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The link between dietary glycemic index and nutrient adequacy

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Abstract

BACKGROUND: Low-glycemic index (low-GI) diets may be less nutritious because of limited food choices. Alternately, high-GI diets could be less healthful because of a higher intake of refined carbohydrate. OBJECTIVE: The objective was to investigate the association between dietary GI, intakes of carbohydrates from high-GI (CHO(high GI)) and low-GI (CHO(low GI)) sources, and the risk of nutrient inadequacy in children and adolescents. DESIGN: Children, aged 2-16 y, who provided 2 plausible 24-h recalls in a national survey were included (n = 4140). The ORs of not meeting the Australian Nutrient Reference Values (NRVs) were calculated by logistic regression. RESULTS: Subjects with higher intakes of CHO(high GI) were found to be at risk of not meeting the NRVs for a wide range of nutrients, including calcium and iodine (both P-trend < 0.001). In comparison with subjects in the lowest quartile of CHO(high GI), those in the highest quartile had 3 times (adjusted OR: 3.13; 95% CI: 2.47, 3.97; P-trend < 0.001) the risk of not meeting the Estimated Average Requirement for calcium. For iodine, the risk increased >5-fold (adjusted OR: 5.45; 95% CI: 3.97, 7.48; P-trend < 0.001). On the other hand, subjects with higher intakes of CHO(low GI) were less likely to meet Adequate Intakes of unsaturated fatty acids (all P-trend < 0.001), despite having lower risks of not meeting the NRVs for most nutrients. CONCLUSION: Children and adolescents who consume more CHO(low GI) are more likely to meet most nutrient recommendations than those consuming higher GI diets.

Keywords

index, link, glycemic, between, dietary, nutrient, adequacy

Disciplines

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The link between dietary glycemic index and nutrient adequacy

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List of abbreviations used: 2007ANCNPAS – 2007 Australian National Children's Nutrition and Physical Activity Survey; AI - Adequate Intake; ALA – alpha linolenic acid; CHO_{highGI} - carbohydrate from higher glycemic index foods; CHO_{lowGI} - carbohydrate from low glycemic index foods; EAR - Estimated Average Requirement; GI – glycemic index; GL – glycemic load; LA- linoleic acid; LCn3PUFA - long chain omega-3 polyunsaturated fatty acids; NRV – Nutrient Reference Value; SFA – saturated fat; UL - Upper Level.

ABSTRACT

BACKGROUND: Low glycemic index (GI) diets may be less nutritious because of limited food choices. Alternately, high GI diets could be less healthful because of higher intake of refined carbohydrate.

OBJECTIVES: To investigate the association between dietary GI, intakes of carbohydrates from high (CHO_{highGI}) and low GI (CHO_{lowGI}) sources, and the risk of nutrient inadequacy in children and adolescents.

DESIGN: Children, aged 2 to 16 years, who provided two plausible 24 h recalls in a national survey were included (n = 4,140). Odds ratios (OR) of not meeting the Australian Nutrient Reference Values (NRV) were calculated by logistic regression.

RESULTS: Subjects with higher intakes of CHO_{highGI} were found to be at risk of not meeting the NRVs for a wide range of nutrients, including calcium and iodine (both $p_{trend} < 0.001$). Compared to subjects in the lowest quartile of CHO_{highGI}, those in the highest quartile had three times (adjusted OR = 3.13; 95%CI: 2.47, 3.97; $p_{trend} < 0.001$) the risk of not meeting the estimated average requirement of calcium. For iodine, the risk was increased more than five-fold (adjusted OR = 5.45; 95%CI: 3.97, 7.48; $p_{trend} < 0.001$). On the other hand, subjects with higher intakes of CHO_{lowGI} were less likely to meet adequate intake levels of unsaturated fatty acids (all $p_{trend} < 0.001$), despite having lower risks of not meeting the NRVs of most nutrients.

CONCLUSION: Children and adolescents consuming more CHO_{lowGI} are more likely to meet most nutrient recommendations than those consuming higher GI diets.

(247 words)

Keywords: glycemic index, Australian, children, adolescent, nutrient adequacy

INTRODUCTION

Diets with a low GI has been associated with reduced risks of chronic diseases such as type 2 diabetes mellitus (1, 2), cardiovascular diseases (2-4) and several forms of cancers (2, 4-7). The mechanism of any relationship between low GI diets and chronic disease has been assumed to be related to lower postprandial blood glucose levels and insulin responses (8). However, a low GI diet may also result in improved nutrient adequacy because foods that are naturally high in nutrients often have a low GI, e.g. dairy foods and the majority of fruits. In contrast, many nutritious foods such as wholemeal breads, brown rice or low fat potatoes have a high GI and there is concern that their exclusion may adversely affect micronutrient intake. Energy dense and/or nutrient poor foods generally have a moderate GI (e.g. soft drinks) but a high intake would increase dietary GL.

To our knowledge, there has been no investigation into the association between dietary GI and nutrient adequacy in either adults or children. The aim of this study was therefore to investigate the association between dietary GI and the odds of not meeting the Australian NRV, using data from the most recent Australian national dataset available to date, the 2007 Australian National Children's Nutrition and Physical Activity Survey (9). Since higher intakes of CHO_{highGI}, but not CHO_{lowGI}, have also recently been linked to an increased risk of coronary heart disease in women (8), we additionally investigated how nutritional adequacy relates to carbohydrate intake from high or low GI foods, respectively.

METHODS

The 2007 Australian National Children's Nutrition and Physical Activity Survey

The 2007ANCNPAS was commissioned in 2007 by the Australian Government Department of Agriculture, Fisheries and Forestry, and the Australian Food and Grocery Council (9). The methodology of the 2007ANCNPAS was previously described in details (10). In brief, the survey measured the dietary intakes of food and beverages as well as use of supplements employing the 24 h recall method. These data were collected on children aged 2-16 years (*n* = 4,834) between 22 February and 30 August 2007. Dietary data were collected from the primary-care giver in children aged 2-8 years; children aged 9 years and older reported their own dietary intake. Dietary intake data were entered into a purpose-built database, with nutrition compositions based on the AUSNUT2007 database (11). The demographics of the participants has been previously described (12).

Data cleaning

Children who completed only one 24 h recall (*n* = 179) were excluded from the analyses, and the plausibility of the remaining food intake data were assessed using the Goldberg cut-off for specific physical activity level (13). We excluded 339 under-reporters and 129 over-reporters based on this method. An additional 47 subjects were excluded because weight and/or height were not recorded and plausibility of food intake data could not be assessed. The final dataset included 4,140 participants (51% male) who provided 2 x 24 h recalls.

Calculation of glycemic load, dietary glycemic index and intakes of low / high glycemic index carbohydrates

The method used to assign GI values to the food items in the 2007ANCNPAS dataset was previously described (12, 14). The GL of each food item was calculated as the corresponding GI (as %) × amount (in grams) of available carbohydrate in a serving of that food. The daily dietary

GL of each subject was calculated as ∑ GL, and the daily dietary GI was obtained by (daily dietary GL / total available carbohydrate intake in the day) × 100%. Carbohydrates from foods with a GI less than the median GI of all food items in the database (GI = 52) were considered CHO_{lowGI}, while those from foods with a GI > 52 were termed CHO_{highGI}.

Comparison to the Australian Nutrient Reference Values

The nutrient intakes of the participants were compared to the latest Australia NRV (15) – for calcium, iron, iodine, zinc, magnesium, phosphorus, vitamin A (as retinol equivalents), thiamin, riboflavin, dietary folate equivalents and vitamin C, intakes lower than the EAR was considered not meeting the NRV; for potassium, LA, ALA, LCn3PUFA, dietary fibre, vitamin D and vitamin E, intakes lower than the AI were considered not meeting the NRV; for sodium, intakes higher than the UL were considered not meeting the NRV. Individuals with energy intake from SFA greater than 10% were considered not meeting the SFA target stated in the NRV. Prevalence of inadequate protein intake was extremely low (data not shown).

Statistical analysis

Data were weighted to account for over- or under-sampling to enable representation of the Australian population aged 2-16 years in terms of age group, gender and region. BMI *z*-scores of the subjects were calculated using the WHO Anthro SPSS macro (version 3.1, June 2010). Dietary GI and carbohydrate variables were adjusted for total energy intake using the residual method (16). Residuals were used to create sex and age-group-specific quartiles. Trends across the quartiles were assessed by linear regression. Pearson's χ^2 test was used to test for differences between numbers of male participants across the quartiles.

Logistic regression analysis was used to calculate the odds ratios of not meeting the Australian NRV by sex and age-group-specific quartiles of GI and carbohydrates from low / higher GI foods. Model 1 included adjustments for age and sex, and Model 2 additionally adjusted for total energy intake. Additional adjustment for BMI *z*-score did not significantly alter the direction, amplitude and/or significance of the associations, and were therefore not presented. Trend analyses across quartiles were performed using ordinal variables containing median GI values for each quartile. Because of the number of tests conducted, $p < 0.01$ was considered to indicate marginal statistical significance, and p value < 0.001 was considered significant to reduce the chance of type I error. All statistical analyses were carried out using Statistical Packages for Social Science version 19.0 (IBM Australia, St Leonards NSW, Australia).

RESULTS

The mean ± SD daily intake of selected nutrients and demographics of the 2007ANCNPAS respondents by age and sex specific quartiles of GI residuals are shown in **Table 1**. Subjects who had a higher GI tended to have a higher proportion of energy from carbohydrate and total available carbohydrate. They also tended to have less energy from sugars, and dietary fibre and calcium.

Table 2 shows the odds ratios of not meeting the Australian NRV by age and sex specific quartiles of GI residuals. In general, apart from SFA and LA, which showed a decreasing trend of risk, subjects with higher GI tended to have higher risks of not meeting the Australian NRVs for most nutrients. Notably, subjects in the highest quartile had more than 4 times the risk of not meeting the NRVs of calcium iodine, riboflavin and vitamin A in model 2. There was no trend across quartiles of GI residuals for intake of iron, zinc, thiamin, and vitamin C.

The risk of not meeting the Australian NRV of selected nutrients by age and sex specific quartiles of CHO_{highGI} residuals are shown in **Table 3**. Significantly increased risks were evident among subjects in the higher quartiles for most nutrients except fibre, LA, iron, sodium, thiamin, dietary folate equivalents and vitamin C.

Subjects with higher intake of CHO_{lowGI} were found to be more likely to meet the Australian NRV for a wide range of nutrients, but they were less likely to meet the AI of LA, ALA and LCn3PUFA (**Table 4**). When compared to subjects in the lowest quartile, the risk of subjects in the highest quartile of CHO_{lowGI} of not meeting the NRV of most nutrients (including dietary fibre, calcium, potassium, iodine) was approximately halved.

We performed sensitivity analyses that included all subjects (*n* = 4655), and also after excluding subjects aged 2 years (*n* = 4112), and the results were similar (Online Supplemental Material T1 to T3).

DISCUSSION

To the best of our knowledge, this study is the first to investigate the association between dietary GI and nutrient adequacy. We have shown that among Australian children and adolescents, those who consume a diet with a lower GI, or more CHO_{lowGI}, were more likely to meet the Australian NRV, that is, have a more nutritionally adequate diet.

In addition, we have also shown that participants who reported the highest consumption of CHO_{highGI} had significantly higher risk of *not* meeting the NRV for a wide range of essential nutrients, such as calcium (multivariate adjusted OR: 3.13), iodine (multivariate adjusted OR: 5.45) and vitamin A (multivariate adjusted OR: 3.77). This suggests that many of the high GI foods consumed by the sample population were of low nutritional quality. A previous study amongst 215 rural Australian children aged 10-12 years reported the main drivers for increasing dietary GI were foods with low nutritional quality such as white breads, soft drinks and sweet drink concentrates (17, 18). Our previous analyses of the 2007ANCNPAS found that among children aged four years or older, white breads and soft drinks contributed a significant proportion of their dietary GL (28 – 46 % among consumers) (12). Similarly, 'tolerated food groups' (i.e. sweets, soft drinks, cakes and cookies, and salty snacks) made a major contribution to the dietary GL of 7-8 year old German children (19).

A higher dietary GI was found to be related to a lower SFA intake. In particular those who consumed large amounts of CHO_{highGI} had a very low risk of not meeting the recommendation for SFA (OR of 0.14 in upper quartile). This suggests that in practice, the reduction in saturated fat intake may often be accompanied by the consumption of lower quality carbohydrate (eg replacing bacon and egg breakfast with cornflakes), although the replacement of saturated fat by good quality carbohydrate is also possible.

In the present study, we also found a novel link between diets rich in CHO_{lowGI} and a lower intake of polyunsaturated fatty acids (ALA, LA and LCn3PUFA). This association may be driven by the fact that a higher intake of carbohydrate foods, irrespective of GI, was associated with lower intake of fat *per se*. For example, children who consumed a low GI breakfast cereal or toasted bread were less likely to consume a breakfast based on eggs and bacon, which has a higher content of fat and LCn3PUFA. This interpretation is in line with the observation that higher intakes of CHO_{highGI} were also related to an increased risk of not meeting the recommendations for ALA and LCn3PUFA, albeit to a lesser degree. It should be noted, however, that many Australian children and adolescents had suboptimal intake of omega-3 fatty acids (20, 21), which may have contributed to this finding.

While the present findings improve our understanding of the potential mechanisms underlying the association between GI and the risk of chronic disease, they are also relevant to the potential impact of considering GI in dietary guidelines for the general population. While some aspects of carbohydrate quality are presently considered, eg choose products high in wholegrains and/or fibre (22, 23), the GI is not. We did not expect to find that a high GI diet would be poorer in quality because many high fiber breads and wholegrain breakfast cereals have a high GI. Indeed, some dieticians have suggested that a focus on low GI may adversely affect dietary quality because it restricts food choice (24, 25). However, our findings imply that the GI may be a better indicator of overall food quality than the fiber or wholegrain content.

In addition, our findings indicate that any association between dietary GI and nutrient adequacy must be considered as an additional mechanism in epidemiological and interventional studies where the GI is the focus. Indeed, adjustment for differences in micronutrient or vitamin intake may mean that GI is no longer related to the risk of chronic disease. Our results also illustrate that dietary advice should simultaneously address the quality of fat and carbohydrate. On the one hand, a focus on reducing SFA intake appears to confer an increased risk of a poor carbohydrate quality, on the other hand a preferred consumption of CHO_{lowGI} alone does not guarantee favourable intake levels of PUFA. The link between CHO_{lowGI} and lower intakes of LCn3PUFA is a concern that needs to be addressed in further studies.

A particular strength of this study is the use of a published method for assigning GI values to the food items in the 2007ANCNPAS food database. Based on this method, 85% of the food items were assigned a GI value in the first two steps, which utilized the current best available sources of GI values, therefore increasing the reliability of the GI values assigned. The use of a nationally representative sample also increased the generalizability of the findings.

This study was however limited in several ways. First, due to the number of tests conducted, the chance of type I error is high. Although the use of a more stringent significance criterion of $p < 0.001$ had reduced the likelihood of such error, the results should be interpreted with caution. In addition, the evidence to support the use of 24 h dietary recall in children is currently limited, despite it being a suitable dietary assessment method to be used for a large sample population. It has also been argued that an accurate dietary assessment among children is especially difficult (26). Using the Goldberg cut-off for specific physical activity level method (13), we have excluded under- and over-reporters based on a scientifically accepted methodology, which is likely to increase the plausibility of our findings, though we cannot exclude the possibility of residual error.

Dietary intake is subject to high day to day variance, and data obtained from two 24 hour recalls may not capture the habitual intake of an individual (26, 27), especially for items that are not frequently consumed (eg seafood). The results of the present study should therefore be interpreted with caution. Increasing the number of recalls may allow a better estimation of habitual intake, however it has been shown that among young children (6 y or below), up to 9 days of recalls are required to ensure a 80% correlation between observed and true mean nutrient intakes of individuals (28). This is both financially and logistically impractical for a national nutrition survey including thousands of subjects. The increase in number of recalls may also increase the chance of under reporting, and is also highly demanding on the participants, which may result in a low response rate, rendering the collected data non-representative. Two 24 h recalls are the usual choice in national nutrition surveys (29-31) to balance the accuracy of the dietary data collected against respondent burden. Ideally, the findings of the present study should be confirmed using datasets that are based on food records.

CONCLUSION

Children and adolescents who had a high dietary GI were at high risk of inadequate intake of several key nutrients. We found that subjects who consumed more carbohydrate from low GI sources were more likely to meet the Australian NRV, achieving a more nutritionally adequate diet. The findings of the present study provide reassurance that the health benefits of a low GI diet, at least amongst children and adolescents, extend beyond the ability to reduce postprandial glycemia. Further research needs to be conducted into the potential impact on fatty acid intake.

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JCYL, AEB, VF and JCBM contributed to the conception of the study. JCYL assigned the glycemic index values with input from VF, performed the statistical analyses under the guidance of AEB, and drafted the manuscript. JCYL, AEB, VF and JCBM critically reviewed and interpreted the data, were involved in the subsequent edits of the manuscript, and have read and approved the final manuscript.

CONFLICT OF INTEREST

JBM is a director of a not-for-profit GI-based food endorsement program in Australia, manages the University of Sydney glycemic index testing service, and is an author of books in The New Glucose Revolution series (Da Capo, Cambridge, MA). JCYL, AB and VF declare they have no competing interest.

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Table 1 – Mean ± SD daily intake of selected nutrients and demographics of 2007ANCNPAS respondents by age and sex specific GI quartiles[1]

	Q1			Q2			Q3			Q4			*p* value[2]
Male (%)	51.1			51.3			51.2			51.2			1.000
Dietary glycemic index	48.4	±	2.5	52.6	±	1.2	55.5	±	1.2	59.9	±	2.6	<0.001
Age (years)	9.3	±	4.3	9.3	±	4.3	9.4	±	4.2	9.5	±	4.2	0.280
BMI (kg/m^2)	18.5	±	3.6	18.3	±	3.4	18.3	±	3.2	18.4	±	3.5	0.156
Energy (kJ)	8236.4	±	2341.6	8167.1	±	2329.7	8370.6	±	2441.8	8182.5	±	2363.2	1.000
Energy from fat (%)	31.8	±	5.5	30.9	±	5.4	30.6	±	5.4	29.9	±	5.5	<0.001
Energy from saturated fat (%)	14.8	±	3.4	14.1	±	3.3	13.7	±	3.2	12.7	±	3.1	<0.001
Energy from protein (%)	17.5	±	3.5	16.6	±	3.4	16.3	±	3.3	16.3	±	3.7	<0.001
Energy from carbohydrates (%)	49.8	±	6.4	51.5	±	6.2	52.2	±	6.1	52.9	±	6.7	<0.001
Energy from sugars (%)	26.3	±	6.3	25.9	±	6.1	25.3	±	6.3	23.4	±	6.7	<0.001
Total available carbohydrates (g)	239.8	±	69.7	246.4	±	72.7	255.9	±	77.2	253.8	±	78.7	<0.001
High GI carbohydrates (g)	96.3	±	39.0	123.4	±	43.3	150.8	±	52.6	176.8	±	63.2	<0.001
Low GI carbohydrates (g)	144.5	±	47.0	124.5	±	41.6	106.4	±	36.9	78.5	±	32.0	<0.001
Dietary fibre (g)	20.8	±	7.8	21.0	±	7.9	20.8	±	7.7	19.7	±	7.2	<0.001
Calcium (mg)	996.9	±	389.4	901.6	±	353.0	844.6	±	331.0	713.9	±	315.6	<0.001

[1]Adjusted for energy using residuals method

[2]*p* values represent *p* for trend tested by linear regression, except for male (%), which was tested by Pearson's χ^2.

Table 2 – Odds ratio[1] (95% Confidence Intervals) of ***NOT*** meeting the Australian Nutrient Reference Values (NRV)[2] for selected nutrients by age and sex specific GI quartiles[3]

	Q1 (ref)	Q2	Q3	Q4	p_{trend}[4]
Median GI	48.9	52.6	55.5	59.3	-
%E from SFA					
Unadjusted	1.00	0.63 (0.46, 0.87)	0.55 (0.40, 0.75)	0.33 (0.25, 0.44)	<0.001
Model 1[5]	1.00	0.63 (0.46, 0.87)	0.55 (0.40, 0.75)	0.33 (0.25, 0.44)	<0.001
Model 2[6]	1.00	0.64 (0.47, 0.88)	0.53 (0.39, 0.73)	0.33 (0.25, 0.45)	<0.001
LA					
Unadjusted	1.00	0.88 (0.73, 1.06)	0.79 (0.66, 0.96)	0.64 (0.54, 0.77)	<0.001
Model 1[5]	1.00	0.88 (0.73, 1.06)	0.80 (0.66, 0.96)	0.65 (0.54, 0.78)	<0.001
Model 2[6]	1.00	0.82 (0.67, 1.01)	0.81 (0.66, 0.99)	0.57 (0.47, 0.70)	<0.001
ALA					
Unadjusted	1.00	0.93 (0.77, 1.11)	0.87 (0.73, 1.04)	0.91 (0.76, 1.09)	0.257
Model 1[5]	1.00	0.92 (0.77, 1.11)	0.87 (0.72, 1.04)	0.91 (0.76, 1.09)	0.252
Model 2[6]	1.00	0.87 (0.72, 1.06)	0.89 (0.73, 1.08)	0.84 (0.69, 1.02)	0.105
LCn3PUFA					
Unadjusted	1.00	1.14 (0.96, 1.36)	0.94 (0.79, 1.14)	0.94 (0.79, 1.11)	0.184
Model 1[5]	1.00	1.14 (0.96, 1.36)	0.93 (0.78, 1.11)	0.93 (0.78, 1.11)	0.170
Model 2[6]	1.00	1.13 (0.95, 1.35)	0.95 (0.80, 1.14)	0.91 (0.76, 1.08)	0.122
Dietary fibre					
Unadjusted	1.00	0.93 (0.78, 1.10)	1.01 (0.85, 1.20)	1.28 (1.08, 1.53)	0.003
Model 1[5]	1.00	0.93 (0.78, 1.10)	1.01 (0.85, 1.20)	1.28 (1.07, 1.52)	0.004
Model 2[6]	1.00	0.88 (0.73, 1.06)	1.05 (0.87, 1.26)	1.26 (1.05, 1.52)	0.005
Calcium					
Unadjusted	1.00	1.42 (1.18, 1.72)	1.52 (1.26, 1.83)	2.95 (2.45, 3.55)	<0.001
Model 1[5]	1.00	1.58 (1.27, 1.96)	1.70 (1.37, 2.10)	4.03 (3.25, 5.00)	<0.001
Model 2[6]	1.00	1.64 (1.28, 2.09)	2.09 (1.64, 2.66)	5.22 (4.09, 6.67)	<0.001
Iron					
Unadjusted	1.00	0.91 (0.58, 1.42)	0.76 (0.47, 1.21)	1.04 (0.68, 1.61)	0.995
Model 1[5]	1.00	0.90 (0.57, 1.42)	0.75 (0.46, 1.20)	1.02 (0.66, 1.60)	0.936
Model 2[6]	1.00	0.76 (0.47, 1.25)	0.74 (0.44, 1.24)	0.78 (0.48, 1.27)	0.337
Potassium					
Unadjusted	1.00	1.18 (0.99, 1.40)	1.44 (1.21, 1.72)	2.23 (1.87, 2.66)	<0.001
Model 1[5]	1.00	1.18 (0.99, 1.40)	1.44 (1.21, 1.72)	2.23 (1.87, 2.66)	<0.001
Model 2[6]	1.00	1.16 (0.95, 1.41)	1.72 (1.41, 2.10)	2.68 (2.19, 3.29)	<0.001
Sodium					
Unadjusted	1.00	1.07 (0.86, 1.34)	1.25 (1.00, 1.58)	1.21 (0.96, 1.52)	0.055
Model 1[5]	1.00	1.08 (0.86, 1.35)	1.27 (1.01, 1.61)	1.23 (0.98, 1.55)	0.040
Model 2[6]	1.00	1.19 (0.93, 1.53)	1.25 (0.97, 1.61)	1.45 (1.12, 1.88)	0.004
Phosphorous					
Unadjusted	1.00	1.75 (1.21, 2.52)	1.81 (1.26, 2.61)	2.31 (1.63, 3.29)	<0.001
Model 1[5]	1.00	1.81 (1.24, 2.64)	1.88 (1.29, 2.73)	2.41 (1.68, 3.47)	<0.001
Model 2[6]	1.00	1.81 (1.18, 2.76)	2.48 (1.61, 3.81)	2.44 (1.61, 3.70)	<0.001

	Q1 (ref)	Q2	Q3	Q4	p_{trend}[4]
Magnesium					
Unadjusted	1.00	1.16 (0.88, 1.53)	1.19 (0.90, 1.56)	1.71 (1.32, 2.21)	<0.001
Model 1[5]	1.00	1.22 (0.89, 1.68)	1.28 (0.93, 1.75)	2.02 (1.49, 2.74)	<0.001
Model 2[6]	1.00	1.15 (0.80, 1.65)	1.62 (1.13, 2.32)	2.17 (1.53, 3.06)	<0.001
Zinc					
Unadjusted	1.00	1.25 (0.75, 2.08)	1.27 (0.77, 2.11)	1.58 (0.97, 2.57)	0.072
Model 1[5]	1.00	1.30 (0.76, 2.22)	1.34 (0.78, 2.28)	1.65 (0.98, 2.75)	0.062
Model 2[6]	1.00	1.23 (0.69, 2.18)	1.63 (0.92, 2.88)	1.54 (0.88, 2.66)	0.091
Iodine					
Unadjusted	1.00	1.40 (1.03, 1.89)	1.94 (1.45, 2.59)	4.31 (3.30, 5.63)	<0.001
Model 1[5]	1.00	1.40 (1.03, 1.91)	1.96 (1.46, 2.62)	4.47 (3.41, 5.87)	<0.001
Model 2[6]	1.00	1.34 (0.97, 1.85)	2.22 (1.63, 3.02)	4.96 (3.72, 6.62)	<0.001
Thiamin					
Unadjusted	1.00	0.51 (0.29, 0.90)	0.65 (0.39, 1.10)	0.67 (0.40, 1.12)	0.160
Model 1[5]	1.00	0.50 (0.28, 0.88)	0.64 (0.38, 1.10)	0.64 (0.38, 1.09)	0.136
Model 2[6]	1.00	0.44 (0.24, 0.79)	0.67 (0.38, 1.16)	0.53 (0.31, 0.93)	0.060
Riboflavin					
Unadjusted	1.00	1.58 (0.64, 3.91)	1.88 (0.78, 4.53)	4.97 (2.28, 10.85)	<0.001
Model 1[5]	1.00	1.59 (0.64, 3.95)	1.91 (0.79, 4.61)	5.06 (2.30, 11.10)	<0.001
Model 2[6]	1.00	1.51 (0.60, 3.83)	2.14 (0.87, 5.30)	4.69 (2.09, 10.53)	<0.001
DFE					
Unadjusted	1.00	0.86 (0.64, 1.14)	0.92 (0.70, 1.22)	1.52 (1.17, 1.97)	<0.001
Model 1[5]	1.00	0.84 (0.62, 1.14)	0.91 (0.68, 1.23)	1.58 (1.20, 2.08)	<0.001
Model 2[6]	1.00	0.79 (0.58, 1.08)	0.96 (0.70, 1.30)	1.53 (1.15, 2.04)	<0.001
Vitamin A RE					
Unadjusted	1.00	1.67 (1.25, 2.24)	2.09 (1.57, 2.77)	3.89 (2.97, 5.08)	<0.001
Model 1[5]	1.00	1.72 (1.27, 2.33)	2.18 (1.63, 2.93)	4.27 (3.23, 5.64)	<0.001
Model 2[6]	1.00	1.72 (1.26, 2.37)	2.56 (1.88, 3.48)	4.72 (3.51, 6.34)	<0.001
Vitamin C					
Unadjusted	1.00	1.17 (0.85, 1.62)	1.48 (1.09, 2.01)	1.33 (0.97, 1.82)	0.037
Model 1[5]	1.00	1.17 (0.85, 1.62)	1.48 (1.09, 2.02)	1.33 (0.97, 1.82)	0.035
Model 2[6]	1.00	1.16 (0.84, 1.59)	1.52 (1.12, 2.07)	1.29 (0.94, 1.77)	0.048
Vitamin D					
Unadjusted	1.00	1.71 (1.34, 2.19)	2.17 (1.67, 2.81)	3.11 (2.33, 4.15)	<0.001
Model 1[5]	1.00	1.75 (1.36, 2.24)	2.23 (1.71, 2.90)	3.24 (2.42, 4.33)	<0.001
Model 2[6]	1.00	1.85 (1.42, 2.42)	2.77 (2.08, 3.69)	3.73 (2.72, 5.11)	<0.001
Vitamin E					
Unadjusted	1.00	1.32 (1.08, 1.61)	1.43 (1.17, 1.75)	1.67 (1.36, 2.06)	<0.001
Model 1[5]	1.00	1.32 (1.08, 1.61)	1.43 (1.17, 1.75)	1.67 (1.36, 2.05)	<0.001
Model 2[6]	1.00	1.33 (1.07, 1.64)	1.57 (1.27, 1.94)	1.71 (1.37, 2.13)	<0.001

SFA – saturated fat; LA – linoleic acid; ALA – alpha linolenic acid; LCn3PUFA – long chain omega-3 polyunsaturated fatty acids; DFE – dietary folate equivalents; RE – retinol equivalents

[1]Odds ratios calculated by logistic regression.

[2]For calcium, iron, iodine, zinc, magnesium, phosphorus, vitamin A RE, thiamin, riboflavin, DFE and vitamin C, intakes lower than the Estimated Average Requirement (EAR) were considered not meeting the NRV; for potassium, LA, ALA, LCn3PUFA, dietary fibre, vitamin D

and vitamin E, intakes lower than the Adequate Intake (AI) were considered inadequate; for sodium, intakes higher than the Upper Level (UL) were considered not meeting the NRV.
[3]Adjusted for energy using the residual method
[4]Tests for trend are based on ordinal variables containing median values for each quartile. $P < 0.01$ was considered to be of marginal statistical significance, and $p < 0.001$ was considered statistically significant.
[5]Adjusted for age and sex
[6]Model 1 with additional adjustment for total energy intake

Table 3 – Odds ratio[1] (95% Confidence Intervals) of ***NOT*** meeting the Australian Nutrient Reference Values (NRV)[2] for selected nutrients by age and sex specific CHO_{highGI} quartiles[3]

	Q1 (ref)	Q2	Q3	Q4	p_{trend}[4]
Median intake (g)	90.4	110.4	133.7	189.2	-
%E from SFA					
Unadjusted	1.00	0.62 (0.43, 0.91)	0.40 (0.28, 0.57)	0.15 (0.11, 0.20)	<0.001
Model 1[5]	1.00	0.62 (0.43, 0.92)	0.40 (0.28, 0.57)	0.15 (0.10, 0.20)	<0.001
Model 2[6]	1.00	0.71 (0.48, 1.05)	0.45 (0.32, 0.65)	0.14 (0.10, 0.20)	<0.001
LA					
Unadjusted	1.00	1.23 (1.03, 1.48)	1.20 (0.99, 1.44)	0.95 (0.80, 1.14)	0.341
Model 1[5]	1.00	1.23 (1.02, 1.48)	1.19 (0.99, 1.43)	0.96 (0.80, 1.14)	0.351
Model 2[6]	1.00	0.98 (0.80, 1.19)	0.99 (0.81, 1.21)	0.91 (0.75, 1.11)	0.370
ALA					
Unadjusted	1.00	1.20 (1.00, 1.44)	1.32 (1.10, 1.58)	1.31 (1.09, 1.58)	0.004
Model 1[5]	1.00	1.20 (1.00, 1.44)	1.32 (1.10, 1.59)	1.31 (1.09, 1.58)	0.004
Model 2[6]	1.00	0.95 (0.78, 1.16)	1.08 (0.88, 1.31)	1.31 (1.07, 1.59)	0.002
LCn3PUFA					
Unadjusted	1.00	1.43 (1.20, 1.71)	1.31 (1.10, 1.57)	1.81 (1.51, 2.15)	<0.001
Model 1[5]	1.00	1.44 (1.20, 1.71)	1.32 (1.10, 1.57)	1.81 (1.51, 2.16)	<0.001
Model 2[6]	1.00	1.30 (1.09, 1.56)	1.21 (1.01, 1.45)	1.81 (1.52, 2.17)	<0.001
Dietary fibre					
Unadjusted	1.00	1.27 (1.07, 1.51)	1.16 (0.98, 1.38)	1.05 (0.88, 1.25)	0.996
Model 1[5]	1.00	1.27 (1.07, 1.52)	1.17 (0.99, 1.39)	1.05 (0.88, 1.25)	0.968
Model 2[6]	1.00	1.05 (0.87, 1.26)	0.98 (0.81, 1.18)	1.02 (0.85, 1.22)	0.997
Calcium					
Unadjusted	1.00	1.31 (1.09, 1.58)	1.67 (1.39 (2.01)	2.12 (1.76, 2.54)	<0.001
Model 1[5]	1.00	1.46 (1.18, 1.81)	2.02 (1.63, 2.49)	2.63 (2.13, 3.25)	<0.001
Model 2[6]	1.00	1.13 (0.89, 1.43)	1.71 (1.35, 2.17)	3.13 (2.47, 3.97)	<0.001
Iron					
Unadjusted	1.00	1.55 (0.98, 2.45)	1.32 (0.83, 2.12)	1.12 (0.69, 1.83)	0.985
Model 1[5]	1.00	1.62 (1.01, 2.58)	1.37 (0.85, 2.21)	1.12 (0.68, 1.85)	0.992
Model 2[6]	1.00	1.05 (0.63, 1.75)	0.85 (0.50, 1.43)	0.93 (0.54, 1.60)	0.643
Potassium					
Unadjusted	1.00	1.62 (1.36, 1.94)	1.57 (1.32, 1.87)	1.69 (1.41, 2.01)	<0.001
Model 1[5]	1.00	1.63 (1.37, 1.94)	1.58 (1.32, 1.94)	1.69 (1.41, 2.01)	<0.001
Model 2[6]	1.00	1.32 (1.08, 1.60)	1.30 (1.07, 1.59)	1.87 (1.53, 2.29)	<0.001
Sodium					
Unadjusted	1.00	0.64 (0.51, 0.81)	0.72 (0.57, 0.91)	0.85 (0.67, 1.08)	0.584
Model 1[5]	1.00	0.63 (0.50, 0.80)	0.71 (0.56, 0.90)	0.85 (0.66, 1.08)	0.603
Model 2[6]	1.00	0.81 (0.63, 1.05)	0.94 (0.72, 1.22)	0.89 (0.68, 1.16)	0.673
Phosphorous					
Unadjusted	1.00	2.10 (1.43, 3.08)	2.15 (1.47, 3.15)	2.89 (2.00, 4.18)	<0.001
Model 1[5]	1.00	2.25 (1.52, 3.43)	2.31 (1.56, 3.42)	3.11 (2.12, 4.54)	<0.001
Model 2[6]	1.00	1.63 (1.05, 2.54)	1.65 (1.06, 2.58)	3.65 (2.37, 5.63)	<0.001

	Q1 (ref)	Q2	Q3	Q4	p_{trend}[4]
Magnesium					
Unadjusted	1.00	1.48 (1.13, 1.95)	1.47 (1.12, 1.93)	1.54 (1.18, 2.03)	0.006
Model 1[5]	1.00	1.80 (1.31, 2.47)	1.79 (1.30, 2.45)	1.78 (1.30, 2.43)	0.002
Model 2[6]	1.00	1.32 (0.92, 1.88)	1.36 (0.95, 1.94)	1.80 (1.26, 2.56)	0.001
Zinc					
Unadjusted	1.00	2.44 (1.32, 4.53)	2.88 (1.58, 5.27)	3.43 (1.90, 6.19)	<0.001
Model 1[5]	1.00	2.81 (1.48, 5.32)	3.42 (1.83, 6.40)	3.89 (2.11, 7.19)	<0.001
Model 2[6]	1.00	2.02 (1.03, 3.95)	2.49 (1.28, 4.82)	3.97 (2.07, 7.59)	<0.001
Iodine					
Unadjusted	1.00	2.54 (1.86, 3.48)	3.11 (2.29, 4.23)	4.61 (3.42, 6.20)	<0.001
Model 1[5]	1.00	2.61 (1.90, 3.58)	3.21 (2.36, 4.38)	4.79 (3.55, 6.47)	<0.001
Model 2[6]	1.00	2.13 (1.53, 2.97)	2.71 (1.96, 3.75)	5.45 (3.97, 7.48)	<0.001
Thiamin					
Unadjusted	1.00	0.77 (0.46, 1.30)	0.66 (0.38, 1.12)	0.58 (0.33, 1.02)	0.050
Model 1[5]	1.00	0.79 (0.47, 1.34)	0.67 (0.38, 1.15)	0.57 (0.32, 1.01)	0.044
Model 2[6]	1.00	0.55 (0.32, 0.95)	0.47 (0.26, 0.83)	0.49 (0.27, 0.89)	0.021
Riboflavin					
Unadjusted	1.00	1.62 (0.67, 3.90)	1.82 (0.77, 4.29)	4.48 (2.08, 9.63)	<0.001
Model 1[5]	1.00	1.68 (0.70, 4.06)	1.89 (0.80, 4.49)	4.61 (2.13, 9.97)	<0.001
Model 2[6]	1.00	1.11 (0.45, 2.77)	1.24 (0.51, 3.03)	4.47 (2.01, 9.93)	<0.001
DFE					
Unadjusted	1.00	0.82 (0.62, 1.08)	0.93 (0.71, 1.21)	0.99 (0.76, 1.29)	0.785
Model 1[5]	1.00	0.82 (0.61, 1.10)	0.95 (0.71, 1.26)	0.98 (0.74, 1.30)	0.826
Model 2[6]	1.00	0.66 (0.48, 0.89)	0.79 (0.59, 1.06)	0.93 (0.70, 1.25)	0.887
Vitamin A RE					
Unadjusted	1.00	1.56 (1.17, 2.09)	2.37 (1.80, 3.12)	3.21 (2.46, 4.20)	<0.001
Model 1[5]	1.00	1.64 (1.22, 2.22)	2.59 (1.95, 3.45)	3.50 (2.65, 4.62)	<0.001
Model 2[6]	1.00	1.31 (0.96, 1.79)	2.19 (1.63, 2.96)	3.77 (2.82, 5.06)	<0.001
Vitamin C					
Unadjusted	1.00	1.21 (0.89, 1.63)	0.98 (0.72, 1.34)	1.11 (0.82, 1.51)	0.767
Model 1[5]	1.00	1.21 (0.89, 1.63)	0.98 (0.72, 1.34)	1.11 (0.82, 1.51)	0.760
Model 2[6]	1.00	1.08 (0.80, 1.46)	0.87 (0.64, 1.20)	1.09 (0.80, 1.48)	0.778
Vitamin D					
Unadjusted	1.00	1.81 (1.42, 2.31)	2.35 (1.81, 3.05)	3.59 (2.67, 4.82)	<0.001
Model 1[5]	1.00	1.83 (1.43, 2.35)	2.38 (1.83, 3.10)	3.72 (2.76, 5.01)	<0.001
Model 2[6]	1.00	1.46 (1.12, 1.91)	2.16 (1.62, 2.86)	4.54 (3.27, 6.30)	<0.001
Vitamin E					
Unadjusted	1.00	1.79 (1.47, 2.18)	1.95 (1.59, 2.38)	2.19 (1.79, 2.69)	<0.001
Model 1[5]	1.00	1.80 (1.47, 2.19)	1.95 (1.60, 2.39)	2.19 (1.79, 2.69)	<0.001
Model 2[6]	1.00	1.51 (1.23, 1.87)	1.75 (1.42, 2.17)	2.37 (1.90, 2.95)	<0.001

CHO_{highGI} – carbohydrates from higher GI foods; SFA – saturated fat; LA – linoleic acid; ALA – alpha linolenic acid; LCn3PUFA – long chain omega-3 polyunsaturated fatty acids; DFE – dietary folate equivalents; RE – retinol equivalents

[1]Odds ratios calculated by logistic regression.

[2]For calcium, iron, iodine, zinc, magnesium, phosphorus, vitamin A RE, thiamin, riboflavin, DFE and vitamin C, intakes lower than the Estimated Average Requirement (EAR) were

considered not meeting the NRV; for potassium, LA, ALA, LCn3PUFA, dietary fibre, vitamin D and vitamin E, intakes lower than the Adequate Intake (AI) were considered inadequate; for sodium, intakes higher than the Upper Level (UL) were considered not meeting the NRV.

[3]Adjusted for energy using the residual method

[4]Tests for trend are based on ordinal variables containing median values for each quartile. $P < 0.01$ was considered to be of marginal statistical significance, and $p < 0.001$ was considered statistically significant.

[5]Adjusted for age and sex

[6]Model 1 with additional adjustment for total energy intake

Table 4 – Odds ratio[1] (95% Confidence Intervals) of ***NOT*** meeting the Australian Nutrient Reference Values (NRV)[2] for selected nutrients by age and sex specific CHO_{lowGI} quartiles[3]

	Q1 (ref)	Q2	Q3	Q4	p_{trend}[4]
Median intake (g)	70.6	91.2	114.1	159.5	-
%E from SFA					
Unadjusted	1.00	1.06 (0.80, 1.40)	1.03 (0.78, 1.36)	0.87 (0.67, 1.13)	0.225
Model 1[5]	1.00	1.06 (0.81, 1.40)	1.03 (0.78, 1.36)	0.87 (0.67, 1.13)	0.225
Model 2[6]	1.00	1.18 (0.89, 1.56)	1.12 (0.85, 1.48)	0.85 (0.65, 1.11)	0.118
LA					
Unadjusted	1.00	1.84 (1.54, 2.21)	1.80 (1.50, 2.15)	2.29 (1.90, 2.75)	<0.001
Model 1[5]	1.00	1.84 (1.53, 2.20)	1.79 (1.50, 2.15)	2.29 (1.90, 2.76)	<0.001
Model 2[6]	1.00	1.64 (1.35, 2.00)	1.65 (1.36, 2.00)	2.64 (2.15, 3.23)	<0.001
ALA					
Unadjusted	1.00	1.43 (1.19, 1.72)	1.37 (1.13, 1.65)	1.53 (1.27, 1.84)	<0.001
Model 1[5]	1.00	1.43 (1.19, 1.73)	1.37 (1.13, 1.65)	1.53 (1.27, 1.84)	<0.001
Model 2[6]	1.00	1.22 (1.00, 1.50)	1.22 (1.00, 1.50)	1.70 (1.39, 2.07)	<0.001
LCn3PUFA					
Unadjusted	1.00	1.62 (1.35, 1.94)	2.09 (1.74, 2.49)	2.22 (1.86, 2.66)	<0.001
Model 1[5]	1.00	1.63 (1.36, 1.95)	2.10 (1.75, 2.51)	2.23 (1.86, 2.67)	<0.001
Model 2[6]	1.00	1.51 (1.26, 1.81)	2.00 (1.67, 2.40)	2.31 (1.92, 2.77)	<0.001
Dietary fibre					
Unadjusted	1.00	0.95 (0.80, 1.13)	0.75 (0.63, 0.89)	0.52 (0.43, 0.61)	<0.001
Model 1[5]	1.00	0.95 (0.80, 1.14)	0.75 (0.63, 0.89)	0.51 (0.43, 0.61)	<0.001
Model 2[6]	1.00	0.78 (0.65, 0.94)	0.61 (0.51, 0.74)	0.47 (0.39, 0.57)	<0.001
Calcium					
Unadjusted	1.00	0.81 (0.68, 0.96)	0.66 (0.56, 0.79)	0.51 (0.42, 0.61)	<0.001
Model 1[5]	1.00	0.79 (0.65, 0.97)	0.60 (0.49, 0.74)	0.42 (0.34, 0.51)	<0.001
Model 2[6]	1.00	0.58 (0.47, 0.73)	0.44 (0.35, 0.56)	0.35 (0.28, 0.45)	<0.001
Iron					
Unadjusted	1.00	0.86 (0.54, 1.35)	1.08 (0.70, 1.65)	0.79 (0.50, 1.26)	0.470
Model 1[5]	1.00	0.88 (0.55, 1.40)	1.11 (0.71, 1.72)	0.78 (0.49, 1.26)	0.455
Model 2[6]	1.00	0.59 (0.35, 0.98)	0.96 (0.59, 1.55)	0.95 (0.57, 1.60)	0.657
Potassium					
Unadjusted	1.00	1.12 (0.94, 1.33)	0.83 (0.70, 0.99)	0.62 (0.52, 0.73)	<0.001
Model 1[5]	1.00	1.13 (0.95, 1.34)	0.84 (0.70, 0.99)	0.62 (0.52, 0.73)	<0.001
Model 2[6]	1.00	0.86 (0.70, 1.05)	0.62 (0.51, 0.76)	0.54 (0.44, 0.66)	<0.001
Sodium					
Unadjusted	1.00	0.69 (0.54, 0.87)	0.68 (0.54, 0.86)	0.80 (0.63, 1.02)	0.197
Model 1[5]	1.00	0.67 (0.53, 0.85)	0.66 (0.52, 0.84)	0.80 (0.62, 1.02)	0.192
Model 2[6]	1.00	0.81 (0.62, 1.05)	0.73 (0.56, 0.95)	0.69 (0.53, 0.90)	0.007
Phosphorous					
Unadjusted	1.00	1.14 (0.83, 1.56)	1.06 (0.77, 1.47)	0.84 (0.60, 1.18)	0.224
Model 1[5]	1.00	1.19 (0.86, 1.66)	1.10 (0.79, 1.53)	0.84 (0.59, 1.18)	0.200
Model 2[6]	1.00	0.87 (0.60, 1.27)	0.94 (0.64, 1.37)	1.00 (0.67, 1.49)	0.878
Magnesium					

	Q1 (ref)	Q2	Q3	Q4	p_{trend}[4]
Unadjusted	1.00	0.93 (0.73, 1.19)	0.83 (0.65, 1.07)	0.65 (0.50, 0.85)	0.001
Model 1[5]	1.00	0.98 (0.73, 1.32)	0.83 (0.61, 1.11)	0.56 (0.41, 0.76)	<0.001
Model 2[6]	1.00	0.74 (0.53, 1.04)	0.66 (0.47, 0.92)	0.53 (0.37, 0.75)	<0.001
Zinc					
Unadjusted	1.00	1.06 (0.65, 1.71)	1.11 (0.69, 1.78)	1.01 (0.62, 1.64)	0.971
Model 1[5]	1.00	1.14 (0.69, 1.90)	1.19 (0.72, 1.97)	0.99 (0.59, 1.66)	0.928
Model 2[6]	1.00	0.89 (0.52, 1.53)	1.05 (0.61, 1.80)	1.12 (0.65, 1.95)	0.534
Iodine					
Unadjusted	1.00	0.61 (0.49, 0.76)	0.45 (0.36, 0.57)	0.28 (0.21, 0.36)	<0.001
Model 1[5]	1.00	0.61 (0.49, 0.76)	0.44 (0.35, 0.57)	0.27 (0.20, 0.35)	<0.001
Model 2[6]	1.00	0.44 (0.35, 0.57)	0.34 (0.26, 0.43)	0.24 (0.18, 0.32)	<0.001
Thiamin					
Unadjusted	1.00	0.93 (0.53, 1.61)	0.86 (0.49, 1.51)	1.10 (0.65, 1.88)	0.695
Model 1[5]	1.00	0.96 (0.55, 1.69)	0.88 (0.50, 1.57)	1.11 (0.65, 1.92)	0.702
Model 2[6]	1.00	0.73 (0.41, 1.32)	0.76 (0.42, 1.38)	1.23 (0.70, 2.16)	0.344
Riboflavin					
Unadjusted	1.00	0.43 (0.22, 0.83)	0.44 (0.23, 0.84)	0.53 (0.29, 0.98)	0.056
Model 1[5]	1.00	0.44 (0.23, 0.86)	0.45 (0.23, 0.86)	0.52 (0.28, 0.98)	0.053
Model 2[6]	1.00	0.30 (0.15, 0.60)	0.36 (0.18, 0.71)	0.60 (0.31, 1.14)	0.163
DFE					
Unadjusted	1.00	0.74 (0.57, 0.96)	0.67 (0.51, 0.87)	0.61 (0.47, 0.80)	<0.001
Model 1[5]	1.00	0.74 (0.56, 0.97)	0.65 (0.49, 0.86)	0.57 (0.43, 0.76)	<0.001
Model 2[6]	1.00	0.63 (0.47, 0.84)	0.58 (0.43, 0.77)	0.57 (0.43, 0.77)	<0.001
Vitamin A RE					
Unadjusted	1.00	0.83 (0.67, 1.04)	0.60 (0.47, 0.76)	0.48 (0.37, 0.61)	<0.001
Model 1[5]	1.00	0.85 (0.67, 1.07)	0.58 (0.46, 0.75)	0.45 (0.35, 0.58)	<0.001
Model 2[6]	1.00	0.68 (0.53, 0.87)	0.48 (0.37, 0.63)	0.43 (0.33, 0.57)	<0.001
Vitamin C					
Unadjusted	1.00	1.04 (0.79, 1.37)	0.74 (0.55, 0.99)	0.53 (0.39, 0.74)	<0.001
Model 1[5]	1.00	1.04 (0.79, 1.37)	0.74 (0.55, 0.99)	0.53 (0.39, 0.74)	<0.001
Model 2[6]	1.00	0.94 (0.71, 1.25)	0.68 (0.50, 0.92)	0.54 (0.39, 0.75)	<0.001
Vitamin D					
Unadjusted	1.00	0.92 (0.70, 1.20)	0.98 (0.74, 1.28)	0.92 (0.70, 1.20)	0.646
Model 1[5]	1.00	0.91 (0.69, 1.19)	0.96 (0.73, 1.27)	0.92 (0.70, 1.20)	0.650
Model 2[6]	1.00	0.68 (0.51, 0.91)	0.76 (0.57, 1.02)	0.89 (0.66, 1.19)	0.793
Vitamin E					
Unadjusted	1.00	1.25 (1.02, 1.54)	1.19 (0.97, 1.46)	1.06 (0.87, 1.29)	0.887
Model 1[5]	1.00	1.26 (1.02, 1.55)	1.19 (0.97, 1.46)	1.06 (0.87, 1.30)	0.888
Model 2[6]	1.00	1.05 (0.84, 1.31)	1.02 (0.82, 1.26)	1.06 (0.85, 1.31)	0.689

CHO_{lowGI} – carbohydrates from low GI foods; SFA – saturated fat; LA – linoleic acid; ALA – alpha linolenic acid; LCn3PUFA – long chain omega-3 polyunsaturated fatty acids; DFE – dietary folate equivalents; RE – retinol equivalents

[1]Odds ratios calculated by logistic regression.

[2]For calcium, iron, iodine, zinc, magnesium, phosphorus, vitamin A RE, thiamin, riboflavin, DFE and vitamin C, intakes lower than the Estimated Average Requirement (EAR) were considered not meeting the NRV; for potassium, LA, ALA, LCn3PUFA, dietary fibre, vitamin D

and vitamin E, intakes lower than the Adequate Intake (AI) were considered inadequate; for sodium, intakes higher than the Upper Level (UL) were considered not meeting the NRV.
[3]Adjusted for energy using the residual method
[4]Tests for trend are based on ordinal variables containing median values for each quartile. $P < 0.01$ was considered to be of marginal statistical significance, and $p < 0.001$ was considered statistically significant.
[5]Adjusted for age and sex
[6]Model 1 with additional adjustment for total energy intake