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Fast Food consumption and Body Mass Index in children and adolescents: an international cross-sectional study

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11 **ABSTRACT:**
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14 **Objective:** To investigate whether reported fast food consumption over the previous year is
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16 associated with higher childhood or adolescent body mass index (BMI).
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20 **Design:** Secondary analysis from a multi-centre, multi-country, cross-sectional study
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22 (International Study of Asthma and Allergies in Children (ISAAC) Phase Three).
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25 **Subjects and Methods:** Parents / guardians of children aged 6-7 completed questionnaires
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27 which included questions about their children's asthma and allergies, fast food consumption, height
28
29 and weight. Adolescents aged 13-14 completed the same questionnaire. The questionnaire asked
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31 "In the past 12 months, how often on average did you (your child) eat fast food/burgers?"
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33 Responses were; infrequent (never / only occasionally), frequent (once / twice a week), or very
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35 frequent (three or more times per week). A general linear mixed model was used to determine the
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37 association between BMI and fast food consumption, adjusting for Gross National Income per capita
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39 by country, reported or measured height and weight, age, and sex.
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44 **Results:** 72,900 children from 17 countries and 199,135 adolescents from 36 countries provided
45
46 data. Frequent and very frequent fast food consumption was reported in 23% and 4% of children,
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48 and 39% and 13% of adolescents. Children in the frequent and very frequent groups had a BMI 0.15
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50 kg/m² and 0.22 kg/m² higher than the infrequent group (P<0.001). Adolescent males in the frequent
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52 and very frequent groups had a BMI 0.14 kg/m² and 0.28kg/m² lower than the infrequent group
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54 (P<0.001). Adolescent females in the frequent and very frequent groups had a BMI 0.19kg/m² lower
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56 than the infrequent group (P<0.001).
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4 51 **Conclusion:** Reported fast food consumption is high in childhood and increases in adolescence.
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6 52 Frequent and very frequent consumption is associated with a higher BMI in children. In contrast, this
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9 53 is associated with a lower BMI in adolescents.
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12 54 **Strengths and limitations of this study:**
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15 55 • 199,135 adolescents from 36 countries and 72,900 children from 17 countries provided
16
17 56 information on their height, weight and fast food consumption.
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20 57 • Many of the countries were middle and low income from which previous data on the
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22 58 association of fast food consumption and BMI had not been reported.
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25 59 • There is an association between increasing frequency of fast food consumption and higher
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27 60 BMIs in 6-7 year old children, but this association was reversed in adolescents.
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30 61 • As this is a cross sectional study, causality cannot be proven, but it provides evidence that
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32 62 among children from many different nations, fast food consumption may contribute to
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34 63 weight gain.
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37 64 • The reverse association observed in adolescents should be interpreted with caution, as the
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39 65 results may be affected by bias, particularly under-reporting of fast food consumption and
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41 66 reverse causation.
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69 INTRODUCTION:

70 The rising prevalence of childhood obesity is marked (1, 2), and there are well documented concerns
71 about the future health implications of obesity in childhood (3-7). This problem has been identified
72 in low and middle income countries as well as affluent countries (8, 9).

73 While potential contributors to the problem of childhood obesity are considered to be multiple and
74 complex, the increasing availability of fast food in many countries has been implicated due to its
75 energy dense and low nutritional nature, large portion sizes and increasing availability (10-13).

76 Studies investigating associations between fast food consumption in children and Body Mass Index
77 (BMI) have produced mixed results, some demonstrating small but significant associations between
78 fast food consumption and increased BMI (12, 14-17), while others have failed to demonstrate a
79 significant association (18-20). Many of these have been single centre studies and involved small
80 populations.

81 The International Study of Asthma and Allergies in Childhood (ISAAC) Phase Three programme was
82 designed to measure time trends in the prevalence and severity of asthma, rhinoconjunctivitis and
83 eczema and to explore the relationship between lifestyle, other putative risk factors and the
84 development of asthma and allergies (21). It also provided the opportunity to explore the
85 relationship between lifestyle factors such as fast food consumption and BMI, as heights, weights
86 and information on the frequency of fast food consumption of participants were gathered in many
87 centres through an optional environmental questionnaire that was answered by parents of children
88 and by the adolescents themselves.

89 We hypothesised that there would be an association between greater fast food consumption and
90 higher BMI in both children and adolescents, and that this association would be observed
91 worldwide.

92 **SUBJECTS AND METHODS:**

93 ISAAC is a multicentre, multi-country, multiphase, cross-sectional study investigating the prevalence
94 of the symptoms of asthma, rhinoconjunctivitis and eczema, and the role of risk factors, as
95 previously described (21). ISAAC Phase Three used the Phase One standardised core questionnaire
96 on symptoms of asthma, rhinoconjunctivitis and eczema, and included an optional environmental
97 questionnaire to collect potential risk factor data including height, weight, and fast food
98 consumption. Adolescents self-completed their questionnaires and parents or guardians completed
99 questionnaires for the children. The questionnaires are on the ISAAC website: isaac.auckland.ac.nz.

100 **Main outcome variable - Body Mass Index:**

101 Height and weight were reported by the parents of the children, and were self-reported by
102 adolescents. In some centres, each subject's height and weight were measured objectively; there
103 were no standardised or specific instructions for doing this. BMI was calculated as weight (kg)/height
104 (m)².

105 **Explanatory variables:**

106 Fast food consumption was established by asking participants to answer the following question: "In
107 the past 12 months, how often, on average, did you [your child] eat the following?"

108 'Fast Food / Burgers' were listed as one option along with 14 other foodstuffs including meat,
109 seafood, fruit and vegetables. The participants were asked to categorise their intake of each listed
110 food as "Never or only occasionally"; "once or twice per week"; or "Three or more times a week".

111 These responses were categorised as 'infrequent', 'frequent' and 'very frequent'. Each variable was
112 examined separately for both age groups.

113 Country Gross National Index (GNI) was based on the 2006 World Bank of Gross National Income by
114 country. The World Bank categories of high income, high middle income, low middle income and low

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4 115 income countries were dichotomised into 'high income' (high and high middle income) and 'low
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6 116 income' (low middle and low income) categories.
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10 **Participants:**

11 118 For children aged 6-7 years, data were submitted from 73 centres in 32 countries (214,706 subjects).

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13 119 For adolescents aged 13-14 years data were submitted from 125 centres in 54 countries (369,881
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15 120 subjects).
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18 121 Centres that provided data on height, weight and fast food consumption for at least 70% of
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20 122 participants were included in our analyses. Individuals without complete age, sex, fast food
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22 123 consumption, height or weight data were excluded.
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26 **Data cleaning:**

27 125 To eliminate likely erroneous BMI data, we applied the following thresholds:
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30 126 - For children in each centre, those in the top and bottom 0.5% of weights and heights, and
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32 127 those with heights less than 1.0 metre were excluded. Children with BMI less than $9\text{kg}/\text{m}^2$
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34 128 and greater than $40\text{kg}/\text{m}^2$ were excluded.
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38 129 - For adolescents in each centre, those in the top and bottom 0.5% of weights and heights,
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40 130 and those with heights less than 1.25 metres were excluded. Adolescents with BMI less than
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42 131 $10\text{kg}/\text{m}^2$ and greater than $45\text{kg}/\text{m}^2$ were excluded.
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45 132 Following sequential application of the exclusion and data cleaning criteria described above, 72,900
46
47 133 children (30 centres / 17 countries) and 199,135 adolescents (74 centres / 36 countries) were
48
49 134 included in the final analysis (Figure 1). Parents provided heights and weights for 60,027 children,
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51 135 while 12,873 children had their heights and weights measured. 154,624 adolescents provided self-
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53 136 reported height and weight while 44,511 adolescents had measured heights and weights.
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57 **Figure 1: Flow of subjects through study.**
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4 138 **STATISTICAL ANALYSIS:**

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6 139 BMI was assessed separately for each age group using a general linear mixed model with centre as a
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8 140 random effect and GNI for each country (low and high), the individual's age, sex, measurement type
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10 141 (reported or measured), and fast food consumption('infrequent', 'frequent' 'very frequent') as fixed
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12 142 effects. The BMI values reported are the modelled means for those who reported infrequent fast
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14 143 food consumption in the children and adolescent groups respectively.

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17 144 In the adolescent group statistically significant interactions were found between sex and fast food
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19 145 consumption, and measurement type and fast food consumption. There was also an interaction
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21 146 found between country GNI and fast food consumption. Consequently, analyses were done
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23 147 separately for each sex, measured height and weight data only, and GNI categories. No similar
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25 148 interactions were found in the children's group, but there were sufficient numbers to analyse each
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27 149 sex separately, which we elected to do.

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32 150 **RESULTS:**

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34 151 **Fast food consumption:**

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36 152 22.6% of children reported frequent fast food consumption and 4.2% reported very frequent fast
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38 153 food consumption. Combined frequent and very frequent fast food consumption in each country
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40 154 ranged from 10% in Poland to 63% in South Korea (Figure 2a).

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43 155 38.7% of adolescents reported frequent fast food consumption and 12.6% reported very frequent
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45 156 consumption. Frequent and very frequent fast food consumption ranged from 15% in Indonesia to
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47 157 79% in South Africa (Figure 2b).

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50 158 **Figure 2: Reported fast food consumption of study participants by country.**

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4 **160 Fast food consumption and BMI:**

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7 **161 Children:**

8 **162** Figure 3a shows the difference in BMI between children with infrequent fast food consumption and
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10 **163** those with frequent and very frequent fast food consumption in each centre.

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13 **164 Figure 3a: The association between reported fast food consumption and BMI of children.**

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15 **165** The estimated mean BMIs in children reporting infrequent fast food consumption were 16.20 and
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17 **166** 16.51 kg/m² for ages 6 and 7 respectively. After controlling for country GNI, centre, age and
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19 **167** measurement type, there was a statistically significant association between frequent and very
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21 **168** frequent fast food consumption and higher BMI with an apparent dose response effect (+0.15 and
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23 **169** +0.22kg/m² for frequent and very frequent fast food consumption respectively), (Table 1). There
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25 **170** was no statistically significant interaction between GNI and fast food consumption in this age group
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27 **171** (P=0.06).

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31 **172 Table 1 – Association between fast food consumption and BMI (SE) of study participants after**
32 **173 adjustment for GNI**

		Difference in BMI (Kg/m ²) compared with infrequent fast food consumption		
	Estimated mean BMI* (Kg/m ²) infrequent fast food consumption	Frequent fast food consumption mean (SE)	Very frequent fast food consumption mean (SE)	P value ⁱ
Children (N=72,900)	16.51	+ 0.15 (0.02)	+ 0.22 (0.05)	P<0.001
Male Children (N=36,778)	16.53	+0.16 (0.03)	+0.24 (0.06)	P<0.001
Female Children (N=36,122)	16.39	+0.14 (0.03)	+0.20 (0.07)	P<0.001
Adolescent Males (N=98,794)	20.02	-0.14 (0.02)	- 0.28 (0.03)	P<0.001
Adolescent Females (N=100,341)	19.98	-0.19 (0.02)	- 0.19 (0.03)	P<0.001
Participants with measured height and weight data				
Children (N=12,873)	15.88	+0.14 (0.05)	+0.13 (0.08)	P=0.02
Adolescent Males (N= 20,384)	19.67	-0.03 (0.05)	-0.11(0.07)	P=0.24

Adolescent Females (N=24,127)	20.15	-0.15 (0.05)	-0.09 (0.06)	P=0.004
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174 ^aEstimated BMIs for children aged 7 years and adolescents aged 14 years.

175 ⁱ P value is a test of whether the estimated mean BMIs for frequent and very frequent fast food consumption are zero.

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177 When boys and girls were analysed separately, both sexes had a significant positive association
178 between frequent and very frequent fast food consumption (Table 1).

179 **Adolescents:**

180 Figure 3b shows the difference in BMI between adolescents with infrequent fast food consumption
181 and those with frequent and very frequent fast food consumption in each centre.

182 **Figure 3b: The association between fast food consumption and BMI of adolescents**

183 In male adolescents, the estimated mean BMIs for those reporting infrequent fast food consumption
184 were 19.74 and 20.02 kg/m² for ages 13 and 14 respectively. After controlling for country GNI,
185 centre, age and measurement type, lower BMI's were significantly associated with greater fast food
186 consumption (Table 1). There was a statistically significant interaction between fast food
187 consumption and GNI. In low GNI countries the frequency of fast food consumption had no
188 association with BMI (+0.01 and -0.03kg/m² in the frequent and very frequent groups respectively
189 (P=0.89 and 0.56)). In high GNI countries, lower BMI's were associated with greater fast food
190 consumption (-0.21 and -0.42kg/m² in the frequent and very frequent groups respectively (P<0.001
191 in both groups)).

192 When analyses were restricted to the 20,384 male adolescents who had measured height and
193 weight data there was a tendency towards a lower BMI with higher fast food consumption, but this
194 was not statistically significant (-0.03kg/m² and -0.11kg/m² in the frequent and very frequent group
195 respectively, (p=0.24)).

196 In female adolescents, the estimated mean BMI's for those reporting infrequent fast food
197 consumption were 19.56 and 19.98 kg/m² for ages 13 and 14 respectively. Lower BMIs were

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4 198 associated with greater fast food consumption and this was statistically significant. There was a
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6 199 statistically significant interaction between fast food consumption and GNI. Both low and high GNI
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8 200 countries had an association between increasing fast food consumption and BMI (low GNI countries
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10 201 $-0.10\text{kg}/\text{m}^2$ and $-0.11\text{kg}/\text{m}^2$ in the frequent and very frequent groups respectively ($P=0.03$ and 0.01),
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12 202 and high GNI countries $-0.24\text{kg}/\text{m}^2$ and $-0.22\text{kg}/\text{m}^2$ in the frequent and very frequent groups
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14 203 respectively ($P<0.0001$ in both cases)).

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18 204 When analyses were restricted to the 24,127 female adolescents who had measured height and
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20 205 weight data, those who ate fast food frequently or very frequently had lower BMIs and this was
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22 206 statistically significant (Table 1).
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25 207 **DISCUSSION:**

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27 208 This international study has identified that 6-7 year old children whose parents reported frequent
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29 209 consumption of fast food had higher BMIs than those whose parents reported infrequent fast food
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31 210 consumption. This association was independent of the affluence of the country and of similar
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33 211 magnitude in boys and girls. By contrast, adolescents who self-reported that they frequently ate fast
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35 212 foods tended to have lower BMIs, with the exception of male adolescents from low GNI countries,
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37 213 where there was no association between fast food consumption and BMI.
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40 214 **Children**

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42 215 Our results in children are consistent with those of Shan et al who found that 'Western fast food'
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44 216 and 'snack food' were associated with overweight and obesity among children aged 2 to 18 years in
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46 217 Beijing(22). However, In New Zealand, Duncan et al found that low levels of physical activity,
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48 218 skipping breakfast and insufficient sleep on weekdays were associated with increased adiposity in 5
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50 219 to 11 year olds, but that fast food consumption was not (20). The magnitude of the association
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52 220 between fast food consumption and BMI in children was small (mean BMI values $0.15\text{ kg}/\text{m}^2$ and
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54 221 $0.22\text{kg}/\text{m}^2$ higher in frequent and very frequent consumers compared to infrequent consumers), and
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4 222 the clinical significance of this is uncertain. Given the long term consequences of overweight and
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6 223 obesity in childhood, even a small change in mean BMI in a population could be of major public
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8 224 health significance.
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11 225 An observational study such as this cannot attribute causality. The association we have found
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13 226 between fast food consumption and BMI in children could be due to other specific dietary factors
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15 227 that have been shown to be associated with fast food consumption, such as higher fat intake,
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17 228 greater consumption of sugary drinks, fewer fruits and non-starchy vegetables(11). Alternatively
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19 229 fast food consumption may be a marker of other factors that influence BMI such as parental BMI,
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21 230 individual socioeconomic circumstances or patterns of activity and inactivity.
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24 25 231 Adolescents

26 232 In our analysis self-reported frequent fast food consumption was associated with a lower BMI in
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28 233 adolescents, with stronger association in higher GNI countries. As far as we are aware, no other
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30 234 studies have demonstrated a lower BMI with higher fast food consumption in adolescence and our
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32 235 findings appear to be in stark contrast to other research findings from high GNI countries. One study
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34 236 showed that increasing fast food consumption in American adolescents was associated with
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36 237 increased weight gain from adolescence to adulthood (12). Another study found that American
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38 238 adolescents who consumed greater quantities of fried food away from home were heavier (23), and,
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40 239 in a further American study, increasing frequency of eating quick-service food was associated with
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42 240 an increasing z-BMI in adolescent females (17). A United Kingdom study found that increased visits
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44 241 to fast food outlets was associated with higher BMI standard deviation scores in teenagers (24). In
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46 242 three of these studies heights and weights were measured to pre-set standards by trained
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48 243 investigators (12, 17, 24), whereas heights and weights of our adolescent participants were mostly
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50 244 self-reported. It is possible that in our study some of the larger participants, particularly from body-
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52 245 image conscious countries or cultures may have under-reported their weights. If this were the case,
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54 246 we might expect that the association between fast food consumption and lower BMI would not be
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4 247 observed when we restricted our analysis to measured height and weight data. Although this was
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6 248 the case in male adolescents, surprisingly the association between higher rates of fast food
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8 249 consumption and lower BMI persisted in female adolescents. We need to consider the possibility
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10 250 that because of the perception of the negative effects of fast food consumption, adolescents who
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12 251 are overweight or obese are likely to have under-reported their actual fast food consumption.
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14 252 Finally, it is possible that our results are influenced by a degree of reverse-causation where those
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16 253 participants who are already overweight or obese are avoiding fast foods in order to reduce their
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18 254 body weight.
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22 Fast food consumption

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24 256 This study has shown that up to 25% of children worldwide consume fast food frequently or very
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26 257 frequently, and this increases to over 50% in the adolescent age group. This is consistent with results
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28 258 of previous studies, particularly those based in the United States and the United Kingdom (11, 25,
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30 259 26). This study has highlighted is the unexpectedly high proportion of fast food consumption in both
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32 260 age groups in many developing countries, for which data have not previously been available. In
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34 261 particular, high prevalence of fast food consumption was observed in centres in Latin America and
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36 262 Asia similar in magnitude to that observed in the United States and Western Europe. Importantly,
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38 263 we have also shown that the association between fast food consumption and higher BMI in children
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40 264 persists among those from both affluent and less affluent countries.
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44 265 Cohort studies have demonstrated that high consumption of fast food at first assessment is
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46 266 associated with higher BMIs later in childhood or adult life (12, 24). If this is the case, despite an
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48 267 apparently lower BMI with higher reported fast food consumption in the adolescent group, the high
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50 268 proportions of adolescents already reporting fast food consumption is of concern, as fast food
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52 269 consumption has been directly linked with insulin resistance, hypertension and other health
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54 270 sequelae (27).
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4 271 **Strengths and limitations:**

5 272 The major strengths of this study were its size and multicentre structure, with 199,135 adolescents
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8 273 from 36 countries and 72,900 children from 17 countries surveyed. Many of the centres were from
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10 274 middle and low income countries from which previous data on the association between fast food
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12 275 consumption and BMI had not been reported.

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15 276 The main limitation to this study is the cross-sectional design which allows identification of
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17 277 associations, but not of temporal sequence or causality. The assessment of subject heights and
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19 278 weights and their fast food consumption was primarily undertaken by questionnaire which raises the
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21 279 possibility of misclassification error, particularly with respect to the parent-reported weights of their
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23 280 children and self-reported weights of the adolescents, thereby influencing the calculated BMI. It is
24
25 281 also possible that parents and adolescents may have misreported fast food consumption.

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29 282 A further consideration is the interpretation of the question about the consumption of burgers / fast
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31 283 foods. While 'burger' is almost universally understood, 'fast food' can be interpreted in a number of
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33 284 ways, including foodstuffs from global restaurant chains, smaller non-franchised food stores, street
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35 285 vendors and even frozen meals heated and served at home. Without knowing the exact kind of fast
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37 286 food consumed, we can make no assessment of the nutritional content or energy density of the food
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39 287 in question. Additionally, while the questionnaire asked about the frequency of burgers / fast food
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41 288 consumption, we have no indication of portion sizes, or if it was accompanied by other items such as
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43 289 sugar sweetened beverages.

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47 290 Finally, centres that objectively measured heights and weights received no standardised instructions
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49 291 for doing this. We have controlled for GNI, centre, measurement type, and sex in our analysis. We
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51 292 have no data available on individual socioeconomic status or parental BMI which could potentially
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53 293 affect young peoples' BMI, nor did we control for physical activity / inactivity of the participants.
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294 **CONCLUSIONS:**

295 There is an association between a high frequency of fast food consumption and higher BMIs in 6-7
296 year old children, but this association is reversed in adolescents. As this is a cross sectional study,
297 causality cannot be proven, however it provides evidence that among children from many different
298 nations, fast food consumption may contribute to weight gain. This reverse association observed in
299 adolescents should be interpreted with caution, as the results may be affected by bias, particularly
300 under-reporting of fast food consumption and reverse causation.

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4 319 **ACKNOWLEDGEMENTS:**

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7
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9
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11
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13
14
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16
17 325 Kids had no role or influence in design and conduct of the study; collection, management, analysis,
18
19 326 and interpretation of the data; and preparation, review, or approval of the manuscript; and decision
20
21 327 to submit the manuscript for publication.

22
23
24 328 **Author Contributions:** Mr A Stewart had access to all the data on the study and takes
25
26 329 responsibility for the integrity of the data and accuracy of the data analysis. *Study concept*
27
28 330 *and design:* All authors. *Acquisition of Data:* ISAAC steering committee. *Drafting of the*
29
30 331 *manuscript:* Braithwaite. *Critical revision of the manuscript for important intellectual*
31
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34
35 333 *Administrative, technical and material support:* All authors. *Study supervision:* Mitchell.

36
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39 335 development of this article.

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41
42 336 **Data Sharing Statement:** Information with respect to all ISAAC studies, including methods, data
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44 337 gathering and results is available on the ISAAC website: isaac.auckland.ac.nz/

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46
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4 343 **ISAAC Steering Committee:**
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6
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4 484 FIGURE LEGENDS
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6 485 **Figure 1: Flow of participants through study. Children are represented in panel (a) and adolescents**
7 **486 in panel (b)**
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11 488 **Figure 2: Reported frequency of fast food consumption by study participants. Children are**
12 **489 represented in panel (a) and adolescents in panel (b)**
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16 491 **Figure 3: Association between BMI of study participants and frequent and very frequent fast food**
17 **492 consumption compared to infrequent fast food consumption. Children are represented in panel (a)**
18 **493 and adolescents in panel (b)**
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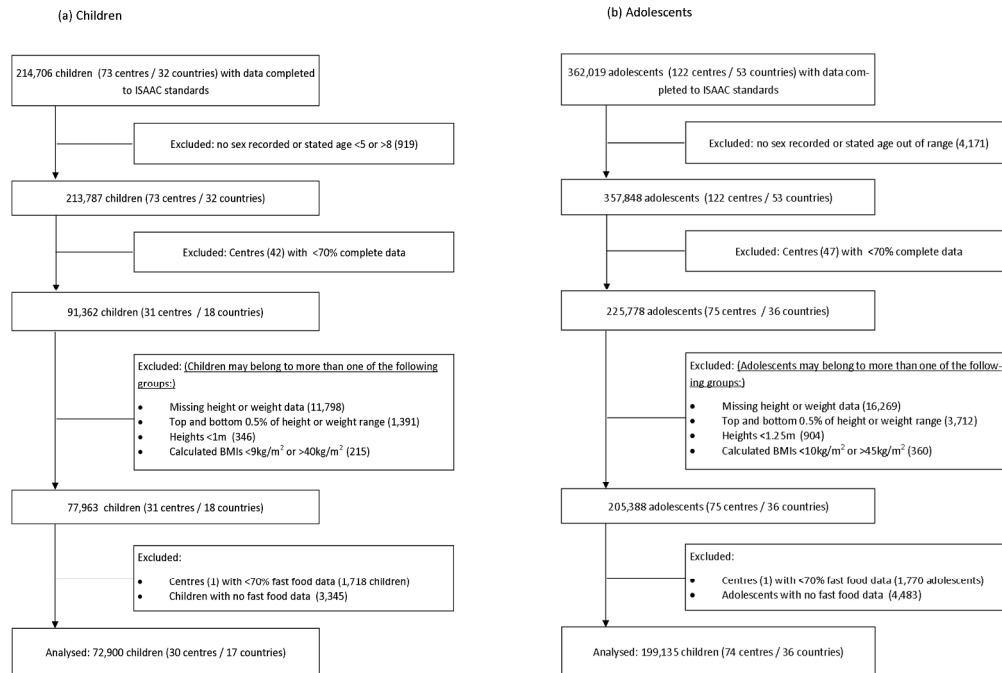


Figure 1: Flow of participants through study. Children are represented in panel (a) and adolescents in panel (b)

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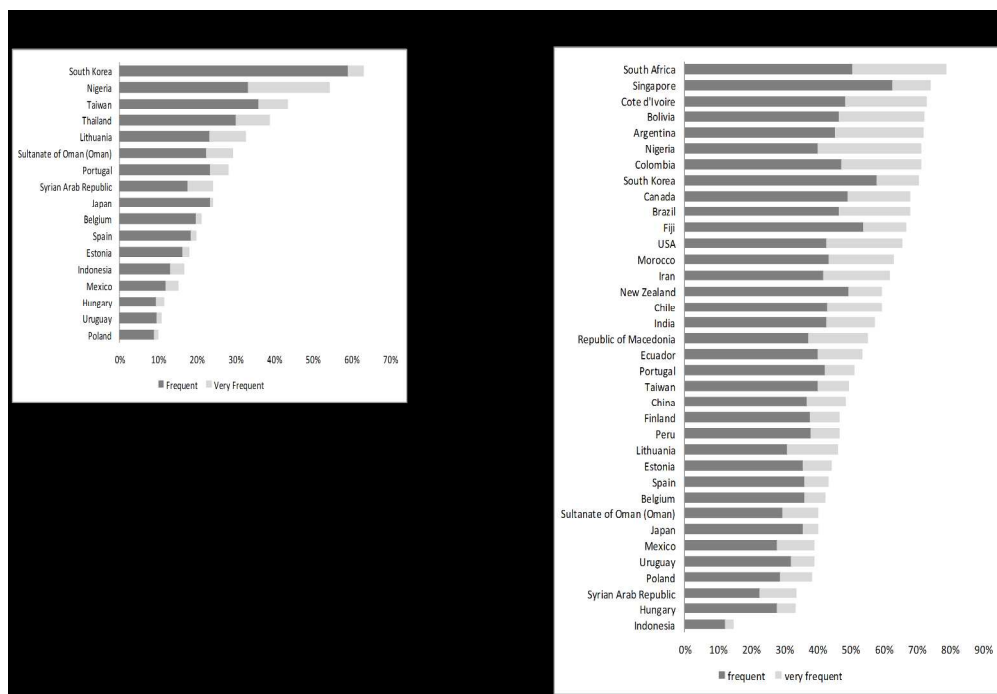


Figure 2: Reported frequency of fast food consumption by study participants. Children are represented in panel (a) and adolescents in panel (b)
261x179mm (300 x 300 DPI)

View only

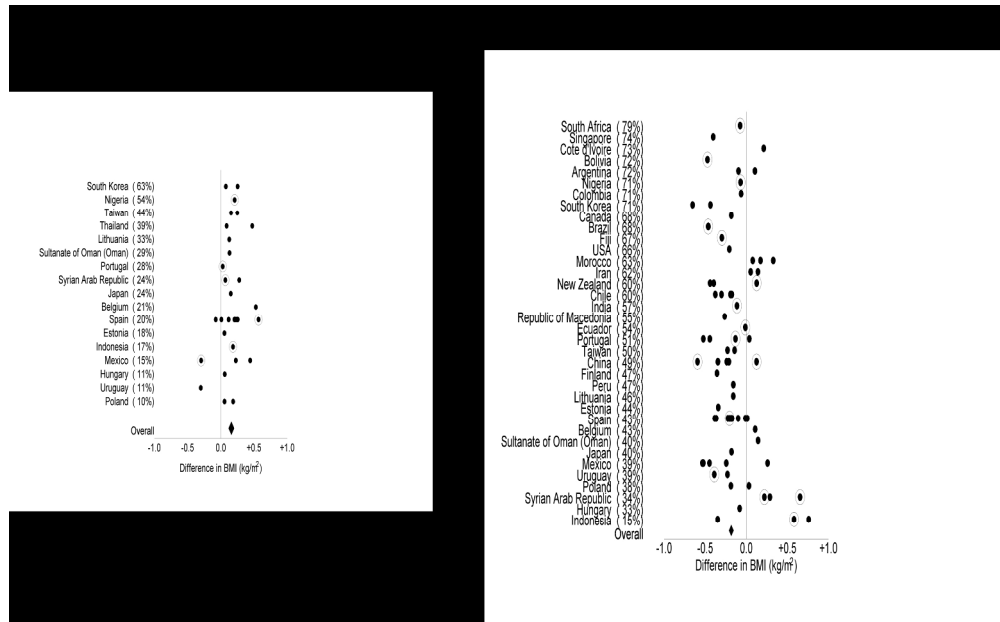


Figure 3: Association between BMI of study participants and frequent and very frequent fast food consumption compared to infrequent fast food consumption. Children are represented in panel (a) and adolescents in panel (b)
 261x161mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	Title page
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	5-6
Methods			
Study design	4	Present key elements of study design early in the paper	5-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
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	6-7
Bias	9	Describe any efforts to address potential sources of bias	7-8
Study size	10	Explain how the study size was arrived at	N/A
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
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	N/A
		(d) If applicable, describe analytical methods taking account of sampling strategy	8
		(e) Describe any sensitivity analyses	N/A
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	Figures 1a and 1b
		(b) Give reasons for non-participation at each stage	Figures 1a and 1b
		(c) Consider use of a flow diagram	Done
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	Figures 1a and 1b
Outcome data	15*	Report numbers of outcome events or summary measures	9-11
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	9-11, including Table 1
		(b) Report category boundaries when continuous variables were categorized	6-7
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9-11
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
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	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
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	2

*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.

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Fast Food consumption and Body Mass Index in children and adolescents: an international cross-sectional study

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Primary Subject Heading:	Paediatrics
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Keywords:	BMI, Fast food consumption, International, Childhood obesity, Childhood overweight

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Manuscripts

Fast Food consumption and Body Mass Index in children and adolescents: an international cross-sectional study

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27 **ABSTRACT:**

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29 **Objective:** To investigate whether reported fast food consumption over the previous year is
30 associated with higher childhood or adolescent body mass index (BMI).

31 **Design:** Secondary analysis from a multi-centre, multi-country, cross-sectional study
32 (International Study of Asthma and Allergies in Children (ISAAC) Phase Three).

33 **Subjects and Methods:** Parents / guardians of children aged 6-7 completed questionnaires
34 which included questions about their children's asthma and allergies, fast food consumption, height
35 and weight. Adolescents aged 13-14 completed the same questionnaire. The questionnaire asked
36 "In the past 12 months, how often on average did you (your child) eat fast food/burgers?"
37 Responses were; infrequent (never / only occasionally), frequent (once / twice a week), or very
38 frequent (three or more times per week). A general linear mixed model was used to determine the
39 association between BMI and fast food consumption, adjusting for Gross National Income per capita
40 by country, measurement type (whether height and weight were reported or measured), age, and
41 sex.

42 **Results:** 72,900 children from 17 countries and 199,135 adolescents from 36 countries provided
43 data. Frequent and very frequent fast food consumption was reported in 23% and 4% of children,
44 and 39% and 13% of adolescents. Children in the frequent and very frequent groups had a BMI 0.15
45 kg/m² and 0.22 kg/m² higher than the infrequent group (P<0.001). Adolescent males in the frequent
46 and very frequent groups had a BMI 0.14 kg/m² and 0.28kg/m² lower than the infrequent group
47 (P<0.001). Adolescent females in the frequent and very frequent groups had a BMI 0.19kg/m² lower
48 than the infrequent group (P<0.001).

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4 49 **Conclusion:** Reported fast food consumption is high in childhood and increases in adolescence.
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7 50 Compared with infrequent fast food consumption, frequent and very frequent consumption is
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9 51 associated with a higher BMI in children and a lower BMI in adolescents.

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12 52 **Strengths and limitations of this study:**
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15 53 • 199,135 adolescents from 36 countries and 72,900 children from 17 countries provided
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17 54 information on their height, weight and fast food consumption.
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21 55 • Many of the countries were middle and low income from which previous data on the
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23 56 association of fast food consumption and BMI had not been reported.
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26 57 • There is an association between increasing frequency of fast food consumption and higher
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28 58 BMIs in 6-7 year old children, but this association was reversed in adolescents.
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31 59 • As this is a cross sectional study, causality cannot be proven, but it provides evidence that
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33 60 among children from many different nations, fast food consumption may contribute to
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35 61 weight gain.
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38 62 • The reverse association observed in adolescents should be interpreted with caution, as the
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40 63 results may be affected by bias, particularly under-reporting of fast food consumption and
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42 64 reverse causation.
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67 INTRODUCTION:

68 The rising prevalence of childhood obesity is marked (1, 2), and there are well documented concerns
69 about the future health implications of obesity in childhood (3-7). This problem has been identified
70 in low and middle income countries as well as affluent countries (8, 9).

71 While potential contributors to the problem of childhood obesity are considered to be multiple and
72 complex, in many countries fast food has been implicated due to its increasing availability, energy
73 density, and large portion sizes. (10-13). Studies investigating associations between fast food
74 consumption in children and Body Mass Index (BMI) have produced mixed results, some
75 demonstrating small but significant associations between fast food consumption and increased BMI
76 (12, 14-17), while others have failed to demonstrate a significant association (18-20). In a systematic
77 review of studies assessing the association between fast food and obesity in 2008, Rosenheck noted
78 that 'it is difficult to ascertain the true relationship between fast food consumption and weight gain
79 or obesity, as many confounding factors such as physical inactivity and less inhibited food
80 consumption are independently associated with both fast food consumption and weight gain or
81 obesity' and that '... residual confounding from immeasurable lifestyle choices will always distort
82 results garnered from observational study designs.'(14).

83 Additionally Rosenheck commented on the sample sizes of the cross-sectional studies, where only
84 one study enrolled more than 5,000 participants, and in general enrolment was closer to the 1,000
85 mark, potentially negatively impacting the power of the studies to effectively assess the association
86 between fast food consumption and weight / obesity. A cross-sectional study large enough to
87 achieve sufficient power to determine an association between fast food consumption and obesity
88 AND adequately address issues of multiple confounding factors is likely to be logistically demanding
89 and prohibitively costly. A secondary analysis of the data from the International Study of Asthma
90 and Allergies in Childhood (ISAAC) Phase Three programme allows an international 'snapshot' of fast
91 food consumption and an assessment of the association between fast food consumption and BMI in

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4 92 72,900 children from 17 countries and 199,135 adolescents from 36 countries at a single point in
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6 93 time, using a simple universal question. While few confounding variables are taken into account, the
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8 94 large numbers involved give power to this analysis.
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11 95 We hypothesised that there would be an association between greater fast food consumption and
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13 96 higher BMI in both children and adolescents, and that this association would be observed
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15 97 worldwide.
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17 18 19 98 **SUBJECTS AND METHODS:**

20 99 The International Study of Asthma and Allergies in Childhood (ISAAC) Phase Three programme was
21
22 100 designed to measure time trends in the prevalence and severity of asthma, rhinoconjunctivitis and
23
24 101 eczema and to explore the relationship between lifestyle, other putative risk factors and the
25
26 102 development of asthma and allergies (21). ISAAC Phase Three used the ISAAC Phase One
27
28 103 standardised core questionnaire on symptoms of asthma, rhinoconjunctivitis and eczema. ISAAC
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30 104 Phase Three provided the additional opportunity to explore the relationship between lifestyle
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32 105 factors such as fast food consumption and BMI, as heights, weights and information on the
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34 106 frequency of fast food consumption of participants were gathered in many centres through an
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36 107 optional environmental questionnaire that was answered by parents of children and by the
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38 108 adolescents themselves.
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43 109 The ISAAC Phase One standardised core questionnaire and ISAAC Phase Three environmental
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45 110 questionnaire are on the ISAAC website: isaac.auckland.ac.nz.
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48 111 Ethical approval was obtained for the original ISAAC Phase Three study, and permission was gained
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50 112 to use the data from ISAAC Phase Three through agreement with the ISAAC Phase Three Steering
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52 113 Committee.
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114 **Main outcome variable - Body Mass Index:**

115 Height and weight were reported by the parents of the children, and were self-reported by
116 adolescents. In some centres, each subject's height and weight were measured objectively; there
117 were no standardised or specific instructions for doing this. BMI was calculated as weight (kg)/height
118 (m)².

119 **Explanatory variables:**

120 Fast food consumption was established by asking participants to answer the following question: "In
121 the past 12 months, how often, on average, did you [your child] eat the following?"

122 'Fast Food / Burgers' were listed as one option along with 14 other foodstuffs including meat,
123 seafood, fruit and vegetables. The participants were asked to categorise their intake of each listed
124 food as "Never or only occasionally"; "once or twice per week"; or "Three or more times a week".

125 These responses were categorised as 'infrequent', 'frequent' and 'very frequent'. Each variable was
126 examined separately for both age groups.

127 Country Gross National Index (GNI) was based on the 2006 World Bank of Gross National Income by
128 country. The World Bank categories of high income, high middle income, low middle income and low
129 income countries were dichotomised into 'high income' (high and high middle income) and 'low
130 income' (low middle and low income) categories.

131 **Participants:**

132 For children aged 6-7 years, data were submitted from 73 centres in 32 countries (214,706 subjects).

133 For adolescents aged 13-14 years data were submitted from 125 centres in 54 countries (369,881
134 subjects).

135 Centres that provided data on height, weight and fast food consumption for at least 70% of
136 participants were included in our analyses. Individuals without complete age, sex, fast food
137 consumption, height or weight data were excluded.

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4 138 Data cleaning:

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6 139 To eliminate likely erroneous BMI data, we applied the following thresholds:

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9 140 - For children in each centre, those in the top and bottom 0.5% of weights and heights, and

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11 141 those with heights less than 1.0 metre were excluded. Children with BMI less than $9\text{kg}/\text{m}^2$

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13 142 and greater than $40\text{kg}/\text{m}^2$ were excluded.

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15
16 143 - For adolescents in each centre, those in the top and bottom 0.5% of weights and heights,

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18 144 and those with heights less than 1.25 metres were excluded. Adolescents with BMI less than

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20 145 $10\text{kg}/\text{m}^2$ and greater than $45\text{kg}/\text{m}^2$ were excluded.

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22
23 146 Following sequential application of the exclusion and data cleaning criteria described above, 72,900

24
25 147 children (30 centres / 17 countries) and 199,135 adolescents (74 centres / 36 countries) were

26
27 148 included in the final analysis (Figure 1). Parents provided heights and weights for 60,027 children,

28
29 149 while 12,873 children had their heights and weights measured. 154,624 adolescents provided self-

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31 150 reported height and weight while 44,511 adolescents had measured heights and weights.

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35 151 **Figure 1: Flow of subjects through study.**

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37 152 **STATISTICAL ANALYSIS:**

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39 153 BMI was assessed separately for each age group using a general linear mixed model with centre as a

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41 154 random effect and GNI for each country (low and high), the individual's age, sex, measurement type

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43 155 (reported or measured), and fast food consumption ('infrequent', 'frequent' 'very frequent') as fixed

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45 156 effects. The BMI values reported are the modelled means for those who reported infrequent fast

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47 157 food consumption in the children and adolescent groups respectively.

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50 158 In the adolescent group statistically significant interactions were found between sex and fast food

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52 159 consumption, and measurement type and fast food consumption. There was also an interaction

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54 160 found between country GNI and fast food consumption. Consequently, analyses were done

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56 161 separately for each sex, measured height and weight data only, and GNI categories. No similar

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4 162 interactions were found in the children's group, but there were sufficient numbers to analyse each
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6 163 sex separately, which we elected to do.
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9 10 164 **RESULTS:**

11 12 165 **Fast food consumption:**

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14 166 22.6% of children reported frequent fast food consumption and 4.2% reported very frequent fast
15
16 167 food consumption. Combined frequent and very frequent fast food consumption in each country
17
18 168 ranged from 10% in Poland to 63% in South Korea (Figure 2a).

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20
21 169 38.7% of adolescents reported frequent fast food consumption and 12.6% reported very frequent
22
23 170 consumption. Frequent and very frequent fast food consumption ranged from 15% in Indonesia to
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25 171 79% in South Africa (Figure 2b).
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28 172 **Figure 2: Reported fast food consumption of study participants by country.**
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32 33 174 **Fast food consumption and BMI:**

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35 175 Children:

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37 176 Figure 3a shows the difference in BMI between children with infrequent fast food consumption and
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39 177 those with frequent and very frequent fast food consumption in each centre.
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42 178 **Figure 3a: The association between reported fast food consumption and BMI of children.**

43
44 179 The estimated mean BMIs in children reporting infrequent fast food consumption were 16.20 and
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46 180 16.51 kg/m² for ages 6 and 7 respectively. After controlling for country GNI, centre, age and
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48 181 measurement type, there was a statistically significant association between frequent and very
49
50 182 frequent fast food consumption and higher BMI with an apparent dose response effect (+0.15 and
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52 183 +0.22kg/m² for frequent and very frequent fast food consumption respectively), (Table 1). There
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54 184 was no statistically significant interaction between GNI and fast food consumption in this age group
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57 185 (P=0.06).
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186 **Table 1 – Association between fast food consumption and BMI (SE) of study participants after**
 187 **adjustment for GNI**

	Difference in mean BMI (Kg/m ²) compared with infrequent fast food consumption			
	Estimated mean BMI* (Kg/m ²) infrequent fast food consumption	Frequent fast food consumption: mean (SE)	Very frequent fast food consumption: mean (SE)	P value ⁱ
Children (N=72,900)	16.51	+ 0.15 (0.02)	+ 0.22 (0.05)	P<0.001
Male Children (N=36,778)	16.53	+0.16 (0.03)	+0.24 (0.06)	P<0.001
Female Children (N=36,122)	16.39	+0.14 (0.03)	+0.20 (0.07)	P<0.001
Adolescent Males (N=98,794)	20.02	-0.14 (0.02)	- 0.28 (0.03)	P<0.001
Adolescent Females (N=100,341)	19.98	-0.19 (0.02)	- 0.19 (0.03)	P<0.001
Participants with measured height and weight data				
Children (N=12,873)	15.88	+0.14 (0.05)	+0.13 (0.08)	P=0.02
Adolescent Males (N= 20,384)	19.67	-0.03 (0.05)	-0.11(0.07)	P=0.24
Adolescent Females (N=24,127)	20.15	-0.15 (0.05)	-0.09 (0.06)	P=0.004

188 *Estimated BMIs for children aged 7 years and adolescents aged 14 years.

189 ⁱ P value is a joint test of whether the differences in BMIs for frequent and very frequent fast food consumption relative to infrequent
 190 fast food consumption are zero.

191

192 When boys and girls were analysed separately, both sexes had a significant positive association
 193 between frequent and very frequent fast food consumption (Table 1).

194 **Adolescents:**

195 Figure 3b shows the difference in BMI between adolescents with infrequent fast food consumption
 196 and those with frequent and very frequent fast food consumption in each centre.

197 **Figure 3b: The association between fast food consumption and BMI of adolescents**

198 In male adolescents, the estimated mean BMIs for those reporting infrequent fast food consumption
 199 were 19.74 and 20.02 kg/m² for ages 13 and 14 respectively. After controlling for country GNI,

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4 200 centre, age and measurement type, lower BMI's were significantly associated with greater fast food
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6 201 consumption (Table 1). There was a statistically significant interaction between fast food
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8 202 consumption and GNI. In low GNI countries the frequency of fast food consumption had no
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10 203 association with BMI (+0.01 and -0.03kg/m² in the frequent and very frequent groups respectively
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12 204 (P=0.89 and 0.56)). In high GNI countries, lower BMI's were associated with greater fast food
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14 205 consumption (-0.21 and -0.42kg/m² in the frequent and very frequent groups respectively (P<0.001
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16 206 in both groups)).

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20 207 When analyses were restricted to the 20,384 male adolescents who had measured height and
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22 208 weight data there was a tendency towards a lower BMI with higher fast food consumption, but this
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24 209 was not statistically significant (-0.03kg/m² and -0.11kg/m² in the frequent and very frequent group
25
26 210 respectively, (p=0.24)).

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30 211 In female adolescents, the estimated mean BMI's for those reporting infrequent fast food
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32 212 consumption were 19.56 and 19.98 kg/m² for ages 13 and 14 respectively. Lower BMIs were
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34 213 associated with greater fast food consumption and this was statistically significant. There was a
35
36 214 statistically significant interaction between fast food consumption and GNI. Both low and high GNI
37
38 215 countries had an association between increasing fast food consumption and BMI (low GNI countries
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40 216 -0.10kg/m² and -0.11kg/m² in the frequent and very frequent groups respectively (P=0.03 and 0.01),
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42 217 and high GNI countries -0.24kg/m² and -0.22kg/m² in the frequent and very frequent groups
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44 218 respectively (P<0.0001 in both cases)).

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47 219 When analyses were restricted to the 24,127 female adolescents who had measured height and
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49 220 weight data, those who ate fast food frequently or very frequently had lower BMIs and this was
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51 221 statistically significant (Table 1).
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4 222 **DISCUSSION:**
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6 223 This international study has identified that 6-7 year old children who consumed fast food frequently
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8 224 had higher BMIs than those who consumed fast food infrequently. This association was independent
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10 225 of the affluence of the country and of similar magnitude in boys and girls. By contrast, adolescents
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12 226 who self-reported that they frequently ate fast foods tended to have lower BMIs, with the exception
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14 227 of male adolescents from low GNI countries, where there was no association between fast food
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16 228 consumption and BMI. We have also found that up to 25% of children worldwide consume fast food
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18 229 frequently or very frequently, and this increases to over 50% in the adolescent age group.
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22 230 **Children**
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24 231 Our results in children are consistent with those of Shan et al who found that 'Western fast food'
25
26 232 and 'snack food' were associated with overweight and obesity among children aged 2 to 18 years in
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28 233 Beijing(22). However, In New Zealand, Duncan et al found that low levels of physical activity,
29
30 234 skipping breakfast and insufficient sleep on weekdays were associated with increased adiposity in 5
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32 235 to 11 year olds, but that fast food consumption was not (20). The magnitude of the association
33
34 236 between fast food consumption and BMI in children was small (mean BMI values 0.15 kg/m² and
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36 237 0.22kg/m² higher in frequent and very frequent consumers compared to infrequent consumers), and
37
38 238 the clinical significance of this is uncertain. Given the long term consequences of overweight and
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40 239 obesity in childhood, even a small change in mean BMI in a population could be of major public
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42 240 health significance.
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46 241 An observational study such as this cannot attribute causality. The association we have found
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48 242 between fast food consumption and BMI in children could be due to other specific dietary factors
49
50 243 that have been shown to be associated with fast food consumption, such as higher fat intake,
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52 244 greater consumption of sugary drinks, fewer fruits and non-starchy vegetables(11). Alternatively
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54 245 fast food consumption may be a marker of other factors that influence BMI such as parental BMI,
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56 246 individual socioeconomic circumstances or patterns of activity and inactivity.
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247 Adolescents

248 In our analysis self-reported frequent fast food consumption was associated with a lower BMI in
249 adolescents, with stronger association in higher GNI countries. As far as we are aware, no other
250 studies have demonstrated a lower BMI with higher fast food consumption in adolescence and our
251 findings appear to be in stark contrast to other research findings from high GNI countries. One study
252 showed that increasing fast food consumption in American adolescents was associated with
253 increased weight gain from adolescence to adulthood (12). Another study found that American
254 adolescents who consumed greater quantities of fried food away from home were heavier (23), and,
255 in a further American study, increasing frequency of eating quick-service food was associated with
256 an increasing z-BMI in adolescent females (17). A United Kingdom study found that increased visits
257 to fast food outlets was associated with higher BMI standard deviation scores in teenagers (24). In
258 three of these studies heights and weights were measured to pre-set standards by trained
259 investigators (12, 17, 24), whereas heights and weights of our adolescent participants were mostly
260 self-reported. It is possible that in our study some of the larger participants, particularly from body-
261 image conscious countries or cultures may have under-reported their weights. In a study evaluating
262 the correlation of measured versus self-reported heights and weights in adolescents, Brener et al
263 found that their study subjects tended to over-report their height by 2.7 inches (6.9cm) on average,
264 and to under-report their weight by 3.5 pounds (1.6kg) on average, resulting in a BMI understated by
265 2.6kg/m^2 when compared to measured values. White adolescents were most likely to over-report
266 their height and female adolescents were more likely to under-report their weight(25). Similarly
267 Danubio et al found that height was over-estimated in males and females (2.1 and 2.8cm
268 respectively), and that weight was understated (1.5kg in males and 1.9kg in females)(26). Rasmussen
269 et al reported that in the COMPASS study, boys and girls who wished to be leaner under-reported
270 their weight and BMI more than subjects who were satisfied with their body size(27). When we
271 restricted our analysis to measured height and weight data only, the association between higher fast
272 food intake and lower BMI was no longer observed in male adolescents, but the association between

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4 273 higher rates of fast food consumption and lower BMI persisted in female adolescents. We need to
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6 274 consider the likelihood that because of the perception of the negative effects of fast food
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8 275 consumption, adolescents who are overweight or obese are likely to have under-reported their
9
10 276 actual fast food consumption. In a review of validation studies on energy-intake reporting in children
11
12 277 and adolescents, Livingstone and Robson describe an increasing in under-reporting of energy intake
13
14 278 reporting as age and BMI increases in childhood and adolescence, with 14%, 25% and 40% of energy
15
16 279 intake under-reported in obese 6 year olds, 10 year olds and adolescents respectively (28). Finally,
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18 280 it is possible that our results are influenced by a degree of reverse-causation where those
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20 281 participants who are already overweight or obese are avoiding fast foods in order to reduce their
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22 282 body weight.
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27 Fast food consumption

28 284 This study has shown that up to 25% of children worldwide consume fast food frequently or very
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30 285 frequently, and this increases to over 50% in the adolescent age group. This is consistent with results
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32 286 of previous studies, particularly those based in the United States and the United Kingdom (11, 29,
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34 287 30). This study has also highlighted the unexpectedly high proportion of fast food consumption in
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36 288 both age groups in many developing countries, for which data have not previously been available. In
37
38 289 particular, high prevalence of fast food consumption was observed in centres in Latin America and
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40 290 Asia similar in magnitude to that observed in the United States and Western Europe. Importantly,
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42 291 we have also shown that the association between fast food consumption and higher BMI in children
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44 292 persists among those from both affluent and less affluent countries.
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48 293 Cohort studies have demonstrated that high consumption of fast food at first assessment is
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50 294 associated with higher BMIs later in childhood or adult life (12, 24). If this is the case, despite an
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52 295 apparently lower BMI with higher reported fast food consumption in the adolescent group, the high
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54 296 proportions of adolescents already reporting fast food consumption is of concern, as fast food
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4 297 consumption has been directly linked with insulin resistance, hypertension and other health
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6 298 sequelae (31).
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10 **Strengths and limitations:**

11 300 The major strengths of this study were its size and multicentre structure, with 199,135 adolescents
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13 301 from 36 countries and 72,900 children from 17 countries surveyed. Many of the centres were from
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15 302 middle and low income countries from which previous data on the association between fast food
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17 303 consumption and BMI had not been reported.
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20 304 The main limitation to this study is the cross-sectional design which allows identification of
21
22 305 associations, but not of temporal sequence or causality. The assessment of subject heights and
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24 306 weights and their fast food consumption was primarily undertaken by questionnaire which raises the
25
26 307 possibility of misclassification error, particularly with respect to the parent-reported weights of their
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28 308 children and self-reported weights of the adolescents, thereby influencing the calculated BMI. It is
29
30 309 also possible that parents and adolescents may have misreported fast food consumption.
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34 310 A further consideration is the interpretation of the question about the consumption of burgers / fast
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36 311 foods. While 'burger' is almost universally understood, 'fast food' can be interpreted in a number of
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38 312 ways, including foodstuffs from global restaurant chains, smaller non-franchised food stores, street
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40 313 vendors and even frozen meals heated and served at home. Without knowing the exact kind of fast
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42 314 food consumed, we can make no assessment of the nutritional content or energy density of the food
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44 315 in question. Additionally, while the questionnaire asked about the frequency of burgers / fast food
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46 316 consumption, we have no indication of portion sizes, or if it was accompanied by other items such as
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48 317 sugar sweetened beverages.
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52 318 Finally, centres that objectively measured heights and weights received no standardised instructions
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54 319 for doing this. We have controlled for GNI, centre, measurement type, and sex in our analysis. We
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4 320 have no data available on individual socioeconomic status or parental BMI which could potentially
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6 321 affect young peoples' BMI, nor did we control for physical activity / inactivity of the participants.
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10 322 **CONCLUSIONS:**

11 323 This cross-sectional study has found that one quarter of children and half of adolescents consume
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13 324 fast food frequently or very frequently. Additionally there was an association between a high
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15 325 frequency of fast food consumption and higher BMIs in 6-7 year old children, but this association
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17 326 was reversed in adolescents. As this is an observational study, causality cannot be proven, however
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19 327 it provides evidence that among children from many different nations, fast food consumption may
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21 328 contribute to weight gain. This reverse association observed in adolescents should be interpreted
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23 329 with caution, as the results may be affected by bias, particularly under-reporting of fast food
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25 330 consumption and reverse causation.
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13 336 responsibility for the integrity of the data and accuracy of the data analysis. *Study concept*
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15 337 *and design:* All authors. *Acquisition of Data:* ISAAC steering committee. *Drafting of the*
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51 352 **Competing interests:** All authors declare that they have no competing interests relating to
52
53 353 the development of this article.
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4 354 **Data Sharing Statement:** Information with respect to all ISAAC studies, including methods, data
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6 355 gathering and results is available on the ISAAC website: isaac.auckland.ac.nz/
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10
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12
13 358 ISAAC Phase Three Study. We are also grateful to the ISAAC Steering Committee, the ISAAC
14
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16 409 Estonia: M-A Riikjärv* (Tallinn); Fiji: R Sa'aga-Banuve (Suva); Finland: J Pekkanen* (Kuopio

17 410 County); Former Yugoslav Republic of Macedonia (FYROM): E Vlaski* (Skopje); Hungary: G

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4 423 (Cartagena), C González Díaz (Bilbao), A López-Silvarrey Varela (A Coruña), MM Morales-
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32 435 **FIGURE LEGENDS**

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34 436 Figure 1: Flow of participants through study. Children are represented in panel (a) and adolescents in
35 437 panel (b)
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39 439 Figure 2: Reported frequency of fast food consumption by study participants. Children are
40 440 represented in panel (a) and adolescents in panel (b)
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44 442 Figure 3: The difference in BMI of study participants that consumed fast food consumption
45 443 frequently and very frequently compared to infrequent fast food consumption. Children are
46 444 represented in panel (a) and adolescents in panel (b). For each country the proportion of
47 445 participants who consume fast food frequently or very frequently is shown in parentheses. Those
48 446 centres with reported height and weights are shown with filled in circles, and those centres that
49 447 measured heights and weights are shown with hollowed circles.
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8 **1 Fast Food consumption and Body Mass Index in children and**
9 **2 adolescents: an international cross-sectional study**
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13 4 Irene Braithwaite *MChB*¹, Alistair W Stewart *BSc*², Robert J Hancox *MD*³, Richard Beasley *DSc*¹, Rinki
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48 23 **Key Words:** BMI, Fast food consumption, international, childhood obesity, childhood
49 24 overweight
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51 25 **Word Count:** Abstract: [288293](#), Article: [2792323229](#)
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ABSTRACT:

Objective: To investigate whether reported fast food consumption over the previous year is associated with higher childhood or adolescent body mass index (BMI).

Design: Secondary analysis from a multi-centre, multi-country, cross-sectional study (International Study of Asthma and Allergies in Children (ISAAC) Phase Three).

Subjects and Methods: Parents / guardians of children aged 6-7 completed questionnaires which included questions about their children's asthma and allergies, fast food consumption, height and weight. Adolescents aged 13-14 completed the same questionnaire. The questionnaire asked "In the past 12 months, how often on average did you (your child) eat fast food/burgers?" Responses were; infrequent (never / only occasionally), frequent (once / twice a week), or very frequent (three or more times per week). A general linear mixed model was used to determine the association between BMI and fast food consumption, adjusting for Gross National ~~income~~ perIncome per capita by country, measurement type (whetherreported or measured height and weight were reported or measured), age, and sex.

Results: 72,900 children from 17 countries and 199,135 adolescents from 36 countries provided data. Frequent and very frequent fast food consumption was reported in 23% and 4% of children, and 39% and 13% of adolescents. Children in the frequent and very frequent groups had a BMI 0.15 kg/m² and 0.22 kg/m² higher than the infrequent group (P<0.001). Adolescent males in the frequent and very frequent groups had a BMI 0.14 kg/m² and 0.28kg/m² lower than the infrequent group (P<0.001). Adolescent females in the frequent and very frequent groups had a BMI 0.19kg/m² lower than the infrequent group (P<0.001).

49 **Conclusion:** Reported fast food consumption is high in childhood and increases in adolescence.

50 Compared with infrequent fast food consumption, frequent and very frequent consumption is
51 associated with a higher BMI in children and ~~-In contrast, this is associated with~~ a lower BMI in
52 adolescents.

53 **Strengths and limitations of this study:**

- 54 • 199,135 adolescents from 36 countries and 72,900 children from 17 countries provided
55 information on their height, weight and fast food consumption.
- 56 • Many of the countries were middle and low income from which previous data on the
57 association of fast food consumption and BMI had not been reported.
- 58 • There is an association between increasing frequency of fast food consumption and higher
59 BMIs in 6-7 year old children, but this association was reversed in adolescents.
- 60 • As this is a cross sectional study, causality cannot be proven, but it provides evidence that
61 among children from many different nations, fast food consumption may contribute to
62 weight gain.
- 63 • The reverse association observed in adolescents should be interpreted with caution, as the
64 results may be affected by bias, particularly under-reporting of fast food consumption and
65 reverse causation.

INTRODUCTION:

The rising prevalence of childhood obesity is marked (1, 2), and there are well documented concerns about the future health implications of obesity in childhood (3-7). This problem has been identified in low and middle income countries as well as affluent countries (8, 9).

While potential contributors to the problem of childhood obesity are considered to be multiple and complex, ~~the increasing availability of fast food~~ in many countries ~~fast food~~ has been implicated due to its ~~increasing availability~~, energy ~~dense and low nutritional nature~~ density, and large portion sizes,

~~and increasing availability~~ (10-13). Studies investigating associations between fast food consumption in children and Body Mass Index (BMI) have produced mixed results, some demonstrating small but significant associations between fast food consumption and increased BMI (12, 14-17), while others have failed to demonstrate a significant association (18-20). ~~Many of these have been single centre~~

~~studies and involved small populations. In a systematic review of studies assessing the association between fast food and obesity in 2008, Rosenheck noted that 'it is difficult to ascertain the true relationship between fast food consumption and weight gain or obesity, as many confounding factors such as physical inactivity and less inhibited food consumption are independently associated with both fast food consumption and weight gain or obesity' and that '... residual confounding from immeasurable lifestyle choices will always distort results garnered from observational study designs.'~~ (14).

~~Additionally Rosenheck commented on the sample sizes of the cross-sectional studies, where only one study enrolled more than 5,000 participants, and in general enrolment was closer to the 1,000 mark, potentially negatively impacting the power of the studies to effectively assess the association between fast food consumption and weight / obesity. A cross-sectional study large enough to achieve sufficient power to determine an association between fast food consumption and obesity AND adequately address issues of multiple confounding factors is likely to be logistically demanding and prohibitively costly.~~

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8 93 [A secondary analysis of the data from the International Study of Asthma and Allergies in Childhood](#)
9 94 [\(ISAAC\) Phase Three programme allows an international 'snapshot' of fast food consumption and an](#)
10 95 [assessment of the association between fast food consumption and BMI in across 72,900 children](#)
11 96 [from 17 countries and 199,135 adolescents from 36 countries at a single point in time, using a simple](#)
12 97 [universal question. While few confounding variables are taken into account, the large numbers](#)
13 98 [involved do bring a degree of give power to the this analysis.](#)
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22 100 [The International Study of Asthma and Allergies in Childhood \(ISAAC\) Phase Three programme was](#)
23 101 [designed to measure time trends in the prevalence and severity of asthma, rhinoconjunctivitis and](#)
24 102 [eczema and to explore the relationship between lifestyle, other putative risk factors and the](#)
25 103 [development of asthma and allergies \(21\). It also provided the opportunity to explore the](#)
26 104 [relationship between lifestyle factors such as fast food consumption and BMI, as heights, weights](#)
27 105 [and information on the frequency of fast food consumption of participants were gathered in many](#)
28 106 [centres through an optional environmental questionnaire that was answered by parents of children](#)
29 107 [and by the adolescents themselves.](#)
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38 108 We hypothesised that there would be an association between greater fast food consumption and
39 109 higher BMI in both children and adolescents, and that this association would be observed
40 110 worldwide.
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44 111 **SUBJECTS AND METHODS:**

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46 112 [The International Study of Asthma and Allergies in Childhood \(ISAAC\) Phase Three programme was](#)
47 113 [designed to measure time trends in the prevalence and severity of asthma, rhinoconjunctivitis and](#)
48 114 [eczema and to explore the relationship between lifestyle, other putative risk factors and the](#)
49 115 [development of asthma and allergies \(21\). ISAAC is a multicentre, multi-country, multiphase, cross-](#)
50 116 [sectional study investigating the prevalence of the symptoms of asthma, rhinoconjunctivitis and](#)
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8 117 ~~eczema, and the role of risk factors, as previously described (21).~~ ISAAC Phase Three used the [ISAAC](#)
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10 118 Phase One standardised core questionnaire on symptoms of asthma, rhinoconjunctivitis and
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12 119 ~~eczema, and included an optional environmental questionnaire to collect potential risk factor data~~
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14 120 ~~including height, weight, and fast food consumption.~~ ISAAC Phase Three provided the ~~and~~ additional
15
16 121 [opportunity to explore the relationship between lifestyle factors such as fast food consumption and](#)
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18 122 [BMI, as heights, weights and information on the frequency of fast food consumption of participants](#)
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20 123 [were gathered in many centres through an optional environmental questionnaire that was answered](#)
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22 124 [by parents of children and by the adolescents themselves.](#)
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24 125 ~~Adolescents self-completed their questionnaires and parents or guardians completed~~
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26 126 ~~questionnaires for the children.~~ The [ISAAC Phase One standardised core questionnaire and ISAAC](#)
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28 127 [Phase Three environmental](#) questionnaires are on the ISAAC website: isaac.auckland.ac.nz.
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30 128 [Ethical approval was obtained for the original ISAAC Phase Three study, and permission was gained](#)
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32 129 [to use the data from ISAAC Phase Three through agreement with the ISAAC Phase Three Steering](#)
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34 130 [Committee.](#)

36 131 **Main outcome variable - Body Mass Index:**

37 132 Height and weight were reported by the parents of the children, and were self-reported by
38
39 133 adolescents. In some centres, each subject's height and weight were measured objectively; there
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41 134 were no standardised or specific instructions for doing this. BMI was calculated as weight (kg)/height
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43 135 (m)².

46 136 **Explanatory variables:**

47 137 Fast food consumption was established by asking participants to answer the following question: "In
48
49 138 the past 12 months, how often, on average, did you [your child] eat the following?"
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52 139 'Fast Food / Burgers' were listed as one option along with 14 other foodstuffs including meat,
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54 140 seafood, fruit and vegetables. The participants were asked to categorise their intake of each listed
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8 141 food as “Never or only occasionally”; “once or twice per week”; or “Three or more times a week”.

9 142 These responses were categorised as ‘infrequent’, ‘frequent’ and ‘very frequent’. Each variable was
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11 143 examined separately for both age groups.

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14 144 Country Gross National Index (GNI) was based on the 2006 World Bank of Gross National Income by
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16 145 country. The World Bank categories of high income, high middle income, low middle income and low
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18 146 income countries were dichotomised into ‘high income’ (high and high middle income) and ‘low
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20 147 income’ (low middle and low income) categories.

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22 148 **Participants:**

23 149 For children aged 6-7 years, data were submitted from 73 centres in 32 countries (214,706 subjects).

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25 150 For adolescents aged 13-14 years data were submitted from 125 centres in 54 countries (369,881
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27 151 subjects).

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30 152 Centres that provided data on height, weight and fast food consumption for at least 70% of
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32 153 participants were included in our analyses. Individuals without complete age, sex, fast food
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34 154 consumption, height or weight data were excluded.

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37 155 **Data cleaning:**

38 156 To eliminate likely erroneous BMI data, we applied the following thresholds:

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40 157 - For children in each centre, those in the top and bottom 0.5% of weights and heights, and
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42 158 those with heights less than 1.0 metre were excluded. Children with BMI less than 9kg/m^2
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44 159 and greater than 40kg/m^2 were excluded.
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47 160 - For adolescents in each centre, those in the top and bottom 0.5% of weights and heights,
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49 161 and those with heights less than 1.25 metres were excluded. Adolescents with BMI less than
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51 162 10kg/m^2 and greater than 45kg/m^2 were excluded.
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8 163 Following sequential application of the exclusion and data cleaning criteria described above, 72,900
9 164 children (30 centres / 17 countries) and 199,135 adolescents (74 centres / 36 countries) were
10 165 included in the final analysis (Figure 1). Parents provided heights and weights for 60,027 children,
11 166 while 12,873 children had their heights and weights measured. 154,624 adolescents provided self-
12 167 reported height and weight while 44,511 adolescents had measured heights and weights.
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18 168 **Figure 1: Flow of subjects through study.**

19 169 **STATISTICAL ANALYSIS:**

20 170 BMI was assessed separately for each age group using a general linear mixed model with centre as a
21 171 random effect and GNI for each country (low and high), the individual's age, sex, measurement type
22 172 (reported or measured), and fast food consumption('infrequent', 'frequent' 'very frequent') as fixed
23 173 effects. The BMI values reported are the modelled means for those who reported infrequent fast
24 174 food consumption in the children and adolescent groups respectively.
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31 175 In the adolescent group statistically significant interactions were found between sex and fast food
32 176 consumption, and measurement type and fast food consumption. There was also an interaction
33 177 found between country GNI and fast food consumption. Consequently, analyses were done
34 178 separately for each sex, measured height and weight data only, and GNI categories. No similar
35 179 interactions were found in the children's group, but there were sufficient numbers to analyse each
36 180 sex separately, which we elected to do.
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43 181 **RESULTS:**

44 182 **Fast food consumption:**

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46 183 22.6% of children reported frequent fast food consumption and 4.2% reported very frequent fast
47 184 food consumption. Combined frequent and very frequent fast food consumption in each country
48 185 ranged from 10% in Poland to 63% in South Korea (Figure 2a).
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186 38.7% of adolescents reported frequent fast food consumption and 12.6% reported very frequent
 187 consumption. Frequent and very frequent fast food consumption ranged from 15% in Indonesia to
 188 79% in South Africa (Figure 2b).

189 **Figure 2: Reported fast food consumption of study participants by country.**

190

191 **Fast food consumption and BMI:**

192 Children:

193 Figure 3a shows the difference in BMI between children with infrequent fast food consumption and
 194 those with frequent and very frequent fast food consumption in each centre.

195 **Figure 3a: The association between reported fast food consumption and BMI of children.**

196 The estimated mean BMIs in children reporting infrequent fast food consumption were 16.20 and
 197 16.51 kg/m² for ages 6 and 7 respectively. After controlling for country GNI, centre, age and
 198 measurement type, there was a statistically significant association between frequent and very
 199 frequent fast food consumption and higher BMI with an apparent dose response effect (+0.15 and
 200 +0.22kg/m² for frequent and very frequent fast food consumption respectively), (Table 1). There
 201 was no statistically significant interaction between GNI and fast food consumption in this age group
 202 (P=0.06).

203 **Table 1 – Association between fast food consumption and BMI (SE) of study participants after**
 204 **adjustment for GNI**

	Difference in <u>mean</u> BMI (Kg/m ²) compared with infrequent fast food consumption			
	Estimated mean BMI* (Kg/m ²) infrequent fast food consumption	Frequent fast food consumption: mean (SE)	Very frequent fast food consumption: mean (SE)	P value ⁱ
Children (N=72,900)	16.51	+ 0.15 (0.02)	+ 0.22 (0.05)	P<0.001
Male Children (N=36,778)	16.53	+0.16 (0.03)	+0.24 (0.06)	P<0.001

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Female Children (N=36,122)	16.39	+0.14 (0.03)	+0.20 (0.07)	P<0.001
Adolescent Males (N=98,794)	20.02	-0.14 (0.02)	- 0.28 (0.03)	P<0.001
Adolescent Females (N=100,341)	19.98	-0.19 (0.02)	- 0.19 (0.03)	P<0.001
Participants with measured height and weight data				
Children (N=12,873)	15.88	+0.14 (0.05)	+0.13 (0.08)	P=0.02
Adolescent Males (N= 20,384)	19.67	-0.03 (0.05)	-0.11(0.07)	P=0.24
Adolescent Females (N=24,127)	20.15	-0.15 (0.05)	-0.09 (0.06)	P=0.004

¹Estimated BMIs for children aged 7 years and adolescents aged 14 years.

¹ P value is a [joint](#) test of whether the [estimated mean differences in](#) BMIs for frequent and very frequent fast food consumption [relative to infrequent fast food consumption](#) are zero.

When boys and girls were analysed separately, both sexes had a significant positive association between frequent and very frequent fast food consumption (Table 1).

Adolescents:

Figure 3b shows the difference in BMI between adolescents with infrequent fast food consumption and those with frequent and very frequent fast food consumption in each centre.

Figure 3b: The association between fast food consumption and BMI of adolescents

In male adolescents, the estimated mean BMIs for those reporting infrequent fast food consumption were 19.74 and 20.02 kg/m² for ages 13 and 14 respectively. After controlling for country GNI, centre, age and measurement type, lower BMI's were significantly associated with greater fast food consumption (Table 1). There was a statistically significant interaction between fast food consumption and GNI. In low GNI countries the frequency of fast food consumption had no association with BMI (+0.01 and -0.03kg/m² in the frequent and very frequent groups respectively (P=0.89 and 0.56)). In high GNI countries, lower BMI's were associated with greater fast food consumption (-0.21 and -0.42kg/m² in the frequent and very frequent groups respectively (P<0.001 in both groups)).

224 When analyses were restricted to the 20,384 male adolescents who had measured height and
225 weight data there was a tendency towards a lower BMI with higher fast food consumption, but this
226 was not statistically significant (-0.03kg/m² and -0.11kg/m² in the frequent and very frequent group
227 respectively, (p=0.24)).

228 In female adolescents, the estimated mean BMI's for those reporting infrequent fast food
229 consumption were 19.56 and 19.98 kg/m² for ages 13 and 14 respectively. Lower BMIs were
230 associated with greater fast food consumption and this was statistically significant. There was a
231 statistically significant interaction between fast food consumption and GNI. Both low and high GNI
232 countries had an association between increasing fast food consumption and BMI (low GNI countries
233 -0.10kg/m² and -0.11kg/m² in the frequent and very frequent groups respectively (P=0.03 and 0.01),
234 and high GNI countries -0.24kg/m² and -0.22kg/m² in the frequent and very frequent groups
235 respectively (P<0.0001 in both cases)).

236 When analyses were restricted to the 24,127 female adolescents who had measured height and
237 weight data, those who ate fast food frequently or very frequently had lower BMIs and this was
238 statistically significant (Table 1).

239 DISCUSSION:

240 This international study has identified that 6-7 year old children ~~whose parents reported frequent~~
241 ~~consumption of~~ who consumed fast food frequently had higher BMIs than those ~~whose parents~~
242 ~~reported infrequent~~ who consumed -fast food ~~consumption infrequently~~. This association was
243 independent of the affluence of the country and of similar magnitude in boys and girls. By contrast,
244 adolescents who self-reported that they frequently ate fast foods tended to have lower BMIs, with
245 the exception of male adolescents from low GNI countries, where there was no association between
246 fast food consumption and BMI. We have also found that up to 25% of children worldwide consume
247 fast food frequently or very frequently, and this increases to over 50% in the adolescent age group.

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248 Children

249 Our results in children are consistent with those of Shan et al who found that 'Western fast food'
250 and 'snack food' were associated with overweight and obesity among children aged 2 to 18 years in
251 Beijing(22). However, In New Zealand, Duncan et al found that low levels of physical activity,
252 skipping breakfast and insufficient sleep on weekdays were associated with increased adiposity in 5
253 to 11 year olds, but that fast food consumption was not (20). The magnitude of the association
254 between fast food consumption and BMI in children was small (mean BMI values 0.15 kg/m² and
255 0.22kg/m² higher in frequent and very frequent consumers compared to infrequent consumers), and
256 the clinical significance of this is uncertain. Given the long term consequences of overweight and
257 obesity in childhood, even a small change in mean BMI in a population could be of major public
258 health significance.

259 An observational study such as this cannot attribute causality. The association we have found
260 between fast food consumption and BMI in children could be due to other specific dietary factors
261 that have been shown to be associated with fast food consumption, such as higher fat intake,
262 greater consumption of sugary drinks, fewer fruits and non-starchy vegetables(11). Alternatively
263 fast food consumption may be a marker of other factors that influence BMI such as parental BMI,
264 individual socioeconomic circumstances or patterns of activity and inactivity.

265 Adolescents

266 In our analysis self-reported frequent fast food consumption was associated with a lower BMI in
267 adolescents, with stronger association in higher GNI countries. As far as we are aware, no other
268 studies have demonstrated a lower BMI with higher fast food consumption in adolescence and our
269 findings appear to be in stark contrast to other research findings from high GNI countries. One study
270 showed that increasing fast food consumption in American adolescents was associated with
271 increased weight gain from adolescence to adulthood (12). Another study found that American
272 adolescents who consumed greater quantities of fried food away from home were heavier (23), and,

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8 273 in a further American study, increasing frequency of eating quick-service food was associated with
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10 274 an increasing z-BMI in adolescent females (17). A United Kingdom study found that increased visits
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12 275 to fast food outlets was associated with higher BMI standard deviation scores in teenagers (24). In
13
14 276 three of these studies heights and weights were measured to pre-set standards by trained
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16 277 investigators (12, 17, 24), whereas heights and weights of our adolescent participants were mostly
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18 278 self-reported. It is possible that in our study some of the larger participants, particularly from body-
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20 279 image conscious countries or cultures may have under-reported their weights. In a study evaluating
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22 280 the correlation of measured versus self-reported heights and weights in adolescents, Brenner et al
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24 281 found that their study subjects tended to over-report their height by 2.7 inches (6.9cm) on average,
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26 282 and to under-report their weight by 3.5 pounds (1.6kg) on average, resulting in a BMI understated by
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28 283 2.6kg/m² when compared to measured values. White adolescents were most likely to over-report
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30 284 their height and female adolescents were more likely to under-report their weight(25) [REF: Brenner
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32 285 —Reliability and validity of self-reported height and weight among high school students]. Similarly
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34 286 Danubio et al found that height was over-estimated in males and females (2.1 and 2.8cm
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36 287 respectively), and that weight was understated (1.5kg in males and 1.9kg in females);(26). [Danubio
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38 288 —comparison of self-reported and measured height and weight: implications of obesity research
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40 289 among young adults]. Rasmussen et al reported that in the COMPASS study, boys and girls who
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42 290 wished to be leaner under-reported their weight and BMI more than subjects who were satisfied
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44 291 with their body size(27). [Rasmussen: Bias and height and weight reported by Swedish adolescents
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46 292 and relations to body dissatisfaction]. If this were the case, we might expect that the association
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48 293 between fast food consumption and lower BMI would not be observed when we restricted our
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50 294 analysis to measured height and weight data only, the association between higher fast food intake
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52 295 and lower BMI was no longer observed in male adolescents, but .Although this was the case in male
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54 296 adolescents, surprisingly the association between higher rates of fast food consumption and lower
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56 297 BMI persisted in female adolescents. We need to consider the possibility-likelihood that because of

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298 the perception of the negative effects of fast food consumption, adolescents who are overweight or
299 obese are likely to have under-reported their actual fast food consumption. [In a meta-analysis review](#)
300 [of validation studies on energy-intake reporting in children and adolescents, Livingstone and Robson](#)
301 [describe an increasing in under-reporting of energy intake reporting as age and BMI increases in](#)
302 [childhood and adolescence, with 14%, 25% and 40% of energy intake under-reported in obese 6 year](#)
303 [olds, 10 year olds and adolescents respectively \(28\)](#) [Livingstone / Robson: Measurement of Dietary](#)
304 [Intake in Children](#). Finally, it is possible that our results are influenced by a degree of reverse-
305 causation where those participants who are already overweight or obese are avoiding fast foods in
306 order to reduce their body weight.

307 Fast food consumption

308 This study has shown that up to 25% of children worldwide consume fast food frequently or very
309 frequently, and this increases to over 50% in the adolescent age group. This is consistent with results
310 of previous studies, particularly those based in the United States and the United Kingdom [\(11, 29,](#)
311 [30\)](#) [\(11, 25, 26\)](#). This study has [also](#) highlighted ~~is~~ the unexpectedly high proportion of fast food
312 consumption in both age groups in many developing countries, for which data have not previously
313 been available. In particular, high prevalence of fast food consumption was observed in centres in
314 Latin America and Asia similar in magnitude to that observed in the United States and Western
315 Europe. Importantly, we have also shown that the association between fast food consumption and
316 higher BMI in children persists among those from both affluent and less affluent countries.

317 Cohort studies have demonstrated that high consumption of fast food at first assessment is
318 associated with higher BMIs later in childhood or adult life [\(12, 24\)](#). If this is the case, despite an
319 apparently lower BMI with higher reported fast food consumption in the adolescent group, the high
320 proportions of adolescents already reporting fast food consumption is of concern, as fast food
321 consumption has been directly linked with insulin resistance, hypertension and other health
322 sequelae [\(31\)](#) [\(27\)](#).

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8 323 **Strengths and limitations:**

9 324 The major strengths of this study were its size and multicentre structure, with 199,135 adolescents
10 325 from 36 countries and 72,900 children from 17 countries surveyed. Many of the centres were from
11 326 middle and low income countries from which previous data on the association between fast food
12 327 consumption and BMI had not been reported.

13 328 The main limitation to this study is the cross-sectional design which allows identification of
14 329 associations, but not of temporal sequence or causality. The assessment of subject heights and
15 330 weights and their fast food consumption was primarily undertaken by questionnaire which raises the
16 331 possibility of misclassification error, particularly with respect to the parent-reported weights of their
17 332 children and self-reported weights of the adolescents, thereby influencing the calculated BMI. It is
18 333 also possible that parents and adolescents may have misreported fast food consumption.

19 334 A further consideration is the interpretation of the question about the consumption of burgers / fast
20 335 foods. While 'burger' is almost universally understood, 'fast food' can be interpreted in a number of
21 336 ways, including foodstuffs from global restaurant chains, smaller non-franchised food stores, street
22 337 vendors and even frozen meals heated and served at home. Without knowing the exact kind of fast
23 338 food consumed, we can make no assessment of the nutritional content or energy density of the food
24 339 in question. Additionally, while the questionnaire asked about the frequency of burgers / fast food
25 340 consumption, we have no indication of portion sizes, or if it was accompanied by other items such as
26 341 sugar sweetened beverages.

27 342 Finally, centres that objectively measured heights and weights received no standardised instructions
28 343 for doing this. We have controlled for GNI, centre, measurement type, and sex in our analysis. We
29 344 have no data available on individual socioeconomic status or parental BMI which could potentially
30 345 affect young peoples' BMI, nor did we control for physical activity / inactivity of the participants.

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CONCLUSIONS:

~~There is~~ [This cross-sectional study has found that one quarter of children and half of adolescents consume fast food frequently or very frequently. Additionally there was](#) an association between a high frequency of fast food consumption and higher BMIs in 6-7 year old children, but this association ~~is was~~ reversed in adolescents. As this is ~~a cross-sectional~~ [an observational](#) study, causality cannot be proven, however it provides evidence that among children from many different nations, fast food consumption may contribute to weight gain. This reverse association observed in adolescents should be interpreted with caution, as the results may be affected by bias, particularly under-reporting of fast food consumption and reverse causation.

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359 Author Contributions: Mr A Stewart had access to all the data on the study and takes

360 responsibility for the integrity of the data and accuracy of the data analysis. *Study concept*

361 *and design*: All authors. *Acquisition of Data*: ISAAC steering committee. *Drafting of the*

362 *manuscript*: Braithwaite. *Critical revision of the manuscript for important intellectual*

363 *content*: all authors. *Statistical analysis*: Stewart. *Obtained Funding*: Mitchell.

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373

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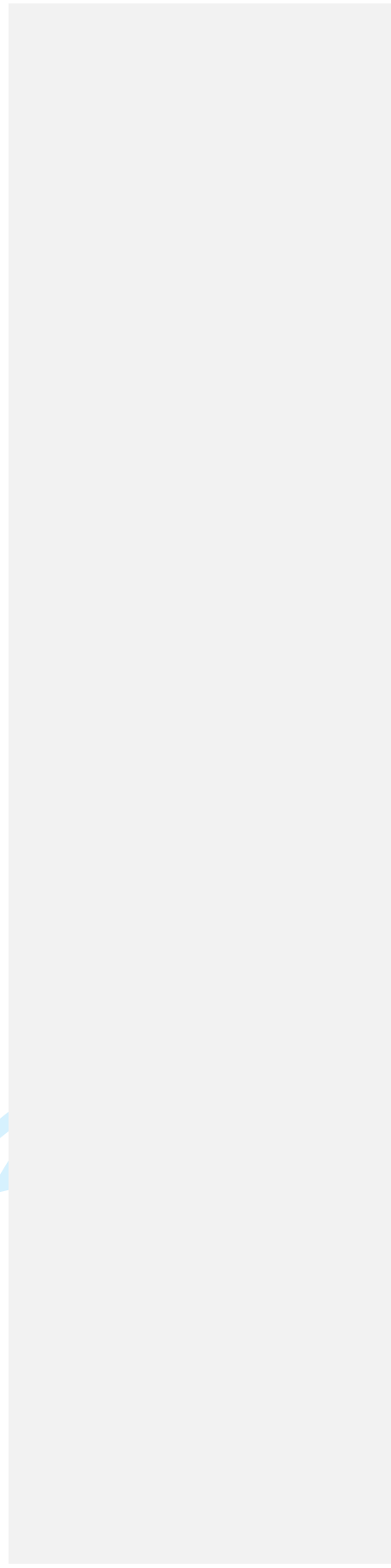
450 M Sears; Chile: V Aguirre; Fiji: L Waqatakirewa; India: J Shah; Indonesia: K Baratawidjaja;

451 Japan: S Nishima; Mexico: M Baeza-Bacab; New Zealand: MI Asher; Singapore: B-W Lee.

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For peer review only

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8 606 FIGURE LEGENDS

9 607 **Figure 1: Flow of participants through study. Children are represented in panel (a) and adolescents**
10 608 **in panel (b)**

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12 610 **Figure 2: Reported frequency of fast food consumption by study participants. Children are**
13 611 **represented in panel (a) and adolescents in panel (b)**

14 612

15 613 **Figure 3: ~~Association between~~The difference in BMI of study participants ~~and frequent and very~~**
16 614 **~~frequent~~that consumed -fast food consumption ~~frequently and very frequently~~ compared to**
17 615 **infrequent fast food consumption. Children are represented in panel (a) and adolescents in panel**
18 616 **(b). For each country the proportion of participants who consume fast food frequently or very**
19 617 **frequently is shown in parentheses. Those centres with reported height and weights are shown**
20 618 **with filled in circles, and those centres that measured heights and weights are shown with**
21 619 **hollowed circles.**

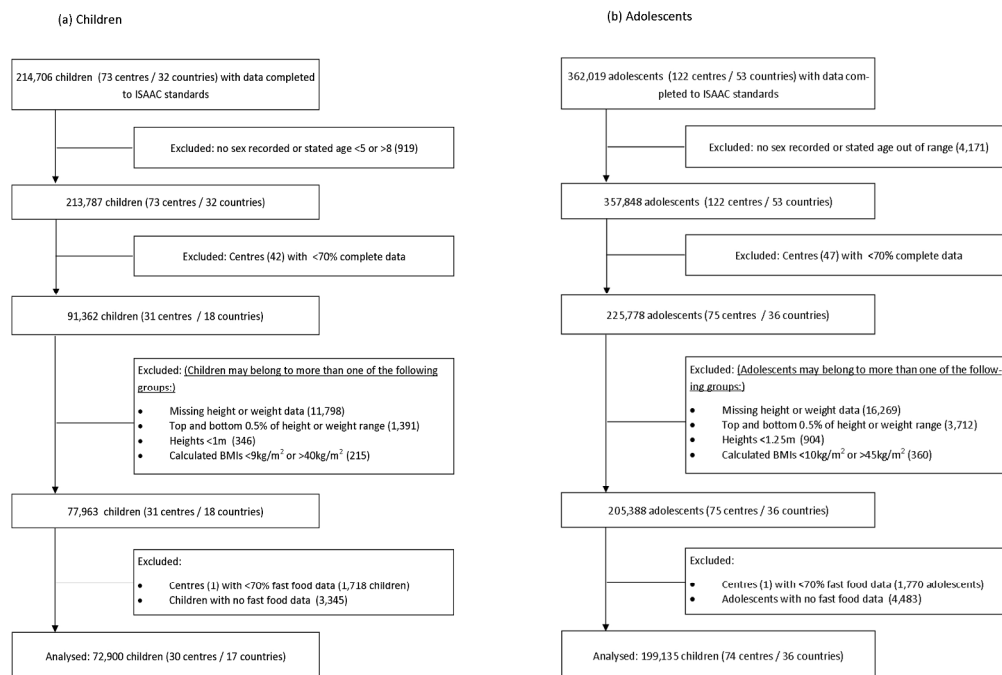


Figure 1: Flow of participants through study. Children are represented in panel (a) and adolescents in panel (b)

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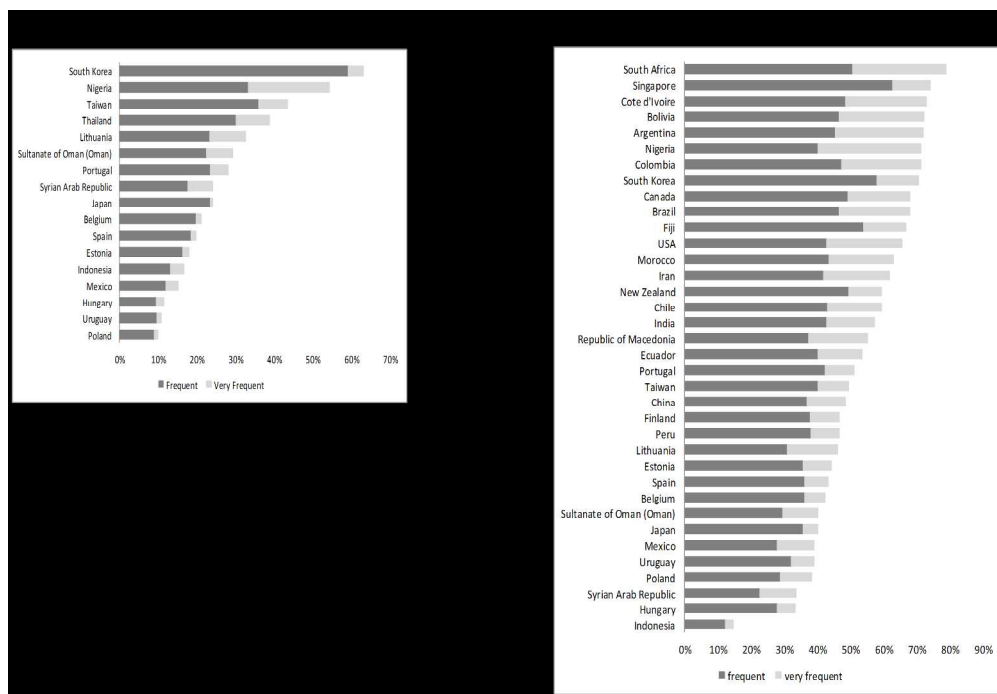


Figure 2: Reported frequency of fast food consumption by study participants. Children are represented in panel (a) and adolescents in panel (b)
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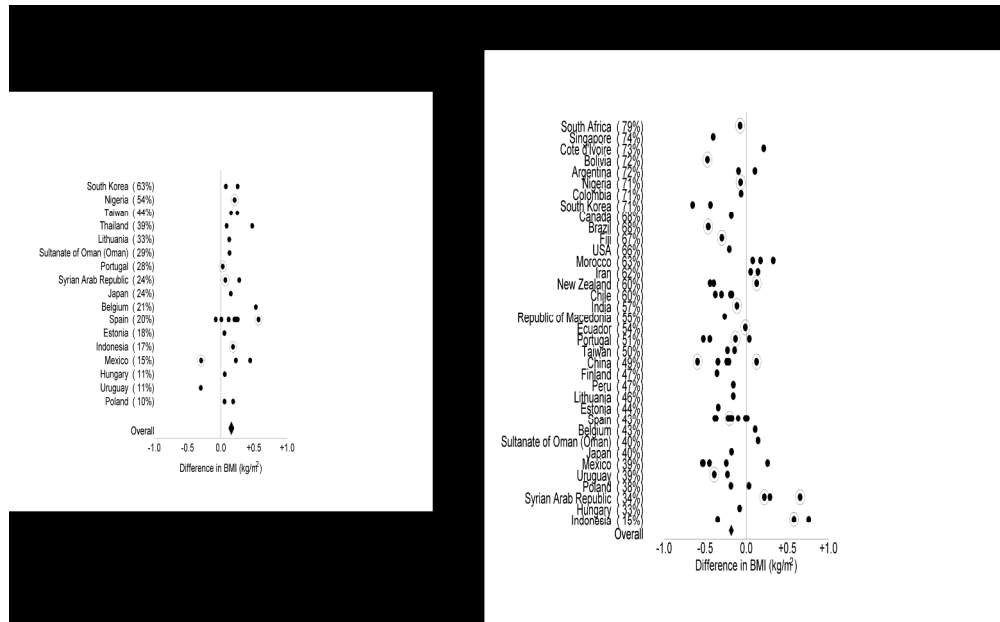


Figure 3: Association between BMI of study participants and frequent and very frequent fast food consumption compared to infrequent fast food consumption. Children are represented in panel (a) and adolescents in panel (b)
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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	Title page
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	5-6
Methods			
Study design	4	Present key elements of study design early in the paper	5-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
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	6-7
Bias	9	Describe any efforts to address potential sources of bias	7-8
Study size	10	Explain how the study size was arrived at	N/A
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
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	N/A
		(d) If applicable, describe analytical methods taking account of sampling strategy	8
		(e) Describe any sensitivity analyses	N/A
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	Figures 1a and 1b
		(b) Give reasons for non-participation at each stage	Figures 1a and 1b
		(c) Consider use of a flow diagram	Done
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	Figures 1a and 1b
Outcome data	15*	Report numbers of outcome events or summary measures	9-11
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	9-11, including Table 1
		(b) Report category boundaries when continuous variables were categorized	6-7
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9-11
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
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	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
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	2

*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.

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Keywords:	BMI, Fast food consumption, International, Childhood obesity, Childhood overweight

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Fast Food consumption and Body Mass Index in children and adolescents: an international cross-sectional study

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27 **ABSTRACT:**

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29 **Objective:** To investigate whether reported fast food consumption over the previous year is
30 associated with higher childhood or adolescent body mass index (BMI).

31 **Design:** Secondary analysis from multi-centre, multi-country, cross-sectional study (International
32 Study of Asthma and Allergies in Children (ISAAC) Phase Three).

33 **Subjects and Methods:** Parents/guardians of children aged 6-7 completed questionnaires
34 which included questions about their children's asthma and allergies, fast food consumption, height
35 and weight. Adolescents aged 13-14 completed the same questionnaire. The questionnaire asked
36 "In the past 12 months, how often on average did you (your child) eat fast food/burgers?"
37 Responses were; infrequent (never/only occasionally), frequent (once/twice a week), or very
38 frequent (three or more times per week). A general linear mixed model was used to determine the
39 association between BMI and fast food consumption, adjusting for Gross National Income per capita
40 by country, measurement type (whether heights/weights were reported or measured), age, and sex.

41 **Results:** 72,900 children (17 countries) and 199,135 adolescents (36 countries) provided data.
42 Frequent and very frequent fast food consumption was reported in 23% and 4% of children, and 39%
43 and 13% of adolescents. Children in the frequent and very frequent groups had a BMI 0.15 kg/m²
44 and 0.22 kg/m² higher than the infrequent group (P<0.001). Adolescent males in the frequent and
45 very frequent groups had a BMI 0.14 kg/m² and 0.28kg/m² lower than the infrequent group
46 (P<0.001). Adolescent females in the frequent and very frequent groups had a BMI 0.19kg/m² lower
47 than the infrequent group (P<0.001).

48 **Conclusion:** Reported fast food consumption is high in childhood and increases in adolescence.
49 Compared with infrequent fast food consumption, frequent and very frequent consumption is

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4 50 associated with a higher BMI in children. Because of residual confounding, reverse causation and
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6 51 likely misreporting, the reverse association observed in adolescents should be interpreted with
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8 52 caution.
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11 **Strengths and limitations of this study:**
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15 54 • 199,135 adolescents from 36 countries and 72,900 children from 17 countries provided
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17 55 information on their height, weight and fast food consumption.
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20 56 • Many of the countries were middle and low income from which previous data on the
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22 57 association of fast food consumption and BMI had not been reported.
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25 58 • There is an association between increasing frequency of fast food consumption and higher
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27 59 BMIs in 6-7 year old children, but this association was reversed in adolescents.
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30 60 • As this is a cross sectional study, causality cannot be proven, but it provides evidence that
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32 61 among children from many different nations, fast food consumption may contribute to
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34 62 weight gain.
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37 63 • The reverse association observed in adolescents should be interpreted with caution, as the
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39 64 results may be affected by bias, particularly under-reporting of fast food consumption and
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68 INTRODUCTION:

69 The rising prevalence of childhood obesity is marked (1, 2), and there are well documented concerns
70 about the future health implications of obesity in childhood (3-7). This problem has been identified
71 in low and middle income countries as well as affluent countries (8, 9).

72 While potential contributors to the problem of childhood obesity are considered to be multiple and
73 complex, in many countries fast food has been implicated due to its increasing availability, energy
74 density, and large portion sizes. (10-13). Studies investigating associations between fast food
75 consumption in children and Body Mass Index (BMI) have produced mixed results, some
76 demonstrating small but significant associations between fast food consumption and increased BMI
77 (12, 14-17), while others have failed to demonstrate a significant association (18-20). In a systematic
78 review of studies assessing the association between fast food and obesity in 2008, Rosenheck noted
79 that 'it is difficult to ascertain the true relationship between fast food consumption and weight gain
80 or obesity, as many confounding factors such as physical inactivity and less inhibited food
81 consumption are independently associated with both fast food consumption and weight gain or
82 obesity' and that '... residual confounding from immeasurable lifestyle choices will always distort
83 results garnered from observational study designs.'(14).

84 Additionally Rosenheck commented on the sample sizes of the cross-sectional studies, where only
85 one study enrolled more than 5,000 participants, and in general enrolment was closer to the 1,000
86 mark, potentially negatively impacting the power of the studies to effectively assess the association
87 between fast food consumption and weight / obesity. A cross-sectional study large enough to
88 achieve sufficient power to determine an association between fast food consumption and obesity
89 AND adequately address issues of multiple confounding factors is likely to be logistically demanding
90 and prohibitively costly. A secondary analysis of the data from the International Study of Asthma
91 and Allergies in Childhood (ISAAC) Phase Three programme allows an international 'snapshot' of fast
92 food consumption and an assessment of the association between fast food consumption and BMI in

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4 93 72,900 children from 17 countries and 199,135 adolescents from 36 countries at a single point in
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6 94 time, using a simple universal question. While few confounding variables are taken into account, the
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8 95 large numbers involved give power to this analysis.
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11 96 We hypothesised that there would be an association between greater fast food consumption and
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13 97 higher BMI in both children and adolescents, and that this association would be observed
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15 98 worldwide.
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19 **SUBJECTS AND METHODS:**

20 100 The International Study of Asthma and Allergies in Childhood (ISAAC) Phase Three programme was
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22 101 designed to measure time trends in the prevalence and severity of asthma, rhinoconjunctivitis and
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24 102 eczema and to explore the relationship between lifestyle, other putative risk factors and the
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26 103 development of asthma and allergies (21). ISAAC Phase Three used the ISAAC Phase One
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28 104 standardised core questionnaire on symptoms of asthma, rhinoconjunctivitis and eczema. ISAAC
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30 105 Phase Three provided the additional opportunity to explore the relationship between lifestyle
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32 106 factors such as fast food consumption and BMI, as heights, weights and information on the
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34 107 frequency of fast food consumption of participants were gathered in many centres through an
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36 108 optional environmental questionnaire that was answered by parents of children and by the
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38 109 adolescents themselves.
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43 110 The ISAAC Phase One standardised core questionnaire and ISAAC Phase Three environmental
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45 111 questionnaire are on the ISAAC website: isaac.auckland.ac.nz.
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48 112 Ethical approval was obtained for the original ISAAC Phase Three study, and permission was gained
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50 113 to use the data from ISAAC Phase Three through agreement with the ISAAC Phase Three Steering
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115 **Main outcome variable - Body Mass Index:**

116 Height and weight were reported by the parents of the children, and were self-reported by
117 adolescents. In some centres, each subject's height and weight were measured objectively; there
118 were no standardised or specific instructions for doing this. BMI was calculated as weight (kg)/height
119 (m)².

120 **Explanatory variables:**

121 Fast food consumption was established by asking participants to answer the following question: "In
122 the past 12 months, how often, on average, did you [your child] eat the following?"

123 'Fast Food / Burgers' were listed as one option along with 14 other foodstuffs including meat,
124 seafood, fruit and vegetables. The participants were asked to categorise their intake of each listed
125 food as "Never or only occasionally"; "once or twice per week"; or "Three or more times a week".

126 These responses were categorised as 'infrequent', 'frequent' and 'very frequent'. Each variable was
127 examined separately for both age groups.

128 Country Gross National Index (GNI) was based on the 2006 World Bank of Gross National Income by
129 country. The World Bank categories of high income, high middle income, low middle income and low
130 income countries were dichotomised into 'high income' (high and high middle income) and 'low
131 income' (low middle and low income) categories.

132 **Participants:**

133 For children aged 6-7 years, data were submitted from 73 centres in 32 countries (214,706 subjects).

134 For adolescents aged 13-14 years data were submitted from 125 centres in 54 countries (369,881
135 subjects).

136 Centres that provided data on height, weight and fast food consumption for at least 70% of
137 participants were included in our analyses. Individuals without complete age, sex, fast food
138 consumption, height or weight data were excluded.

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4 139 Data cleaning:

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6 140 To eliminate likely erroneous BMI data, we applied the following thresholds:

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9 141 - For children in each centre, those in the top and bottom 0.5% of weights and heights, and

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11 142 those with heights less than 1.0 metre were excluded. Children with BMI less than $9\text{kg}/\text{m}^2$

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13 143 and greater than $40\text{kg}/\text{m}^2$ were excluded.

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16 144 - For adolescents in each centre, those in the top and bottom 0.5% of weights and heights,

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18 145 and those with heights less than 1.25 metres were excluded. Adolescents with BMI less than

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20 146 $10\text{kg}/\text{m}^2$ and greater than $45\text{kg}/\text{m}^2$ were excluded.

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23 147 Following sequential application of the exclusion and data cleaning criteria described above, 72,900

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25 148 children (30 centres / 17 countries) and 199,135 adolescents (74 centres / 36 countries) were

26
27 149 included in the final analysis (Figure 1). Parents provided heights and weights for 60,027 children,

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29 150 while 12,873 children had their heights and weights measured. 154,624 adolescents provided self-

30
31 151 reported height and weight while 44,511 adolescents had measured heights and weights.

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35 152 **Figure 1: Flow of subjects through study.**

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37 153 **STATISTICAL ANALYSIS:**

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39 154 BMI was assessed separately for each age group using a general linear mixed model with centre as a

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41 155 random effect and GNI for each country (low and high), the individual's age, sex, measurement type

42
43 156 (reported or measured), and fast food consumption ('infrequent', 'frequent' 'very frequent') as fixed

44
45 157 effects. The BMI values reported are the modelled means for those who reported infrequent fast

46
47 158 food consumption in the children and adolescent groups respectively.

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50 159 In the adolescent group statistically significant interactions were found between sex and fast food

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52 160 consumption, and measurement type and fast food consumption. There was also an interaction

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54 161 found between country GNI and fast food consumption. Consequently, analyses were done

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56 162 separately for each sex, measured height and weight data only, and GNI categories. No similar

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4 163 interactions were found in the children's group, but there were sufficient numbers to analyse each
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6 164 sex separately, which we elected to do.
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9 10 165 **RESULTS:**

11 12 166 **Fast food consumption:**

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14 167 22.6% of children reported frequent fast food consumption and 4.2% reported very frequent fast
15
16 168 food consumption. Combined frequent and very frequent fast food consumption in each country
17
18 169 ranged from 10% in Poland to 63% in South Korea (Figure 2a).
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20
21 170 38.7% of adolescents reported frequent fast food consumption and 12.6% reported very frequent
22
23 171 consumption. Frequent and very frequent fast food consumption ranged from 15% in Indonesia to
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25 172 79% in South Africa (Figure 2b).
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28 173 **Figure 2: Reported fast food consumption of study participants by country.**
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32 33 175 **Fast food consumption and BMI:**

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35 176 Children:

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37 177 Figure 3a shows the difference in BMI between children with infrequent fast food consumption and
38
39 178 those with frequent and very frequent fast food consumption in each centre.
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42 179 **Figure 3a: The association between reported fast food consumption and BMI of children.**

43
44 180 The estimated mean BMIs in children reporting infrequent fast food consumption were 16.20 and
45
46 181 16.51 kg/m² for ages 6 and 7 respectively. After controlling for country GNI, centre, age and
47
48 182 measurement type, there was a statistically significant association between frequent and very
49
50 183 frequent fast food consumption and higher BMI with an apparent dose response effect (+0.15 and
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52 184 +0.22kg/m² for frequent and very frequent fast food consumption respectively), (Table 1). There
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54 185 was no statistically significant interaction between GNI and fast food consumption in this age group
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56
57 186 (P=0.06).
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187 **Table 1 – Association between fast food consumption and BMI (SE) of study participants after**
 188 **adjustment for GNI**

	Difference in mean BMI (Kg/m ²) compared with infrequent fast food consumption			
	Estimated mean BMI* (Kg/m ²) infrequent fast food consumption	Frequent fast food consumption: mean (SE)	Very frequent fast food consumption: mean (SE)	P value ⁱ
Children (N=72,900)	16.51	+ 0.15 (0.02)	+ 0.22 (0.05)	P<0.001
Male Children (N=36,778)	16.53	+0.16 (0.03)	+0.24 (0.06)	P<0.001
Female Children (N=36,122)	16.39	+0.14 (0.03)	+0.20 (0.07)	P<0.001
Adolescent Males (N=98,794)	20.02	-0.14 (0.02)	- 0.28 (0.03)	P<0.001
Adolescent Females (N=100,341)	19.98	-0.19 (0.02)	- 0.19 (0.03)	P<0.001
Participants with measured height and weight data				
Children (N=12,873)	15.88	+0.14 (0.05)	+0.13 (0.08)	P=0.02
Adolescent Males (N= 20,384)	19.67	-0.03 (0.05)	-0.11(0.07)	P=0.24
Adolescent Females (N=24,127)	20.15	-0.15 (0.05)	-0.09 (0.06)	P=0.004

189 *Estimated BMIs for children aged 7 years and adolescents aged 14 years.

190 ⁱ P value is a joint test of whether the differences in BMIs for frequent and very frequent fast food consumption relative to infrequent
 191 fast food consumption are zero.

193 When boys and girls were analysed separately, both sexes had a significant positive association

194 between frequent and very frequent fast food consumption (Table 1).

195 **Adolescents:**

196 Figure 3b shows the difference in BMI between adolescents with infrequent fast food consumption

197 and those with frequent and very frequent fast food consumption in each centre.

198 **Figure 3b: The association between fast food consumption and BMI of adolescents**

199 In male adolescents, the estimated mean BMIs for those reporting infrequent fast food consumption

200 were 19.74 and 20.02 kg/m² for ages 13 and 14 respectively. After controlling for country GNI,

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4 201 centre, age and measurement type, lower BMI's were significantly associated with greater fast food
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6 202 consumption (Table 1). There was a statistically significant interaction between fast food
7
8 203 consumption and GNI. In low GNI countries the frequency of fast food consumption had no
9
10 204 association with BMI (+0.01 and -0.03kg/m² in the frequent and very frequent groups respectively
11
12 205 (P=0.89 and 0.56)). In high GNI countries, lower BMI's were associated with greater fast food
13
14 206 consumption (-0.21 and -0.42kg/m² in the frequent and very frequent groups respectively (P<0.001
15
16 207 in both groups)).

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20 208 When analyses were restricted to the 20,384 male adolescents who had measured height and
21
22 209 weight data there was a tendency towards a lower BMI with higher fast food consumption, but this
23
24 210 was not statistically significant (-0.03kg/m² and -0.11kg/m² in the frequent and very frequent group
25
26 211 respectively, (p=0.24)).

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30 212 In female adolescents, the estimated mean BMI's for those reporting infrequent fast food
31
32 213 consumption were 19.56 and 19.98 kg/m² for ages 13 and 14 respectively. Lower BMIs were
33
34 214 associated with greater fast food consumption and this was statistically significant. There was a
35
36 215 statistically significant interaction between fast food consumption and GNI. Both low and high GNI
37
38 216 countries had an association between increasing fast food consumption and BMI (low GNI countries
39
40 217 -0.10kg/m² and -0.11kg/m² in the frequent and very frequent groups respectively (P=0.03 and 0.01),
41
42 218 and high GNI countries -0.24kg/m² and -0.22kg/m² in the frequent and very frequent groups
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44 219 respectively (P<0.0001 in both cases)).

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47 220 When analyses were restricted to the 24,127 female adolescents who had measured height and
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49 221 weight data, those who ate fast food frequently or very frequently had lower BMIs and this was
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51 222 statistically significant (Table 1).
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4 223 **DISCUSSION:**
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6 224 This international study has identified that 6-7 year old children who consumed fast food frequently
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8 225 had higher BMIs than those who consumed fast food infrequently. This association was independent
9
10 226 of the affluence of the country and of similar magnitude in boys and girls. By contrast, adolescents
11
12 227 who self-reported that they frequently ate fast foods tended to have lower BMIs, with the exception
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14 228 of male adolescents from low GNI countries, where there was no association between fast food
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16 229 consumption and BMI. We have also found that up to 25% of children worldwide consume fast food
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18 230 frequently or very frequently, and this increases to over 50% in the adolescent age group.
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21
22 231 **Children**
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24 232 Our results in children are consistent with those of Shan et al who found that 'Western fast food'
25
26 233 and 'snack food' were associated with overweight and obesity among children aged 2 to 18 years in
27
28 234 Beijing(22). However, In New Zealand, Duncan et al found that low levels of physical activity,
29
30 235 skipping breakfast and insufficient sleep on weekdays were associated with increased adiposity in 5
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32 236 to 11 year olds, but that fast food consumption was not (20). The magnitude of the association
33
34 237 between fast food consumption and BMI in children was small (mean BMI values 0.15 kg/m² and
35
36 238 0.22kg/m² higher in frequent and very frequent consumers compared to infrequent consumers), and
37
38 239 the clinical significance of this is uncertain. Given the long term consequences of overweight and
39
40 240 obesity in childhood, even a small change in mean BMI in a population could be of major public
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42 241 health significance.
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46 242 An observational study such as this cannot attribute causality. The association we have found
47
48 243 between fast food consumption and BMI in children could be due to other specific dietary factors
49
50 244 that have been shown to be associated with fast food consumption, such as higher fat intake,
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52 245 greater consumption of sugary drinks, fewer fruits and non-starchy vegetables(11). Alternatively
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54 246 fast food consumption may be a marker of other factors that influence BMI such as parental BMI,
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56 247 individual socioeconomic circumstances or patterns of activity and inactivity.
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248 Adolescents

249 In our analysis self-reported frequent fast food consumption was associated with a lower BMI in
250 adolescents, with stronger association in higher GNI countries. As far as we are aware, no other
251 studies have demonstrated a lower BMI with higher fast food consumption in adolescence and our
252 findings appear to be in stark contrast to other research findings from high GNI countries. One study
253 showed that increasing fast food consumption in American adolescents was associated with
254 increased weight gain from adolescence to adulthood (12). Another study found that American
255 adolescents who consumed greater quantities of fried food away from home were heavier (23), and,
256 in a further American study, increasing frequency of eating quick-service food was associated with
257 an increasing z-BMI in adolescent females (17). A United Kingdom study found that increased visits
258 to fast food outlets was associated with higher BMI standard deviation scores in teenagers (24). In
259 three of these studies heights and weights were measured to pre-set standards by trained
260 investigators (12, 17, 24), whereas heights and weights of our adolescent participants were mostly
261 self-reported. It is possible that in our study some of the larger participants, particularly from body-
262 image conscious countries or cultures may have under-reported their weights. In a study evaluating
263 the correlation of measured versus self-reported heights and weights in adolescents, Brener et al
264 found that their study subjects tended to over-report their height by 2.7 inches (6.9cm) on average,
265 and to under-report their weight by 3.5 pounds (1.6kg) on average, resulting in a BMI understated by
266 2.6kg/m^2 when compared to measured values. White adolescents were most likely to over-report
267 their height and female adolescents were more likely to under-report their weight(25). Similarly
268 Danubio et al found that height was over-estimated in males and females (2.1 and 2.8cm
269 respectively), and that weight was understated (1.5kg in males and 1.9kg in females)(26). Rasmussen
270 et al reported that in the COMPASS study, boys and girls who wished to be leaner under-reported
271 their weight and BMI more than subjects who were satisfied with their body size(27). When we
272 restricted our analysis to measured height and weight data only, the association between higher fast
273 food intake and lower BMI was no longer observed in male adolescents, but the association between

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4 274 higher rates of fast food consumption and lower BMI persisted in female adolescents. We need to
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6 275 consider the likelihood that because of the perception of the negative effects of fast food
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8 276 consumption, adolescents who are overweight or obese are likely to have under-reported their
9
10 277 actual fast food consumption. In a review of validation studies on energy-intake reporting in children
11
12 278 and adolescents, Livingstone and Robson describe an increasing in under-reporting of energy intake
13
14 279 reporting as age and BMI increases in childhood and adolescence, with 14%, 25% and 40% of energy
15
16 280 intake under-reported in obese 6 year olds, 10 year olds and adolescents respectively (28). Finally,
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18 281 it is possible that our results are influenced by a degree of reverse-causation where those
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20 282 participants who are already overweight or obese are avoiding fast foods in order to reduce their
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22 283 body weight.
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27 284 Fast food consumption

28 285 This study has shown that up to 25% of children worldwide consume fast food frequently or very
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30 286 frequently, and this increases to over 50% in the adolescent age group. This is consistent with results
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32 287 of previous studies, particularly those based in the United States and the United Kingdom (11, 29,
33
34 288 30). This study has also highlighted the unexpectedly high proportion of fast food consumption in
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36 289 both age groups in many developing countries, for which data have not previously been available. In
37
38 290 particular, high prevalence of fast food consumption was observed in centres in Latin America and
39
40 291 Asia similar in magnitude to that observed in the United States and Western Europe. Importantly,
41
42 292 we have also shown that the association between fast food consumption and higher BMI in children
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44 293 persists among those from both affluent and less affluent countries.
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48 294 Cohort studies have demonstrated that high consumption of fast food at first assessment is
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50 295 associated with higher BMIs later in childhood or adult life (12, 24). If this is the case, despite an
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52 296 apparently lower BMI with higher reported fast food consumption in the adolescent group, the high
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54 297 proportions of adolescents already reporting fast food consumption is of concern, as fast food
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4 298 consumption has been directly linked with insulin resistance, hypertension and other health
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6 299 sequelae (31).
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10 **Strengths and limitations:**

11 301 The major strengths of this study were its size and multicentre structure, with 199,135 adolescents
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13 302 from 36 countries and 72,900 children from 17 countries surveyed. Many of the centres were from
14
15 303 middle and low income countries from which previous data on the association between fast food
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17 304 consumption and BMI had not been reported.
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20 305 The main limitation to this study is the cross-sectional design which allows identification of
21
22 306 associations, but not of temporal sequence or causality. The assessment of subject heights and
23
24 307 weights and their fast food consumption was primarily undertaken by questionnaire which raises the
25
26 308 possibility of misclassification error, particularly with respect to the parent-reported weights of their
27
28 309 children and self-reported weights of the adolescents, thereby influencing the calculated BMI. It is
29
30 310 also possible that parents and adolescents may have misreported fast food consumption.
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33
34 311 A further consideration is the interpretation of the question about the consumption of burgers / fast
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36 312 foods. While 'burger' is almost universally understood, 'fast food' can be interpreted in a number of
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38 313 ways, including foodstuffs from global restaurant chains, smaller non-franchised food stores, street
39
40 314 vendors and even frozen meals heated and served at home. Without knowing the exact kind of fast
41
42 315 food consumed, we can make no assessment of the nutritional content or energy density of the food
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44 316 in question. Additionally, while the questionnaire asked about the frequency of burgers / fast food
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46 317 consumption, we have no indication of portion sizes, or if it was accompanied by other items such as
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48 318 sugar sweetened beverages.
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52 319 Finally, centres that objectively measured heights and weights received no standardised instructions
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54 320 for doing this. We have controlled for GNI, centre, measurement type, and sex in our analysis. We
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4 321 have no data available on individual socioeconomic status or parental BMI which could potentially
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6 322 affect young peoples' BMI, nor did we control for physical activity / inactivity of the participants.
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10 323 **CONCLUSIONS:**

11 324 This cross-sectional study has found that one quarter of children and half of adolescents consume
12
13 325 fast food frequently or very frequently. Additionally there was an association between a high
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15 326 frequency of fast food consumption and higher BMIs in 6-7 year old children, but this association
16
17 327 was reversed in adolescents. As this is an observational study, causality cannot be proven, however
18
19 328 it provides evidence that among children from many different nations, fast food consumption may
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21 329 contribute to weight gain. This reverse association observed in adolescents should be interpreted
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23 330 with caution, as the results may be affected by bias, particularly under-reporting of fast food
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25 331 consumption and reverse causation.
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54 422 **Author Contributions:** Mr A Stewart had access to all the data on the study and takes

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56 423 responsibility for the integrity of the data and accuracy of the data analysis. *Study concept*
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14
15 data gathering and results is available on the ISAAC website: isaac.auckland.ac.nz/
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18 430 **FIGURE LEGENDS**

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20 431 **Figure 1: Flow of participants through study. Children are represented in panel (a) and adolescents**
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22 **in panel (b)**
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25 434 **Figure 2: Reported frequency of fast food consumption by study participants. Children are**
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27 **represented in panel (a) and adolescents in panel (b)**
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30 437 **Figure 3: The difference in BMI of study participants that consumed fast food consumption**
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32 **frequently and very frequently compared to infrequent fast food consumption. Children are**
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34 **represented in panel (a) and adolescents in panel (b). For each country the proportion of**
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36 **participants who consume fast food frequently or very frequently is shown in parentheses. Those**
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38 **centres with reported height and weights are shown with filled in circles, and those centres that**
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40 **measured heights and weights are shown with hollowed circles.**
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For peer review only

Fast Food consumption and Body Mass Index in children and adolescents: an international cross-sectional study

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27 **ABSTRACT:**

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29 **Objective:** To investigate whether reported fast food consumption over the previous year is
30 associated with higher childhood or adolescent body mass index (BMI).

31 **Design:** Secondary analysis from a multi-centre, multi-country, cross-sectional study
32 (International Study of Asthma and Allergies in Children (ISAAC) Phase Three).

33 **Subjects and Methods:** Parents / guardians of children aged 6-7 completed questionnaires
34 which included questions about their children's asthma and allergies, fast food consumption, height
35 and weight. Adolescents aged 13-14 completed the same questionnaire. The questionnaire asked
36 "In the past 12 months, how often on average did you (your child) eat fast food/burgers?"
37 Responses were; infrequent (never / only occasionally), frequent (once / twice a week), or very
38 frequent (three or more times per week). A general linear mixed model was used to determine the
39 association between BMI and fast food consumption, adjusting for Gross National Income per capita
40 by country, measurement type (whether height and weight were reported or measured), age, and
41 sex.

42 **Results:** 72,900 children from 17 countries and 199,135 adolescents from 36 countries provided
43 data. Frequent and very frequent fast food consumption was reported in 23% and 4% of children,
44 and 39% and 13% of adolescents. Children in the frequent and very frequent groups had a BMI 0.15
45 kg/m² and 0.22 kg/m² higher than the infrequent group (P<0.001). Adolescent males in the frequent
46 and very frequent groups had a BMI 0.14 kg/m² and 0.28kg/m² lower than the infrequent group
47 (P<0.001). Adolescent females in the frequent and very frequent groups had a BMI 0.19kg/m² lower
48 than the infrequent group (P<0.001).

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4 49 | • **Conclusion:** Reported fast food consumption is high in childhood and increases in
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7 50 | adolescence. Compared with infrequent fast food consumption, frequent and very frequent
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9 51 | consumption is associated with a higher BMI in children. Because of residual confounding,
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11 52 | reverse causation and likely misreporting, the reverse association observed in adolescents
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13 53 | should be interpreted with caution.
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16 54 | ~~and a lower BMI in adolescents.~~

55 **Strengths and limitations of this study:**

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23 56 | • 199,135 adolescents from 36 countries and 72,900 children from 17 countries provided
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25 57 | information on their height, weight and fast food consumption.
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28 58 | • Many of the countries were middle and low income from which previous data on the
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30 59 | association of fast food consumption and BMI had not been reported.
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33 60 | • There is an association between increasing frequency of fast food consumption and higher
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35 61 | BMIs in 6-7 year old children, but this association was reversed in adolescents.
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38 62 | • As this is a cross sectional study, causality cannot be proven, but it provides evidence that
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40 63 | among children from many different nations, fast food consumption may contribute to
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42 64 | weight gain.
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45 65 | • The reverse association observed in adolescents should be interpreted with caution, as the
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47 66 | results may be affected by bias, particularly under-reporting of fast food consumption and
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70 INTRODUCTION:

71 The rising prevalence of childhood obesity is marked (1, 2), and there are well documented concerns
72 about the future health implications of obesity in childhood (3-7). This problem has been identified
73 in low and middle income countries as well as affluent countries (8, 9).

74 While potential contributors to the problem of childhood obesity are considered to be multiple and
75 complex, in many countries fast food has been implicated due to its increasing availability, energy
76 density, and large portion sizes. (10-13). Studies investigating associations between fast food
77 consumption in children and Body Mass Index (BMI) have produced mixed results, some
78 demonstrating small but significant associations between fast food consumption and increased BMI
79 (12, 14-17), while others have failed to demonstrate a significant association (18-20). In a systematic
80 review of studies assessing the association between fast food and obesity in 2008, Rosenheck noted
81 that 'it is difficult to ascertain the true relationship between fast food consumption and weight gain
82 or obesity, as many confounding factors such as physical inactivity and less inhibited food
83 consumption are independently associated with both fast food consumption and weight gain or
84 obesity' and that '... residual confounding from immeasurable lifestyle choices will always distort
85 results garnered from observational study designs.'(14).

86 Additionally Rosenheck commented on the sample sizes of the cross-sectional studies, where only
87 one study enrolled more than 5,000 participants, and in general enrolment was closer to the 1,000
88 mark, potentially negatively impacting the power of the studies to effectively assess the association
89 between fast food consumption and weight / obesity. A cross-sectional study large enough to
90 achieve sufficient power to determine an association between fast food consumption and obesity
91 AND adequately address issues of multiple confounding factors is likely to be logistically demanding
92 and prohibitively costly. A secondary analysis of the data from the International Study of Asthma
93 and Allergies in Childhood (ISAAC) Phase Three programme allows an international 'snapshot' of fast
94 food consumption and an assessment of the association between fast food consumption and BMI in

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4 95 72,900 children from 17 countries and 199,135 adolescents from 36 countries at a single point in
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6 96 time, using a simple universal question. While few confounding variables are taken into account, the
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8 97 large numbers involved give power to this analysis.
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11 98 We hypothesised that there would be an association between greater fast food consumption and
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13 99 higher BMI in both children and adolescents, and that this association would be observed
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16 100 worldwide.

101 **SUBJECTS AND METHODS:**

102 The International Study of Asthma and Allergies in Childhood (ISAAC) Phase Three programme was
103 designed to measure time trends in the prevalence and severity of asthma, rhinoconjunctivitis and
104 eczema and to explore the relationship between lifestyle, other putative risk factors and the
105 development of asthma and allergies (21). ISAAC Phase Three used the ISAAC Phase One
106 standardised core questionnaire on symptoms of asthma, rhinoconjunctivitis and eczema. ISAAC
107 Phase Three provided the additional opportunity to explore the relationship between lifestyle
108 factors such as fast food consumption and BMI, as heights, weights and information on the
109 frequency of fast food consumption of participants were gathered in many centres through an
110 optional environmental questionnaire that was answered by parents of children and by the
111 adolescents themselves.

112 The ISAAC Phase One standardised core questionnaire and ISAAC Phase Three environmental
113 questionnaire are on the ISAAC website: isaac.auckland.ac.nz.

114 Ethical approval was obtained for the original ISAAC Phase Three study, and permission was gained
115 to use the data from ISAAC Phase Three through agreement with the ISAAC Phase Three Steering
116 Committee.

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4 117 **Main outcome variable - Body Mass Index:**

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6 118 Height and weight were reported by the parents of the children, and were self-reported by
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8 119 adolescents. In some centres, each subject's height and weight were measured objectively; there
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10 120 were no standardised or specific instructions for doing this. BMI was calculated as weight (kg)/height
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12 121 (m)².

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16 122 **Explanatory variables:**

17 123 Fast food consumption was established by asking participants to answer the following question: "In
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19 124 the past 12 months, how often, on average, did you [your child] eat the following?"

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22 125 'Fast Food / Burgers' were listed as one option along with 14 other foodstuffs including meat,
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24 126 seafood, fruit and vegetables. The participants were asked to categorise their intake of each listed
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26 127 food as "Never or only occasionally"; "once or twice per week"; or "Three or more times a week".

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29 128 These responses were categorised as 'infrequent', 'frequent' and 'very frequent'. Each variable was
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31 129 examined separately for both age groups.

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34 130 Country Gross National Index (GNI) was based on the 2006 World Bank of Gross National Income by
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36 131 country. The World Bank categories of high income, high middle income, low middle income and low
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38 132 income countries were dichotomised into 'high income' (high and high middle income) and 'low
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40 133 income' (low middle and low income) categories.

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44 134 **Participants:**

45 135 For children aged 6-7 years, data were submitted from 73 centres in 32 countries (214,706 subjects).

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47 136 For adolescents aged 13-14 years data were submitted from 125 centres in 54 countries (369,881
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49 137 subjects).

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52 138 Centres that provided data on height, weight and fast food consumption for at least 70% of
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54 139 participants were included in our analyses. Individuals without complete age, sex, fast food
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56 140 consumption, height or weight data were excluded.

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4 141 Data cleaning:

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6 142 To eliminate likely erroneous BMI data, we applied the following thresholds:

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9 143 - For children in each centre, those in the top and bottom 0.5% of weights and heights, and
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11 144 those with heights less than 1.0 metre were excluded. Children with BMI less than $9\text{kg}/\text{m}^2$
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13 145 and greater than $40\text{kg}/\text{m}^2$ were excluded.
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16 146 - For adolescents in each centre, those in the top and bottom 0.5% of weights and heights,
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18 147 and those with heights less than 1.25 metres were excluded. Adolescents with BMI less than
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20 148 $10\text{kg}/\text{m}^2$ and greater than $45\text{kg}/\text{m}^2$ were excluded.
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23 149 Following sequential application of the exclusion and data cleaning criteria described above, 72,900
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25 150 children (30 centres / 17 countries) and 199,135 adolescents (74 centres / 36 countries) were
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27 151 included in the final analysis (Figure 1). Parents provided heights and weights for 60,027 children,
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29 152 while 12,873 children had their heights and weights measured. 154,624 adolescents provided self-
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31 153 reported height and weight while 44,511 adolescents had measured heights and weights.
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35 154 **Figure 1: Flow of subjects through study.**

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37 155 **STATISTICAL ANALYSIS:**

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39 156 BMI was assessed separately for each age group using a general linear mixed model with centre as a
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41 157 random effect and GNI for each country (low and high), the individual's age, sex, measurement type
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43 158 (reported or measured), and fast food consumption ('infrequent', 'frequent' 'very frequent') as fixed
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45 159 effects. The BMI values reported are the modelled means for those who reported infrequent fast
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47 160 food consumption in the children and adolescent groups respectively.
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51 161 In the adolescent group statistically significant interactions were found between sex and fast food
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53 162 consumption, and measurement type and fast food consumption. There was also an interaction
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55 163 found between country GNI and fast food consumption. Consequently, analyses were done
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57 164 separately for each sex, measured height and weight data only, and GNI categories. No similar
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4 165 interactions were found in the children's group, but there were sufficient numbers to analyse each
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6 166 sex separately, which we elected to do.
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9 10 167 **RESULTS:**

11 12 168 **Fast food consumption:**

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14 169 22.6% of children reported frequent fast food consumption and 4.2% reported very frequent fast
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16 170 food consumption. Combined frequent and very frequent fast food consumption in each country
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18 171 ranged from 10% in Poland to 63% in South Korea (Figure 2a).

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21 172 38.7% of adolescents reported frequent fast food consumption and 12.6% reported very frequent
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23 173 consumption. Frequent and very frequent fast food consumption ranged from 15% in Indonesia to
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25 174 79% in South Africa (Figure 2b).
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28 175 **Figure 2: Reported fast food consumption of study participants by country.**
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32 33 177 **Fast food consumption and BMI:**

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35 178 Children:

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37 179 Figure 3a shows the difference in BMI between children with infrequent fast food consumption and
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39 180 those with frequent and very frequent fast food consumption in each centre.
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42 181 **Figure 3a: The association between reported fast food consumption and BMI of children.**

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44 182 The estimated mean BMIs in children reporting infrequent fast food consumption were 16.20 and
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46 183 16.51 kg/m² for ages 6 and 7 respectively. After controlling for country GNI, centre, age and
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48 184 measurement type, there was a statistically significant association between frequent and very
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50 185 frequent fast food consumption and higher BMI with an apparent dose response effect (+0.15 and
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52 186 +0.22kg/m² for frequent and very frequent fast food consumption respectively), (Table 1). There
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54 187 was no statistically significant interaction between GNI and fast food consumption in this age group
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57 188 (P=0.06).
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189 **Table 1 – Association between fast food consumption and BMI (SE) of study participants after**
 190 **adjustment for GNI**

	Difference in mean BMI (Kg/m ²) compared with infrequent fast food consumption			P value ⁱ
	Estimated mean BMI* (Kg/m ²) infrequent fast food consumption	Frequent fast food consumption: mean (SE)	Very frequent fast food consumption: mean (SE)	
Children (N=72,900)	16.51	+ 0.15 (0.02)	+ 0.22 (0.05)	P<0.001
Male Children (N=36,778)	16.53	+0.16 (0.03)	+0.24 (0.06)	P<0.001
Female Children (N=36,122)	16.39	+0.14 (0.03)	+0.20 (0.07)	P<0.001
Adolescent Males (N=98,794)	20.02	-0.14 (0.02)	- 0.28 (0.03)	P<0.001
Adolescent Females (N=100,341)	19.98	-0.19 (0.02)	- 0.19 (0.03)	P<0.001
Participants with measured height and weight data				
Children (N=12,873)	15.88	+0.14 (0.05)	+0.13 (0.08)	P=0.02
Adolescent Males (N= 20,384)	19.67	-0.03 (0.05)	-0.11(0.07)	P=0.24
Adolescent Females (N=24,127)	20.15	-0.15 (0.05)	-0.09 (0.06)	P=0.004

191 *Estimated BMIs for children aged 7 years and adolescents aged 14 years.

192 ⁱ P value is a joint test of whether the differences in BMIs for frequent and very frequent fast food consumption relative to infrequent
 193 fast food consumption are zero.

195 When boys and girls were analysed separately, both sexes had a significant positive association
 196 between frequent and very frequent fast food consumption (Table 1).

197 **Adolescents:**

198 Figure 3b shows the difference in BMI between adolescents with infrequent fast food consumption
 199 and those with frequent and very frequent fast food consumption in each centre.

200 **Figure 3b: The association between fast food consumption and BMI of adolescents**

201 In male adolescents, the estimated mean BMIs for those reporting infrequent fast food consumption
 202 were 19.74 and 20.02 kg/m² for ages 13 and 14 respectively. After controlling for country GNI,

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4 203 centre, age and measurement type, lower BMI's were significantly associated with greater fast food
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6 204 consumption (Table 1). There was a statistically significant interaction between fast food
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8 205 consumption and GNI. In low GNI countries the frequency of fast food consumption had no
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10 206 association with BMI (+0.01 and -0.03kg/m² in the frequent and very frequent groups respectively
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12 207 (P=0.89 and 0.56)). In high GNI countries, lower BMI's were associated with greater fast food
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14 208 consumption (-0.21 and -0.42kg/m² in the frequent and very frequent groups respectively (P<0.001
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16 209 in both groups)).

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20 210 When analyses were restricted to the 20,384 male adolescents who had measured height and
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22 211 weight data there was a tendency towards a lower BMI with higher fast food consumption, but this
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24 212 was not statistically significant (-0.03kg/m² and -0.11kg/m² in the frequent and very frequent group
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26 213 respectively, (p=0.24)).

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30 214 In female adolescents, the estimated mean BMI's for those reporting infrequent fast food
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32 215 consumption were 19.56 and 19.98 kg/m² for ages 13 and 14 respectively. Lower BMIs were
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34 216 associated with greater fast food consumption and this was statistically significant. There was a
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36 217 statistically significant interaction between fast food consumption and GNI. Both low and high GNI
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38 218 countries had an association between increasing fast food consumption and BMI (low GNI countries
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40 219 -0.10kg/m² and -0.11kg/m² in the frequent and very frequent groups respectively (P=0.03 and 0.01),
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42 220 and high GNI countries -0.24kg/m² and -0.22kg/m² in the frequent and very frequent groups
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44 221 respectively (P<0.0001 in both cases)).

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47 222 When analyses were restricted to the 24,127 female adolescents who had measured height and
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49 223 weight data, those who ate fast food frequently or very frequently had lower BMIs and this was
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51 224 statistically significant (Table 1).
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225 **DISCUSSION:**

226 This international study has identified that 6-7 year old children who consumed fast food frequently
227 had higher BMIs than those who consumed fast food infrequently. This association was independent
228 of the affluence of the country and of similar magnitude in boys and girls. By contrast, adolescents
229 who self-reported that they frequently ate fast foods tended to have lower BMIs, with the exception
230 of male adolescents from low GNI countries, where there was no association between fast food
231 consumption and BMI. We have also found that up to 25% of children worldwide consume fast food
232 frequently or very frequently, and this increases to over 50% in the adolescent age group.

233 **Children**

234 Our results in children are consistent with those of Shan et al who found that 'Western fast food'
235 and 'snack food' were associated with overweight and obesity among children aged 2 to 18 years in
236 Beijing(22). However, In New Zealand, Duncan et al found that low levels of physical activity,
237 skipping breakfast and insufficient sleep on weekdays were associated with increased adiposity in 5
238 to 11 year olds, but that fast food consumption was not (20). The magnitude of the association
239 between fast food consumption and BMI in children was small (mean BMI values 0.15 kg/m² and
240 0.22kg/m² higher in frequent and very frequent consumers compared to infrequent consumers), and
241 the clinical significance of this is uncertain. Given the long term consequences of overweight and
242 obesity in childhood, even a small change in mean BMI in a population could be of major public
243 health significance.

244 An observational study such as this cannot attribute causality. The association we have found
245 between fast food consumption and BMI in children could be due to other specific dietary factors
246 that have been shown to be associated with fast food consumption, such as higher fat intake,
247 greater consumption of sugary drinks, fewer fruits and non-starchy vegetables(11). Alternatively
248 fast food consumption may be a marker of other factors that influence BMI such as parental BMI,
249 individual socioeconomic circumstances or patterns of activity and inactivity.

250 Adolescents

251 In our analysis self-reported frequent fast food consumption was associated with a lower BMI in
252 adolescents, with stronger association in higher GNI countries. As far as we are aware, no other
253 studies have demonstrated a lower BMI with higher fast food consumption in adolescence and our
254 findings appear to be in stark contrast to other research findings from high GNI countries. One study
255 showed that increasing fast food consumption in American adolescents was associated with
256 increased weight gain from adolescence to adulthood (12). Another study found that American
257 adolescents who consumed greater quantities of fried food away from home were heavier (23), and,
258 in a further American study, increasing frequency of eating quick-service food was associated with
259 an increasing z-BMI in adolescent females (17). A United Kingdom study found that increased visits
260 to fast food outlets was associated with higher BMI standard deviation scores in teenagers (24). In
261 three of these studies heights and weights were measured to pre-set standards by trained
262 investigators (12, 17, 24), whereas heights and weights of our adolescent participants were mostly
263 self-reported. It is possible that in our study some of the larger participants, particularly from body-
264 image conscious countries or cultures may have under-reported their weights. In a study evaluating
265 the correlation of measured versus self-reported heights and weights in adolescents, Brener et al
266 found that their study subjects tended to over-report their height by 2.7 inches (6.9cm) on average,
267 and to under-report their weight by 3.5 pounds (1.6kg) on average, resulting in a BMI understated by
268 $2.6\text{kg}/\text{m}^2$ when compared to measured values. White adolescents were most likely to over-report
269 their height and female adolescents were more likely to under-report their weight(25). Similarly
270 Danubio et al found that height was over-estimated in males and females (2.1 and 2.8cm
271 respectively), and that weight was understated (1.5kg in males and 1.9kg in females)(26). Rasmussen
272 et al reported that in the COMPASS study, boys and girls who wished to be leaner under-reported
273 their weight and BMI more than subjects who were satisfied with their body size(27). When we
274 restricted our analysis to measured height and weight data only, the association between higher fast
275 food intake and lower BMI was no longer observed in male adolescents, but the association between

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4 276 higher rates of fast food consumption and lower BMI persisted in female adolescents. We need to
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6 277 consider the likelihood that because of the perception of the negative effects of fast food
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8 278 consumption, adolescents who are overweight or obese are likely to have under-reported their
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10 279 actual fast food consumption. In a review of validation studies on energy-intake reporting in children
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12 280 and adolescents, Livingstone and Robson describe an increasing in under-reporting of energy intake
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14 281 reporting as age and BMI increases in childhood and adolescence, with 14%, 25% and 40% of energy
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16 282 intake under-reported in obese 6 year olds, 10 year olds and adolescents respectively (28). Finally,
17
18 283 it is possible that our results are influenced by a degree of reverse-causation where those
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20 284 participants who are already overweight or obese are avoiding fast foods in order to reduce their
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22 285 body weight.
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27 286 Fast food consumption

28 287 This study has shown that up to 25% of children worldwide consume fast food frequently or very
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30 288 frequently, and this increases to over 50% in the adolescent age group. This is consistent with results
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32 289 of previous studies, particularly those based in the United States and the United Kingdom (11, 29,
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34 290 30). This study has also highlighted the unexpectedly high proportion of fast food consumption in
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36 291 both age groups in many developing countries, for which data have not previously been available. In
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38 292 particular, high prevalence of fast food consumption was observed in centres in Latin America and
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40 293 Asia similar in magnitude to that observed in the United States and Western Europe. Importantly,
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42 294 we have also shown that the association between fast food consumption and higher BMI in children
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44 295 persists among those from both affluent and less affluent countries.
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48 296 Cohort studies have demonstrated that high consumption of fast food at first assessment is
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50 297 associated with higher BMIs later in childhood or adult life (12, 24). If this is the case, despite an
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52 298 apparently lower BMI with higher reported fast food consumption in the adolescent group, the high
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54 299 proportions of adolescents already reporting fast food consumption is of concern, as fast food
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4 300 consumption has been directly linked with insulin resistance, hypertension and other health
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6 301 sequelae (31).
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10 **302 Strengths and limitations:**

11 303 The major strengths of this study were its size and multicentre structure, with 199,135 adolescents
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13 304 from 36 countries and 72,900 children from 17 countries surveyed. Many of the centres were from
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15 305 middle and low income countries from which previous data on the association between fast food
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17 306 consumption and BMI had not been reported.
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20 307 The main limitation to this study is the cross-sectional design which allows identification of
21
22 308 associations, but not of temporal sequence or causality. The assessment of subject heights and
23
24 309 weights and their fast food consumption was primarily undertaken by questionnaire which raises the
25
26 310 possibility of misclassification error, particularly with respect to the parent-reported weights of their
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28 311 children and self-reported weights of the adolescents, thereby influencing the calculated BMI. It is
29
30 312 also possible that parents and adolescents may have misreported fast food consumption.
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34 313 A further consideration is the interpretation of the question about the consumption of burgers / fast
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36 314 foods. While 'burger' is almost universally understood, 'fast food' can be interpreted in a number of
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38 315 ways, including foodstuffs from global restaurant chains, smaller non-franchised food stores, street
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40 316 vendors and even frozen meals heated and served at home. Without knowing the exact kind of fast
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42 317 food consumed, we can make no assessment of the nutritional content or energy density of the food
43
44 318 in question. Additionally, while the questionnaire asked about the frequency of burgers / fast food
45
46 319 consumption, we have no indication of portion sizes, or if it was accompanied by other items such as
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48 320 sugar sweetened beverages.
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52 321 Finally, centres that objectively measured heights and weights received no standardised instructions
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54 322 for doing this. We have controlled for GNI, centre, measurement type, and sex in our analysis. We
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4 323 have no data available on individual socioeconomic status or parental BMI which could potentially
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6 324 affect young peoples' BMI, nor did we control for physical activity / inactivity of the participants.
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10 **CONCLUSIONS:**

11 326 This cross-sectional study has found that one quarter of children and half of adolescents consume
12
13 327 fast food frequently or very frequently. Additionally there was an association between a high
14
15 328 frequency of fast food consumption and higher BMIs in 6-7 year old children, but this association
16
17 329 was reversed in adolescents. As this is an observational study, causality cannot be proven, however
18
19 330 it provides evidence that among children from many different nations, fast food consumption may
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21 331 contribute to weight gain. This reverse association observed in adolescents should be interpreted
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23 332 with caution, as the results may be affected by bias, particularly under-reporting of fast food
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25 333 consumption and reverse causation.
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4 521 FIGURE LEGENDS

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6 522 **Figure 1: Flow of participants through study. Children are represented in panel (a) and adolescents**
7 523 **in panel (b)**
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11 525 **Figure 2: Reported frequency of fast food consumption by study participants. Children are**
12 526 **represented in panel (a) and adolescents in panel (b)**
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16 528 **Figure 3: The difference in BMI of study participants that consumed fast food consumption**
17 529 **frequently and very frequently compared to infrequent fast food consumption. Children are**
18 530 **represented in panel (a) and adolescents in panel (b). For each country the proportion of**
19 531 **participants who consume fast food frequently or very frequently is shown in parentheses. Those**
20 532 **centres with reported height and weights are shown with filled in circles, and those centres that**
21 533 **measured heights and weights are shown with hollowed circles.**
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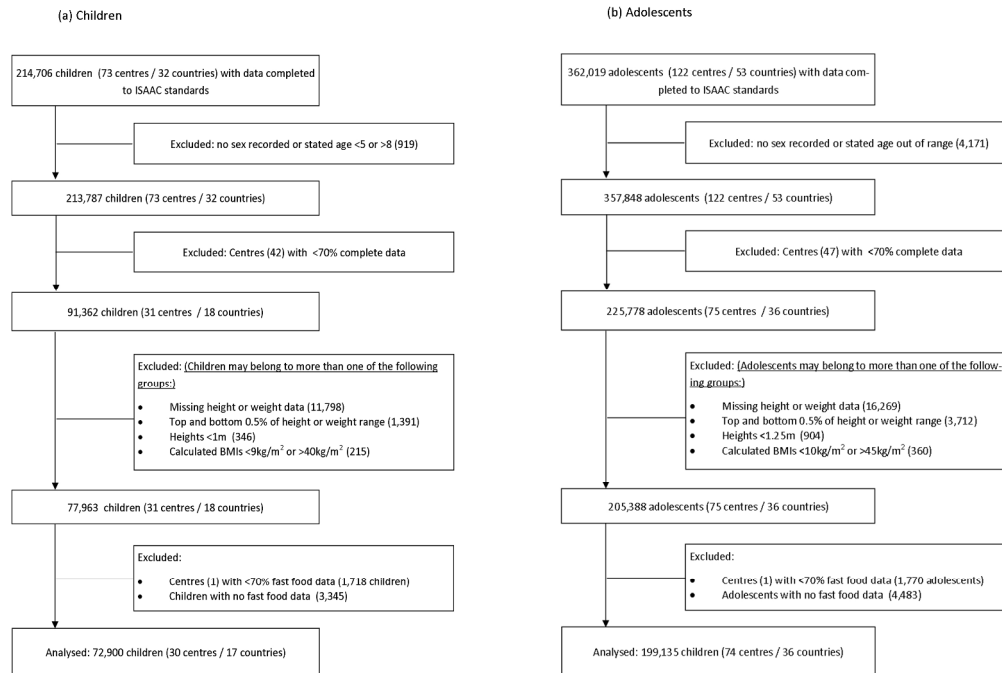


Figure 1: Flow of participants through study. Children are represented in panel (a) and adolescents in panel (b)

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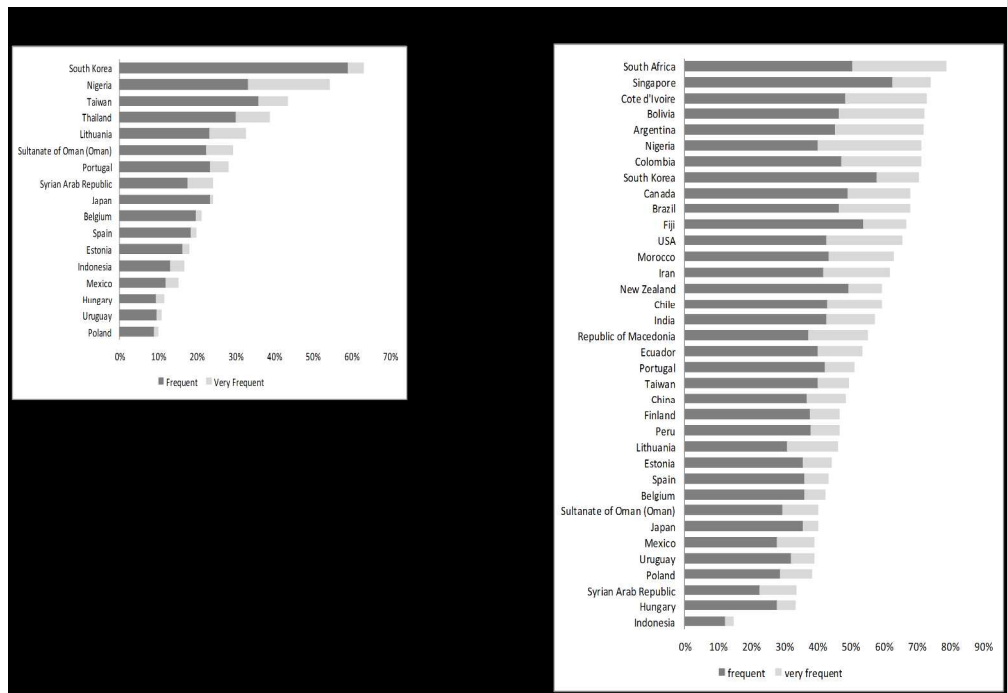


Figure 2: Reported frequency of fast food consumption by study participants. Children are represented in panel (a) and adolescents in panel (b)
261x179mm (300 x 300 DPI)

View only

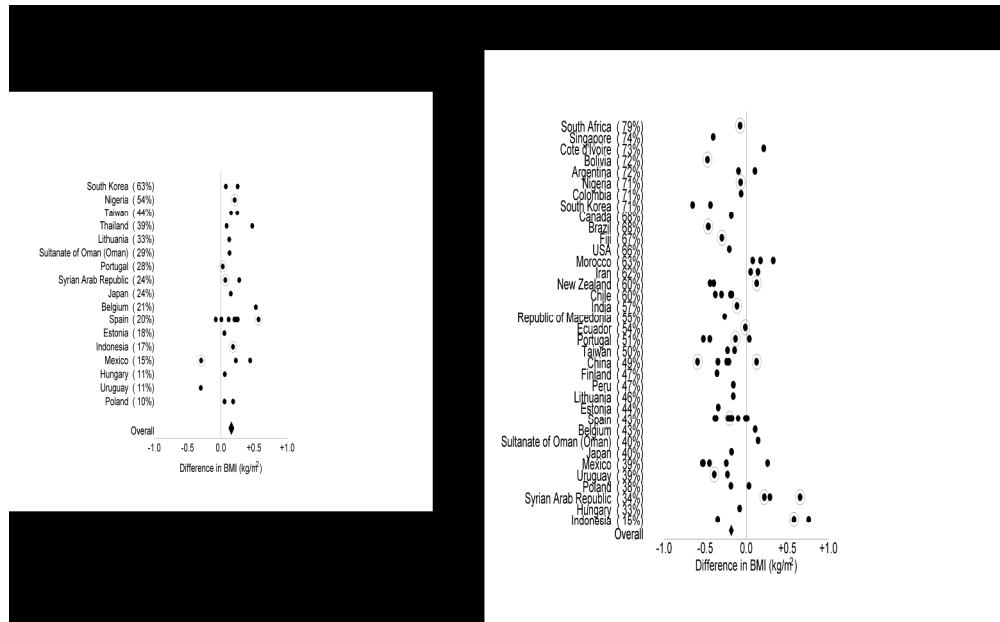


Figure 3: Association between BMI of study participants and frequent and very frequent fast food consumption compared to infrequent fast food consumption. Children are represented in panel (a) and adolescents in panel (b)
 261x161mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	Title page
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	5-6
Methods			
Study design	4	Present key elements of study design early in the paper	5-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
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	6-7
Bias	9	Describe any efforts to address potential sources of bias	7-8
Study size	10	Explain how the study size was arrived at	N/A
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
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	N/A
		(d) If applicable, describe analytical methods taking account of sampling strategy	8
		(e) Describe any sensitivity analyses	N/A
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	Figures 1a and 1b
		(b) Give reasons for non-participation at each stage	Figures 1a and 1b
		(c) Consider use of a flow diagram	Done
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	Figures 1a and 1b
Outcome data	15*	Report numbers of outcome events or summary measures	9-11
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	9-11, including Table 1
		(b) Report category boundaries when continuous variables were categorized	6-7
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9-11
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
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	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
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	2

*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.