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Food choices: Concordance in 11-12 year old Australians and their parents

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Food choices: Concordance in 11-12 year old Australians and their parents

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Abbreviations: BMI: body mass index; CC: Pearson's correlation coefficient; CheckPoint: Child Health CheckPoint; CI: confidence interval; Disadvantage Index: Index of Relative Socioeconomic Disadvantage; LSAC: Longitudinal Study of Australian Children; RC: linear regression coefficient; RDI: recommended daily intake; REDCap: Research Electronic Data Capture; SD: standard deviation

ABSTRACT

Objectives: Snack foods – typically high in salt, sugar, fat and/or energy – are likely important to the obesity epidemic. In the context of a population-based health assessment involving parent-child dyads at child age 11-12 years, we report cross-generational concordance in intake at a controlled snack food observation.

Design: Cross-sectional study (Child Health CheckPoint), nested within the Longitudinal Study of Australian Children.

Setting: Assessment centres in seven Australian cities, February 2015-March 2016.

Participants: Of all participating CheckPoint families (n=1874), 1294 children (50.4% girls) and 1245 parents (85.9% mothers) with snack data were included. Survey weights and methods were applied to account for the clustered multistage sample design.

Outcome measures: Partway through the 3.5 hour assessment, parents and children attended *Food Stop* separately for a timed 15 minute 'snack break'. One of four standardised box size/content combinations was randomly provided to all participants on any given day. Total food mass, energy, nutrients and sodium consumed was measured to the nearest 0.1g. Pearson's correlation coefficients and adjusted multivariable linear regression models assessed parent-child concordance in each variable.

Results: Children consumed less grams (152g (SD 79) vs 169g (SD 75) but more energy (1284kJ (SD 482) vs 1173kJ (SD 55) than parents. Parent-child concordance, as measured by adjusted regression coefficients, was small, ranging from 0.06 for sodium intake to 0.15 for carbohydrate intake. Compared to children with parents' energy intake on the 90th centile, children whose parents were on the 10th centile ate on average 167.6kJ more. When extrapolated to one similar unsupervised snack on a daily basis, this equates to an additional 61,231kJ per year, or 1.65 kg additional body fat.

Conclusions: Although modest at an individual level, this measured parent-child concordance in unsupervised daily snack situations could account for substantial annual population differences in energy, fat and sodium intake for 11-12 year olds.

ARTICLE SUMMARY

Strengths and limitations of this study

- This study uses an objective measure to assess food intake, rather than self-reporting methodology used in previous parent-child concordance studies.
- This is the largest study, to the best of our knowledge, to assess food intake using an objective measure at the population level.
- By separating children from their parents while they are eating, we are able to assess children's independent snack food choices free of immediate parental influence.
- Participants chose from a limited diversity of snacks, so choices may not reflect true snack preferences when choosing from a wider range of sources.

INTRODUCTION

Pre-packaged snack foods are among the leading causes of modern dietary imbalances[1] and contribute to high rates of obesity.[2] Snack foods are readily available and highly palatable, and children (and adults) may not readily understand their nutritional value or lack thereof.[3] Generally, these foods are high in sugar, fat and energy, contain few micronutrients and may be substituted for healthier foods in one's diet.[4 5] Australia, similar to many countries such as the US, Sweden and the Netherlands, recommends that children and adults consume a maximum of 14-17% of their daily energy intake from these "extra" foods.[6 7] Unfortunately, people typically get around 30% of their energy intake from snack foods.[8-12]

Given that childhood diet patterns tend to persist into adolescence and adulthood,[13 14] it is important to understand the mechanisms underlying children's food choices in order to reduce diet-related morbidity and mortality. Children may be influenced by their parent's eating behaviour through a number of mechanisms. Parents select the food that is available to their children within the home, and may model eating behaviour that children learn to imitate, or exert authoritarian control over their children's intake.[15-17] However, as children gain autonomy, their food intake, and in particular snack intake, more regularly occurs away from their home environment and parental presence.[18] Such independent food choices may contribute to children's future weight and health trajectory, particularly given that children are more likely to select palatable, high-energy snack foods when away from parents.[19 20] If children's independent snack choices are predicted by that of their parents, this could indicate a role for dietary interventions aimed at also modifying parent's diets in order to improve health outcomes for their children. Conversely, if children's snack choices are poorly predicted by those of their parents, this could indicate further research into other influences, and interventions targeting parental dietary choice would seem less likely to yield results.

Previous population studies have reported small to moderate parent-child concordance of dietary choices.[21-27] In a systematic review of 15 studies, Wang et al reported mean correlation coefficients between parents' and children's dietary intake of 0.17 for energy intake and 0.19 for fat intake.[28] However, these studies predominantly used self-report measures such as 24-hour recalls or food diaries, known to yield imprecise and even physiologically implausible food intake estimates[29 30] due to recall difficulty, subjectivity and underreporting.[31-35] Further, such studies have predominantly assessed overall dietary intakes rather than focusing specifically on snack choice.

Precision in understanding parent-child similarities in snack choices most likely requires objective tools that can accurately measure the quantity, energy and macronutrients consumed. Because of the challenges associated with measuring snacking in large free-living populations, objective measures have so far only been used in relatively small homogenous samples of adults and children.[36-42] None has looked at the association between children's choices and those of their parents, and most have assessed behaviours around eating, such as parenting techniques and self-served portion size.

The Child Health CheckPoint, nested within *Growing Up in Australia* (also known as the Longitudinal Study of Australian Children, LSAC), offers a unique opportunity to study parent-child concordance of food choice objectively in the context of a population-based sample undergoing a health assessment. Partway through the CheckPoint was the 15-minute *Food Stop*, visited by each parent and child separately, offering free choice from a standardised box of pre-weighed snack food items. In this quasi-natural 'rest-stop' setting, we aimed to determine the correlations between child and parent consumption of total snack food mass, energy, macronutrients and sodium.

METHODS

Study Design and Participants: Details of the initial study design and recruitment are outlined elsewhere.[43] Briefly, LSAC recruited a nationally representative cohort of 5107 infants[44] (B cohort) using a 2-stage sampling design with postcode as primary sampling unit, and followed families up in biennial data collection waves up to 2015. The initial recruitment rate in 2004 was 57.2%, of whom 73.7% (n=3764) were retained to LSAC wave 6 in 2014.

B cohort participants in the wave 6 visit were invited to share their contact details with the CheckPoint team. In late 2014 and 2015, families that consented were then sent an information pack via post and received an information and recruitment phone call. The Child Health CheckPoint – LSAC's detailed cross-sectional biophysical assessment - was nested between LSAC waves 6 and 7 (child age 11-12 years), and took place between February 2015 and March 2016 (see detailed description of CheckPoint methods[43]). Ultimately, 1874 families participated (figure 1). The CheckPoint offered a specialised 3.5 hour visit to a Main Assessment Centre in 7 capital cities/larger regional towns, a 2.5 hour visit to a Mini Assessment Centre in 8 smaller regional centres, and 1.5 home visits to a further 365 families who could not attend any centre (figure 1).

Ethics and Consent: The CheckPoint data collection protocol was approved by The Royal Children's Hospital (Melbourne, Australia) Human Research Ethics Committee (33225D) and the Australian Institute of Family Studies Ethics Committee (14-26). The attending parents/caregivers provided written informed consent for themselves and their children to participate in the study.

***Food Stop* procedure:** *Food Stop* was a 15 minute stations offered roughly midway through the 3.5 hour pre-set circuit at the CheckPoint's Main Assessment Centre visits; it was not offered at smaller centres or home visits. CheckPoint sessions were held between 8:30am and 6:45pm, with children arriving at *Food Stop* between 11:15am and 6pm, and parents between 10:30am to 5:15pm. Families unable to attend a main assessment centre (n=517) were offered a mini-assessment centre visit (smaller regional centres) or home visit, neither visit included the *Food Stop* station.

Food Stop was designed as a randomised controlled trial (ISRCTN12538380) of four box combinations to assess the effects of snack box size and the number of snack items on food intake in children and parents. Each study day was randomly assigned to one of the four box combinations: a small box containing 15-25% of a child or adult's recommended daily intake (RDI) of energy (box combination 1), a large box containing 15-25% of RDI of energy (box combination 2), a small box containing 25-30% of RDI of energy (box combination 3) or a large box containing 25-30% of RDI of energy (box combination 4). Thus each dyad received the same box combination, but (because based on RDI of energy) parents received more energy per box within that combination than did the child (supplementary table 1 details size and contents of each box combination). Participants with food allergies were offered a specific allergy box and excluded from this analysis.

Prior to CheckPoint attendance, parents were mailed an information booklet which briefly described each station, including *Food Stop* and its intent to measure food intake. Because each child and parent participated in the CheckPoint circuit separately, parents arrived at *Food Stop* approximately two hours, and children approximately three hours, from arrival. Both children and parents had venesection performed in the preceding station, *Young Bloods*, during which they were asked to give a hunger rating from 1 to 7 (1=Not, 7= Very).

On entering the *Food Stop* area, a research assistant provided the participant with a prepacked snack box. Each box was discreetly labelled with the participants' identification number so that leftover foods could be recorded. The research assistant informed participants that a) they had a 15-minute break before their next CheckPoint assessment, b) this was an opportunity to eat any of the foods provided in the snack box, to relax and/or to finish their CheckPoint questionnaire, c) not to take any of the food items away from the area, and d) to leave all rubbish and half-eaten food in the snack box when they left *Food Stop*. Participants participated in *Food Stop* by themselves or, less frequently, in groups of two; very occasionally three or four attended *Food Stop* at once (seated separately). Parent-child dyads never attended *Food Stop* together. After 15 minutes, a researcher escorted the participant to their next station. The *Food Stop* researcher stored the snack box with any packaging or uneaten food still inside.

***Food Stop* measures:** An independent researcher later inspected each participant's snack box for completely eaten, partially eaten or unopened food items and recorded this information using REDCap (Research Electronic Data Capture), an electronic database. The nutritional characteristics of the food items were determined from food packaging (supplementary table 1). Partially eaten food items were weighed using calibrated weight scales (BSK500BSS) accurate to the nearest 1g. To determine the energy and nutrients consumed from partially eaten food items, the percentage eaten (determined by weight) was multiplied by the total energy or nutrients indicated on the food packaging.

Additional sample characteristics: Relative socioeconomic position was calculated using Socio-Economic Indexes for Areas scores, determined from the postcode of the participant's primary address and compiled from data collected in the 2011 Australian census. Specifically, we selected the Index of Relative Socioeconomic Disadvantage (Disadvantage Index), which describes relative social and economic disadvantage of Australian suburbs.[45] Higher scores indicate less disadvantage, with a national mean of 1000 and standard deviation of 100.

Height, to the nearest 0.1 cm, was measured using a portable rigid stadiometer (Invicta IP0955, Leicester, UK), without shoes or socks, in light clothing, and in duplicate. A third measurement was taken if the difference of the first two measurements exceeded 0.5 cm; final height was the mean of all measurements made. Weight, to the nearest 0.1 kg, was measured with an InBody230 bio-electrical impedance analysis scale (Biospace Co. Ltd. Seoul, South Korea) Body mass index (BMI) was calculated as weight (kg) divided by height (m) squared. For children, an age- and sex-adjusted BMI z-score was calculated using the US Centers for Disease Control growth reference charts.[46] These measures have been described in further detail elsewhere.[43]

Statistical analysis: Concordance between parents and children was assessed by: 1) Pearson's correlation coefficients with 95% confidence intervals; 2) linear regressions with child variable as dependent variable and parent variable as independent variable adjusted for parent and child age and BMI, Disadvantage Index and box combination. In models including both sexes, regression analyses were further adjusted for parent and child sex.

Population summary statistics and proportions were estimated by applying survey weights and survey procedures that took clustering in the sampling frame into account using Stata version 14.2 survey procedures.[48]. Survey weights were calculated taking into account the selection probability of each child, and were adjusted for non-response, loss to follow up and benchmarked to population numbers in major (post-stratification) categories of the population of children born in 2004. More detail on the calculation of weights is provided elsewhere.[47]

RESULTS

Sample: Figure 1 shows the participant retention through LSAC to the Child Health CheckPoint and participation in *Food Stop*. Of 1356 families who attended a main assessment centre, 1294 children and 1245 parents attended the *Food Stop* and had valid data recorded. Table 1 summarises the participant characteristics. As expected, the mean age of children was 12 years old and parents were in mid-life (mean 43.9 years, SD: 5.6).

Table 1: Participant characteristics; values are mean (SD) except where specified as %.

Characteristic	Children (n=1254-1294)	Parents (n=1205-1245)
Age (years)	12.0 (0.4)	43.9 (5.6)
Height (cm)	153.2 (7.9)	166.2 (8.0)
BMI (kg/m^2)	-	28.2 (6.4)
BMI z-score	0.38 (1.00)	-
Disadvantage Index	1012 (60)	1011 (61)
Time since last eaten (hours)	4.6 (2.2)	3.9 (2.4)
Hunger rating (1=Not, 7=Very)	4.2 (1.4)	2.9 (1.5)
Time at *Food Stop* (min)	12.4 (3.8)	12.0 (4.5)
Male sex, %	49.6	14.1
Box combination, %		
1[a] (n=348)	26.7	26.7
2[b] (n=320)	25.3	24.3
3[c] (n=278)	22.0	22.4
4[d] (n=348)	26.0	26.6

BMI: body mass index; Disadvantage Index: the Index of Relative Socioeconomic Disadvantage; n: numberSD: standard deviation; RDI: Recommended Daily Intake.

[a]Box combination 1: small box containing 15-20% of RDI
[b]Box combination 2: large box containing 15-20% of RDI
[c]Box combination 3: small box containing 25-30% of RDI
[d]Box combination 4: large box containing 25-30% of RDI

While the sex distribution in children was even, fathers made up only 14.1% of the parent population. The mean BMI z-score of children in the sample population was 0.38 standard deviations above the population reference values. Similarly, mean parental BMI was in the overweight category, consistent with national data showing that most Australian adults are overweight or obese.[49] Mean duration at *Food Stop* for both children and parents was slightly less than the assigned 15 minutes for children (12.4 minutes ± SD 3.8) and parents (12.0 minutes ± SD 4.5).

Food, energy and nutrient intake: Table 2 shows means, standard deviations and confidence intervals for all food intake variables in the sample of children and parents. In all food intake variables, the distribution ranged from 0.0g (for participants who ate no food items from their assigned snack box) to the maximum available (for those who ate all food items). Despite energy intake being higher in children (1284kJ) than in parents (1173kJ), the mean total food mass intake was lower in children (152g) than in parents (169g), reflecting children's choices of lighter but more energy dense food items.

Table 2: Summary of food intake variables in children and parents.

Consumption	Children (n=1294)			Parents (n=1245)		
	mean	SD	95% CI	mean	SD	95% CI
Grams (g)	152	79	146 to 158	169	75	163 to 174
Energy (kJ)	1284	482	1248 to 1319	1173	559	1133 to 1214
Protein (g)	5.6	2.3	5.5 to 5.8	5.2	2.5	5.0 to 5.4
Saturated fat (g)	6.2	2.6	6.0 to 6.3	4.8	3.0	4.6 to 5.0
Sodium (mg)	292	165	281 to 304	293	178	281 to 305
Sugar (g)	23	9.5	22.0 to 23.4	20	10.3	19.1 to 20.7
Carbohydrates (g)	45	17.6	44.2 to 46.8	39	17.6	38.1 to 40.6
Total fat (g)	11.1	4.7	10.7 to 11.4	10.3	5.8	9.9 to 10.7

CI: confidence interval; n: number of participants included in analysis; SD: standard deviation.

Figures 2a and 2b represent the distribution of total food, energy and nutrient intake in children and parents, stratified by sex. Similar distributions were seen for boys and girls, and for mothers and fathers. Energy intake was approximately normally distributed in the sample population of children and parents, but intake of grams and specific nutrients showed bimodal distributions that are attributable to specific food items. For example, the peaches contributed a relatively large proportion (150g) to the total weight of the box (supplementary table 1): those who ate the peaches were always in the higher peak, and those who didn't were always in the lower peak, of the distribution regardless of what other foods were consumed. Similarly, the cheese contributed a relatively large proportion of the total sodium and saturated fat (supplementary table 1), leading to bimodal distributions of these variables according to whether participants did or did not consume the cheese. Protein, sugar, carbohydrates and total fat intake were more evenly distributed across food items and thus did not show such obvious bimodal distributions.

Parent-child concordance: Figure 3 shows Pearson's correlation coefficients stratified by parent and child sex, with horizontal lines indicating the 95% confidence interval; supplementary table 2 provides the underlying estimates for reference. The graphical presentation highlights the similar size of effect for all variables. Father-child (both father-son and father-daughter) estimates showed wider confidence intervals than the estimates for mothers, reflecting the small numbers of fathers in the sample.

Table 3 shows unadjusted Pearson's correlation coefficients and adjusted linear regression coefficients for the 1242 parent-child dyads. Every intake variable showed a significant, positive correlation between child-parent dyads. All were modest, ranging from 0.08 (95% CI 0.00 to 0.14) for sodium intake to 0.20 (95% CI 0.14 to 0.26) for carbohydrate intake. In the adjusted linear regression analyses, the associations remained small but generally strong. For instance, for each gram higher parent total fat intake, child fat intake was 0.08 grams higher (p= 0.008).

Table 3: Parent-child concordance, as correlations and regression adjusted for covariates

Consumption	Pearson's Correlation (n=1194)		Linear Regression* (n=1185)	
	CC	95% CI	RC	P-value
Grams (g)	0.12	0.06 to 0.18	0.13	<0.001
Energy (kJ)	0.18	0.11 to 0.24	0.12	<0.001
Protein (g)	0.15	0.08 to 0.22	0.11	0.001
Saturated fat (g)	0.10	0.02 to 0.17	0.07	0.02
Sodium (mg)	0.08	0.00 to 0.14	0.06	0.04
Sugar (g)	0.12	0.06 to 0.19	0.09	0.002
Carbohydrates (g)	0.20	0.14 to 0.26	0.15	<0.001
Total fat (g)	0.12	0.05 to 0.19	0.08	0.008

CC: Pearson's correlation coefficient; RC: estimated regression coefficient. *Adjusted for child and parent age, sex and BMI, Disadvantage Index and box combination

Table 4 extrapolates from Table 3. While correlations were small, at the population level this modest degree of parent-child concordance in daily snacks away from parents could account for substantial differences in energy, fat and sodium intake for 11-12 year olds. For example, a child whose parent's snack energy intake was on the 90th percentile ate on average 167.6 kJ more than a child whose parent's snack energy was on the 10th percentile. If extrapolated to one similar unsupervised snack on a daily basis, this would equate to the child consuming an additional 61,231 kJ per year, equating to 1.65 additional kg of body fat each year (assuming that an excess of 37 kJ results in 1g excess fat). A similar extrapolation for parent snack energy on the 75th vs 25th percentile would result in 0.91 kg additional body fat each year.

Table 4: Child excess intake according to parent intake centiles

Food	Parent Food Stop intake			Parent-child adjusted regression coefficient (from Table 3)	Child projected excess intake on going from lower to higher parent percentile: per day / year*	
	mean	Difference across percentiles				
		10^{th} to 90^{th}	25^{th} to 75^{th}		10^{th} to 90^{th}	25^{th} to 75^{th}
Grams (g)	169	189	63	0.13	24.6 / 8,974	8.2 / 2,991
Energy (kJ)	1173	1397	773	0.12	167.6 / 61,231	92.8 / 33,881
Na (mg)	293	510	321	0.06	30.6 / 11,177	19.3 / 7,035
Total fat (g)	10.3	14.7	7.2	0.08	1.2 / 430	0.57 / 210

*Assumes 1 unsupervised snack of this size each day over a year

DISCUSSION

Principal findings: This is the first population-based study to describe the intake of total food, energy, nutrient and sodium consumed from standardised snack boxes provided separately, in a controlled setting, to 11-12 year old children and their parents. Every food intake variable was positively correlated in parent-child dyads, with no obvious differences seen for mother-son vs mother-daughter dyads (numbers of fathers were too small to draw conclusions). Although modest at an individual level, this degree of parent-child concordance in a single daily snack free of parental supervision could account for substantial differences in energy, fat and sodium intake over the course of a year for the population of Australian 11-12 year olds.

Strengths & limitations: To the best of our knowledge, this is the largest and only population-based study to assess snack food intake using an objective measure. Objectively measured laboratory meals have been used in studies limited by small sample sizes, and have predominantly been used to investigate environmental factors influencing food intake,[36-38 40] rather than parent-child concordance. Previous studies looking at parent-child concordance of food intake have used self-report measures to assess dietary intake, which do not provide objective food intake data but instead rely on subjective reports from participants. Our study is unique in avoiding the inaccuracies and underreporting of food intake when self-report measures are used.[31-35] By looking specifically at children's snack choices independent of their parent, our study removes the influence of direct parental modeling and of parents trying to guide their child's eating by direct (e.g. "You should eat something otherwise you'll be hungry in an hour") or indirect prompts (e.g. "This is very good, you'll like that too") prompts. It therefore evaluates the extent to which food choices are transmitted either by genetic predisposition or learned eating behaviour, i.e. behaviour that will continue to occur with or without immediate parental presence.

The narrow selection of snacks available in the snack box may limit its ability to predict true snack intake in Australian children and their parents when able to choose snack options from a wider range of sources. The snack box provided was limited to non-perishable food items that could be stored and moved easily to and from assessment centres around a very large country. This consisted of pre-packaged items with easily obtained nutritional information, and excluded items such as fresh fruit and vegetables.

While participants were not formally fasted and received snack boxes at varying times of the day with non-uniform duration of fasting, adjustments made for hunger rating demonstrated no significant effect on parent-child concordance. However, as food and energy intake is known to vary from meal to meal and from day to day in a given individual,[50 51] a single snack may be insufficient to accurately estimate true food choices in children and their parents.

Strengths and weaknesses in relation to other studies: The small correlations found in our study support previous studies examining parent-child correlation of food intake. The slightly higher associations between parents and children in energy and nutrient intake (0.2-0.3) in previous population studies[21-27] may reflect that few studies have specifically evaluated children's independent food choices away from their parents. In one study of Dutch households with children aged one to 30 years of age, Feunekes et al found that the resemblance between children's and their parents' fat and energy intake was higher for foods eaten within the home than elsewhere,[22] indicating a greater role for alternate influences on food choices when away from the family environment. Our study's small correlations support these findings. In other words, when eating away from the family and without parental control, children may be less likely to choose similarly to their parents, reducing already-small associations.

Meaning and implications for clinicians and policymakers: The immediate conclusion is that the nutritional amount and quality of independent snack choices must be influenced by factors other than parents, such as individual preferences, the presence of peers, availability of food, previous experiences and food advertising.[19 52] All of these may need to be targeted if seeking to improve snack quality and quantity. Nonetheless, at the population level this modest degree of parent-child concordance in daily snack situations even when away from direct parental supervision could account for substantial differences in energy, fat and sodium intake for 11-12 year olds over time, and this could suffice for sustained changes in body composition and body mass. While it is unclear whether these are genetically-driven or learned behaviours, targeting parent snack behaviours remains a potential avenue for influencing older children's eating behaviour.

Unanswered questions and future research: This study indicates further research into the complex mechanisms driving parental influence on children's independent snack intake. Sample sizes would need to be large enough to account for the small concordance for individual parent-child pairs. Tackling poor nutrition in childhood and its associated morbidity likely requires an integrated, multifaceted approach, which may include modifiable mechanisms such as learned behaviour transmitted from parent to child.

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REDCap (Research Electronic Data Capture) electronic data capture tools were used in this study. More information about this software can be found at: www.project-redcap.org.

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CONTRIBUTIONS:

PV is the lead author of the manuscript and assisted in initial data collection. JAK is a study Investigator who oversaw the *Food Stop* conception, execution and analyses, and provided advice and critical review of this manuscript. SC is the study project manager, coordinated data collection and provided critical review of this manuscript. AG assisted with statistical analysis and contributed to the writing of the manuscript. FKM and LB are study Investigators and contributed to the writing and editing of this manuscript. PJ and KG are collaborators with CheckPoint and provided critical review of the manuscript. MW is the Principal Investigator of the Child Health CheckPoint, planned the analyses and provided critical review of the manuscript.

DATA SHARING STATEMENT: Dataset and technical documents available from Growing Up in Australia: The Longitudinal Study of Australian Children via low-cost license for bona fide researchers. More information is available at www.growingupinaustralia.gov.au

FIGURE CAPTIONS AND FOOTNOTES:

Figure 1: Participant flow from recruitment into LSAC to participation in *Food Stop*

Figure 2a: Distribution of food intake variables in children

Figure 2b: Distribution of food intake variable in parents

Figure 3: Parent-child concordance, as represented by Pearson's correlations.

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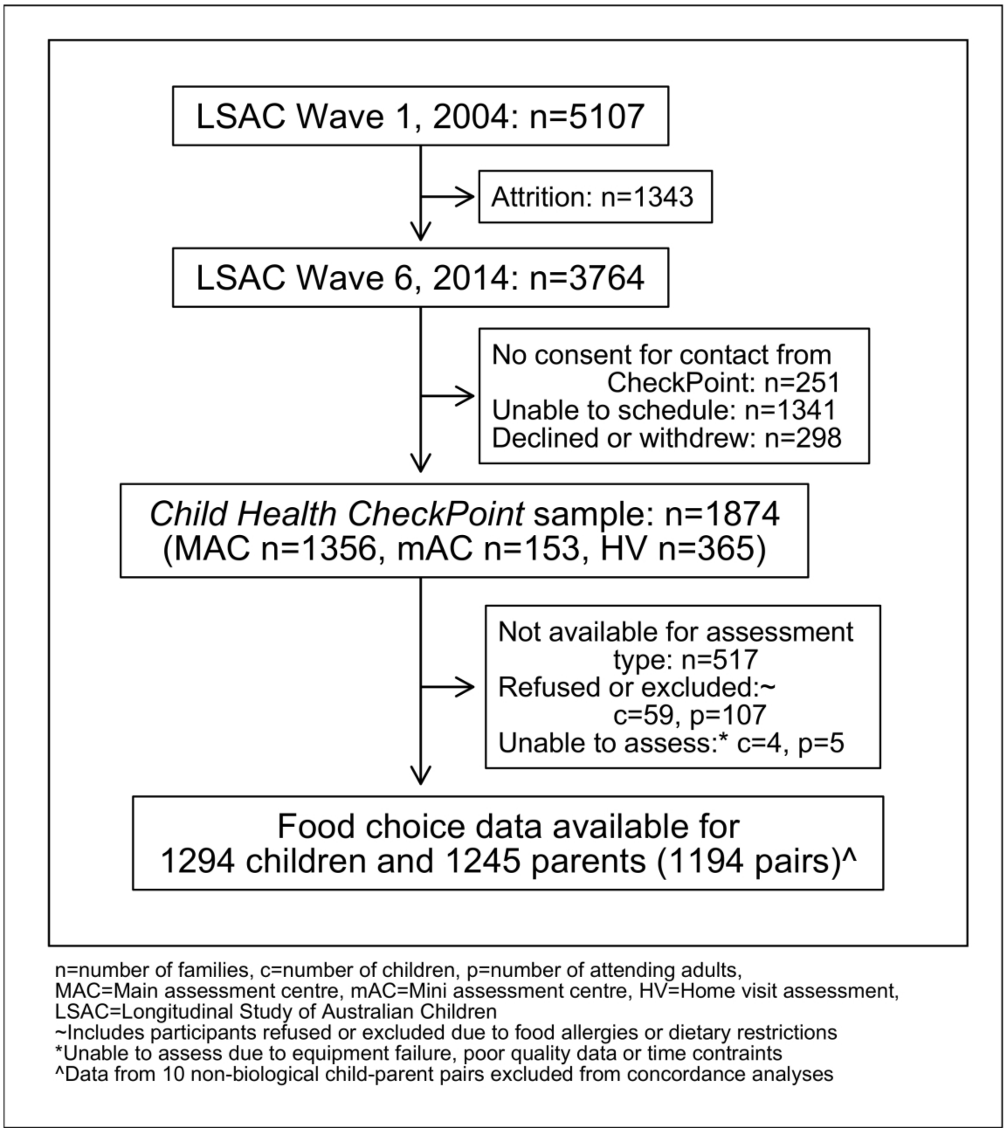

Figure 1: Participant flow from recruitment into LSAC to participation in Food Stop

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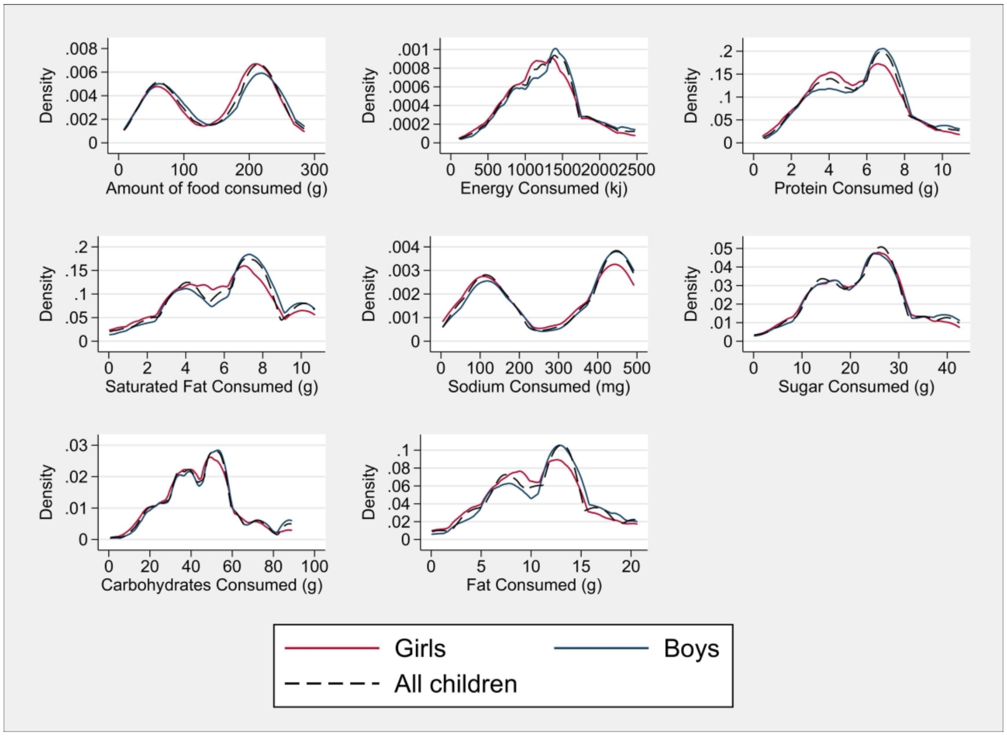

Figure 2a: Distribution of food intake variables in children

290x211mm (300 x 300 DPI)

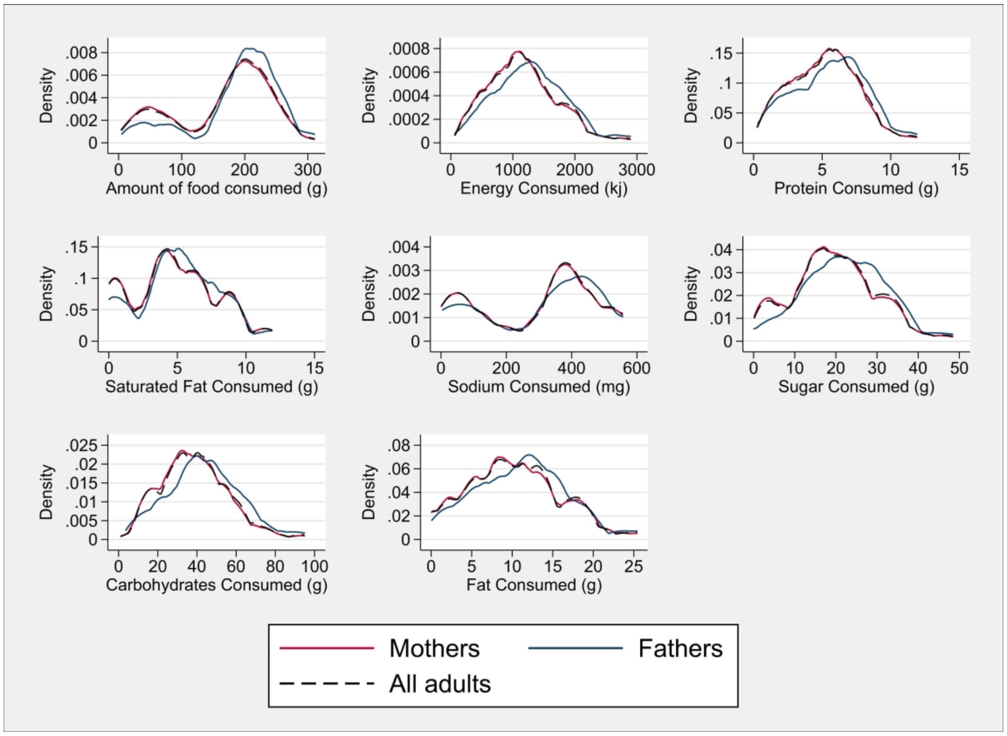

Figure 2b: Distribution of food intake variable in parents

290x211mm (300 x 300 DPI)

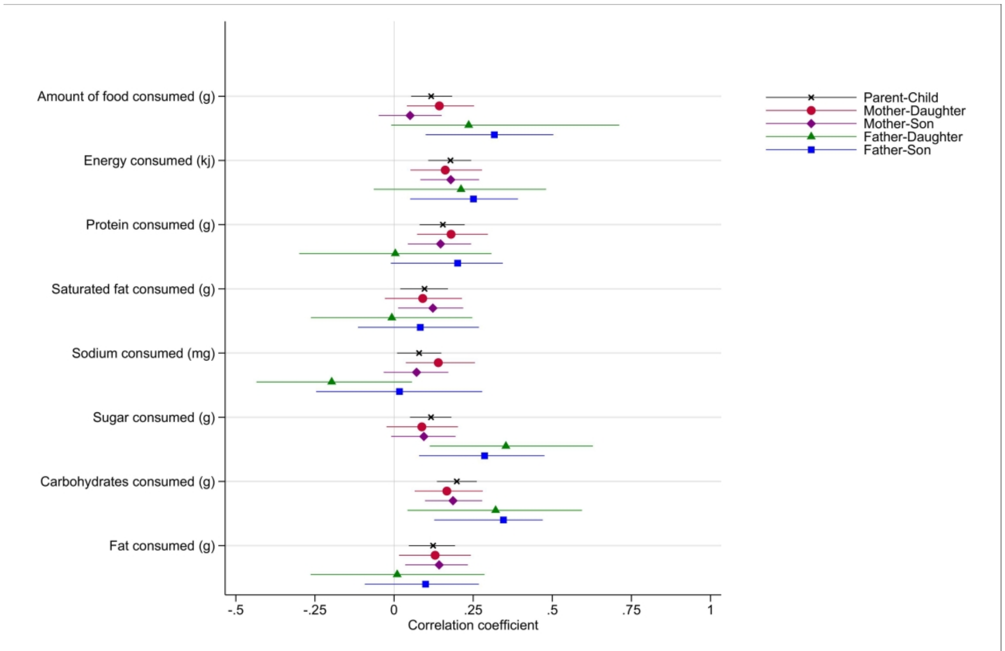

Figure 3: Parent-child concordance, as represented by Pearson's correlations.

324x211mm (300 x 300 DPI)

SUPPLEMENTARY DOCUMENTS:

Supplementary table 1: Information on Food Items and Box Combinations

Food Item	Grams[a]	Kilojoules	Protein (g)	Fat (g)	Saturated fat (g)	Carbohydrates (g)	Sugar (g)	Sodium (mg)
Peaches in syrup[b]	150	295	1	<1	<1	16	13	5
Flavoured rice crackers	18	250	1	1	<1	13	<1	65
Miniature wheat fruit bites	22	310	1	<1	<1	15	5	10
Cheese wedge	20	285	3	6	4	1	1	320
Miniature animal-shaped biscuits	25	426	2	3	2	16	6	66
Miniature Oreo biscuits	27	472	1	5	2	9	9	122
Fruit muesli bar	24	374	2	3	<1	13	3	8
Miniature milk chocolate bar[c]	13	266	1	4	2	7	7	9

Box[d]	Total energy per box (kJ)	Food items contained in box
Combinations 1 & 2	*Children:* 1522 (15-20% of child RDI[e])	Peaches in syrup, Flavoured rice crackers, Cheese wedge, Miniature animal-shaped biscuits, Milk chocolate bar 1
	Parents: 1942 (15-20% of adult RDI[e])	Peaches in syrup, Flavoured rice crackers, Cheese wedge, Miniature Oreo biscuits, Fruit muesli bar 1, Milk chocolate bar 1
Combinations 3 & 4	*Children:* 2472 (25-30% of child RDI[e])	Peaches in syrup, Flavoured rice crackers, Miniature wheat fruit bites, Cheese wedge, Miniature animal-shaped biscuits, Fruit muesli bar 1, Miniature milk chocolate bar 1, Miniature milk chocolate bar 2
	Parents: 2892 (25-30% of adult RDI[e])	Peaches in syrup, Flavoured rice crackers, Miniature wheat fruit bites, Cheese wedge, Miniature Oreo biscuits, Fruit muesli bar 1, Fruit muesli bar 2, Miniature milk chocolate bar 1, Miniature milk chocolate bar 2

[a]Because each item naturally varied from its listed package weight, 20 individual items (reference units) were weighed and the mean grams derived for each item. This mean item weight is listed here and used in all calculations for derived variables. [b]Peaches were discontinued by manufacturers part way through data collection. We replaced the peaches with mixed fruit (same brand/appearance) for the final 123 families who participated in CheckPoint. Mixed fruit g=150; kJ=348. [c]Participants (381 families) in the beginning months of CheckPoint received 11g milk chocolate bars (kJ=224). Part way through data collection, the manufacturers replaced the 11g bar with the 13g bar.

[d]Box combination details

Box combination 1: Small number of snack food items, small snack box (18.0cm x 12.0cm x 5.0cm; volume 1080cm^3)

Box combination 2: Small number of snack food items, large snack box (19.5cm x 14.0cm x 56.5cm; volume 1774.5cm^3)

Box combination 3: Large number of snack food items, small snack box (18.0cm x 12.0cm x 5.0cm; volume 1080cm^3)

Box combination 4: Large number of snack food items, large snack box (19.5cm x 14.0cm x 56.5cm; volume 1774.5cm^3)

[e]Australian children (11-12 years) with light activity levels are recommended to consume 8650kJ per day.[53] Australian adults (19-50 years) with light activity levels are recommended to consume 9823kJ per day.[53]

Supplementary table 2: Parent-child concordance stratified by parent and child sex

Consumption	Mothers				Fathers			
	Sons (n=499 to 504)		Daughters (n=525 to 527)		Sons (n=89 to 91)		Daughters (n=72)	
Pearson's correlation	**CC**	**95% CI**	**CC**	**95% CI**	**CC**	**95% CI**	**CC**	**95% CI**
Grams (g)	0.08	-0.01 to 0.16	0.11	0.02 to 0.19	0.16	-0.05 to 0.36	0.21	-0.03 to 0.42
Energy (kJ)	0.15	0.07 to 0.24	0.15	0.07 to 0.24	0.16	-0.05 to 0.35	0.26	0.03 to 0.46
Protein (g)	0.12	0.04 to 0.21	0.16	0.08 to 0.25	0.18	-0.03 to 0.37	0.16	-0.08 to 0.38
Saturated fat (g)	0.11	0.02 to 0.20	0.11	0.02 to 0.19	0.11	-0.10 to 0.31	0.08	-0.16 to 0.30
Sodium (mg)	0.09	0.00 to 0.18	0.15	0.06 to 0.23	0.09	-0.12 to 0.29	0.02	-0.22 to 0.25
Sugar (g)	0.11	0.03 to 0.20	0.10	0.01 to 0.18	0.13	-0.07 to 0.33	0.25	0.02 to 0.45
Carbohydrates (g)	0.18	0.09 to 0.26	0.16	0.07 to 0.24	0.21	0.00 to 0.40	0.32	0.09 to 0.51
Total fat (g)	0.12	0.03 to 0.20	0.13	0.04 to 0.21	0.12	-0.09 to 0.31	0.14	-0.09 to 0.36
Linear regression	**RC**	**P-value**	**RC**	**P-value**	**RC**	**P-value**	**RC**	**P-value**
Grams (g)	0.09	0.05	0.12	0.004	0.12	0.28	0.27	0.10
Energy (kJ)	0.11	0.002	0.14	<0.001	0.07	0.44	0.16	0.13
Protein (g)	0.10	0.02	0.16	<0.001	0.10	0.29	0.06	0.64
Saturated fat (g)	0.10	0.01	0.11	0.005	0.08	0.38	0	0.99
Sodium (mg)	0.08	0.06	0.14	0.001	0.05	0.66	-0.01	0.96
Sugar (g)	0.10	0.01	0.09	0.01	0.07	0.47	0.17	0.12
Carbohydrates (g)	0.14	<0.001	0.15	<0.001	0.08	0.42	0.23	0.04
Total fat (g)	0.08	0.02	0.11	0.003	0.07	0.39	0.05	0.67

CC: Pearson's correlation coefficient; CI: confidence interval; RC: estimated linear regression coefficient

STROBE Statement—checklist of items that should be included in reports of observational studies

Paper title: Food choices: Concordance in 11-12 year old Australians and their parents
Person completing checklist: Prudence Vivarini

	Item No	Recommendation	Page number
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1,2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4,5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up ~~*Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale~~ for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	5
		~~(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed~~ ~~*Case-control study*—For matched studies, give matching criteria and the number of controls per case~~	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	8
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed ~~*Case-control study*—If applicable, explain how matching of cases and controls was addressed~~	8

~~*Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy~~		
(*e*) Describe any sensitivity analyses	8	

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	Figure 1
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	9
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	7
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11, 13, 15
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16,17
Generalisability	21	Discuss the generalisability (external validity) of the study results	17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Food choices: Concordance in 11-12 year old Australians and their parents

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Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Paediatrics, Public health, Nutrition and metabolism
Keywords:	Energy intake, Food preferences, Snacks, Children, Inheritance patterns, Epidemiologic studies

SCHOLARONE™ Manuscripts

Food choices: Concordance in 11-12 year old Australians and their parents

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Keywords: energy intake, food preferences, snacks, parents, children, inheritance patterns, correlation studies, epidemiologic studies, cross-sectional studies

Word count: 3613

Abbreviations: BMI: body mass index; CC: Pearson's correlation coefficient; CheckPoint: Child Health CheckPoint; CI: confidence interval; Disadvantage Index: Index of Relative Socioeconomic Disadvantage; LSAC: Longitudinal Study of Australian Children; RC: linear regression coefficient; RDI: recommended daily intake; REDCap: Research Electronic Data Capture; SD: standard deviation

ABSTRACT

Objectives: Snack foods – typically high in salt, sugar, fat and/or energy – are likely important to the obesity epidemic. In the context of a population-based health assessment involving parent-child dyads at child age 11-12 years, we report cross-generational concordance in intake at a controlled snack food observation.

Design: Cross-sectional study (Child Health CheckPoint), nested within the Longitudinal Study of Australian Children.

Setting: Assessment centres in seven Australian cities, February 2015-March 2016.

Participants: Of all participating CheckPoint families (n=1874), 1299 children (50.3% girls) and 1274 parents (85.9% mothers) with snack data were included. Survey weights and methods were applied to account for the clustered multistage sample design.

Outcome measures: Partway through the 3.5 hour assessment, parents and children attended *Food Stop* separately for a timed 15 minute 'snack break'. One of four standardised box size/content combinations was randomly provided to all participants on any given day. Total food mass, energy, nutrients and sodium consumed was measured to the nearest 1g. Pearson's correlation coefficients and adjusted multivariable linear regression models assessed parent-child concordance in each variable.

Results: Children consumed less grams (151g (SD 80) vs 165g (SD 79)) but more energy (1393kJ (SD 537) vs 1290kJ (SD 658)) than parents. Parent-child concordance coefficients were small, ranging from 0.07 for sodium intake to 0.17 for carbohydrate intake. Compared to children with parents' energy intake on the 10^{th} centile, children whose parents were on the 90^{th} centile ate on average 227.4kJ more. If extrapolated to one similar unsupervised snack on a daily basis, this equates to an additional 83,050kJ per year, which could have a cumulative impact on additional body fat.

Conclusions: Although modest at an individual level, this measured parent-child concordance in unsupervised daily snack situations could account for substantial annual population differences in energy, fat and sodium intake for 11-12 year olds.

ARTICLE SUMMARY

Strengths and limitations of this study

- This study uses an objective measure to assess food intake, rather than self-reporting methodology used in previous parent-child concordance studies.
- This is the largest study, to the best of our knowledge, to assess food intake using an objective measure at the population level.
- By separating children from their parents while they are eating, we are able to assess children's independent snack food choices free of immediate parental influence.
- Participants chose from a limited diversity of snacks, so choices may not reflect true snack preferences when choosing from a wider range of sources.

INTRODUCTION

Pre-packaged snack foods are among the leading causes of modern dietary imbalances[1] and contribute to high rates of obesity.[2] Snack foods are readily available and highly palatable, and children (and adults) may not readily understand their nutritional value or lack thereof.[3] Generally, these foods are high in sugar, fat and energy, contain few micronutrients and may be substituted for healthier foods in one's diet.[4 5] Australia, similar to many countries such as the US, Sweden and the Netherlands, recommends that children and adults consume a maximum of 14-17% of their daily energy intake from these "extra" foods.[6 7] Unfortunately, people typically get around 30% of their energy intake from snack foods.[8-12]

Given that childhood diet patterns tend to persist into adolescence and adulthood,[13 14] it is important to understand the mechanisms underlying children's food choices in order to reduce diet-related morbidity and mortality. Children may be both positively and negatively influenced by their parent's eating behaviour through a number of mechanisms.[15 16] Parents select the food that is available to their children within the home. They may also model eating behaviour that children learn to imitate, or may influence their children's intake through varying general parenting and/or specific eating practices (e.g. authoritative parenting, indulgent feeding, pressure to eat).[17-19] All these variables, along with any genetic influences, may shape children's eating behaviour, such that eating patterns become ingrained and present even when eating occurs away from the parent and/or family environment. That is, as children gain autonomy, their food intake, and in particular snack intake, more regularly occurs away from their home environment and away from parental presence.[20] Such *independent* food choices may contribute to children's future weight and health trajectory, particularly given that children are more likely to select palatable, high-energy snack foods when away from parents.[21 22] Strong concordance might indicate that snack intake could be mainly targeted via family interventions. On the other hand, low concordance would support interventions that also target the child as an autonomous individual and/or their non-home environments.

Previous population studies have reported small-to-moderate parent-child concordance of dietary choices.[23-29] Though the majority of these studies focus on preschool or school aged children (3 to 14 years),[25-28] one focused on adult offspring (18 to 23 years)[29] and two included very broad age ranges (1 to 30 years),[23 24] but created tighter age groups for analyses. Overall, concordance estimates appear to be stronger at the nutrient level than at the food group level.[23-29] One of these studies indicated that, as the age of children increases, parent-child dietary concordance decreases.[23] Although this result may reflect children's increasing autonomy and a reduction in parental influence as they age, it was only obtained for the measure of overall diet quality and not for nutrient-level analyses.[23]

In a systematic review of 15 studies, Wang et al reported mean correlation coefficients between parents' and children's dietary intake of 0.17 for energy intake and 0.19 for fat intake.[30] However, these studies predominantly used self-report measures such as 24-hour recalls or food diaries, known to yield imprecise and even physiologically implausible food intake estimates[31 32] due to recall difficulty, subjectivity and underreporting.[33-37] Further, such studies have predominantly assessed overall dietary intakes rather than focusing specifically on snack choice.

Precision in understanding parent-child similarities in snack choices most likely requires objective tools that can accurately measure the quantity, energy and macronutrients consumed. Because of the challenges associated with measuring snacking in large free-living populations, objective measures have so far only been used in relatively small homogenous samples of adults and children.[38-43] None has looked at the association between children's choices and those of their parents, and most have assessed behaviours around eating, such as parenting techniques and self-served portion size.

The Child Health CheckPoint, nested within *Growing Up in Australia* (also known as the Longitudinal Study of Australian Children, LSAC), offers a unique opportunity to study parent-child concordance of food choice objectively in the context of a population-based sample undergoing a health assessment. Partway through the CheckPoint was the 15-minute *Food Stop*, visited by each parent and child separately, offering free choice from a standardised box of pre-weighed snack food items. In this quasi-natural 'rest-stop' setting, we aimed to determine the correlations between child and parent consumption of total snack food mass, energy, macronutrients and sodium.

METHODS

Study Design and Participants: Details of the initial study design and recruitment are outlined elsewhere.[44 45] Briefly, LSAC recruited a nationally representative cohort of 5107 infants[46] (B cohort) using a 2-stage sampling design with postcode as primary sampling unit, and followed families up in biennial data collection waves up to 2015. The initial recruitment rate in 2004 was 57.2%, of whom 73.7% (n=3764) were retained to LSAC wave 6 in 2014. A more detailed description of the CheckPoint study design is available elsewhere.[46 47]

B cohort participants in the wave 6 visit were invited to share their contact details with the CheckPoint team. In late 2014 and 2015, families that consented were then sent an information pack via post and received an information and recruitment phone call. The Child Health CheckPoint – LSAC's detailed cross-sectional biophysical assessment - was nested between LSAC waves 6 and 7 (child age 11-12 years), and took place between February 2015 and March 2016 (see detailed description of CheckPoint methods[47]). Ultimately, 1874 families participated (figure 1). The CheckPoint offered a specialised 3.5 hour visit to a Main Assessment Centre in 7 capital cities/larger regional towns, a 2.5 hour visit to a Mini Assessment Centre in 8 smaller regional centres, and 1.5 home visits to a further 365 families who could not attend any centre (figure 1). *Food Stop* was only included at the Main Assessment Centres.

Ethics and Consent: The CheckPoint data collection protocol was approved by The Royal Children's Hospital (Melbourne, Australia) Human Research Ethics Committee (33225D) and the Australian Institute of Family Studies Ethics Committee (14-26). The attending parents/caregivers provided written informed consent for themselves and their children to participate in the study.

***Food Stop* procedure:** *Food Stop* was a 15 minute station offered roughly midway through the 3.5 hour pre-set circuit at the CheckPoint's Main Assessment Centre visits. CheckPoint sessions were held between 8:30am and 6:45pm, with children arriving at *Food Stop* between 11:15am and 6pm, and parents between 10:30am to 5:15pm.

Food Stop was designed as a randomised controlled trial (ISRCTN12538380) of four box combinations to assess the effects of snack box size and the number of snack items on food intake in children and parents. Each study day was randomly assigned to one of the four box combinations: a small box containing 15-20% of a child or adult's recommended daily intake (RDI) of energy (box combination 1), a large box containing 15-20% of RDI of energy (box combination 2), a small box containing 25-30% of RDI of energy (box combination 3) or a large box containing 25-30% of RDI of energy (box combination 4). Thus each dyad received the same box combination, but (because based on RDI of energy) parents received more energy per box within that combination than did the child (supplementary table 1 details size and contents of each box combination). Participants with food allergies were offered a specific allergy box and excluded from this analysis.

Prior to CheckPoint attendance, parents were mailed an information booklet which briefly described each station, including *Food Stop* and its intent to measure food intake. Because each child and parent participated in the CheckPoint circuit separately, parents arrived at *Food Stop* approximately two hours, and children approximately three hours, from arrival. Both children and parents had venesection performed in a preceding station, *Young Bloods* (5 minutes prior to *Food Stop* for children, 30 minutes prior to *Food Stop* for parents), during which they were asked to give a hunger rating from 1 to 7 (1=Not, 7=Very).

On entering the *Food Stop* area, a research assistant provided the participant with a prepacked snack box. Each box was discreetly labelled with the participants' identification number so that leftover foods could be recorded. The research assistant informed participants that a) they had a 15-minute break before their next CheckPoint assessment, b) this was an opportunity to eat any of the foods provided in the snack box, to relax and/or to finish their CheckPoint questionnaire, c) not to take any of the food items away from the area, and d) to leave all rubbish and half-eaten food in the snack box when they left *Food Stop*. Most individuals participated in *Food Stop* by themselves. During busy school holiday periods, an unrelated child and parent were frequently in *Food Stop* at the same time but seated separately, and very occasionally three or four participants attended *Food Stop* at the same time. After 15 minutes, a researcher escorted the participant to their next station. The *Food Stop* researcher stored the snack box with any packaging or uneaten food still inside.

***Food Stop* measures:** An independent researcher later inspected each participant's snack box for completely eaten, partially eaten or unopened food items and recorded this information using REDCap (Research Electronic Data Capture), an electronic database. The nutritional characteristics of the food items were determined from food packaging (supplementary table 1). Partially eaten food items were weighed using calibrated weight scales (BSK500BSS) accurate to the nearest 1g. To determine the energy and nutrients consumed from partially eaten food items, the percentage eaten (determined by weight) was multiplied by the total energy or nutrients indicated on the food packaging.

Additional sample characteristics: Relative socioeconomic position was calculated using Socio-Economic Indexes for Areas scores, determined from the postcode of the participant's primary address and compiled from data collected in the 2011 Australian census. Specifically, we selected the Index of Relative Socioeconomic Disadvantage (Disadvantage Index), which describes relative social and economic disadvantage of Australian suburbs.[48] Higher scores indicate less disadvantage, with a national mean of 1000 and standard deviation of 100.

Height, to the nearest 0.1 cm, was measured using a portable rigid stadiometer (Invicta IP0955, Leicester, UK), without shoes or socks, in light clothing, and in duplicate. A third measurement was taken if the difference of the first two measurements exceeded 0.5 cm; final height was the mean of all measurements made. Weight, to the nearest 0.1 kg, was measured with an InBody230 bio-electrical impedance analysis scale (Biospace Co. Ltd. Seoul, South Korea) Body mass index (BMI) was calculated as weight (kg) divided by height (m) squared. For children, an age- and sex-adjusted BMI z-score was calculated using the US Centers for Disease Control growth reference charts.[49] These measures have been described in further detail elsewhere.[47]

Statistical analysis: Concordance between parents and children was assessed by: 1) Pearson's correlation coefficients with 95% confidence intervals; 2) linear regressions with child variable as dependent variable and parent variable as independent variable adjusted for parent and child age and BMI, Disadvantage Index and box combination. In models including both sexes, regression analyses were further adjusted for parent and child sex.

Summary statistics and proportions were estimated by applying survey weights and survey procedures that took clustering in the sampling frame into account using Stata version 14.2 survey procedures.[50] Survey weights were calculated taking into account the selection probability of each child, and were adjusted for non-response, loss to follow up and benchmarked to population numbers in major (post-stratification) categories of the population of children born in 2004. More detail on the calculation of weights is provided elsewhere.[51]

Patient and Public Involvement: Because LSAC is a population-based longitudinal study, no patient groups were involved in its design or conduct. To our knowledge, the public was not involved in the study design, recruitment or conduct of LSAC study or its CheckPoint module. Parents received a summary health report for their child and themselves at or soon after the assessment visit. They consented to take part knowing that they would not otherwise receive individual results about themselves or their child.

RESULTS

Sample: Figure 1 shows the participant retention through LSAC to the Child Health CheckPoint and participation in *Food Stop*. Of 1356 families who attended a main assessment centre, 1299 children and 1274 parents attended the *Food Stop* and had valid data recorded. Table 1 summarises the participant characteristics. As expected, the mean age of children was 12 years old and parents were in mid-life (mean 43.9 years, SD: 5.6).

Table 1: Participant characteristics; values are mean (SD) except where specified as %.

Characteristic	Children (n=1259-1299)	Parents (n=1231-1274)
Age (years)	12.0 (0.4)	43.9 (5.6)
Height (cm)	153.2 (7.9)	166.2 (8.0)
BMI (kg/m^2)	-	28.2 (6.4)
BMI z-score	0.37 (1.00)	-
Disadvantage Index	1012 (60)	1012 (61)
Time since last eaten (hours)	4.6 (2.2)	4.0 (2.5)
Hunger rating (1=Not, 7=Very)	4.2 (1.4)	2.8 (1.5)
Time at *Food Stop* (min)	12.4 (3.8)	12.0 (4.4)
Male sex, %	49.7	14.1
Box combination, %		
1[a]	26.6 (n=348)	26.5 (n=338)
2[b]	21.9 (n=279)	22.5 (n=278)
3[c]	25.4 (n=322)	24.8 (n=309)
4[d]	26.1 (n=350)	26.2 (n=349)

BMI: body mass index; Disadvantage Index: the Index of Relative Socioeconomic Disadvantage; n: number; SD: standard deviation; RDI: Recommended Daily Intake.
[a]Box combination 1: small box containing 15-20% of RDI
[b]Box combination 2: large box containing 15-20% of RDI
[c]Box combination 3: small box containing 25-30% of RDI
[d]Box combination 4: large box containing 25-30% of RDI

While the sex distribution in children was even, fathers made up only 14.1% of the parent population. The mean BMI z-score of children in the sample population was 0.37 standard deviations above the population reference values. Similarly, mean parental BMI was in the overweight category, consistent with national data showing that most Australian adults are overweight or obese.[52] Mean duration at *Food Stop* for both children and parents was slightly less than the assigned 15 minutes for children (12.4 minutes ± SD 3.8) and parents (12.0 minutes ± SD 4.4).

Food, energy and nutrient intake: Table 2 shows means, standard deviations and confidence intervals for all food intake variables in the sample of children and parents. In all food intake variables, the distribution ranged from 0.0g (for participants who ate no food items from their assigned snack box) to the maximum available (for those who ate all food items). Despite energy intake being higher in children (1393kJ) than in parents (1290kJ), the mean total food mass intake was lower in children (151g) than in parents (165g), reflecting children's choices of lighter but more energy dense food items.

Table 2: Summary of food intake variables in children and parents.

Consumption	Children (n=1299)			Parents (n=1274)		
	mean	SD	95% CI	mean	SD	95% CI
Grams (g)	151	80	145 to 157	165	79	159 to 170
Energy (kJ)	1393*	537	1353 to 1432	1290	658	1245 to 1336
Protein (g)	6.0	2.5	5.8 to 6.2	5.6	2.9	5.4 to 5.8
Saturated fat (g)	6.3	2.8	6.2 to 6.5	5.0	3.3	4.7 to 5.2
Sodium (mg)	309	171	297 to 321	305	192	292 to 318
Sugar (g)	24.0	10.3	23.2 to 24.7	21.2	11.6	20.4 to 22.0
Carbohydrates (g)	50.0	19.8	48.5 to 51.5	43.8	21.1	42.3 to 45.2
Total fat (g)	11.6	5.0	11.3 to 11.9	11.0	6.6	10.6 to 11.5

CI: confidence interval; n: number of participants included in analysis; SD: standard deviation.
*Equivalent to 30% of children's Basal Metabolic Rate (BMR) = 4689kJ.

Figures 2 and 3 represent the distribution of total food, energy and nutrient intake in children and parents, stratified by sex. Similar distributions were seen for boys and girls, and for mothers and fathers. Energy intake was approximately normally distributed in the sample population of children and parents, but intake of grams and specific nutrients showed bimodal distributions that are attributable to specific food items. For example, the peaches contributed a relatively large proportion (150g) to the total weight of the box (supplementary table 1): those who ate the peaches were always in the higher peak, and those who did not were always in the lower peak, of the distribution regardless of what other foods were consumed. Similarly, the cheese contributed a relatively large proportion of the total sodium and saturated fat (supplementary table 1), leading to bimodal distributions of these variables according to whether participants did or did not consume the cheese. Protein, sugar, carbohydrates and total fat intake were more evenly distributed across food items and thus did not show such obvious bimodal distributions.

Parent-child concordance: Figure 4 shows Pearson's correlation coefficients stratified by parent and child sex, with horizontal lines indicating the 95% confidence interval; supplementary table 2 provides the underlying estimates for reference. The graphical presentation highlights the similar size of effect for all variables. Father-child (both father-son and father-daughter) estimates showed wider confidence intervals than the estimates for mothers, reflecting the small numbers of fathers in the sample.

Table 3 shows unadjusted Pearson's correlation coefficients and adjusted linear regression coefficients for the 1227 parent-child dyads. Every intake variable showed a significant, positive correlation between child-parent dyads. All were modest, ranging from 0.08 (95% CI 0.01 to 0.15) for sodium intake to 0.22 (95% CI 0.15 to 0.28) for carbohydrate intake. In the adjusted linear regression analyses, the associations remained small but generally strong. For instance, for each gram higher parent total fat intake, child fat intake was 0.08 grams higher (p= 0.003).

Table 3: Parent-child concordance, as correlations and regression adjusted for covariates

Consumption	Pearson's Correlation (n=1227)		Linear Regression* (n=1218)	
	CC	95% CI	RC	P-value
Grams (g)	0.14	0.07 to 0.20	0.14	<0.001
Energy (kJ)	0.19	0.12 to 0.26	0.13	<0.001
Protein (g)	0.17	0.09 to 0.23	0.12	<0.001
Saturated fat (g)	0.10	0.02 to 0.17	0.08	0.01
Sodium (mg)	0.08	0.01 to 0.15	0.07	0.03
Sugar (g)	0.14	0.07 to 0.20	0.11	<0.001
Carbohydrates (g)	0.22	0.15 to 0.28	0.17	<0.001
Total fat (g)	0.13	0.06 to 0.20	0.08	0.003

CC: Pearson's correlation coefficient; RC: estimated regression coefficient. *Adjusted for child and parent age, sex and BMI, Disadvantage Index and box combination. Note: Values were virtually identical in sensitivity analyses including only the children who participated in *Food Stop* alone (data available on request).

Table 4 extrapolates from Table 3. While correlations were small, at the population level this modest degree of parent-child concordance in children's daily snacks away from parents could account for substantial differences in energy, fat and sodium intake for 11-12 year olds. For example, a child whose parent's snack energy intake was on the 90th percentile ate on average 227.4 kJ more than a child whose parent's snack energy was on the 10th percentile – this projected additional consumption is equivalent to 5% of children's Basal Metabolic Rate. If extrapolated to one similar unsupervised snack on a daily basis, this may equate to the child consuming an additional 83,050 kJ per year, which could have a substantial cumulative impact on additional body fat over a period of years.

Table 4: Child additional intake according to parent intake centiles

Food	Parent Food Stop intake			Parent-child adjusted regression coefficient (from Table 3)	Child projected additional intake on going from lower to higher parent percentile: per day / year*	
	mean	Difference across percentiles				
		10th to 90th	25th to 75th		10th to 90th	25th to 75th
Grams (g)	165	214	128	0.14	30.0 / 10,963	17.9 / 6,540
Energy (kJ)	1290	1749	877	0.13	227.4 / 83,050	114.0 / 41,653
Na (mg)	305	552	331	0.07	38.6 / 14,115	23.2 / 8,459
Total fat (g)	11.0	18.8	8.4	0.08	1.5 / 550	0.68 / 247

*Assumes 1 unsupervised snack of this size each day over a year (365.25 days).

DISCUSSION

Principal findings: This is the first population-based study to describe the intake of total food, energy, nutrient and sodium consumed from standardised snack boxes provided separately, in a controlled setting, to 11-12 year old children and their parents. Every food intake variable was positively correlated in parent-child dyads, with no obvious differences seen for mother-son vs mother-daughter dyads (numbers of fathers were too small to draw conclusions). Although modest at an individual level, this degree of parent-child concordance in a single daily snack free of parental supervision could account for substantial differences in energy, fat and sodium intake over the course of a year for the population of Australian 11-12 year olds.

Strengths & limitations: To the best of our knowledge, this is the largest and only population-based study to assess snack food intake using an objective measure. Objectively measured laboratory meals have been used in studies limited by small sample sizes, and have predominantly been used to investigate environmental factors influencing food intake,[38 39 41] rather than parent-child concordance. Previous studies looking at parent-child concordance of food intake have used self-report measures to assess dietary intake, which do not provide objective food intake data but instead rely on subjective reports from participants. Our study is unique in avoiding the inaccuracies and underreporting of food intake when self-report measures are used.[33-37] By looking specifically at children's snack choices independent of their parent, our study removes the influence of direct parental modeling and of parents trying to guide their child's eating by direct (e.g. "You should eat something otherwise you'll be hungry in an hour") or indirect prompts (e.g. "This is very good, you'll like that too") prompts. It therefore evaluates the extent to which food choices are transmitted either by genetic predisposition or learned eating behaviour, i.e. behaviour that will continue to occur with or without immediate parental presence.

The narrow selection of snacks available in the snack box may limit its ability to predict true snack intake in Australian children and their parents when able to choose snack options from a wider range of sources. The snack box provided was limited to non-perishable food items that could be stored and moved easily to and from assessment centres around a very large country. This consisted of pre-packaged items with easily obtained nutritional information, and excluded items such as fresh fruit and vegetables. Additionally, given that participants were observed in a study centre rather than their usual environment, their intake might not fully reflect their usual snacking behaviour. Last, when it was not possible for individuals to be in *Food Stop* alone, they had their snack in the same room as but separate from one (and occasionally more than one) unrelated individuals. In a final sensitivity analyses, we re-ran our analyses only with the children who ate entirely alone; results were virtually unchanged.

While participants were not formally fasted and received snack boxes at varying times of the day with non-uniform duration of fasting, adjustments made for hunger rating demonstrated no significant effect on parent-child concordance. However, as food and energy intake is known to vary from meal to meal and from day to day in a given individual,[53 54] a single snack may be insufficient to accurately estimate true food choices in children and their parents.

Strengths and weaknesses in relation to other studies: The small correlations found in our study support previous studies examining parent-child correlation of food intake. The slightly higher associations between parents and children in energy and nutrient intake (0.2-0.3) in previous population studies[23-29] may reflect that few studies have specifically evaluated children's independent food choices away from their parents. In one study of Dutch households with children aged one to 30 years of age, Feunekes et al found that the resemblance between children's and their parents' fat and energy intake was higher for foods eaten within the home than elsewhere,[24] indicating a greater role for alternate influences on food choices when away from the family environment. Our study's small correlations support these findings. In other words, when eating away from the family and without parental control, children may be less likely to choose similarly to their parents, reducing already-small associations.

Meaning and implications for clinicians and policymakers: The immediate conclusion is that the nutritional amount and quality of independent snack choices must be influenced by factors other than parents, such as individual preferences, the presence of peers, availability of food, previous experiences and food advertising.[21 55] All of these may need to be targeted if seeking to improve snack quality and quantity. Nonetheless, at the population level this modest degree of parent-child concordance in daily snack situations even when away from direct parental supervision could account for substantial differences in energy, fat and sodium intake for 11-12 year olds over time, and this could suffice for changes in body composition and body mass. While it is unclear whether these are genetically-driven or learned behaviours, targeting parent snack behaviours remains a potential avenue for influencing older children's eating behaviour.

Unanswered questions and future research: This study warrants further research into the complex mechanisms driving parental influence on children's independent snack intake. Such research will require large sample sizes so it is adequately powered to detect low concordances for individual parent-child pairs, as reported in the current and previous studies. Tackling poor nutrition in childhood and its associated morbidity likely requires an integrated, multifaceted approach, which may include modifiable mechanisms such as learned behaviour transmitted from parent to child.

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REDCap (Research Electronic Data Capture) electronic data capture tools were used in this study. More information about this software can be found at: www.project-redcap.org.

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CONTRIBUTIONS:

PV is the lead author of the manuscript and assisted in initial data collection. JAK is a study Investigator who oversaw the *Food Stop* conception, execution and analyses, and provided advice and critical review of this manuscript. SC is the study project manager, coordinated data collection and provided critical review of this manuscript. AG assisted with statistical analysis and contributed to the writing of the manuscript. FKM and LB are study Investigators and contributed to the writing and editing of this manuscript. PJ and KG are collaborators with CheckPoint and provided critical review of the manuscript. MW is the Principal Investigator of the Child Health CheckPoint, planned the analyses and provided critical review of the manuscript.

DATA SHARING STATEMENT: Dataset and technical documents available from Growing Up in Australia: The Longitudinal Study of Australian Children via low-cost license for bona fide researchers. More information is available at www.growingupinaustralia.gov.au

FIGURE CAPTIONS AND FOOTNOTES:

Figure 1: Participant flow from recruitment into LSAC to participation in *Food Stop*

Figure 2: Distribution of food intake variables in children

Figure 3: Distribution of food intake variable in parents

Figure 4: Parent-child concordance, as represented by Pearson's correlations.

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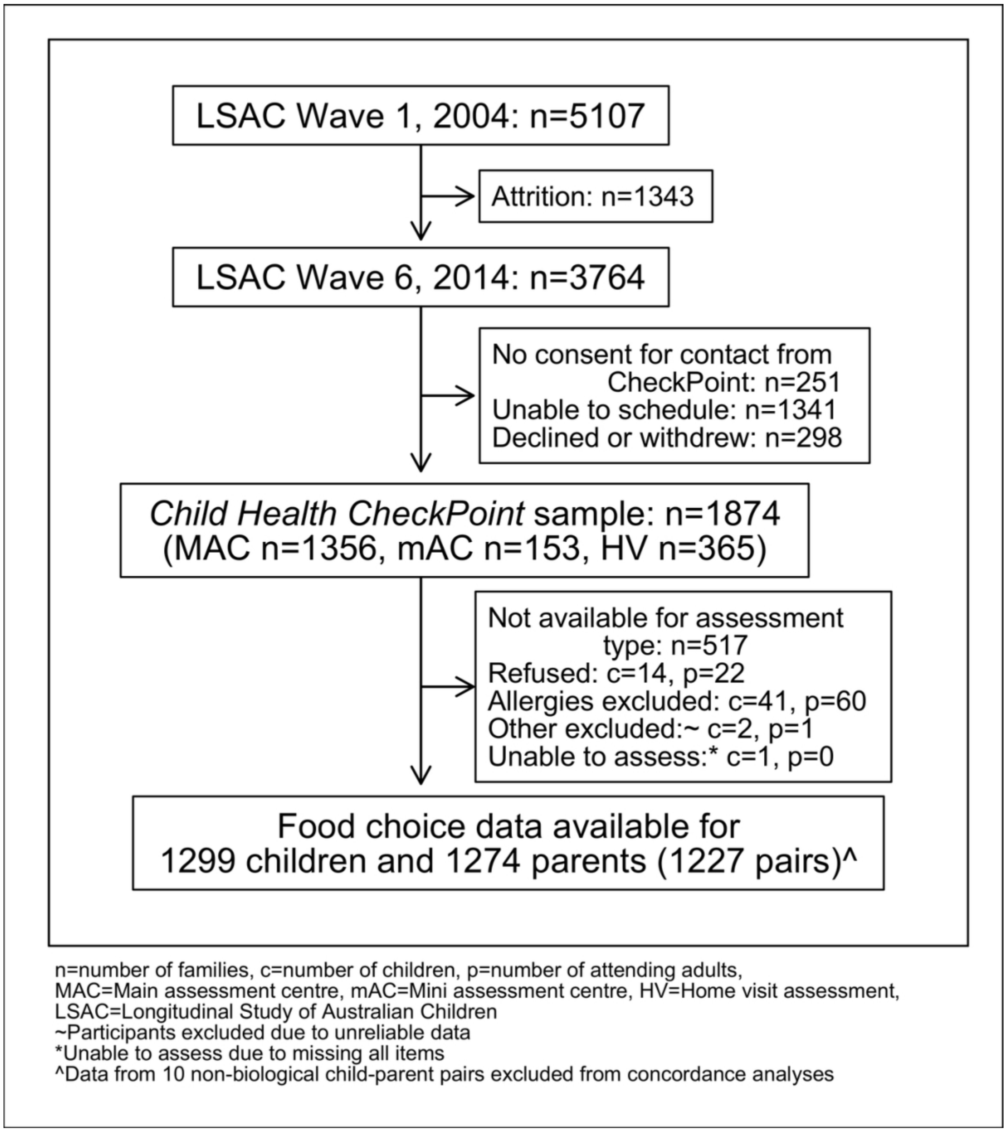

Figure 1: Participant flow from recruitment into LSAC to participation in Food Stop

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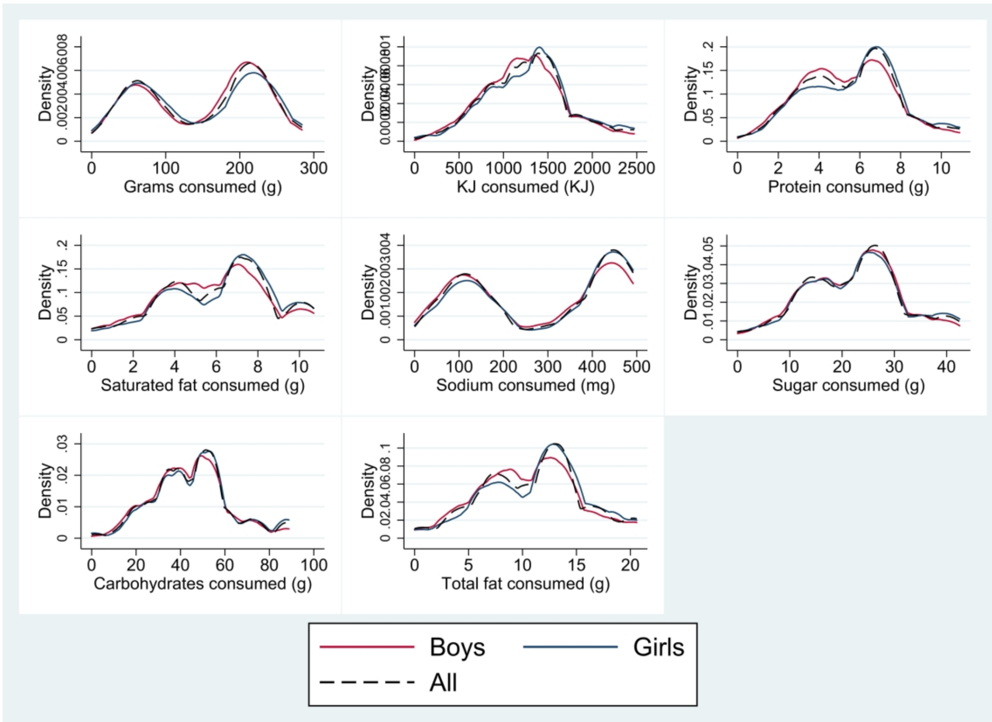

Figure 2: Distribution of food intake variables in children

101x73mm (600 x 600 DPI)

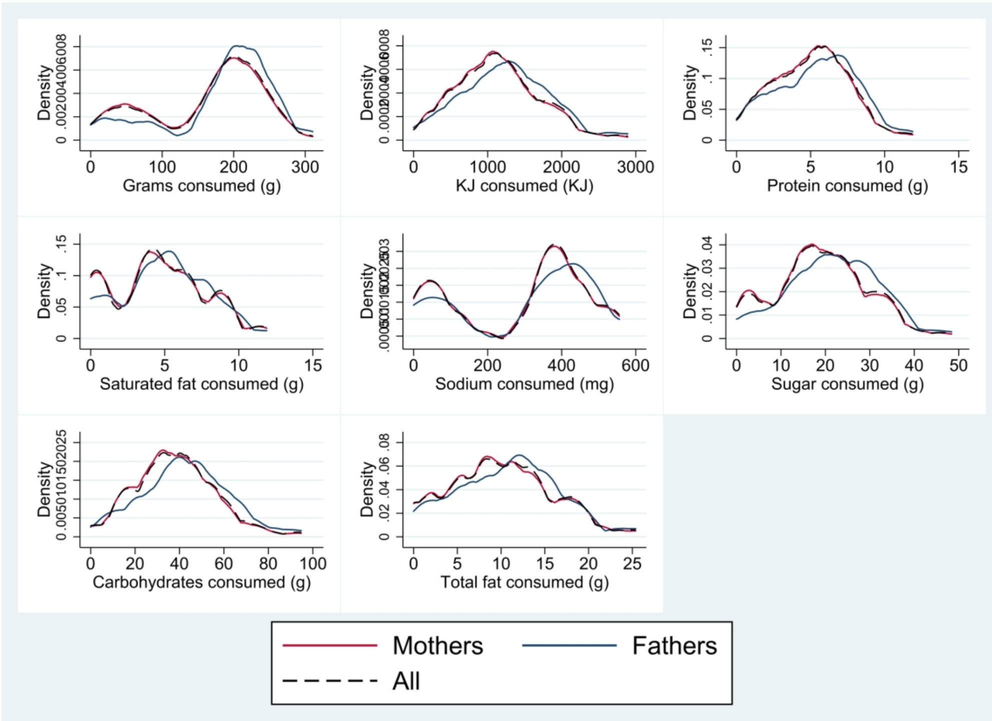

Figure 3: Distribution of food intake variable in parents

101x73mm (600 x 600 DPI)

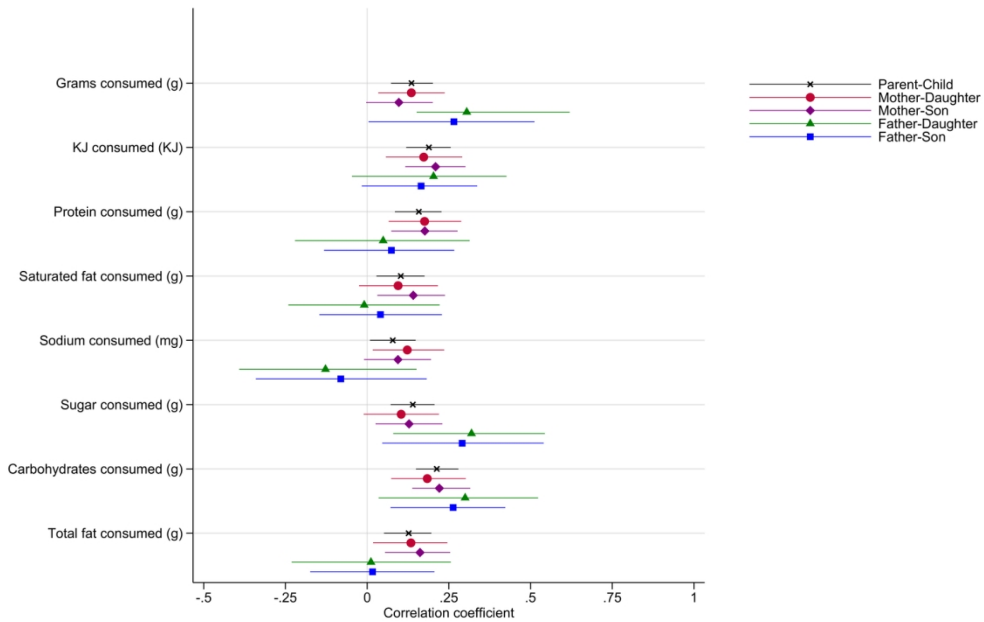

Figure 4: Parent-child concordance, as represented by Pearson's correlations

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SUPPLEMENTARY DOCUMENTS:

Supplementary table 1: Information on Food Items and Box Combinations

Food Item	Grams[a]	Kilojoules	Protein (g)	Fat (g)	Saturated fat (g)	Carbohydrates (g)	Sugar (g)	Sodium (mg)
Peaches in juice	150	316	1	<1	<1	17	14	5
Flavoured rice crackers	18	308	1	1	<1	15	<1	79
Miniature wheat fruit bites	22	336	2	<1	<1	17	5	11
Cheese wedge	20	290	3	6	4	1	1	326
Miniature animal-shaped biscuits	25	458	2	3	2	17	7	71
Miniature Oreo biscuits	27	555	1	6	3	10	10	144
Fruit muesli bar	24	452	2	4	<1	16	4	10
Miniature milk chocolate bar[c]	13	279	1	4	2	7	7	9

Box[d]	Total energy per box (kJ)	Food items contained in box
Combinations 1 & 2	*Children:* 1651 (15-20% of child RDI[e])	Peaches in juice, Flavoured rice crackers, Cheese wedge, Miniature animal-shaped biscuits, Milk chocolate bar 1
	Parents: 2201 (15-20% of adult RDI[e])	Peaches in juice, Flavoured rice crackers, Cheese wedge, Miniature Oreo biscuits, Fruit muesli bar 1, Milk chocolate bar 1
Combinations 3 & 4	*Children:* 2718 (25-30% of child RDI[e])	Peaches in juice, Flavoured rice crackers, Miniature wheat fruit bites, Cheese wedge, Miniature animal-shaped biscuits, Fruit muesli bar 1, Miniature milk chocolate bar 1, Miniature milk chocolate bar 2
	Parents: 3267 (25-30% of adult RDI[e])	Peaches in juice, Flavoured rice crackers, Miniature wheat fruit bites, Cheese wedge, Miniature Oreo biscuits, Fruit muesli bar 1, Fruit muesli bar 2, Miniature milk chocolate bar 1, Miniature milk chocolate bar 2

[a]Because each item naturally varied from its listed package weight, 20 individual items (reference units) were weighed and the mean grams derived for each item. This mean item weight is listed here and used in all calculations for derived variables. [b]Peaches were discontinued by manufacturers part way through data collection. We replaced the peaches with fruit salad (same brand/appearance) for the final 123 families who participated in CheckPoint. Fruit salad g=150; kJ=348. [c]Participants (381 families) in the beginning months of CheckPoint received 11g milk chocolate bars (kJ=224). Part way through data collection, the manufacturers replaced the 11g bar with the 13g bar.

[d]Box combination details

Box combination 1: Small number of snack food items, small snack box (18.0cm x 12.0cm x 5.0cm; volume 1080cm^3)

Box combination 2: Small number of snack food items, large snack box (19.5cm x 14.0cm x 6.5cm; volume 1774.5cm^3)

Box combination 3: Large number of snack food items, small snack box (18.0cm x 12.0cm x 5.0cm; volume 1080cm^3)

Box combination 4: Large number of snack food items, large snack box (19.5cm x 14.0cm x 6.5cm; volume 1774.5cm^3)

[e]Australian children (11-12 years) with light activity levels are recommended to consume 8650kJ per day.[53] Australian adults (19-50 years) with light activity levels are recommended to consume 9823kJ per day.[53]

Supplementary table 2: Parent-child concordance stratified by parent and child sex

Consumption	Mothers				Fathers			
	Sons (n=512 to 517)		Daughters (n=539 to 541)		Sons (n=93 to 95)		Daughters (n=74)	
Pearson's correlation	**CC**	**95% CI**	**CC**	**95% CI**	**CC**	**95% CI**	**CC**	**95% CI**
Grams (g)	0.10	-0.00 to 0.20	0.14	0.03 to 0.24	0.27	0.00 to 0.51	0.30	0.15 to 0.62
Energy (kJ)	0.21	0.12 to 0.30	0.18	0.06 to 0.29	0.16	-0.03 to 0.33	0.21	-0.05 to 0.43
Protein (g)	0.18	0.08 to 0.28	0.19	0.08 to 0.29	0.07	-0.13 to 0.27	0.07	-0.21 to 0.33
Saturated fat (g)	0.14	0.03 to 0.24	0.09	-0.03 to 0.21	0.02	-0.16 to 0.21	-0.01	-0.24 to 0.22
Sodium (mg)	0.10	-0.00 to 0.20	0.13	0.02 to 0.24	-0.09	-0.35 to 0.17	-0.12	-0.38 to 0.16
Sugar (g)	0.13	0.03 to 0.23	0.10	-0.01 to 0.22	0.28	0.04 to 0.52	0.32	0.08 to 0.53
Carbohydrates (g)	0.22	0.14 to 0.32	0.19	0.08 to 0.30	0.25	0.06 to 0.41	0.29	0.03 to 0.52
Total fat (g)	0.17	0.06 to 0.25	0.14	0.03 to 0.25	0.01	-0.18 to 0.21	0.02	-0.22 to 0.27
Linear regression	**RC**	**P-value**	**RC**	**P-value**	**RC**	**P-value**	**RC**	**P-value**
Grams (g)	0.12	0.02	0.15	0.01	0.18	0.14	0.37	0.01
Energy (kJ)	0.15	<0.001	0.15	0.002	0.06	0.54	0.11	0.25
Protein (g)	0.14	0.002	0.17	0.001	0.02	0.83	0.00	0.98
Saturated fat (g)	0.11	0.01	0.09	0.06	-0.01	0.92	-0.04	0.73
Sodium (mg)	0.08	0.08	0.12	0.01	-0.09	0.44	-0.08	0.47
Sugar (g)	0.11	0.01	0.10	0.04	0.14	0.16	0.22	0.01
Carbohydrates (g)	0.19	<0.001	0.18	0.001	0.11	0.27	0.21	0.03
Total fat (g)	0.11	0.004	0.11	0.01	-0.01	0.92	-0.03	0.77

CC: Pearson's correlation coefficient; CI: confidence interval; RC: estimated linear regression coefficient

STROBE Statement—checklist of items that should be included in reports of observational studies

Paper title: Food choices: Concordance in 11-12 year old Australians and their parents
Person completing checklist: Prudence Vivarini

	Item No	Recommendation	Page number
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1,2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4,5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up ~~*Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale~~ for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	5
		~~(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed~~ ~~*Case-control study*—For matched studies, give matching criteria and the number of controls per case~~	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	8
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed ~~*Case-control study*—If applicable, explain how matching of cases and controls was addressed~~	8

~~*Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy~~		
(*e*) Describe any sensitivity analyses	8	

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	Figure 1
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	9
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	7
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11, 13, 15
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16,17
Generalisability	21	Discuss the generalisability (external validity) of the study results	17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.