrient and each BPFAS score (child behavior: frequency, child behavior: problem, parent feelings/strategies: frequency, parent feelings/strategies: problem). If significant associations were found, we determined how the relationship differed between children with ASD and children with ND using linear regression.

## Chapter 5

### RESULTS

#### 5.1 Parent and Child Characteristics

Parent and child demographic characteristics are summarized in **Table A1**. The study has enrolled 30 children to date: 10 children (33%) with ASD and 20 children (66%) with ND. There were no statistically significant differences between children with ASD and children with ND for child age, sex, ethnicity, or race. There were no significant differences between children with ASD and children with ND for parent sex, parent ethnicity, and education level.

#### 5.2 Nutrient Intake

Average micronutrient and macronutrient intake are summarized in **Table A2**. There were no significant differences in nutrient intake between children with ASD compared to children with ND for any of the macronutrients or micronutrients assessed. The percent Acceptable Macronutrient Distribution Range (AMDR) met for each macronutrient is summarized in **Table A3**. The sample size in one or more cells was <5 subjects and as such statistical differences between groups could not be determined. All children, with ASD and with ND, had a mean percent of energy from protein that was within the AMDR. The majority ( $\geq 85\%$ ) of children in both groups

had percent of energy from carbohydrate that was within the AMDR. For children with ASD and children with ND, the majority (65-80%) had a percent of energy from fat that was within the AMDR; a smaller percentage (20-30%) had a fat intake that was greater than the AMDR.

The percent Recommended Dietary Allowance (RDA)/Adequate Intake (AI) met for each macronutrient is summarized in **Table A4**. For children with ASD compared to children with ND, there were no significant differences in the percent of children with intake at or above the RDA, percent above the EAR but less than the RDA, or percent below the EAR or AI, for vitamins C, D, K, iron, potassium, or phosphorus. For vitamin A, vitamin B12, calcium, and zinc, the sample size in one or more cells was <5 subjects and as such statistical differences between groups could not be determined.

### **5.3 Behavioral Pediatrics Feeding Assessment Scale and Nutrient Intake**

Differences in BPFAS Scores between groups are summarized in **Table A5**. Compared to children with ND, children with ASD had significantly higher scores for child behavior frequency, child behavior problem, and parent feelings/strategies problem.

Correlations between BPFAS scores for child behavior frequency, child behavior problem, parent feelings/strategies frequency, and parent feelings/strategies problem and intake of each nutrient are summarized in **Table A6**. In children with ASD, there was a significant inverse relationship between vitamin C intake and child

behavior: frequency ( $r=-0.632$ ,  $p<0.05$ ) and parent feelings/strategies: frequency scores ( $r= -0.634$   $p<0.05$ ). In children with ND, there was a significant positive relationship ( $p<0.05$ ) between calcium and phosphorus intake and the child behavior: problem scores.

## Chapter 6

### DISCUSSION AND CONCLUSION

This study is ongoing and to date, a total of 30 subjects have been enrolled: 20 children with ND and 10 children with ASD. While the current sample size allowed for analysis of these preliminary data, the sample size at this time is too small for inferential analyses and conclusions.

In subjects' who completed the study, the group with ASD were primarily male (80%), white, and non-Hispanic, while the group with ND were only 55% male but also primarily White and non-Hispanic. The findings related to gender are consistent with the literature as the prevalence of ASD is four times as great in males compared to females.<sup>2</sup> In our study, most children with ASD were White, however our sample size (N=10) was very small and ASD diagnoses occur among individuals regardless of racial background.<sup>2</sup> No differences between children with ASD and children with ND were found for parent age, race, ethnicity, or income. This differs from literature on children with ASD that have reported parents of children with ASD tend to be slightly older than parents of children with ND;<sup>21,23,43,44</sup> such data from our study may change as the sample size increases.

The first aim of this study was to evaluate the nutrient intake of children with ASD compared to children with ND. We hypothesized that children with ASD would

have insufficient intakes of key vitamins such as vitamin A, B<sub>12</sub>, C, D, and K, and minerals such as calcium, iron, potassium, phosphorus and zinc) as compared to children with ND. With our small sample size to date, we found no statistically significant differences between groups in intake of macronutrients (carbohydrate, protein, and fat), vitamins and minerals. With respect to macronutrient intake of children with ASD, the literature reports mixed results. Research has reported that children with ASD consumed a higher total energy and percent calories from carbohydrates.<sup>31</sup> Others however have reported that children aged 4-8 years with ASDs consumed less energy, a lower percentage of calories from protein, but also a greater percentage of carbohydrates compared to controls.<sup>6</sup> Conversely other studies have found that children with ASD have significantly lower consumption of carbohydrates compared to controls.<sup>6,9</sup> Differences in results may be due to the severity of ASD within the cohort of each study, and not all studies of diet report data on ASD severity.

We found no significant differences between groups for the intakes of vitamins B<sub>12</sub>, C, D and K, and minerals iron calcium, phosphorus, potassium and zinc. Notably, in children with ASD and in children with ND, intake of vitamin D was below RDA for intakes for a large majority of the children (90% and 95%, respectively). This may be due to poor intake of dairy products or may partially be due to limitations in nutrient databases regarding the number of foods in which vitamin D content has been assessed.<sup>45</sup> Moreover, the DRI for vitamin D assumes no vitamin D is contributed to the human body by sun exposure,<sup>46</sup> and as such vitamin D from diet

only may be below physiologic needs. Just over half of subjects in each group had intakes below the recommended Adequate Intake (AI) for vitamin K which could be due to poor intake of green leafy vegetables and other foods rich in vitamin K. Finally, in children with ASD and in children with ND, intakes of potassium were below the RDA for 60% and 85% of children respectively which may be indicative of poor fruit intake.

A second aim of our study was to evaluate the mealtime behaviors in children with ASD compared to children with ND. Results from the Behavioral Pediatrics Feeding Assessment Scale (BPFAS) showed that children with ASD, compared to children with ND, had significantly higher scores for child behavior: frequency, child behavior: problem, and parent feelings/strategies: problem. Despite our small sample size, the higher scores for children with ASD were anticipated given that children with ASD tend to experience greater and more frequent problematic behaviors during mealtimes compared to their ND peers.<sup>28,30,31</sup> Most studies that have used the BPFAS to measure mealtime behaviors do not always report the breakdown of scores for each domain, therefore our ability to compare our scores for each domain to the literature is limited to only one study of children ages 4 to 16 years which found that children with ASD had significantly higher child behavior frequency and higher parent feelings/strategies frequency scores compared to controls with ND.<sup>31</sup> More research is needed in which all four scores from the BPFAS are reported.

Finally, our third aim was to examine the relationship between dietary intake of key nutrients and mealtime behavior scores in children with ASD and in children

with ND. We found an inverse relationship between meeting the RDA for Vitamin C intake and child behavior: frequency and parent feelings/strategies: frequency scores in children with ASD only. A larger sample size is needed to fully evaluate the relationship between mealtime behavior scores on the BPFAS and specific nutrient inadequacies in this population.

A major strength of this study is the simultaneous measurement of nutrient intake and mealtime behaviors among young children with ASD. The major limitation of the current study is the small sample size. As such the results are preliminary and must be interpreted with caution.

To date, our preliminary data found children with ASD tend to score higher in all categories on the BPFAS. In addition, there appears to be a significant inverse association between vitamin C intake and child behavior: frequency and parent feelings/strategies: frequency scores. A larger sample size is needed to fully assess the relationship between intake of all nutrients and mealtime behaviors scores in children with ASD and compare those findings to children with ND.

## REFERENCES

1. American Psychological Association. *Diagnostic and Statistical Manual of Mental Disorders DSM-5*. 5th ed. Arlington: American Psychiatric Publishing; 2013.
2. Centers for Disease Control and Prevention. Data & Statistics on Autism Spectrum Disorder. <https://www.cdc.gov/ncbddd/autism/data.html>. Published 2020. Accessed May 8, 2019.
3. Malhi P, Venkatesh L, Bharti B, Singhi P. Feeding Problems and Nutrient Intake in Children with and without Autism: A Comparative Study. *Indian J Pediatr*. 2017;84(4):283-288.
4. Bandini LG, Anderson SE, Curtin C, et al. Food selectivity in children with autism spectrum disorders and typically developing children. *J Pediatr*. 2010;157(2):259-264.
5. Zimmer MH, Hart LC, Manning-Courtney P, Murray DS, Bing NM, Summer S. Food variety as a predictor of nutritional status among children with autism. *J Autism Dev Disord*. 2012;42:549-556.
6. Hyman SL, Stewart PA, Schmidt B, et al. Nutrient intake from food in children with autism. *Pediatrics*. 2012;130(SUPPL. 2).
7. Sharp WG, Berry RC, McCracken C, et al. Feeding problems and nutrient intake in children with autism spectrum disorders: A meta-analysis and comprehensive review of the literature. *J Autism Dev Disord*. 2013;43(9):2159-

2173.

8. Bicer AH, Alsaffar AA. Body mass index, dietary intake and feeding problems of Turkish children with autism spectrum disorder (ASD). *Res Dev Disabil.* 2013;34(11):3978-3987.
9. Shmaya Y, Eilat-Adar S, Leitner Y, Reif S, Gabis L. Nutritional deficiencies and overweight prevalence among children with autism spectrum disorder. *Res Dev Disabil.* 2015;38:1-6.
10. Xiong N, Ji C, Li Y, He Z, Bo H, Zhao Y. The physical status of children with autism in China. *Res Dev Disabil.* 2009;30:70-76.
11. Must A, Eliasziw M, Phillips SM, et al. The Effect of Age on the Prevalence of Obesity among US Youth with Autism Spectrum Disorder. *Child Obes.* 2016;13(1):25-35.
12. Nor NK, Ghazali AH, Ismail J. Prevalence of Overweight and Obesity Among Children and Adolescents With Autism Spectrum Disorder and Associated Risk Factors. *Front Pediatr.* 2019;7(February):1-10.
13. Hill AP, Zuckerman KE, Fombonne E. Obesity and Autism. *Pediatrics.* 2015;136(6):1051-1061.
14. Broder-Fingert S, Brazauskas K, Lindgren K, Iannuzzi D, Van Cleave J. Prevalence of overweight and obesity in a large clinical sample of children with autism. *Acad Pediatr.* 2014;14(4):408-414.
15. Segal M, Eliasziw M, Phillips S, et al. Intellectual disability is associated with increased risk for obesity in a nationally representative sample of U.S. children.

*Disabil Health J.* 2016;9(3):392-398.

16. Centers for Disease Control and Prevention. Behavior Consequences of Obesity More Immediate Health Risks. 2015.  
<https://www.cdc.gov/obesity/childhood/causes.html>.
17. McAuliffe T, Cordier R, Vaz S, Thomas Y, Falkmer T. Quality of Life, Coping Styles, Stress Levels, and Time Use in Mothers of Children with Autism Spectrum Disorders: Comparing Single Versus Coupled Households. *J Autism Dev Disord.* 2017;47:3189-3203.
18. Derguy C, M'Bailara K, Michel G, Roux S, Bouvard M. The Need for an Ecological Approach to Parental Stress in Autism Spectrum Disorders: The Combined Role of Individual and Environmental Factors. *J Autism Dev Disord.* 2016;46:1895-1905.
19. Krakovich TM, Mcgrew JH, Yu Y, Ruble LA. Stress in Parents of Children with Autism Spectrum Disorder: An Exploration of Demands and Resources. *J Autism Dev Disord.* 2016;46:2042-2053.
20. Seymour M, Wood C, Giallo R, Jellett R. Fatigue, stress and coping in mothers of children with an autism spectrum disorder. *J Autism Dev Disord.* 2013;43(7):1547-1554.
21. Lai WW, Goh TJ, Oei TPS, Sung M. Coping and Well-Being in Parents of Children with Autism Spectrum Disorders (ASD). *J Autism Dev Disord.* 2015;45(8):2582-2593.
22. Valicenti-mcdermott M, Lawson K, Hottinger K, et al. Parental Stress in

- Families of Children With Autism and Other Developmental Disabilities. *J Child Neurol.* 2015;30(13):1728-1735.
23. Craig F, Operto FF, De Giacomo A, et al. Parenting stress among parents of children with Neurodevelopmental Disorders. *Psychiatry Res.* 2016;242:121-129.
  24. Baker BL, Blacher J, Olsson MB. Preschool children with and without developmental delay: Behaviour problems, parents' optimism and well-being. *J Intellect Disabil Res.* 2005;49(8):575-590.
  25. Zablotsky B, Bradshaw CP, Stuart EA. The association between mental health, stress, and coping supports in mothers of children with autism spectrum disorders. *J Autism Dev Disord.* 2013;43:1380-1393.
  26. Estes A, Olson E, Sullivan K, et al. Parenting-related stress and psychological distress in mothers of toddlers with autism spectrum disorders. *Brain Dev.* 2013;35(2):133-138.
  27. Bandini LG, Curtin C, Eliasziw M, et al. Food selectivity in a diverse sample of young children with and without intellectual disabilities. *Appetite.* 2019;133:433-440.
  28. Crist W, Napier-Phillips A. Mealtime behaviors of young children: A comparison of normative and clinical data. *J Dev Behav Pediatr.* 2001;22(5):279-286.
  29. Davis AM, Canter KS, Stough CO, Gillette MD, Patton S. Measurement of mealtime behaviors in rural overweight children: An exploratory factor analysis

- of the behavioral pediatrics feeding assessment scale. *J Pediatr Psychol*. 2014;39(3):332-339.
30. Allen SL, Smith IM, Duku E, et al. Behavioral pediatrics feeding assessment scale in young children with autism spectrum disorder: Psychometrics and associations with child and parent variables. *J Pediatr Psychol*. 2014;40(6):581-590.
  31. Castro K, Faccioli LS, Baronio D, Gottfried C, Perry IS, Riesgo R. Feeding behavior and dietary intake of male children and adolescents with autism spectrum disorder: A case-control study. *Int J Dev Neurosci*. 2016;53:68-74.
  32. American Psychological Association. Autism Spectrum Disorder. Diagnostic and statistical manual of mental disorders: DSM-5.
  33. Genetics Home Reference. Autism Spectrum Disorder. American Psychiatric Association. <https://ghr.nlm.nih.gov/condition/autism-spectrum-disorder>. Published 2019. Accessed May 8, 2019.
  34. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders*. 5th ed. Washington, DC, USA: American Psychiatric Publishing; 2013.
  35. Muskens JB, Velders FP, Staal WG. Medical comorbidities in children and adolescents with autism spectrum disorders and attention deficit hyperactivity disorders: a systematic review. *Eur Child Adolesc Psychiatry*. 2017;26:1093-1103.
  36. Howe C, Eggett A. What is Autism Spectrum Disorder? *Groupwork Child with*

- Autism Spectr Disord.* 2018;6:1-18.
37. Kral TVE, Souders MC, Tompkins VH, Remiker AM, Eriksen WT, Pinto-Martin JA. Child Eating Behaviors and Caregiver Feeding Practices in Children with Autism Spectrum Disorders. *Public Health Nurs.* 2015;32(5):488-497.
  38. Kral TVE, Eriksen WT, Souders MC, Pinto-Martin JA. Eating behaviors, diet quality, and gastrointestinal symptoms in children with autism spectrum disorders: A brief review. *J Pediatr Nurs.* 2013;28(6):548-556.
  39. Lockner DW, Crowe TK, Skipper BJ. Dietary Intake and Parents' Perception of Mealtime Behaviors in Preschool-Age Children with Autism Spectrum Disorder and in Typically Developing Children. *J Am Diet Assoc.* 2008;108(8):1360-1363. doi:10.1016/j.jada.2008.05.003
  40. Crist W, McDonnell P, Beck M, Gillespie C, Barrett P, Mathews J. Behavior at Mealtimes and the Young Child with Cystic Fibrosis. *Dev Behav Pediatr.* 1994;15(3):157-161.
  41. Fryer CD, Carroll MD, Ogden CL. *Prevalence of Overweight, Obesity, and Severe Obesity Among Children and Adolescents Aged 2-19 Years: United States, 1963-1965 Through 2015-2016.*; 2018.
  42. Yang YJ, Kim MK, Hwang SH, Ahn Y, Shim JE, Kim DH. Relative validities of 3-day food records and the food frequency questionnaire. *Nutr Res Pract.* 2010;4(2):142-148.
  43. Lee GK, Lopata C, Volker MA, et al. Health-related quality of life of parents of children with high-functioning autism spectrum disorders. *Focus Autism Other*

- Dev Disabl.* 2009;24(4):227-239.
44. Giovagnoli G, Postorino V, Fatta LM, et al. Behavioral and emotional profile and parental stress in preschool children with autism spectrum disorder. *Res Dev Disabil.* 2015;45-46:411-421. doi:10.1016/j.ridd.2015.08.006
  45. Holden JM, Lemar LE, Exler J. Vitamin D in foods: Development of the US Department of Agriculture database. *Am J Clin Nutr.* 2008;87(4):1092-1096. doi:10.1093/ajcn/87.4.1092s
  46. Ross CA, Taylor CL, Yaktine AL, Del Valle HB. *Dietary Reference Intakes Calcium Vitamin D.*; 2018. doi:10.1016/j.crma.2018.11.003

## Appendix A

### TABLES

Table 1. Participant Demographics

	<b>Children with ASD (N=10)</b>	<b>Children with ND (N=20)</b>
<b>Child Age, mean <math>\pm</math> SD</b>	4.50 $\pm$ 1.17	5.12 $\pm$ 1.08
<b>Child Sex, N (%)</b>		
Male	8 (80)	11 (55)
Female	2 (20)	9 (45)
<b>Child Ethnicity, N (%)</b>		
Hispanic or Latino	1 (10)	1 (5)
Non-Hispanic or Latino	9 (90)	19 (95)
<b>Child Race, N (%)</b>		
White	7 (70)	11 (55)
Black or African American	1 (10)	6 (30)
American Indian or Alaskan Native	0	0
Asian or Asian American	0	1 (5)
Native Hawaiian or Pacific Islander	0	0
Other	0	1 (5)
More than one race	2 (20)	1 (5)
<b>Parent Age, mean (SD)</b>	39.2 $\pm$ 6.6	37.6 $\pm$ 6.9
<b>Parent Sex, N (%)</b>		
Female	10 (100)	19 (90)
Male	0	1 (10)
<b>Parent Ethnicity, N (%)</b>		
Hispanic or Latino	0	1 (5)
Non-Hispanic or Latino	10 (100)	19 (95)
<b>Parent Race, N (%)</b>		
White	8 (80)	12 (60)
Black or African American	1 (10)	6 (30)
American Indian or Alaskan Native	0	0
Asian or Asian American	0	1 (5)

	<b>Children with ASD (N=10)</b>	<b>Children with ND (N=20)</b>
Native Hawaiian or Pacific Islander	0	0
Other	0	1 (5)
Two or more	1 (10)	0
<b>Parent Education, N (%)</b>		
Grade school completed (grades 1-8)	10 (100)	20 (100)
High school diploma (grade 12 achieved)	10 (100)	20 (100)
Trade School graduate	2 (20)	2 (20)
Bachelor's Degree (4 years)	5 (50)	14 (70)
Advanced degree granted (>4 years)	3 (30)	10 (50)
<b>Household Income, N (%)</b>		
< \$50,000	4 (40)	7 (35)
≥ \$50,000 to <\$75,000	3 (30)	3 (15)
≥ \$75,000 to <\$100,000	0	8 (10)
≥ \$100,000	3 (30)	2 (10)
<p>Autism Spectrum Disorder (ASD); neurotypical development (ND).  Differences in child/maternal characteristics between children with ASD compared to children with ND were determined by two-sample Student's t-tests for normally distributed continuous variables (all variables except parent age and child age) and Mann-Whitney U-test for non-normally distributed continuous variables. For categorical variables, differences between groups were determined by Pearson's chi-squared test for categorical variables and Fisher's Exact Probability tests for categorical values with an expected cell count of &lt;5 (child sex, child race, child ethnicity, parent sex, and parent ethnicity).  The sample size in one or more cells was too small for inferential statistical analysis of parent race and household income.</p>		

Table 2.      Macronutrient and Micronutrient Intake

	<b>Diagnosis</b>					
	<b>Children with ASD N=10</b>			<b>Children with ND N=20</b>		
<b>Macronutrients</b>	Mean ± SD	Median	Range	Mean ± SD	Median	Range
Total calories (kcal/d)	1592 ± 504	1571	846 – 2375	1511 ± 288	1480	828 – 1933
Protein (g)	50.3 ± 18.6	53.9	26.1 – 83.7	50.9 ± 13.7	50.1	23.7 – 76.8
Carbohydrate (g)	218.2 ± 74.2	204.7	113.3 – 320.8	206.2 ± 45.2	195.9	133.5 – 283.6

Fat (g)	60.4 ± 181	60.8	26.8 – 91.1	57.1 ± 15.1	60.1	23.1 – 79.9
<b>Micronutrients</b>						
Vitamin A (mcg/d)	566.2 ± 259.3	569.3	275.1 – 1108.4	540.7 ± 187.2	554.2	176.4 – 906.2
Vitamin B <sub>12</sub> (mcg/d)	3.0 ± 2.1	2.3	1.1 – 8.4	3.2 ± 2.1	3.0	0.04 – 9.5
Vitamin C (mg/d)	55.9 ± 42.6	44.1	9.1 – 113.7	64.6 ± 38.8	68.7	7.4 – 147.8
Vitamin D (mcg/d)	5.2 ± 3.8	5.0	0.8 – 13.0	5.0 ± 3.4	4.9	0.04- 11.3
Vitamin K (mcg/d)	43.7 ± 23.8	36.9	16.3 – 91.9	53.9 ± 34.3	50.1	9.9 – 174.0
Calcium (mg/d)	968.1 ± 448.6	933.5	437.3 – 1714.3	848.1 ± 377.9	828.1	234.9 – 1642.7
Iron (mg/d)	9.9 ± 4.1	9.1	4.9 – 18.6	11.3 ± 4.0	10.5	4.4 – 21.1
Potassium (mg/d)	1789.5 ± 680	1600.2	668.8 – 2871.1	1755.9 ± 502.0	1822.4	387.2 – 1288.1
Phosphorus (mg/d)	950.2 ± 352.7	876.3	505.8 – 1696.9	923.7 ± 240.0	921.6	620.1 – 2796.8
Zinc (mg/d)	6.7 ± 3.3	5.8	3.3 – 14.2	7.7 ± 2.3	7.1	3.9 – 11.8
<p>Autism Spectrum Disorder (ASD); neurotypical development (ND).  Differences in nutrient intake between children with ASD compared to children with neurotypical development were determined by two-sample Student's t-tests for normally distributed variables (all variables except Vitamin B<sub>12</sub>, Vitamin K, and Zinc) and Mann-Whitney U-test for non-normally distributed variables.  These data are preliminary, enrollment is ongoing, and results should be interpreted with caution.</p>						

Table 3. Macronutrient Distribution Ranges (AMDR)

	Diagnosis					
	Children with ASD			Children with ND		
	% Above the AMDR	% Within the AMDR	% Below the AMDR	% Above the AMDR	% Within the AMDR	% Below the AMDR
<b>Macronutrients</b>	<b>N (%)</b>	<b>N (%)</b>	<b>N (%)</b>	<b>N (%)</b>	<b>N (%)</b>	<b>N (%)</b>
Protein (g)	0	10 (100)	0	0	20 (100)	0
Carbohydrate (g)	0	9 (90)	1 (10)	2 (10)	17 (85)	1 (5)
Fat (g)	2 (20)	8 (80)	0	6 (30)	13 (65)	1 (5)

Autism Spectrum Disorder (ASD); neurotypical development (ND).  
Differences in %AMDR met between children with ASD compared to children with ND assessed by Fisher’s exact tests however given the sample size in one or more cells was <5, statistical differences could not be determined.  
These data are preliminary, enrollment is ongoing, and results should be interpreted with caution.

Table 4. Micronutrient Intake Compared to the Dietary Reference Intakes (DRI)

	Diagnosis					
	Children with ASD			Children with ND		
	% at or above RDA or AI	% above EAR but less than RDA	% Below EAR or AI	% at or above RDA or AI	% above EAR but less than RDA	% Below EAR or AI
<b>Micronutrients</b>	<b>N (%)</b>	<b>N (%)</b>	<b>N (%)</b>	<b>N (%)</b>	<b>N (%)</b>	<b>N (%)</b>
Vitamin A (mcg/d)	<b>7 (70)</b>	<b>3 (30)</b>	<b>0</b>	<b>17 (85)</b>	<b>1 (5)</b>	<b>2 (10)</b>
Vitamin B <sub>12</sub> (mcg/d)	<b>9 (90)</b>	<b>1 (10)</b>	<b>0</b>	<b>18 (90)</b>	<b>1 (5)</b>	<b>1 (5)</b>
Vitamin C (mg/d)	<b>6 (60)</b>	<b>4 (40)</b>	<b>0</b>	<b>16 (80)</b>	<b>0</b>	<b>4 (20)</b>
Vitamin D (mcg/d)	<b>0</b>	<b>1 (10)</b>	<b>9 (90)</b>	<b>0</b>	<b>1 (5)</b>	<b>19 (95)</b>
Vitamin K (mcg/d)	4 (40)	---	6 (60)	9 (45)	---	11 (55)
Calcium (mg/d)	<b>5 (50)</b>	<b>1 (10)</b>	<b>4 (40)</b>	<b>10 (50)</b>	<b>3 (15)</b>	<b>7 (35)</b>
Iron (mg/d)	<b>6 (60)</b>	<b>4 (40)</b>	<b>0</b>	<b>13 (65)</b>	<b>7 (35)</b>	<b>0</b>
Potassium (mg/d)	4 (40)	---	6 (60)	3 (15)	---	17 (85)
Phosphorus (mg/d)	<b>10 (100)</b>	<b>0</b>	<b>0</b>	<b>19 (95)</b>	<b>0</b>	<b>1 (5)</b>
Zinc (mg/d)	<b>6 (60)</b>	<b>3 (30)</b>	<b>1 (10)</b>	<b>18 (90)</b>	<b>1 (5)</b>	<b>1 (5)</b>

Autism Spectrum Disorder (ASD); neurotypical development (ND).  
Recommended Dietary Allowances (RDAs) in **bold type** and Adequate Intakes (AIs) in ordinary type.  
Differences in %EAR/RDA or AI met between children with ASD compared to children with ND assessed by Fisher’s exact tests. Given the sample size in one or more cells was <5, statistical differences between groups could not be determined for Vitamins A, Vitamin B<sub>12</sub>. Calcium, and Zinc.  
These data are preliminary, enrollment is ongoing, and results should be interpreted with caution.

Table 5. BPFAS Child and Parent Frequency and Problem Scores

	All Children Mean $\pm$ SD N=30		Children with ASD Mean $\pm$ SD N=10		Children with ND Mean $\pm$ SD N=20		<i>p</i> -value
	Mean $\pm$ SD	Median	Mean $\pm$ SD	Median	Mean $\pm$ SD	Median	
Child behavior: frequency	50.03 $\pm$ 10.6	48.50	57.90 $\pm$ 11.4	62.00	46.10 $\pm$ 7.8	45.50	<b>0.011</b>
Child behavior: problem	4.13 $\pm$ 4.7	3.00	7.30 $\pm$ 5.9	7.00	2.62 $\pm$ 3.1	2.00	<b>0.031</b>
Parent feelings/strategies: frequency	18.39 $\pm$ 5.3	18.00	20.90 $\pm$ 6.6	22.00	17.45 $\pm$ 4.34	17.00	0.156
Parent feelings/strategies: problem	1.39 $\pm$ 2.3	0.00	3.20 $\pm$ 3.0	3.00	0.55 $\pm$ 1.14	0.00	<b>0.015</b>
<p>Autism Spectrum Disorder (ASD); neurotypical development (ND).  <b>Bold <i>p</i>-values</b> indicate statically significant differences (<math>p &lt; 0.05</math>). Student's <i>t</i>-tests were used to assess for between group differences in Child behavior: frequency and Parent feelings/strategies: frequency. Child behavior: problem and Parent feelings/strategies: problem scores were not normally distributed and between group differences were assessed via Mann-Whitney U tests.</p>							

Table 6. Correlations between BPFAS Scores and Micronutrient Intake

	Diagnosis							
	Children with ASD N=10				Children with ND N=20			
	Child behavior: frequency	Child behavior: problem	Parent feelings/strategies: frequency	Parent feelings/strategies: problem	Child behavior: frequency	Child behavior: problem	Parent feelings/strategies: frequency	Parent feelings/strategies: problem
% RDA Vitamin A (mcg/d)	0.067	0.450	-0.271	0.193	0.079	0.308	0.156	0.202
% RDA Vitamin B <sub>12</sub> (mcg/d)	-0.117	0.146	-0.406	-0.224	-0.058	0.278	0.311	0.275
% RDA Vitamin C (mg/d)	<b>-0.632*</b>	-0.353	<b>-0.634*</b>	-0.517	0.093	-0.049	-0.025	0.157
% RDA Vitamin D (mcg/d)	-0.067	0.152	-0.178	0.037	0.011	0.153	0.296	0.260
% AI Vitamin K (mcg/d)	0.067	0.085	-0.203	-0.118	0.107	0.037	0.008	0.187
% RDA Calcium (mg/d)	0.055	0.492	-0.160	0.330	0.118	<b>0.445*</b>	0.217	0.217
% RDA Iron (mg/d)	-0.092	0.207	-0.302	-0.162	-0.103	0.091	-0.094	-0.069
% AI Potassium (mg/d)	-0.153	0.122	-0.209	-0.093	0.211	0.107	-0.060	0.066
% RDA Phosphorus (mg/d)	-0.080	0.340	-0.363	0.006	0.162	<b>0.520*</b>	0.186	0.156
% RDA Zinc (mg/d)	-0.067	0.280	-0.345	-0.100	0.002	0.346	0.087	0.127

Autism Spectrum Disorder (ASD); neurotypical development (ND).

\***Bold text** indicates values significant at p<0.05

Spearman's correlations were used to evaluate the relationship between micronutrient intake and BPFAS scores in children with ASD and in children with ND.

These data are preliminary, enrollment is ongoing, and results should be interpreted with caution.

## Appendix B

### IRB APPROVAL LETTER



Institutional Review Board  
210H HULLIHEN HALL  
NEWARK, DE 19716  
PHONE: 302-831-2137  
FAX: 302-831-2828

DATE: January 16, 2020

TO: Jaimie Lafferty, B.S.  
FROM: University of Delaware IRB

STUDY TITLE: [1326546-4] Parent stress, parent feeding styles, and nutrient intake among families of young children with Autism Spectrum Disorder (ASD)

SUBMISSION TYPE: Continuing Review/Progress Report

ACTION: APPROVED

APPROVAL DATE: January 16, 2020

EXPIRATION DATE: January 13, 2021

REVIEW TYPE: Expedited Review

REVIEW CATEGORY: Expedited review category # (4,7)  
*Research with Children Subpart D- 45 CFR 46.404)*

Thank you for your Continuing Review/Progress Report submission to the University of Delaware Institutional Review Board (UD IRB). The UD IRB has reviewed and APPROVED the proposed research and submitted documents via Expedited Review in compliance with the pertinent federal regulations.

As the Principal Investigator for this study, you are responsible for and agree that:

- All research must be conducted in accordance with the protocol and all other study forms as approved in this submission. Any revisions to the approved study procedures or documents must be reviewed and approved by the IRB prior to their implementation. Please use the UD amendment form to request the review of any changes to approved study procedures or documents.
- Informed consent is a process that must allow prospective participants sufficient opportunity to discuss and consider whether to participate. IRB-approved and stamped consent documents must be used when enrolling participants and a written copy shall be given to the person signing the informed consent form.
- Unanticipated problems, serious adverse events involving risk to participants, and all non-compliance issues must be reported to this office in a timely fashion according with the UD requirements for reportable events. All sponsor reporting requirements must also be followed.

Oversight of this study by the UD IRB REQUIRES the submission of a CONTINUING REVIEW seeking the renewal of this IRB approval, which will expire on January 13, 2021. A continuing review/progress report form and up-to-date copies of the protocol form and all other approved study materials must be submitted to the UD IRB at least 45 days prior to the expiration date to allow for the required IRB review of that report.

If you have any questions, please contact the UD IRB Office at (302) 831-2137 or via email at [hsrb-research@udel.edu](mailto:hsrb-research@udel.edu). Please include the study title and reference number in all correspondence with this office.