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Title: Disparities exist between the Australian Guide to Healthy Eating and the dietary intakes of young children aged 2 to 3 years

Running title: Children intakes compared to national guidelines

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ABSTRACT

Aim: To compare dietary intakes of young children to the Australian Guide to Healthy Eating (AGHE) and Nutrient Reference Values (NRV's).

Methods: Dietary intakes of 54 children (50% girls) aged two to three years (mean 2.7 years) from the Women and Their Children's Health (WATCH) study were reported by mothers using a validated 120-item food frequency questionnaire. Daily consumption of AGHE food group servings, macronutrients, and micronutrients were compared to the AGHE and NRV's using t-test with significance set at $P < 0.05$.

Results: No child achieved all AGHE targets, with the majority consuming less breads/cereals (1.9 vs 4.0 servings/day), vegetables (1.3 vs 2.5), and meat/alternatives (0.7 vs 1.0), all $P < 0.0001$. Adequate servings were observed for dairy (2.2 vs 1.5) and fruit (1.3 vs 1.0). Macronutrients were within recommended ranges, although 96% exceeded saturated fatty acid recommendations. Children who met selected NRV's consumed more fruit (1.4 vs 1.0; $P < 0.0086$), dairy (2.2 vs 1.5; $P < 0.0001$) and discretionary foods (2.6 vs ≤ 1.0 ; $P < 0.0001$) but less breads/cereals (2.0 vs 4.0; $P < 0.0001$) and vegetables (1.3 vs 2.5; $P < 0.0001$) servings, compared to the AGHE recommended servings.

Conclusions: Child dietary intakes did not align with AGHE, while adequate nutrient profiles were achieved by various dietary patterns. Future studies involving data from larger, representative samples of children are warranted.

Key words: Dietary intake; NRVs; Children; Nutritional Status, Australian Guide to Healthy Eating

INTRODUCTION

Childhood nutrition can have a lifelong impact on an individual's health.¹⁻³ Current research indicates that dietary patterns, including frequency, variety and amount of food habitually consumed, track from childhood through to adulthood.²⁻⁴ The early years, between ages of one and three, are a time when eating patterns, skills, knowledge and attitude towards food begin to develop.^{5,6} Healthy childhood eating patterns are essential for the provision of sufficient energy and nutrients for growth, cognitive development,⁷ and to reduce the risk of nutrition-related chronic disease later in life.⁸

In Australia, a healthy diet is characterised by the consumption of a variety of foods from the five core food groups, which are (i) bread/cereals, mostly wholegrain and/or high fibre varieties; (ii) fruit; (iii) vegetables and legumes/beans; (iv) dairy products, such as reduced fat milk yoghurt, and cheese; and (v) lean meats/alternatives, such as poultry, fish, eggs, nuts, and legumes, with additional allowances for low intakes of unsaturated fat and discretionary foods (energy-dense, nutrient-poor).⁹ These are operationalized as a recommended number of daily servings in the Australian Guide to Healthy Eating (AGHE).⁹ The 2013 AGHE was developed from a detailed evidence-base in conjunction with a Food Modelling System^{10,11} to establish a range of virtual diets: the Foundation Diets and Total Diets. This was achieved by converting the Nutrient Reference Values (NRV's) into combinations of types and amounts of foods within the core food groups to meet the nutritional requirements of each age and gender group, factoring in height and physical activity levels.¹¹ The information was simplified into the AGHE, a user-friendly food selection guide.⁹

NRV's outline the average nutrient requirements needed on a daily basis to meet physiological function and to prevent deficiency or chronic disease.¹² NRV's for population average intakes are termed 'estimated average requirements' (EAR) and 'adequate intakes' (AI).¹² The EAR refers to the everyday nutrient intake level needed to meet the requirements of 50% of the

healthy population in a specific life-stage and gender group.¹² When an EAR cannot be determined, then an AI, which is the average daily nutrient intake level that is likely to be sufficient, based on observed or experimentally determined estimation of nutrient intake by an apparently healthy cohort, is used.¹² The Upper Level of Intake (UL) refers to the maximum average daily nutrient intake level likely to have no adverse health effects to the majority of individuals in the general population.¹²

No studies have examined and compared the dietary intakes of young Australian children aged two to three years to the AGHE age-appropriate recommendations thus far. This is because prior to 2013, there were no quantitative dietary guidelines for children less than four years of age, limiting the comparison of dietary patterns in this age group to age appropriate standards.¹³ The 1995 National Nutrition Survey (NNS),¹⁴ the 2007 Australian National Children's Nutrition and Physical Activity Survey (ANCNPAS),¹⁵ the Childhood Asthma Prevention Study (CAPS),¹⁶ and the 2010 Australia National Infant Feeding Survey: indicator results¹⁷ have all included young children, but were only able to describe food and nutrient intakes in reference to older children, rather than evaluating intakes based on comparison with age-appropriate national food group serving recommendations.

The aim of this study was to evaluate whether the dietary intakes of a sample of Australian children aged two to three years met (i) the minimum recommended age-appropriate daily food group servings in the AGHE, and (ii) the NRV's for vitamin A, thiamin, folate, calcium, iron and zinc.

METHODS

This is a secondary data analysis of child dietary intakes from the Women and Their Children's Health (WATCH) cohort.¹⁸ Pregnant women less than 18 gestational weeks were eligible to participate in the WATCH study.¹⁸ Participants needed to reside locally and be able to be present at the arranged study visits at the John Hunter Hospital.¹⁸ Between June 2006 and December 2007, 180 eligible participants were recruited to the study through various approaches, such as via research midwives at the John Hunter Hospital antenatal clinic, local media coverage, and by word of mouth.¹⁸ The majority of participants (n=133, 74% of sample) remained enrolled two years after study commencement, although not all participants completed all components at study visits.¹⁸ Ethics approval for the WATCH study was obtained from the Hunter New England Human Research Ethics Committee and the University of Newcastle Human Research Ethics Committee.

Standardised procedures of data collection were used, with detailed methods published elsewhere.^{18,19} Briefly, anthropometry measurements and dietary intakes for the mothers and children were collected by qualified dietitians at the annual study visit.¹⁸ Data on socio-economic status, health and lifestyle variables were also obtained via a self-reported questionnaire at the first study visit.¹⁸ Dietary data of 57 children aged two to three years, including one set of twins, were available for the current analysis.

The toddler version of the Australian Child and Adolescent Eating Survey (ACAES) was used to evaluate the dietary intake of children at age two or three years.²⁰ The ACAES is a 120-item semi-quantitative food frequency questionnaire (FFQ) that was previously validated for energy intake using the gold-standard doubly labelled water method in Australian children,²¹⁻²⁴ including those aged two to three years.^{20,22,23} Mothers were asked to complete the ACAES for their child's intake over the past six months as this reporting period is designed to capture children's usual eating habits.²⁵ An individual response is required for each food item in the ACAES, with varied frequency options ranging from 'never' to 'four or more times per day',¹⁸

and for some beverages up to ‘seven or more glasses per day’.²⁰ Toddler-specific portion sizes were derived from the 2007 ANCNPAS¹⁵ unpublished data purchased from the Australian Social Science Data Archive, Australian National University.²⁰ Additional questions regarding food-related behaviours are described in detail elsewhere.¹⁸ FFQs were included if they had less than five missing responses, with three FFQs excluded for this reason.

Raw data from the FFQ were entered into FoodWorks Professional (Xyris Software, Brisbane, QLD, Australia) based on AUSNUT 2007 to derive the amount (weight mass) of daily food consumption and nutrient intakes. Food consumption data were then exported into Microsoft Excel (Microsoft Cooperation, 2010, Seattle, United States) spreadsheets and categorised into food groups corresponding to the core and discretionary groups of AGHE,⁹ which has been published previously²⁶ and reported in a number of studies.^{22,27,28} Food portions were converted into a number of servings based on the AGHE standard serving sizes.⁹ When food items were not specified in the AGHE, standard portions were derived based on similar energy values of other food items in the same AGHE food group. For example, a standard portion of cheese spread/cream cheese was deemed to be 55g as this amount provides a similar energy value to the standard serving size of plain milk (250ml), hard cheese (40g), and ricotta cheese (120g). To calculate consumption of combination dishes, foods were broken into their component ingredients and assigned into the appropriate food groups. For example, the food item ‘beef/lamb pieces with vegetables’ was disaggregated into meat and vegetables food groups in the weight ratio of 2:1. Foods that do not fit into any of the core food groups were evaluated as ‘discretionary foods’.⁹ Nutrient intake data were compared with the NRV’s to assess nutritional adequacy.

All data manipulation and statistical analyses was undertaken using JMP® (version 10. SAS Institute Inc., Cary, NC, 1989-2007). Results were considered statistically significant with *P*-values <0.05. Descriptive statistics were undertaken to describe maternal and child

characteristics by age groups. Demographic characteristics of mothers (n=53) were compared to the baseline sample (n=177) using t-tests. Body Mass Index (BMI) z-scores for the children were calculated using the LMS statistical method.²⁹ Main outcome measures included children's daily consumption of the AGHE food groups, macronutrients, and micronutrients; and the proportion of children meeting recommendations as per the AGHE and NRV's by age groups. The majority of dietary variables were normally distributed (Shapiro-Wilk Goodness of Fit tests). Differences between dietary intakes of children and the AGHE recommended number of daily servings were assessed using t-tests. The initial analysis included the whole sample and all nutrients. Individual mean daily macronutrient and micronutrient intakes were compared to the EAR or AI to assess whether the children in this study met the NRV's.¹² Selected nutrients important for healthy growth and development were investigated in the sub-sample (n=47) in addition to the number of daily servings from the AGHE food groups to investigate different aspects of diet. Daily food groups and macronutrient intakes were assessed for those meeting the EARs for vitamin A, thiamin, folate, calcium, iron and zinc. These nutrients were selected as key nutrients for health and were deemed as most important for children's development and health.^{30,31} They also represent both fat-soluble and water-soluble vitamins, in addition to minerals.¹²

RESULTS

The majority of the mothers were aged between 25 and 34 years old at age of delivery (62%), married (68%), and had attained post-year 12 educational qualifications (55%). No significant difference was found between these maternal characteristics compared to baseline data. Young children (n=54) in the current study were aged 2 to 3 years (mean age 2.7 years) with equal numbers of boys (n=27) and girls (n=27). The group mean BMI $\pm$ standard deviation (SD) was

16.4 kg/m² $\pm$ 1.6. Using the LMS statistical method,²⁹ the mean z-scores $\pm$ SD for weight was 0.4 $\pm$ 1.1, height 0.5 $\pm$ 1.1, and BMI 0.1 $\pm$ 1.0.

Table 1 reports the mean intake of the children as per the AGHE, and proportion of young children who achieved the AGHE food group recommendations. The study found that no child achieved AGHE recommendations for all food groups. Eighty five percent of children in the current study consumed one or more servings of discretionary foods daily. Food groups with the greatest disparity between reported intake and the AGHE recommendations (proportion with intakes $\geq$ recommendations, mean servings/day) were breads/cereals (0%, 1.9 vs. 4.0 servings/day; $P < 0.0001$), vegetables (6%, 1.3 vs. 2.5 servings/day; $P < 0.0001$), and meat/alternatives (19%, 0.7 vs 1.0 serving/day; $P < 0.0001$).

The nutrient profile and the proportion of children who achieved the age-appropriate NRV's are presented in Table 2. The mean macronutrient profile was: 48.5% of total energy intake (%E) from carbohydrate; 17.7%E from protein; and 32.8%E from total fat, including 16%E from saturated fatty acids (SFA). The greatest disparities between children's intakes and recommendations were observed in dietary fibre and potassium, where 46% and 56% of children met the target respectively. In addition, 50% of children exceeded the UL for zinc¹² and 96% of children exceeded the National Health and Medical Research Council SFA recommendation of <10% of energy intake.³² For the remaining nutrients, at least 83% of children met the respective NRV.

Further analysis was undertaken on a subsample of children (n=47) who met the EARs for vitamin A, thiamin, folate, calcium, iron and zinc, to evaluate their core food group and macronutrient intakes (Table 3). The macronutrient intakes of this subgroup were similar to the main study sample (n=54) with 100% of children meeting the relevant NRV's,¹² although intakes of SFA exceeded recommendations.³² This subgroup had significantly higher mean

daily servings of fruit, excluding juice (1.4 vs. 1.0; $P<0.05$), dairy (2.2 vs. 1.5; $P<0.001$), and discretionary foods (2.6 vs. ≤ 1.0 ; $P<0.001$), plus significantly lower mean daily servings of breads and cereals (2.0 vs. 4.0; $P<0.001$), vegetables (1.3 vs. 2.5; $P<0.001$), and meat (0.7 vs. 1.0; $P<0.001$) compared to the AGHE recommendations.

DISCUSSION

This is the first Australian study to compare the dietary patterns of children aged two to three years to the current AGHE age-appropriate daily food group serving recommendations. The study found that no child achieved AGHE recommendations for all food groups. The majority of children had daily food group serving intakes below AGHE recommendations for the bread/cereals, vegetables, and meat/alternatives groups. This is similar to the 2007 ANCNPAS where 86 to 90% of children aged two to three were eating at least 1-3 servings/day of fruit (including juice) but less than 2 servings/day of vegetables (including potatoes).¹⁵ The consumption of cereals, meat, dairy products, and discretionary foods cannot be directly compared to the previous study due to changes in the standard serving sizes in the AGHE between the two analyses. The ANCNPAS assessed dietary intake via 24-hour recalls. Parents or care givers reported child intakes for the preceding 24 hours and therefore may not reflect usual intake.^{33,34} In the current study, child dietary intake was measured using a validated FFQ^{20,22,23} and compared to the 2013 AGHE, which includes serving sizes and recommendations specifically for young children aged two to three years. Hence, the results in the current analysis may better represent usual child dietary patterns.

The common discretionary foods consumed included snack bars, cakes and muffins, sweet biscuits, and potato chips/French fries, which contributed to an average 28% of total energy intake in the young children within the current study. ‘Discretionary foods’ are high in energy,

added sugars, salt, saturated fat and therefore should be eaten less often and in limited amounts.⁹ In the 1995 NNS, 2007 ANCNPAS and the Feeding Healthy Foods to Kids, discretionary foods were over-consumed by Australian children aged two to three years, contributing to 33%E, 35%E and 29%E, respectively.^{28,35} Australian toddlers (aged 16-24 months) in the CAPS study also reported high intakes of discretionary foods, contributing to 25-30%E.³⁶ Evidence shows discretionary foods displace nutrient dense foods and are negatively associated with protein and micronutrient intakes.³⁶ These results raise concern regarding a relatively consistent high consumption (25-35%E) of discretionary foods among young children over the last decade.

The mean macronutrient distributions in the current study were mostly within the acceptable ranges, although SFA intakes exceeded recommendations and dietary fibre was below recommendations. These findings were supported by a survey conducted in a larger sample of young Australian children of a similar age. A cross-sectional survey involving children aged one to five years (n=300) in South Australia found similar results with 50%E (vs. 48.5%E) from carbohydrate, 17%E (vs. 17.7%E) from protein, 33%E (vs. 32.8%E) from fat, and 16%E (vs. 16%E) from SFA.³⁷ Fibre intake in the current study (13.6g/day) was above that assessed in children two to three years (10.4g/day) in South Australia, and about equal to the AI of 14g/day. The consistency of the dietary patterns among young Australian children in different states warrants the conduct of future studies in a nationally representative population sample.

High SFA intakes in the current study were related to intakes of full fat dairy products and discretionary foods, which were the main sources of SFA. Five out of eight children who met the AGHE recommendations for discretionary foods (up to 1 serve/day) also met the EARs for selected nutrients. However, only 4% of children met the guidelines³² for consuming <10% of total energy from SFA, compared to 15-16% of two to three years olds in 2007 ANCNPAS.¹⁵ This finding is consistent with the South Australian study,³⁷ which found only 5% of children

older than two years had a SFA intake within the recommendations,³² with milk and other dairy products also the most common sources of SFA. The Australia Dietary Guidelines for children and adolescents³² recommend reduced-fat dairy products from age two years. Hence children in the current study would have been at the age where a transition from full-fat dairy products to reduced-fat varieties is appropriate, meaning that dairy as a major SFA source was to be expected. Given that 28%E was derived from discretionary foods, it is not surprising that SFA intakes were high.

The micronutrient intakes in the current study met or exceeded all age-specific NRV's, with the exception of vitamin C, iron, folate, and potassium. This is similar to ANCNPAS where not all two to three year olds met their NRV's for vitamin C, iron, and calcium.¹⁵ Moreover, 50% of the children in the current study exceeded the UL for zinc. These results also agree with ANCNPAS.¹⁵ In both studies the primary dietary sources of zinc were milk products, meat and poultry, and cereal products. It is possible that children in this age group are at risk of excessive zinc intakes.³⁸ However, these findings need to be interpreted with caution given that adverse effects secondary to high dietary zinc intakes have not been reported in Australia. Therefore our study supports Rangan & Samman's (2012) conclusions that the current UL for the 2 to 3 years age group may be underestimated and should be reviewed.³⁸

Further analyses were undertaken to assess whether the eating patterns of children who met the NRV's for vitamin A, thiamin, folate, calcium, iron, and zinc, were similar or different to the eating pattern suggested by the AGHE. The majority of children in this study met the NRV targets by following a pattern that deviated from the age-appropriate recommendations. This demonstrated that young children could meet the NRV's for selected nutrients by consuming a significantly greater number of daily servings of fruit (excluding juice), dairy, in combination with significantly lower mean daily servings of breads/cereals, vegetables, and meat/alternatives compared to the AGHE. Implications of these findings indicate that

modelling of food group patterns to inform future refinements of the AGHE could consider this approach. Potentially this would lead to incorporation of even greater diversity in the distribution of food group servings, within optimal nutrient intake ranges.

Findings from the present study are similar to those of nationally representative studies of American and Belgian children where a large proportion did not meet national recommendations for food group servings.^{39,40} Sixty percent and 93% of American children aged one to 18 years did not consume the recommended number of servings of fruit and vegetables, respectively.³⁹ The majority (>50%) of younger Belgian children aged three to seven years did not meet the recommended number of servings of fruits, vegetables, and dairy products.⁴⁰

The current study has a few limitations and in particular the small sample size. Hence, results from this study may not be representative of other populations and ethnicities and should be interpreted with caution. The study, although not population-based, is the first Australian study to examine associations between dietary patterns of children aged two to three years compared to the revised 2013 AGHE.⁹ While the FFQ data were proxy-reported by mothers with a possibility of reporting bias as parents were unable to observe child intake at preschool or day-care, the ACAES has been validated for total energy intake¹⁸ in preschool age children and micronutrient intakes in children above 5 years.^{20,21} While FFQs are able to capture usual intake over a longer timeframe,²⁵ and reliable for estimating micronutrient intakes in infants and pre-school children,⁴¹ it is acknowledged that the ACAES has not been validated at the food group level. In addition, it must be acknowledged that for younger children the six months reporting period of the FFQ may not accurately reflect their usual intake over that time. A further limitation is that not all EARs and AIs were considered in the sub-sample analysis and hence results should be interpreted with caution.

In conclusion, the dietary patterns of Australian children aged two to three in the current study do not align with the recommended daily servings in the AGHE. Children who achieved the NRV's for nutrients important for health and development consumed more fruit, dairy and discretionary servings than current recommendations. Further studies in larger nationally representative population samples should be undertaken to evaluate whether the current findings apply. Findings from larger cohorts may help to inform the future modelling of food patterns to incorporate even greater diversity in the distribution of food group servings, while optimising nutrient intakes.

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Conflict of Interest

The authors declare that they have no competing interests.

Authorship

LKC, LMW, AJH, MLB, TLB, and CEC contributed to the methodological design of the study, LKC performed data analysis and prepared the manuscript. LKC, LMW, TLB, AJH, MLB, RS, and CEC contributed to the revision of the manuscript and tables. AJH, CEC and RS established the original WATCH cohort and MLB contributed to the data collection. This study was undertaken as a part requirement for the degree of Bachelor of Nutrition and Dietetics (Honours) at the University of Newcastle (LKC), Australia. All authors contributed to reviewing, editing, and approving the final version of the manuscript.

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