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Contributions of Early Care and Education Programs to Diet Quality in Children Aged 3 to 4 Years in Central North Carolina

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All authors contributed to conceptualization of this study. CTL supervised data management. CTL and SM performed data analysis. CTL and SM wrote the first draft. All authors reviewed and commented on subsequent drafts of the manuscript.

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Courtney Luecking, Stephanie Mazzucca, and Amber Vaughn declare that they have no conflicts of interest to report.

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Research Snapshot

Research question: What proportion of 3-4-year-old children's dietary intake occurs at early care and education (ECE) centers? Is diet quality at ECE centers higher than away from ECE centers and higher on weekdays compared to weekends?

Key findings: In this cross-sectional analysis of observed dietary intake of 840 3-4-year-old children at ECE centers and the corresponding parent-reported dietary intake outside of child care, children consumed approximately 40% of energy and nutrients at ECE centers. Diet quality, as measured by the Healthy Eating Index-2015, was higher at ECE centers than away from ECE centers and on weekdays than weekends (both $p<0.0001$).

Title: Contributions of early care and education to 3- to 4-year-old children's diet quality in central North Carolina

Abstract:

Background. Parents and early care and education (ECE) are the key influencers of young children's diets, but there is limited information about how each contribute to children's overall diet quality.

Objective. This study aimed to determine what proportion of children's dietary intake occurs within the ECE setting and whether diet quality is higher at ECE centers and, consequently, on weekdays than weekends.

Design. This cross-sectional analysis of a larger cluster randomized controlled trial used multiple 24-hour dietary intakes measured through a combination of the Dietary Observation in Child Care protocol and parent-reported food diaries.

Participants/setting. Participants (n=840) included children 3-4 years of age enrolled in ECE centers in central North Carolina for whom 24-hour dietary intake was captured via observation of meals and snacks consumed at ECE and parent-report of all remaining meals and snacks. Data were collected from 2015 to 2016.

Main outcome measures. Diet quality at ECE and elsewhere was evaluated using the Healthy Eating Index (HEI)-2015.

Statistical analyses performed. Mixed effects models were used to determine differences in mean HEI-2015 component and total scores. Models were adjusted for children's age and sex and accounted for clustering within ECE centers and families.

Results. Children consumed approximately 40% of daily energy, nutrients, and food groups at ECE centers. The mean total HEI-2015 score was higher for foods and beverages consumed at ECE centers (58.3 ± 0.6) than elsewhere (52.5 ± 0.6) ($p<0.0001$). The mean total HEI-2015 score was also higher on weekdays (58.5 ± 0.5) than on weekends (51.3 ± 0.5) ($p<0.0001$).

Conclusions. Children consume a majority of dietary intake away from ECE centers. Overall, diet quality is low, but the quality of foods consumed by children at ECE centers is higher than that consumed elsewhere. ECE centers remain an important source of nutrition and further investigation is warranted to identify ways to support both ECE centers and families to provide healthier eating environments.

Background

Early childhood, defined as birth to 5 years of age, is a time of significant growth and development that establishes the foundation for future physical, social, emotional, and cognitive health.[1,2] Dietary patterns and eating behaviors formed during this period have a lasting influence on preferences, energy balance, and health in later childhood and into adulthood.[3–7] To support optimal growth and development, young children require nutrient dense diets so that nutrient requirements may be achieved within appropriate levels of energy.[8,9] The Dietary Guidelines for Americans aged 2 years and older offer evidence-based recommendations for the prevention of chronic disease over the lifespan, and have evolved from focus on individual dietary components (e.g., nutrients and food groups) to focus on the dietary patterns, or combinations of foods consumed.[9] While evidence suggests most young children in the United States (US) consume adequate amounts of many essential nutrients (e.g., protein, riboflavin),[10,11] they also consume inadequate amounts of vegetables, fruit, and whole grains[12,13] and excessive amounts of sweet and salty snacks and sugar-sweetened beverages.[14–16] Overall, research indicates children in the U.S. are not achieving dietary recommendations for healthy eating.[17–19]

Young children are dependent on their adult caregivers for the food and beverages provided. For most children, the two most influential caregivers are their parents and early care and education (ECE) providers.[20] Hence, the home/family and ECE settings are critical environments for shaping children's dietary intake.[21,22] Given the importance of ECE, a federal food program, the Child and Adult Care Food Program (CACFP), offers reimbursement to ECE programs that serve nutritious meals and snacks to low-income children.[23] There is evidence that participating programs serve healthier foods and beverages and children consume healthier diets.[24–26] While

several studies have described young children's dietary intakes at home and/or at ECE settings,[27–39] there is little information, especially in the US,[40,41] to account for or compare each setting's contribution to total dietary intake. Furthermore, reports have often commented on specific nutrients or food groups consumed and lack a more general interpretation of food patterns or quality. Because the establishment of healthy dietary patterns during early childhood is critical for lifelong health,[1] a more nuanced and pragmatic understanding of the contributions of home and ECE environments to the overall pattern and quality of children's consumption is needed.

The aims of this study were to: 1) describe the total dietary intake among 3- to 4-year-old children attending ECE centers in relation to age-appropriate recommendations from the Dietary Guidelines for Americans and identify the proportion of consumption coming from ECE centers; 2) evaluate whether the quality of dietary intake patterns, as measured by the Healthy Eating Index (HEI)-2015,[42] at ECE centers is different from that when children are with parents; and 3) assess whether the quality of dietary intake differs between weekdays (when children attend ECE centers) and weekends. The authors hypothesized diet quality would be higher at ECE centers than with parents and, subsequently, weekdays would exhibit higher diet quality than weekends.

Materials and Methods

Participants and setting

Data for this cross-sectional study were collected as part of a larger cluster randomized controlled trial in central North Carolina evaluating the effectiveness of an 8-month social marketing campaign (*Healthy Me, Healthy We*) to improve 3- to 4-year-old children's dietary

and physical activity behaviors.[43] Eligibility criteria for the larger trial specified that ECE centers have at least one classroom with 3-4-year-old children, provide lunch, have a quality rating of 3-5 stars (on a 5-star scale) or be exempt from the quality rating, and not exclusively serve children with special needs. Child participants had to be 3-4 years of age and enrolled at a participating center. One parent participated with each child and provided written consent. The Institutional Review Board at the University of North Carolina at Chapel Hill approved study protocols.

Measures

Data collection occurred in two waves, prior to randomization, between July and September in 2015 and 2016. Data collection procedures included a combination of self-administered surveys, physical assessments, and observation.

Demographics. Parents completed surveys containing questions about child age, sex, race, and ethnicity, as well as parent sex, education, and household income. Center directors completed surveys about the ECE center characteristics, including accreditation, subsidies, affiliations, and total number of children enrolled.

Anthropometrics. Trained data collectors measured children's height and weight at their respective ECE centers using standard protocols.[43] Height and weight were used to calculate body mass index (BMI, kg/m^2), and the Centers for Disease Control and Prevention growth reference (2000) was used to determine age- and sex-specific BMI percentiles.[44] Children with a sex specific BMI-for-age at or above the 85^{th} percentile were classified as overweight or obese.

Parents completed self-report measures for their height and weight; BMI was calculated using these self-reported values.

Dietary Intake. To assess 24-hour intake across multiple settings and caregivers, dietary intake was measured using a combination of observation and parent-report.[45,46] Data were collected for three days – two consecutive weekdays (Tuesday/Wednesday or Thursday/Friday) and one weekend day. On weekdays, data collectors trained and certified on the Dietary Observation in Child Care (DOCC) protocol observed and recorded all food and beverages consumed by participating children while at the ECE center.[47] Parents completed food records for corresponding weekdays as well as one weekend day. Parents received instruction to document all food and beverages consumed outside of child care in real-time, including brand names and methods of preparation. A portion size estimation guide was provided and reviewed to aid parents in estimating amounts children consumed. Members of the research team reviewed all records – observation and parent-report – and contacted data collectors and parents, as needed, within one week to clarify or collect additional information regarding the types or quantities of food and drink consumed as well as potentially missing information (e.g., no drinks recorded).

Observed and parent-reported dietary intakes were merged to create 24-hour records that were entered into the Nutrition Data System for Research (NDSR) software (versions 2015 and 2016).[48] During entry, NDSR prompts location of meals and snacks, which provided the ability to capture whether food was eaten at ECE centers (i.e., DOCC data) or any other location (i.e., parent report). Final nutrient analyses were completed using NDSR version 2017 (July 2017)[49] to

obtain energy intake, macronutrients, micronutrients, and food group equivalents consistent with units required to generate total and component HEI-2015 scores.

Dietary intake was summarized in regard to nutritional goals for the healthy US-style eating pattern set forth by the 2015-2020 Dietary Guidelines for Americans for moderately active 3-4-year-old boys and girls.[9] Key elements include energy intake, macronutrient distribution (percent energy intake from carbohydrates, fat, protein, as well as added sugar and saturated fat), trans fat, sodium, and food group equivalents (fruit, vegetables, grains, protein, and dairy). Overall diet quality was evaluated using the HEI-2015, a quantitative measure of alignment with the Guidelines.[42,50] The density-based scoring system (i.e., amount consumed per 1,000 kcal) allows for the examination of quality of intake standardized for the quantity consumed.[50,51] The HEI-2015 includes 13 components – nine adequacy components (dietary components to increase) and four moderation components (dietary components to decrease). While most components are standardized per calorie, the fatty acid (adequacy) component represents the ratio of healthier unsaturated to less healthy saturated fats. Component scores typically range from 0 to 10 points, but for components where one is a subset of another (e.g., Total Vegetables and Greens and Beans), each component is scored 0 to 5 points. All components sum for a maximum score of 100, with a higher total HEI score indicating greater consistency with the Dietary Guidelines. Summarizing dietary intake in these two manners provided the ability to view the absolute intake of key nutrients and food groups, the nutrient density of foods and beverages consumed, as well as an overall indicator of diet quality.

153 *Generating HEI scores.* Distinct output files from the NDSR for total day and location-specific
154 (i.e., ECE center vs. all other locations) were imported to SAS version 9.4[52] to calculate
155 component and total HEI-2015 scores for each child using publicly available SAS code from the
156 Nutrition Coordinating Center (University of Minnesota, Minneapolis). This simple HEI scoring
157 algorithm accounts for multiple days of intake per child by summing data across days prior to
158 generating a single set of standardized component and total scores for each child by setting and
159 weekday/weekend.[50]
160
161 Statistical Analysis
162 This cross-sectional analysis comprised children for whom dietary intake was both observed at
163 the ECE center and reported for time outside of child care within a 24-hour period, including
164 children who provided only one of the intended two weekdays of record. Children with two
165 weekdays of intake were compared to children with only one weekday, but no differences were
166 detected between groups. Demographic characteristics of children and parents, characteristics of
167 centers, and children's dietary intakes and diet quality scores were summarized using descriptive
168 statistics, including frequencies for categorical data and means and standard deviations for
169 continuous data. Mixed effects models were used to determine whether mean HEI-2015
170 component and total scores differed by setting (i.e., ECE center or with parents) and weekdays
171 compared to weekend. These models included random intercepts to account for clustering within
172 ECE centers and children within families as well as accounting for repeated measures on
173 children. Children's age and sex were determined to be confounders *a priori* and were included
174 in adjusted models. In considering the opportunity for multiple comparisons within HEI-2015

total and component scores, the alpha was adjusted using a Bonferroni correction and set at 0.00019 (0.05/26 comparisons). All statistical analyses were performed in SAS version 9.4.[52]

Results

Sample Characteristics

Of the 908 children from 98 ECE centers who provided baseline data for the larger cluster randomized controlled trial, 840 children met inclusion criteria for this analysis (Table 1). Children with no dietary information were excluded (n=2) as were those when weekday diet data were missing corresponding pieces from the parent-reported records (n=40) or observations at the ECE center (n=26). Most children (n=711) had two complete weekdays of record, while the others (n=129) had one complete weekday of record. A majority of children had a day of record for the weekend (n=826), including children who only had information for one weekday (93%).

A majority of children were white (45%) or African American (38%), and about one-quarter of the children (26%) were classified as overweight or obese (sex-specific BMI-for-age ≥ 85th percentile). Parents completing study measures were primarily female (86%) and a majority of parents (64%) were classified as overweight or obese (BMI ≥ 25.0). Nearly half of the parents (47%) reported having a college or graduate-level degree and family income was reflective of that in North Carolina. A variety of types of ECE centers were represented in the sample (e.g., faith-based, Head Start), and most accepted child care subsidies (92%) and participated in the CACFP (73%).

Dietary Intake

198 *Dietary Intakes*. Children's dietary intakes at ECE centers and with parents, as well as on
199 weekdays and weekend days, are shown in Table 2. For parent-reported records, meals and
200 snacks were most frequently consumed at home (68%) or 'other' locations that included
201 restaurants (23%). Although specific dietary recommendations are dependent on the age and sex
202 of a child, the average 24-hour dietary intake for weekdays and weekends consistently fell short
203 of recommendations for vegetables, dairy, and whole grains and exceeded recommended limits
204 for sodium and percent energy intake from saturated fat and added sugars. On weekdays when
205 children consumed foods and beverages both at ECE and with parents, the majority of the total
206 day's energy (61%), food groups (50-70%), sodium (61%), and added sugars (65%) were
207 consumed with parents. When comparing weekdays and weekend days, children consumed more
208 energy and sodium, as well as a higher percent of energy from added sugar and saturated fat, on
209 weekends.
210
211 *Quality of Intake by Setting.* The mean total HEI-2015 scores for the food and beverage
212 consumed at ECE (58.3 ± 0.6) and with parents (52.5 ± 0.6) indicate children's dietary patterns
213 on the measured days of intake did not coincide with national recommendations at either setting
214 (Table 3). However, differences in scores generally suggest that children consumed a healthier
215 assortment of foods and beverages while at ECE.[50] Statistically significant differences were
216 observed for 9 of the 13 HEI-2015 component scores, exceptions being greens and beans,
217 seafood and plant proteins, fatty acids, and sodium. Food and beverage consumed at ECE
218 appeared to provide more total fruit, whole fruit, whole grains, and dairy, as well as less added
219 sugars and saturated fats per calorie. Food consumed with parents provided more total vegetables
220 and total protein as well as fewer refined grains per calorie. Although many component scores

across both settings were low, mean component scores less than 50% of the maximum component score help identify the greatest opportunities for improvement. Components with these very low scores were similar across settings and included: total vegetables, greens and beans, whole grains, seafood and plant proteins, and fatty acids.

Quality of Intake on Weekdays and Weekends. The mean total HEI-2015 scores for weekdays (58.5 ± 0.5) and weekends (51.3 ± 0.5) similarly showed that on the measured days of intake, children did not consume diets consistent with recommendations for the prevention of chronic disease (Table 3). The total HEI score for weekdays was higher than weekends. This difference was statistically significant and may be clinically meaningful.[50] Statistically significant differences were observed for 8 of the 13 component scores, exceptions being total protein foods, seafood and plant proteins, fatty acids, refined grains, and sodium. Weekday consumption provided more total fruit, whole fruit, total vegetables, greens and beans, dairy, and whole grains, as well as less added sugars and saturated fats per calorie. Regardless of the day of the week, many component scores were low to moderate at best, and highlight opportunity for improvement. The lowest component scores across weekday and weekend included total vegetables, greens and beans, whole grains, seafood and plant proteins, fatty acids, refined grains, and sodium.

Discussion

This cross-sectional analysis of observed dietary intake of 3- to 4-year-old children at ECE centers and corresponding parent-reported intake outside of child care revealed, similar to results from nationally representative samples of children who may or may not attend child care, that the

quality of children's diets is low.[12–19] Results also showed the quality of foods and beverages children consumed at ECE centers was in fact higher than what was consumed elsewhere, as well as on weekdays, when children are in child care, than on weekends, when they are not. Because of the short-term and long-term effects of dietary intake during early childhood, improving diet quality to ensure children meet nutrient recommendations within appropriate levels of energy remains of critical importance.[54]

Previous investigations into the dietary intake of young children attending ECE centers have either narrowly assessed setting (i.e., only ECE centers or only home),[36–39] a portion of the day,[41] or summarized total intake that was not identified by setting,[28,32–35] making it difficult to draw meaningful insights about the individual and complementary roles ECE centers and parents have on children's dietary intake. Only one report (from 1999) had previously distinguished consumption at ECE centers from home for an entire day.[40] Results from this study mirror previous findings in that children consumed inadequate amounts of food groups (e.g., vegetables and whole grains) and other dietary constituents important for healthy development while also consuming excess sodium and added sugars.[28,32–35,40] However, differences in these results from other studies signal that focusing on only portions of the day or absolute intake may misrepresent total dietary intake.[41]

Based on the amount of time children spend in care outside the home, national guidelines suggest that ECE provide up to one-half to two-thirds of children's daily nutrient requirements.[55] However, results from this study, similar to findings estimating the proportion of preschool-aged children's intake occurring outside of child care,[36] indicate children consume approximately 40%

of energy and nutrients at child care and instead consume about 60% of their diet with parents. While this is less than current recommendations, the higher total HEI-2015 score at ECE centers signifies children consumed more nutrient dense foods there than with parents. It is plausible that participation in the CACFP provides children access to healthier foods and beverages within ECE centers than what is provided by parents.[33,38,39] In addition, lower total HEI-2015 scores with parents may be related to the fact that approximately 12% of dietary intake of children aged 2 – 5 years comes from quick-service restaurants.[56] This not only affirms the critical role ECE centers play in improving the overall quality of children's dietary intake,[22] but also the importance of synergy and partnership between ECE providers and parents to ensure children have consistent access and encouragement to consume healthier foods and drinks.[21,40,57] Priorities for improving quality of dietary intake are similar for ECE centers and families, and intervention efforts should focus on improving the availability of healthy foods and encouraging children to eat them. Specifically, the availability and consumption of more vegetables, particularly greens and beans and seafood and plant proteins, less sodium and added sugars, and to substitute whole grains for refined grains and polyunsaturated and monounsaturated fatty acids for saturated fats.

A key strength of the current study is the use of a quantitative measure of overall diet quality, the HEI-2015 score. The density-based scoring system used to calculate the HEI-2015 separates diet quality from quantity, which not only allows for interpretation of the nutrient density of the combination of foods and beverages consumed but also for comparison across settings and days in which absolute intake differed.[50] In addition, the component scores of the HEI-2015 make it straightforward to identify specific targets for dietary interventions that can be translated to food-based recommendations. For example, although children in this study, on average, consumed

amounts of protein foods within range of recommendations, use of the HEI-2015 component scores provided more detailed information that the quality of sources of protein could be improved through substituting seafood and plant proteins.

Other assets of this study include the collection and data management of 24-hour dietary intake in a large sample of children using a highly regarded diet analysis program (NDSR) in which data across multiple settings and caregivers could be both distinguished and linked. While dietary assessment in general is not without limitations, combining a valid and reliable direct observation method[47] with parent-reported food diaries minimized bias in obtaining 24-hour intake for children who spend time with multiple caregivers.[45,58] However, caution is warranted when interpreting findings, as some differences may be the result of different methods of data collection.

Other limitations include the generalizability of these results. This sample represents the types of ECE centers and families receiving care in central North Carolina. However, results are comparable to studies conducted in other states.[28,32–35,40] Another limitation regarding generalizability relates to the calculation of HEI-2015 scores with a simple scoring method. This method is based on individuals' intake on the observed days; therefore it may not capture episodic consumption of infrequently consumed food groups or subgroups, nor does it estimate usual intake or adjust for measurement error.[59] However, it can be used to estimate individual-level scores that can then be used in more advanced statistical models.[50,60] To answer these research questions, it was necessary to use mixed effects models to control for clustering within ECE centers, relationships between HEI-2015 scores and individual children's characteristics

(i.e., age, sex), and the within subject comparison of looking at dietary intake by setting or portion of the week (i.e., groups were not independent of one another).

Conclusions

This sample of 3- to 4-year-old children attending ECE centers in central North Carolina consumed about 60% of their diet with parents and 40% at ECE centers. In general, children fell short of recommendations for vegetables, dairy, and whole grains and exceeded recommendations for sodium and percent energy intake from added sugars and saturated fats as specified in the USDA Food Patterns. A deeper look at consumption specifically within ECE centers and with parents revealed that children consumed higher quality foods and beverages at ECE centers, most notably through more whole fruits, dairy, whole grains, and less added sugars and saturated fat per calorie. Similarly, in comparing weekdays to weekends, children consumed higher quality foods and beverages on weekdays than weekends. While ECE centers remain an important source of nutrition for young children, there is still room for improvement. These findings highlight the value of evaluating overall eating patterns, as opposed to specific nutrients or portions of the day, and warrant further investigation about how to more effectively include and support parents in fostering healthier eating environments so that children eat well across settings and ultimately achieve higher quality dietary intake that positively influences longer-term health.

References

1. Institute of Medicine. *From Neurons to Neighborhoods*. Washington, D.C.: National Academies Press; 2000.
2. Holt KA, Wooldridge NH, Story MT, Sofka D, eds. *Bright Futures: Nutrition*. 3rd ed. Itasca, IL: The American Academy of Pediatrics; 2011.
3. Okubo H, Crozier SR, Harvey NC, et al. Diet quality across early childhood and adiposity at 6 years: the Southampton Women's Survey. *Int J Obes*. 2015;39(10):1456-1462.
4. Birch LL, Davison KK. Family environmental factors influencing the developing behavioral controls of food intake and childhood overweight. *Pediatr Clin North Am*. 2001;48(4):893-907.
5. Schwartz C, Scholtens PAMJ, Lalanne A, Weenen H, Nicklaus S. Development of healthy eating habits early in life. Review of recent evidence and selected guidelines. *Appetite*. 2011;57(3):796-807.
6. Skinner JD, Carruth BR, Wendy B, Ziegler PJ. Children's food preferences: a longitudinal analysis. *J Am Diet Assoc*. 2002;102(11):1638-1647.
7. Gordon-Larsen P, The NS, Adair LS. Longitudinal trends in obesity in the United States from adolescence to the third decade of life. *Obesity*. 2010;18(9):1801-1804.
8. Brown JE, Isaacs JS, Krinke UB, et al. *Nutrition Through the Life Cycle*. 5th ed. Stamford, CT: Cengage Learning; 2014.
9. U.S. Department of Health and Human Services, U.S. Department of Agriculture. *2015 - 2020 Dietary Guidelines for Americans.* 8th ed. US Dept of Health and Human Services website. https://health.gov/dietaryguidelines/2015/guidelines/. Published December 2015. Accessed September 16, 2019.

10. Butte NF, Fox MK, Briefel RR, et al. Nutrient Intakes of US Infants, Toddlers, and Preschoolers Meet or Exceed Dietary Reference Intakes. *J Am Diet Assoc*. 2010;110(12):S27-S37.
11. Bailey RL, Catellier DJ, Jun S, et al. Total Usual Nutrient Intakes of US Children (Under 48 Months): Findings from the Feeding Infants and Toddlers Study (FITS) 2016. *J Nutr*. 2018;148(9S):1557S-1566S.
12. Guenther PM, Casavale KO, Kirkpatrick SI, et al. *Diet Quality of Americans in 2001-02 and 2007-08 as Measured by the Healthy Eating Index-2010*. Alexandria, VA: Center for Nutrition Policy and Promotion, U.S. Department of Agriculture; 2013: Nutrition Insight 51.
13. Welker EB, Jacquier EF, Catellier DJ, Anater AS, Story MT. Room for Improvement Remains in Food Consumption Patterns of Young Children Aged 2-4 Years. *J Nutr*. 2018;148(9S):1536S-1546S.
14. Keast DR, Fulgoni VL, Nicklas TA, O'Neil CE. Food sources of energy and nutrients among children in the United States: National Health and Nutrition Examination Survey 2003–2006. *Nutrients*. 2013;5(1):283-301.
15. Ford CN, Slining MM, Popkin BM. Trends in dietary intake among US 2- to 6-year-old children, 1989-2008. *J Acad Nutr Diet*. 2013;113(1):35-42.
16. Kay M, Welker E, Jacquier E, et al. Beverage Consumption Patterns among Infants and Young Children (0–47.9 Months): Data from the Feeding Infants and Toddlers Study, 2016. *Nutrients*. 2018;10(7):825.
17. Ogata BN, Hayes D. Position of the Academy of Nutrition and Dietetics: nutrition guidance for healthy children ages 2 to 11 years. *J Acad Nutr Diet*. 2014;114(8):1257-

1276.

18. Fox MK, Condon E, Briefel RR, Reidy KC, Deming DM. Food consumption patterns of young preschoolers: are they starting off on the right path? *J Am Diet Assoc*. 2010;110(12 Suppl):S52-9.

19. Fox MK, Gearan E, Cannon J, et al. Usual food intakes of 2- and 3-year old U.S. children are not consistent with dietary guidelines. *BMC Nutr*. 2016;2(1):67.

20. Corcoran L, Steinley K, Grady S. *Early Childhood Program Participation, Results from the National Household Education Surveys Program of 2016* (NCES 2017-101.REV). National Center for Education Statistics website. https://nces.ed.gov/pubs2017/2017101REV.pdf. Accessed September 16, 2019.

21. Skouteris H, McCabe M, Swinburn B, Newgreen V, Sacher P, Chadwick P. Parental influence and obesity prevention in pre-schoolers: a systematic review of interventions. *Obes Rev*. 2011;12(5):315-328.

22. Larson N, Ward DS, Neelon SB, Story M. What Role Can Child-Care Settings Play in Obesity Prevention? A Review of the Evidence and Call for Research Efforts. *J Am Diet Assoc*. 2011;111(9):1343-1362.

23. U.S. Department of Agriculture, Food and Nutrition Service. *Child and Adult Care Food Program*. US Dept of Agriculture website. https://www.fns.usda.gov/cacfp/child-and-adult-care-food-program. Accessed September 16, 2019.

24. Ritchie LD, Boyle M, Chandran K, et al. Participation in the Child and Adult Care Food Program Is Associated with More Nutritious Foods and Beverages in Child Care. *Child Obes*. 2012; 8(3):224-229.

25. Korenman S, Abner KS, Kaestner R, Gordon RA. The Child and Adult Care Food

Program and the nutrition of preschoolers. *Early Child Res Q*. 2013;28(2):325-336.

26. Schwartz MB, Henderson KE, Grode G, et al. Comparing Current Practice to Recommendations for the Child and Adult Care Food Program. *Child Obes*. 2015;11(5):491-498.

27. Goldbohm R, Rubingh C, Lanting C, Joosten K. Food Consumption and Nutrient Intake by Children Aged 10 to 48 Months Attending Day Care in The Netherlands. *Nutrients*. 2016;8(7):428.

28. Larowe TL, Adams AK, Jobe JB, Cronin KA, Vannatter SM, Prince RJ. Dietary Intakes and Physical Activity among Preschool Aged Children living in Rural American Indian Communities Prior to a Family-based Healthy Lifestyle Intervention. *J Am Diet Assoc*. 2010;110(7):1049-1057.

29. Gubbels J, Raaijmakers L, Gerards S, Kremers S. Dietary Intake by Dutch 1- to 3-Year-Old Children at Childcare and at Home. *Nutrients*. 2014;6(1):304-318.

30. Bernardi JR, Cezaro C De, Fisberg RM, Fisberg M, Vitolo MR. Estimation of energy and macronutrient intake at home and in the kindergarten programs in preschool children. *J Pediatr*. 86(1):59-64.

31. Gerritsen S, Anderson SE, Morton SM, Wall CR. Pre-school nutrition-related behaviours at home and early childhood education services: findings from the Growing Up in New Zealand longitudinal study. *Public Health Nutr*. 2018;21(07):1222-1231.

32. Bollella MC, Boccia LA, Nicklas TA, et al. Assessing dietary intake in preschool children: The healthy start project - New York. *Nutr Res*. 1999;19(1):37-48.

33. Bruening KS, Gilbride JA, Passannante MR, McClowry S. Dietary Intake and Health Outcomes among Young Children Attending 2 Urban Day-care Centers. *J Am Diet Assoc*.

1999;99(12):1529-1535.

34. Bucholz EM, Desai MM, Rosenthal MS. Dietary intake in Head Start vs non-Head Start preschool-aged children: results from the 1999-2004 National Health and Nutrition Examination Survey. *J Am Diet Assoc*. 2011;111(7):1021-1030.

35. Mier N, Piziak V, Octelina Castillo-Ruiz, Velazquez G, Alfaro ME, Ramirez JA. Nutrition Provided to Mexican-American Preschool Children on the Texas-Mexico Border. *J Am Diet Assoc*. 2007;107:311-315.

36. Robson SM, Khoury JC, Kalkwarf HJ, Copeland K. Dietary Intake of Children Attending Full-Time Child Care: What Are They Eating Away from the Child-Care Center? *J Acad Nutr Diet*. 2015;115(9):1472-1478.

37. Padget A, Briley ME. Dietary Intakes at Child-Care Centers in Central Texas Fail to Meet Food Guide Pyramid Recommendations. *J Am Diet Assoc*. 2005;105:790-793.

38. Romo-Palafox MJ, Ranjit N, Sweitzer SJ, et al. Adequacy of Parent-Packed Lunches and Preschooler's Consumption Compared to Dietary Reference Intake Recommendations. *J Am Coll Nutr*. 2017;36(3):169-176.

39. Andreyeva T, Kenney EL, O'Connell M, Sun X, Henderson KE. Predictors of Nutrition Quality in Early Child Education Settings in Connecticut. *J Nutr Educ Behav*. 2018;50(5):458-467.

40. Briley ME, Jastrow S, Vickers J, Roberts-Gray C. Dietary intake at child-care centers and away: Are parents and care providers working as partners or at cross-purposes? *J Am Diet Assoc*. 1999;99:950-954.

41. Sisson SB, Kiger AC, Anundson KC, et al. Differences in preschool-age children's dietary intake between meals consumed at childcare and at home. *Prev Med reports*. 2017;6:33-

37.

42. Krebs-Smith SM, Pannucci TE, Subar AF, et al. Update of the Healthy Eating Index: HEI-2015. *J Acad Nutr Diet*. 2018;118(9):1591-1602.

43. Hennink-Kaminski H, Vaughn AE, Hales D, Moore RH, Luecking CT, Ward DS. Parent and child care provider partnerships: Protocol for the Healthy Me, Healthy We (HMHW) cluster randomized control trial. *Contemp Clin Trials*. 2018;64:49-57.

44. Kuczmarski RJ, Ogden CL, Guo SS, et al. 2000 CDC Growth Charts for the United States: methods and development. *Vital Health Stat 11*. 2002;(246):1-190.

45. Baranowski T, Sprague D, Baranowski JH, Harrison JA. Accuracy of maternal dietary recall for preschool children. *J Am Diet Assoc*. 1991;91(6):669-674.

46. Burrows TL, Martin RJ, Collins CE. A Systematic Review of the Validity of Dietary Assessment Methods in Children when Compared with the Method of Doubly Labeled Water. *J Am Diet Assoc*. 2010;110(10):1501-1510.

47. Ball SC, Benjamin SE, Ward DS. Development and Reliability of an Observation Method to Assess Food Intake of Young Children in Child Care. *J Am Diet Assoc*. 2007;107(4):656-661.

48. NDSR [computer program]. Version 2016. Minneapolis, MN: University of Minnesota Nutrition Coordinating Center; 2016.

49. NDSR [computer program]. Version 2017. Minneapolis, MN: University of Minnesota Nutrition Coordinating Center; 2017.

50. Kirkpatrick SI, Reedy J, Krebs-Smith SM, et al. Applications of the Healthy Eating Index for Surveillance, Epidemiology, and Intervention Research: Considerations and Caveats. *J Acad Nutr Diet*. 2018;118(9):1603-1621.

51. Guenther PM, Casavale KO, Reedy J, et al. Update of the Healthy Eating Index: HEI-2010. *J Acad Nutr Diet*. 2013;113(4):569-580.
52. SAS [computer program]. Version 9.4. Cary, NC: SAS Institute, Inc.; 2018.
53. Stallings VA, Harrison M, Oria M, eds. *Dietary Reference Intakes for Sodium and Potassium*. Washington, D.C.: National Academies Press; 2019.
54. Dietary Guidelines Advisory Committee. *Scientific Report of the 2015 Dietary Guidelines Advisory Committee: Advisory Report to the Secretary of Health and Human Services and the Secretary of Agriculture*. US Dept of Health and Human Services website. https://health.gov/dietaryguidelines/2015-scientific-report/PDFs/Scientific-Report-of-the-2015-Dietary-Guidelines-Advisory-Committee.pdf. Accessed September 16, 2019.
55. Benjamin-Neelon SE. Position of the Academy of Nutrition and Dietetics: Benchmarks for Nutrition in Child Care. *J Acad Nutr Diet*. 2018;118(7):1291-1300.
56. U.S. Department of Agriculture, Agricultural Research Service. Food Patterns Equivalents Intakes from Food: Mean Amounts Consumed per Individual, by Family Income as % of Poverty Level and Age, *What We Eat in America,* NHANES 2015-2016. US Dept of Agriculture website. www.ars.usda.gov/nea/bhnrc/fsrg. Accessed September 16, 2019.
57. Ward DS, Welker E, Choate A, et al. Strength of obesity prevention interventions in early care and education settings: A systematic review. *Prev Med (Baltim)*. 2017;95:S37-S52.
58. Thompson FE, Kirkpatrick SI, Subar AF, et al. The National Cancer Institute's Dietary Assessment Primer: A Resource for Diet Research. *J Acad Nutr Diet*. 2015;115(12):1986-1995.
59. Epidemology and Genomics Research Program. *Overview of the Methods & Calculations*. National Cancer Institute website. https://epi.grants.cancer.gov/hei/hei-methods-and-

calculations.html. Accessed September 16, 2019.

60. Thomson JL, Tussing-Humphreys LM, Landry AS, Goodman MH. No Improvements in Postnatal Dietary Outcomes Were Observed in a Two-Arm, Randomized, Controlled, Comparative Impact Trial among Rural, Southern, African-American Women. *J Acad Nutr Diet*. 2018;118(7):1196-1207.

Table 1. Demographic and anthropometric characteristics of 840 parent-child dyads from 98 early care and education centers in North Carolina in 2015 – 2016 who had at least one weekday record containing dietary intake at both child care and with parents and characteristics of centers

Children	
	mean ± SD[a]
Age, years (n=837)	4 ± 0.6
	n (%)
Sex, female (n=838)	410 (48.9)
Race (n=797)	
White	362 (45.4)
Black or African American	305 (38.2)
Asian	18 (2.3)
American Indian or Alaska Native	3 (0.4)
More than one race	95 (11.9)
Not specified	14 (1.8)
Ethnicity (n=808)	
Hispanic or Latino	73 (8.7)
Anthropometric (n=836)	*mean ± SD*
BMI[b] percentile	61.3 ± 27.8
	n (%)

BMI-for-age ≥85th percentile	214 (25.6)
Parents	***n (%)***
Sex, female (n=819)	704 (86.0)
Highest level of education completed (n=804)	
High school diploma/GED or lower	134 (16.7)
Some college	191 (23.8)
Associate degree	101 (12.6)
College degree or higher	378 (47.0)
Annual family household income (n=717)	
Under $30,000	242 (33.8)
$30,000 - $59,999	158 (22.0)
$60,000 or more	317 (44.2)
	mean ± SD
BMI (n=779)	28.8 ± 7.4
Weight status	*n (%)*
Underweight (BMI <18.5)	11 (1.4)
Normal weight (BMI 18.5 to <25)	269 (34.5)
Overweight (BMI 25.0 to <30)	230 (29.5)
Obese (BMI ≥30.0)	269 (34.5)
Centers	***n (%)***
Accredited by the National Association for the Education of Young Children	22 (22.4)

Accepts child care subsidies	90 (91.8)
Participates in the Child and Adult Care Food Program	71 (72.5)
Other program affiliations[c]	
NC Pre-K or other pre-kindergarten	33 (33.7)
Faith-based	20 (20.4)
Head Start and/or Early Head Start	11 (11.2)
Military	3 (3.1)
Native American or Alaska Native tribe	1 (1.0)
	mean, range
Total child enrollment	87, 28-218

[a] SD = standard deviation

[b] BMI = body mass index, calculated as kg/m^2

[c] Centers could select all options that applied

Table 2. Dietary intakes of 3-4-year-old children attending center-based early care and education in central North Carolina in 2015 – 2016

Dietary Component	Recommended Daily Intake[a]	Weekday at ECE[b] (n=840) (mean ± SD[c])	Weekday with Parents (n=840) (mean ± SD)	Total Weekday (n=840) (mean ± SD)	Total Weekend (n=826) (mean ± SD)
Energy, kcal[d]	1200 – 1400	503 ± 169	771 ± 278	1274 ± 301	1426 ± 468
Carbohydrate, % energy	45 – 65	58.7 ± 8.6	54.2 ± 10.01	54.8 ± 6.3	51.6 ± 20.3
Fat, % energy	25 – 35	27.2 ± 7.2	32.0 ± 7.7	29.6 ± 5.3	33.1 ± 7.4
Protein, % energy	10 – 30	15.9 ± 3.9	15.4 ± 4.6	15.7 ± 3.2	14.7 ± 3.9
Sodium, mg	<1200 - <1500[e]	782 ± 340	1219 ± 521	2000 ± 614	2322 ± 924
Saturated fat, % energy	<10	9.2 ± 3.2	10.6 ± 3.6	10.1 ± 2.5	11.0 ± 3.3
Trans fat, g	Limit	0.6 ± 0.5	0.9 ± 0.6	1.5 ± 0.8	1.6 ± 1.2
Added sugars, % energy	<10	11.1 ± 6.4	13.8 ± 8.7	12.9 ± 5.8	14.1 ± 8.2
Fruit, cup-equivalents	1 – 1.5	0.5 ± 0.4	0.6 ± 0.6	1.1 ± 0.7	1.0 ± 1.0
Vegetables, cup-equivalents	1.5	0.2 ± 0.2	0.4 ± 0.4	0.6 ± 0.4	0.6 ± 0.6

Grains, ounce-equivalents	4 – 5	2.1 ± 0.9	2.7 ± 1.5	4.8 ± 1.7	5.2 ± 2.6
Whole grains, ounce-equivalents	2 – 2.5	0.4 ± 0.5	0.4 ± 0.6	0.8 ± 0.8	0.7 ± 1.0
Protein foods, ounce-equivalents	3 – 4	0.9 ± 0.8	2.0 ± 1.4	2.9 ± 1.7	3.9 ± 2.6
Dairy, cup-equivalents	2.5	1.1 ± 0.6	1.0 ± 0.8	2.1 ± 1.0	1.7 ± 1.2

[a] Based on Dietary Reference Intakes and Healthy US-style USDA Food Patterns for moderately active 3-4-year-old girls and boys

[b] ECE = early care and education

[c] SD = standard deviation

[d] Energy is based on estimated average requirements, not a recommended daily intake

[e] Chronic Disease Risk Reduction Intake[53]

Table 3. Healthy Eating Index-2015 scores[a] by setting and day of the week of 3-4-year-old children attending center-based early care and education in central North Carolina in 2015 – 2016

HEI-2015[b] Component	Maximum Points	Weekday at ECE[c,d] (n=840) (mean ± SE[e])	Weekday with Parents[d] (n=840) (mean ± SE)	p-value[f]	Total Weekday (n=840) (mean ± SE)	Total Weekend (n=826) (mean ± SE)	p-value[f]
Adequacy							
Total fruits	5	4.2 ± 0.1	3.0 ± 0.1	**<0.0001**	4.0 ± 0.1	3.1 ± 0.1	**<0.0001**
Whole fruits	5	4.3 ± 0.1	2.8 ± 0.1	**<0.0001**	4.1 ± 0.1	2.9 ± 0.1	**<0.0001**
Total vegetables	5	1.8 ± 0.1	2.3 ± 0.1	**<0.0001**	2.2 ± 0.1	1.9 ± 0.1	**<0.0001**
Greens and beans	5	0.9 ± 0.1	1.2 ± 0.1	0.001	1.4 ± 0.1	0.9 ± 0.1	**<0.0001**
Whole grains	10	4.3 ± 0.2	3.1 ± 0.2	**<0.0001**	4.1 ± 0.2	3.1 ± 0.2	**<0.0001**
Dairy	10	9.3 ± 0.1	7.2 ± 0.1	**<0.0001**	9.0 ± 0.1	7.0 ± 0.1	**<0.0001**
Total protein foods	5	2.9 ± 0.1	3.8 ± 0.1	**<0.0001**	3.8 ± 0.1	4.0 ± 0.1	0.004
Seafood and plant proteins	5	1.2 ± 0.1	1.4 ± 0.1	0.159	1.9 ± 0.1	1.6 ± 0.1	0.01

Fatty acids	10	4.6 ± 0.2	4.8 ± 0.2	0.245	4.5 ± 0.2	5.1 ± 0.2	0.0003
Moderation							
Refined grains	10	4.4 ± 0.2	5.5 ± 0.2	**<0.0001**	4.9 ± 0.1	4.9 ± 0.1	0.63
Sodium	10	5.3 ± 0.2	4.9 ± 0.2	0.009	4.9 ± 0.1	4.5 ± 0.1	0.002
Added sugars	10	7.4 ± 0.1	6.2 ± 0.1	**<0.0001**	6.7 ± 0.1	6.1 ± 0.1	**<0.0001**
Saturated fats	10	7.7 ± 0.1	6.5 ± 0.1	**<0.0001**	7.1 ± 0.1	6.1 ± 0.1	**<0.0001**
Total HEI-2015 Score	100	58.3 ± 0.6	52.5 ± 0.6	**<0.0001**	58.5 ± 0.5	51.3 ± 0.5	**<0.0001**

[a] Scores adjusted for child sex, age in years, and account for clustering by centers and repeated measures on children

[b] HEI-2015 = Healthy Eating Index-2015

[c] ECE = early care and education

[d] Based only on weekday records of intake

[e] SE = standard error

[f] p-values bolded denote those that reached statistical significance for correcting for multiple comparisons using Bonferroni correction ($p<0.00019$)