British Journal of Nutrition (2011), **106**, 307–316
doi:10.1017/S0007114511001528

Review Article

Fatty acid intakes of children and adolescents are not in line with the dietary intake recommendations for future cardiovascular health: a systematic review of dietary intake data from thirty countries

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(Received 30 July 2010 – Revised 28 February 2011 – Accepted 28 February 2011 – First published online 18 April 2011)

Abstract

Fatty acid composition of the diet may influence cardiovascular risk from early childhood onwards. The objective of the present study was to perform a systematic review of dietary fat and fatty acid intakes in children and adolescents from different countries around the world and compare these with the population nutrient intake goals for prevention of chronic diseases as defined by the WHO (2003). Data on fat and fatty acid intake were mainly collected from national dietary surveys and from population studies all published during or after 1995. These were identified by searching PubMed, and through nutritionists at local Unilever offices in different countries. Fatty acid intake data from thirty countries mainly from developed countries were included. In twenty-eight of the thirty countries, mean SFA intakes were higher than the recommended maximum of 10 % energy, whereas in twenty-one out of thirty countries mean PUFA intakes were below recommended (6–10 % energy). More and better intake data are needed, in particular for developing regions of the world, and future research should determine the extent to which improvement of dietary fatty acid intake in childhood translates into lower CHD risk in later life. Despite these limitations, the available data clearly indicate that in the majority of the countries providing data on fatty acid intake, less than half of the children and adolescents meet the SFA and PUFA intake goals that are recommended for the prevention of chronic diseases.

Key words: Children: SFA: PUFA: CVD

CVD is the leading cause of premature death and disability globally[1]. Major clinical complications of CVD such as CHD, myocardial infarction and stroke manifest at middle or older age. However, it has been established that the atherogenic process (i.e. onset of lesions and fatty streaks in the aorta and coronary arteries) starts earlier, in childhood[2,3]. Furthermore, worrisome incidences of elevated CVD risk factors in children and adolescents have been observed in several countries[4–7]. In a recent survey of 324 Chilean children aged 4 years, 20 % had high total and LDL-cholesterol levels and 50 % of children had low HDL-cholesterol levels[5]. Children with elevated cholesterol levels tend to have higher levels later in life, and they are thus likely to have increased risk of CVD in adulthood[8–10].

For adults, it has been established that the fatty acid composition of the diet is a key factor affecting the blood lipid risk profile[11]. There is strong and convincing evidence that higher intakes of SFA and *trans*-fatty acids (TFA) and lower intakes of PUFA (mainly linoleic acid (LA; 18 : 2*n*-6) and α-linolenic acid (ALA; 18 : 3*n*-3)) have adverse effects on the blood lipid risk profile[12] and increase the risk of CHD[11,13]. Evidence on the effects of dietary fatty acids on blood lipids in children is much less abundant than that in adults. Nevertheless, several studies indicate that dietary fatty acids affect serum lipids in children in the same way as they do in adults[14,15]. Corvalan *et al.*[5] suggest that the high prevalence of children with elevated LDL-cholesterol and low HDL-cholesterol in Chile is due to the high content of SFA and TFA in the local diet. In the Dietary Intervention Study in Children (DISC)[16] and the Special Turku coronary Risk factor Intervention Project for children (STRIP)[17], diets with reduced SFA (< 10 % energy; %E), increased PUFA (6–10 %E) and a total fat content of about 30 %E were found to lower total and LDL-cholesterol in children.

Reducing SFA intake is a major focus of most international dietary guidelines and recommendations aimed to prevent CVD. The WHO emphasises the need for the general population

Abbreviations: ALA, α-linolenic acid; %E, percentage energy; LA, linoleic acid; TFA, *trans*-fatty acid.

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to lower intakes of SFA and TFA, and to increase intakes of PUFA[18]. However, reliable data on fat and fatty acid intake in children are lacking, and the relationship between fatty acid intake in childhood and risk of future chronic disease is not clearly established. Uauy & Dangour[19] recently reviewed dietary fat and fatty acid intake recommendations for children (2–18 years). They concluded that, in view of the limited evidence currently available, fat and fatty acid intakes in children above the age of 2 years should follow the dietary guidelines for adults that aim at the prevention of future chronic disease.

Here we report a systematic review of the available population data on fatty acid intake in children and adolescents from various countries across the world. Reported intakes are compared with the population nutrient intake goals for the prevention of chronic diseases as defined by the WHO[18].

Methods

Search strategy

To estimate dietary fat and fatty acid intakes in children and adolescents, a literature search in PubMed (from 1995 to March 2010) was conducted using the following search string: (total fat, saturated fats, SAFA, polyunsaturated fats, PUFA, monounsaturated fatty acid, MUFA) AND (consumption OR dietary OR intake OR survey) AND (children OR adolescents) as words in the abstract. Reference lists of all articles of interest were checked for additional studies. No language restrictions were used. In addition to the PubMed literature search, national intake data were collected through nutritionists at local Unilever offices representing eighty-one countries.

The initial search yielded 845 publications and reports (Fig. 1). These publications and reports were screened to determine eligibility of data based on the following criteria: (1) representative national survey or observational study measuring dietary fatty acid intake; (2) published during or after 1995; (3) data from healthy children or adolescents (aged $>$ 2–18 years); and (4) complete information provided on intake of total fat plus individual fatty acids (SFA, MUFA and PUFA). For countries where multiple data were available, data from national dietary surveys were preferred. If these were not available, representative data from population-based observational studies were considered, and when these were not available, data from household food budget

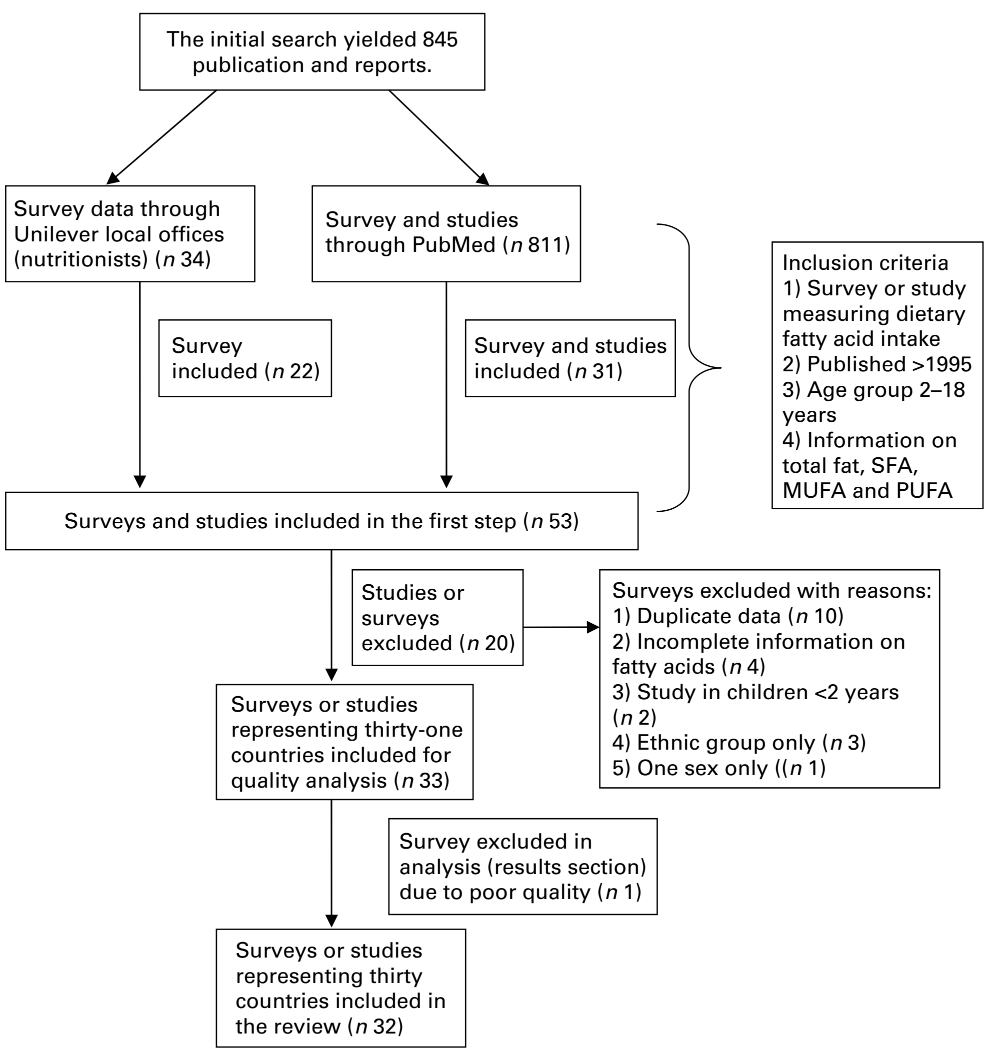

Fig. 1. Selection procedure and number of surveys and studies included and excluded from the review.

surveys were considered. This initial selection resulted in fifty-three potentially eligible data sources. In a subsequent selection step, twenty studies were excluded for the following reasons: (1) duplicate data set in a similar age group from the same country (*n* 10) so in these cases only the most recent datasets were used; (2) incomplete information on individual fatty acid intakes (*n* 4); (3) surveys only reporting data of specific ethnic or minority groups in the population (*n* 3); (4) studies which included children aged < 2 years (*n* 2); and (5) data reported for one sex only (*n* 1).

Quality of data

The included data were assessed and scored on quality using four criteria: (1) type of data source; (2) dietary assessment method; (3) year of publication; and (4) sample size (Table 1) [18,20–22]. Survey type and dietary assessment method were given the highest weight (maximum score of 3) in the quality score. For year of publication and sample size the maximum score was 2. The total attainable quality score of a study thus ranged between 4 and 10.

Based on the resulting total score, data were divided into three categories: (1) high quality (total score 9–10); (2) medium quality (total score 6–8); and (3) low quality (total score 4–5).

Quantitative data synthesis

From each data source, we extracted the mean values and standard deviations of total fat, SFA, MUFA and PUFA intakes. Where fatty acid intakes were expressed as absolute amounts (g), values were converted to percentage of total energy intake (%E), using the reported mean energy intake. Where data were reported for subgroups (for example, by age range or by sex), a weighted mean was calculated by weighting the mean intake of each subgroup by the number of the subjects in the subgroup. When standard deviations were not given, they were calculated using the population sample size and reported standard errors of the mean.

The percentage of children from each country meeting the recommended intake for SFA (% < 10 %E) and PUFA (% 6–10 %E) was estimated using the reported mean values and standard deviations, assuming a normal distribution of the data. The calculated *z*-scores ($(x - \mu)/\text{SD}$) were used to find *P* values (the probability) based on a normal distribution probability table[23].

For France, The Netherlands, Australia, and Mexico the standard deviations or standard errors of the mean of intakes were not available and therefore the percentage of children meeting the recommendations for these countries could not be calculated.

Recommended fatty acid intake

The mean intakes for each country were compared with the general population nutrient intake goals set by the WHO in 2003[18] for the prevention of chronic diseases: total fat 15–30 %E; SFA < 10 %E, TFA < 1 %E and PUFA 6–10 %E (of which 5–8 %E of *n*-6 (LA) and 1–2 %E of *n*-3 fatty acids (ALA)). For EPA and DHA there are no quantitative nutrient intake goals, but intakes for children are advised to be consistent with the general goal for the adult population, which is regular intake of one to two fatty fish meals per week[18].

Results

Data from thirty-one countries met the inclusion criteria. National dietary surveys were available for twenty-two countries; for eight countries, population-based observational studies (including one control group from a population-based intervention study) provided representative data on fat and fatty acid intake. Based on predefined scoring criteria, the quality of the intake data was high for twelve countries and medium for eighteen countries. Household food budget survey data were found for only one country (Brazil). Because the quality score was low and the results difficult to compare with those from other countries, we excluded these data from Brazil (Fig. 1).

From two countries, Belgium and New Zealand, two separate datasets reported intake in children and adolescents each and the quality scores were similar for the two different datasets from these countries (Table 2). Thus the present systematic review resulted in thirty-two eligible data set representing thirty countries.

Table 1. Criteria for evaluating scoring the data quality

Score	Type of data source*	Dietary assessment method†	Year of data publication‡	Sample size§
1	Household budget survey	Single 24 h recall or FFQ	≥1995–2000	<1000
2	Population-based study	Repeated 24 h recall or 48 h recall, 24 h recall + FFQ	>2000	>1000
3	National nutrition survey	(Weighed) food record, minimum of 3 d, or 7 d	–	–
Maximum score per criterion	3	3	2	2

* National dietary surveys scored 3, as these are the preferred type of study to estimate the distribution of nutrient intake in a population. Population-based studies were scored 2, as these tend not to be nationally representative. Household food budget surveys were scored 1, as they are of limited value in estimating the food intake of an individual[20–22].

† Weighed food record (3 and 7 d) methods are the highest-quality dietary assessment method for estimating the usual intake of foods in individuals, and hence were scored 3. Multiple 24 h recalls, or combining two different dietary assessment methods, such as 24 h recall with FFQ, increases the reliability and improves the dietary assessment, and hence were scored 2. On its own, the FFQ or 24 h recall was scored 1, due to lower quality of the methods for assessing usual intake[20–22].

‡ Recent data (published > 2000) scored 2, as data older than 10 years may not be representative of current fatty acid intake due to changes in consumption patterns of oils and fats in various countries[18]. Older surveys from ≥ 1995–2000 were scored 1 and data older than 15 years were not included.

§ Studies of larger sample size (>1000) were scored 2, while data with < 1000 subjects were scored 1.

https://doi.org/10.1017/S0007114511001528 Published online by Cambridge University Press

British Journal of Nutrition

Table 2. Characteristics of surveys and studies providing dietary intake data for thirty countries

Country and reference	Year of publication	Name/type of data source	Sample size (n)	Age group (years)	Dietary method	Quality	Score
Australia[43]	1998	National nutrition survey	3007	2–18	24 h recall and FFQ	Medium	8
Austria[44]	2003	Dietary survey on nutritional status	1188	3–18	3 and 7 d weighed food record	High	10
Belgium[45,46]	2007	Cross-sectional study	661	2·5–6·5	3 d estimated diet record	Medium	8
	2003	Cross-sectional study	341	13–18	7 d food record using a semi-structured diary	Medium	8
Bulgaria[47]	1998	Nutritional status survey	948	1–18	24 h recall	Medium	6
Canada[48]	2004	Nutrition survey	13 956	1–18	24 h recall	Medium	8
Costa Rica[49]	2005	Cross-sectional study	275	12–19	3 d food record	Medium	8
Denmark[50]	2002	National dietary survey	969	4–17	7 d record in a pre-coded questionnaire	High	9
Finland[51]	2000	Control group of population-based intervention study	411	3	4 d food record	Medium	8
France[52]	2004	Dietary survey	1190	3–14	7 d food record	High	10
Germany[53]	2007	ESKIMO (nutrition survey)	2508	6–17	6–11 years: 3 d food record filled in by parents; 12–17 years: dietary history interview of the past 4 weeks	High	9
Greece[54]	1997	National nutrition survey	1936	2–14	3 d diet dairy	High	9
Hungary[55]	2007	Nutrition and health survey	235	11–14	3 × 24 h recall + FFQ	Medium	8
Iceland[56]	2009	Observational study	165	7	3 d weighed dietary record	Medium	8
India*[57]	2009	Cross-sectional study	797	13–18	24 h recall + FFQ	Medium	7
Ireland[58]	2009	Cross-sectional consumption survey	1035	5–17	7 d food dairy	High	10
Israel[59]	2006	MABAT youth survey	5760	12–18	24 h recall and FFQ	High	9
Italy[60]	1996	Nutrition survey	35 072	7–10	FFQ, and in subsample 24 h recall + 7 d weighed food record	Medium	8
Japan[61]	2008	Child health study	25 033	6–15	Diet history questionnaire	Medium	7
Mexico[62]	2009	MHNS 1999	16 397	5–18	24 h recall	Medium	8
Netherlands[63]	1998	Dutch national food consumption survey	1539	1–19	2 d diet record	Medium	8
New Zealand[64,65]	2003	National nutrition survey	3275	5–14	24 h recall	Medium	7
	1999	National nutrition survey	202	15–18	24 h recall + FFQ	Medium	8
Norway[66–68]	2002–2005	National nutrition surveys	3935	2–13	Pre-coded 4 d food diary	High	10
Poland[69]	2003	Household food consumption survey	1241	1–18	24 h recall	Medium	8
Portugal[70]	2005	Cross-sectional study	4297	7–9	24 h recall	Medium	7
Spain[71]	2001	Enkid study (national survey)	2855	2–24	Two 24 h recalls (a second 24 h recall in 25 % of the sample) + FFQ	High	9
South Africa[72]	2000	National food consumption survey	2894	1–9	24 h recall + FFQ	Medium	8
Sweden[73]	2006	Nutrition survey	2495	4–12	7 d dietary record	High	9
Turkey[74]	2005	Cross-sectional study	300	12–19	3 d food record	Medium	8
UK[42]	2000	National diet and nutrition survey	1701	4–18	7 d dietary record	High	10
USA[75]	2005–2006	NHANES nutrition survey	4029	2–19	Two 24 h recalls	High	9

ESKIMO, Ernährungsstudie als KIGGS -modul; MABAT, Israeli National Health and Nutrition Study; MHNS, Mexican Health and Nutrition Survey; NHANES, National Health and Nutrition Examination Survey.
* See unpublished results in Misra et al.[57]; data from a representative sample from the general population in New Delhi, India.

Mean daily intake of total fat ranged across countries from 23 to 40 %E in children and from 25 to 40 %E in adolescents (Table 3). In three of the thirty countries, namely Japan, Mexico and South Africa, the mean total fat intakes of children and adolescents met the recommended total fat intake (<30 %E). The percentage of children meeting the recommended fat intake (<30 %E) ranged from 2 to 85 % in all countries.

Mean daily intake of SFA ranged across countries from 1 to 15·2 %E in children and from 1 to 15·8 %E in adolescents (Table 3). In twenty-eight out of the thirty countries, children and adolescents had mean SFA intakes above the recommended WHO population nutrient intake maximum of 10 %E (Table 3 and Fig. 2). In all countries, less than 50 % of children and adolescents met the recommended (<10 %E) SFA intake, except for Japan (100 %) and South Africa (91 %).

Mean daily intake of PUFA ranged across countries from 3·5 to 9·7 %E in children and from 3·6 to 11·2 %E in adolescents (Table 3), and was lower than the recommended WHO population nutrient intake range for PUFA (6–10 %E) in twenty-one out of the thirty countries (Table 3 and Fig. 3). Similar to SFA, less than 50 % of children and adolescents from all countries

Table 3. Intake of total fat, SFA, MUFA and PUFA among children (aged 2–10 years) and adolescents (aged 11–18 years) in thirty countries
(Mean values and standard deviations)

			Total energy (kJ)		Total fat (%E)		SFA (%E)		MUFA (%E)		PUFA (%E)		Percentage of children meeting the recommended levels of fat and fatty acid intake		
Country and reference	Age (years)	Subjects (*n*)	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	<30 %E total fat	<10 %E SFA	6–10 %E PUFA
Australia[43]	2–11	1921	7577	n/a	33·0	n/a	14·6	n/a	11·4	n/a	4·3	n/a	n/a	n/a	n/a
	12–18	1086	10 572	n/a	32·9	n/a	14·0	n/a	11·7	n/a	4·5	n/a	n/a	n/a	n/a
Austria[44]	3–10	477	5255	1447	34·5	5·2	15·0	2·0	11·7	1·0	5·2	2·0	19	1	36
	11–8	311	7493	2196	33·5	5·7	15·8	2·0	12·1	2·0	5·5	2·0	27	0	41
Belgium[45,46]	2·5–6·6	661	–	–	29·8	3·9	13·4	2·2	10·7	1·5	4·4	1·1	52	6	9
	13–18	341	9690	1987	35·7	4·7	15·4	2·4	14·3	2·3	5·9	1·4	11	1	50
Bulgaria[47]	1–10	438	7577	3259	35·7	7·7	14·2	5·1	10·1	2·9	9·7	3·5	23	21	40
	10–18	510	10 326	3916	35·9	8·3	13·2	5·3	10·1	3·1	11·2	3·8	24	27	30
Canada*[48]	1–8	5352	7045	4280	30·1	12·2	11·4	7·4	10·9	5·1	4·3	5·2	50	43	25
	9–18	8604	9886	6995	30·9	13·7	10·6	5·8	12·1	5·6	5·2	4·5	47	46	30
Costa Rica[49]	12–18	275	8959	4760	31·7	6·5	11·4	3·3	8·6	3·0	5·7	2·9	40	34	40
Denmark[50]	4–9	490	8192	1895	34·0	4·1	15·0	2·4	12·0	1·6	4·7	0·8	16	2	6
	10–17	479	8991	2497	32·4	4·7	14·0	2·5	11·0	1·8	4·4	0·8	30	6	2
Finland[51]	3	411	5171	970	33·2	4·5	14·7	2·6	10·8	1·9	4·7	1·2	24	4	16
France[52]	3–8	535	7150	n/a	35·0	n/a	14·3	n/a	11·2	n/a	3·5	n/a	n/a	n/a	n/a
	9–14	555	8518	n/a	35·0	n/a	13·6	n/a	10·9	n/a	3·6	n/a	n/a	n/a	n/a
Germany[53]	6–11	1234	7296	1518	32·0	5·5	14·0	4·4	11·5	3·6	4·3	1·8	36	18	19
	12–17	1274	10 874	3690	32·9	6·0	14·4	6·0	11·6	4·8	4·9	2·4	31	23	32
Greece[54]	2–9		n/a	n/a	40·5	7·0	15·2	4·4	16·9	14·0	5·8	3·2	7	12	39
	10–14	1936	n/a	n/a	40·5	7·0	14·7	4·6	17·5	15·6	6·5	3·5	7	15	41
Hungary[55]	11–14	235	9798	1690	34·6	5·0	10·7	2·2	10·5	2·1	8·3	2·0	18	38	69
Iceland[56]	7	165	7257	1327	31·8	4·8	13·8	2·6	9·3	1·8	3·8	1·2	35	7	4
India†[57]	13–18	797	n/a	n/a	34·0	6·6	11·1	3·9	9·7	2·6	9·0	3·4	27	39	44
Ireland[58]	5–12	594	n/a	n/a	34·0	4·2	14·7	2·5	11·6	1·8	4·9	1·3	17	3	22
	13–17	441	n/a	n/a	35·6	5·0	14·3	2·7	12·7	2·2	5·7	1·6	13	6	45
Israel[59]	12 –18	5760	10 849	5999	31·3	4·7	11·3	2·4	10·3	2·2	6·9	1·7	39	29	69
Italy[60]	7–10	35 072	8644	3033	34·1	6·3	12·3	3·2	11·5	2·7	5·6	2·1	26	24	43
Japan[61]	6–15	25 033	8428	2412	29·8	5·4	1·0	0·2	9·5	2·0	6·5	1·3	51	100	67
Mexico[62]	5–11	8690	5732	n/a	25·5	n/a	11·1	n/a	8·7	n/a	5·2	n/a	n/a	n/a	n/a
	12–18	7707	6836	n/a	25·4	n/a	10·4	n/a	8·7	n/a	5·8	n/a	n/a	n/a	n/a
Netherlands[63]	1–10	768	7100	n/a	32·2	n/a	12·9	n/a	11·1	n/a	6·1	n/a	n/a	n/a	n/a
	10–19	771	10 593	n/a	35·4	n/a	13·8	n/a	12·5	n/a	6·8	n/a	n/a	n/a	n/a
New Zealand*[64,65]	5–14	3275	8610	4512	33·1	12·5	14·5	6·3	10·9	5·7	3·8	2·3	40	24	18
	15–18	202	10 635	5516	34·5	13·0	14·5	6·0	12·0	7·0	5·0	3·5	36	23	32
Norway[66–68]	2–4	2111	6192	1497	32·9	4·9	14·2	2·5	10·0	1·7	5·8	1·8	28	5	47
	9–13	1824	8443	2497	31·1	5·2	13·6	2·6	9·8	2·0	5·5	1·7	42	8	40
Poland[69]	1–9	488	n/a	n/a	30·9	7·8	11·6	3·7	12·9	3·9	4·1	2·3	45	33	21
	13–18	753	n/a	n/a	34·2	7·2	11·4	3·8	14·6	3·9	5·1	2·7	28	36	35
Portugal[70]	7–9	4297	n/a	n/a	35·3	6·6	12·7	3·3	14·6	3·4	4·9	1·6	21	21	27
Spain[71]	2–13	1279	7393	895	39·1	4·5	13·9	2·0	15·5	2·5	4·7	1·0	2	3	12
	14–24	1576	10 489	1497	39·9	4·0	13·0	2·0	16·4	2·0	5·2	1·0	1	7	24
South Africa[72]	1–9	2894	6853	3246	23·0	8·0	6·0	3·0	8·0	3·0	6·0	2·5	81	91	46
Sweden[73]	4–8	1479	6962	1472	31·5	4·3	14·3	2·4	11·3	1·8	3·6	0·9	36	4	1
	11–12	1016	7359	2087	31·5	4·6	14·0	2·3	11·5	2·1	3·7	1·0	37	4	1
Turkey[74]	12–19	300	7849	2543	34·8	6·4	12·0	7·7	11·6	7·6	5·5	3·9	23	40	34
UK[42]	4–10	837	6593	1267	35·5	4·0	14·6	2·3	11·5	1·6	5·6	1·4	8	2	41
	11–18	864	7891	1866	35·7	4·7	13·8	2·2	11·8	2·0	6·3	1·6	11	4	59
USA*[75]	2–11	1914	7422	3351	32·6	11·1	11·7	4·9	11·9	4·5	6·2	4·4	41	36	33
	12–19	2115	9648	6451	33·2	15·1	11·5	4·3	12·1	7·8	6·6	3·2	42	36	44

%E; percentage energy; n/a, not available.
* Standard deviation calculated from the standard error of the mean.
† See unpublished results in Misra *et al.*[57]; data from a representative sample from the general population in New Delhi, India.

met the recommended (6–10 %E) PUFA intake, with the exceptions of Hungary (69 %), Israel (69 %), Japan (67 %) and the UK (59 % of 11- to 18-year-olds) (Table 3). Even in countries with the highest mean total fat intakes (>35 %E), namely Belgium, France, Portugal and Spain, mean PUFA intakes did not reach the lower 6 %E limit of the recommended range.

For eleven of the thirty countries, additional data on LA and ALA intakes were available; and for five countries data on the long-chain *n*-3 fatty acids EPA and DHA were also reported (Table 4). Mean intake of ALA was lower than the recommended 1–2 %E in ten countries, and mean intake of LA was lower than the recommended 5–8 %E in eight out of these eleven countries (Table 4). In five countries, mean

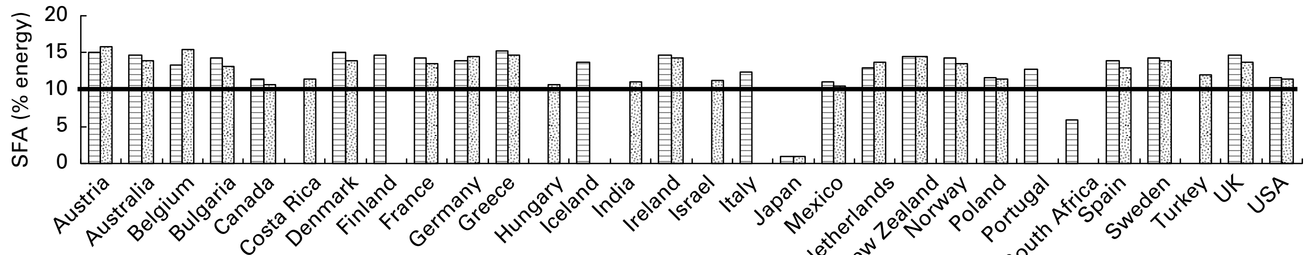

Fig. 2. SFA intakes (% energy) in children (▤) and adolescents (▨) in thirty countries. Values are means. (—), Cut-off for the maximum dietary SFA (10 % energy) intake recommended by the WHO[18].

intakes of total EPA and DHA varied between 45 and 150 mg in children and between 40 and 160 mg in adolescents (Table 4).

In two of the five countries for which TFA intake data were available (India and the UK), reported mean TFA intakes exceeded the recommended maximum of 1 %E (Table 5).

Discussion

The present review indicates that in the majority of the countries for which fatty acid intake data are available, at least half of the children and adolescents do not meet the recommended SFA and PUFA intakes for the prevention of CVD[18]. This is of public health concern, because dietary fat quality is an established determinant of the blood lipids and CVD risk[11], and fatty acid intake in childhood may have large consequences for CVD incidence in future adult populations.

Elevated blood cholesterol levels occur early in life

Cohort studies in the USA[24], Finland[25] and Chile[5] have reported elevated total and LDL-cholesterol levels in children from as young as 4 years old[5]. Recent national data from the USA show that 6·6 % of 12- to 17-year-old adolescents have elevated levels of LDL-cholesterol (≥3·3 mmol/l) and that 9·6 % of 6- to 17-year-olds are classified as having hypercholesterolaemia (total cholesterol ≥ 5·1 mmol/l)[26]. An elevated cholesterol level is likely to track from childhood into adulthood; children with high cholesterol levels have a substantially increased risk of hyperlipidaemia as adults[8]. For example, in the Muscatine Study 48·5 % of girls and 68 % of boys and in the Bogalusa Heart Study 50 % of children with elevated total cholesterol in childhood (5–18 years) also had elevated levels (≥5·17 mmol/l) later in young adulthood (20–30 years)[8,10].

In line with these observations, nowadays there are growing consensus and emphasis on the need for a life-course approach in the prevention of nutrition-related chronic diseases[18,19,27–29]. In view of the rising incidence of overweight and obesity in children and its consequences for cardiometabolic risk, this approach is becoming increasingly important. Lifestyle and dietary patterns are established at an early age; and healthy diet and lifestyle behaviours are likely to be more easily adopted if introduced in early childhood[27,30].

Evidence on the effects of dietary fat on blood cholesterol in children

Many controlled dietary intervention studies in adults have established that replacing dietary SFA with PUFA reduces LDL-cholesterol[11] and CHD risk[11,13]. However, only few studies have investigated the effect of dietary fatty acids on blood cholesterol levels in children. Early indications that diet influences plasma cholesterol the same way in children as in adults came from the Young Finns Study, in which it was observed that plasma cholesterol was positively associated with SFA intake in 12-year-old children[31]. The Finnish Special Turku coronary Risk factor Intervention Project for children (STRIP) aimed to reduce SFA intake of healthy infants at age 7 months by dietary counselling of mothers, and demonstrated that lower SFA (<10 %) and higher PUFA (about 10 %) intake in the intervention group resulted in a significant reduction of total and LDL-cholesterol levels[17,32]. These improvements were maintained up to at least 14 years

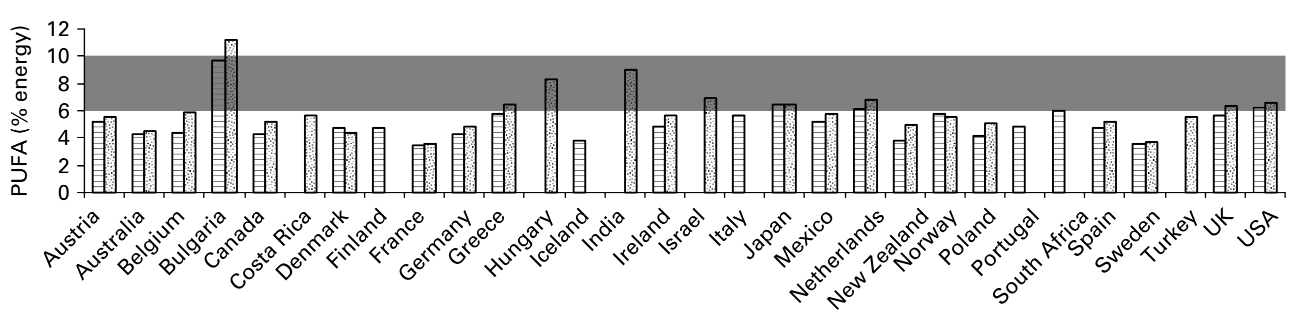

Fig. 3. PUFA intakes (% energy) in children (▤) and adolescents (▨) in thirty countries. Values are means. (—), Total PUFA intake range (6–10 % energy) recommended by the WHO[18].

Table 4. Linoleic acid (*cis*-18 : 2*n*-6; LA), α-linolenic acid (*cis*-18 : 3*n*-3; ALA), EPA and DHA intakes among children and adolescents*
(Mean values and standard deviations)

Country and reference	Age (years)	Subjects (*n*)	LA (% energy)		ALA (% energy)		EPA (mg)		DHA (mg)	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
Australia[76]	2–11	1921	3·9	n/a	0·4	n/a	20	n/a	44	n/a
	12–18	1086	3·9	n/a	0·4	n/a	37	n/a	70	n/a
Austria[44]	3–10	477	4·4	n/a	0·7	n/a	20	n/a	75	n/a
	11–18	311	4·0	n/a	0·5	n/a	30	n/a	95	n/a
Costa Rica[49]	12–18	275	3·4	0·7	0·2	0	60	15	60	30
Finland[51]	3	411	3·5	1·0	0·5	0·2	n/a	n/a	n/a	n/a
Iceland[56]	7	165	2·8	1·0	0·8	0·3	n/a	n/a	n/a	n/a
India[57]	13–18	797	8·2	3·5	1·0	0·7	n/a	n/a	n/a	n/a
Japan[61]	6–15	25 033	4·6	1·2	0·9	0·3	n/a	n/a	n/a	n/a
Mexico[62]	5–11	8690	3·8	n/a	0·2	n/a	n/a	n/a	n/a	n/a
	12–18	7707	3·9	n/a	0·4	n/a	n/a	n/a	n/a	n/a
Sweden[73]	4–8	1479	2·9	0·8	0·6	0·2	40	70	110	150
	11–12	1016	3·0	0·9	0·6	0·2	40	70	120	150
UK[42]	4–10	837	4·8	1·2	0·7	0·2	n/a	n/a	n/a	n/a
	11–18	864	5·4	1·4	0·9	0·3	n/a	n/a	n/a	n/a
USA†[75]	2–11	1914	5·6	4·8	0·5	0·5	15	70	30	140
	12–19	2115	6·1	5·6	0·5	0·4	10	60	30	120

n/a, Not available;
* Total *n*-3 fatty acid intakes can be derived from summing the data for ALA, EPA and DHA.
† Standard deviation calculated from the standard error of the mean.

of age[33]. The Dietary Intervention Study in Children (DISC), conducted in children with elevated LDL-cholesterol levels, showed that a diet low in total fat (28 %E), SFA (<8 %E) and cholesterol, and high in PUFA (9 %E) significantly lowered LDL-cholesterol after 3 years of follow-up[16]. A recent cross-sectional analysis in 12-month-old Swedish infants showed that a diet higher in PUFA was associated with lower total and LDL-cholesterol levels in girls, although not significantly in boys, independent of the total amount of fat consumed[34]. Overall, the available evidence in children from intervention and longitudinal studies indicates that consuming lower amounts of SFA and high PUFA in childhood has the potential to decrease serum cholesterol both in children with normal lipid levels[32,35,36] and to a larger extent in hypercholesterolaemic children[15,16,37,38]. An improved blood lipid profile in childhood can be hypothesised to slow the development of atherosclerosis and decrease CHD risk in later life[4,7,29]. Controlled long-term intervention studies are needed to determine the extent to which improvement of fat and fatty acid intake in childhood translates into less CHD in adulthood. However, evidence from one longitudinal cohort[39] suggests that paediatric metabolic syndrome, defined as three or more abnormal CVD risk factors during childhood, is predictive for adult CVD events.

Methodological considerations

To our knowledge, the present paper is the first systematic review providing an overview of fatty acid intakes in children and adolescents in different populations around the world. Most data come from Europe, North America, Australia and New Zealand while data from Asia, Africa and South America are scarce. According to predefined quality criteria, the intake data were scored as ‘high’ and ‘medium’ for all included countries. Additionally, national dietary surveys, which are the preferred type of research to estimate the distribution of nutrient intake in populations, were available for the majority (twenty-two out of thirty) of countries and for the other countries (eight), representative data from observational studies were used. We therefore do not anticipate substantial bias in the presented data due to differences in methods to assess fatty acid intake.

Although any method to assess food and nutrient intake has inherent weaknesses[40], data for the majority (twenty-four out of thirty) countries in the present review were based on higher-quality assessments methods, including 3–7 d weighed food records, multiple 24 h dietary recalls and 24 h dietary recalls combined with FFQ. Hence, in these twenty-four countries the quality of the reported fat and fatty acid intake data is likely to be higher than in the six

Table 5. *Trans*-fatty acid (TFA) intake in children and adolescents in five countries
(Mean values and standard deviations)

Country and reference	Age (years)	*n*	TFA (% energy)	
			Mean	SD
Denmark[50]	4–9	490	0·6	0·1
	10–17	479	0·6	0·1
Finland[51]	3	411	0·6	0·5
India[57]	13–18	797	1·1	n/a
Mexico[62]	5–11	8690	0·4	0·4
	12–18	7707	0·4	0·4
UK[42]	4–10	837	1·3	0·3
	11–18	864	1·3	0·3

n/a, Not available.

countries where intake was estimated with single FFQ or 24 h recalls (Bulgaria, Canada, Mexico, New Zealand, Poland and Portugal). Moreover, nutrients such as *n*-3 fatty acids have large variations in intake and any dietary assessment method used[23] may not be suitable for measuring thier intake unless specially designed. Also, reported TFA intake may not be reliable, as for many countries there are no good data on their main dietary sources and contents in foods.

We could not evaluate the quality of food composition databases used in the surveys and studies due to limited information provided for several countries. However, for the majority of countries with established national dietary surveys it should be assumed that fatty acid content of foods in the applied food composition databases was reasonably accurate.

Overall, the possibility that differences in reported intake could be partly due to differences in the data collection methods cannot be entirely excluded. However, for most countries, higher SFA intakes and lower PUFA intakes than recommended are reported, without apparent differences due to quality of the underlying studies. Nevertheless, it is likely that a major part of the variation in reported intakes between populations reflects true underlying differences in intakes and type of fats and oils consumed.

To estimate the percentage of children meeting the recommendations for SFA and PUFA intakes, we assumed a normal distribution of intakes in the populations. This assumption may not hold for developing countries such as India[41] where the data were derived from a study with a small sample size and where the variability in fat intake can be large depending on the region and income level, which may result in a skewed or bimodal distribution of data. However, data on fats and fatty acids in children from Western countries are usually normally distributed, even with differences in region or socio-economic status[42]. Thus, our estimations of the percentage children meeting recommendations are probably more reliable for these Western countries than for other countries.

Because of the methodological limitations, interpretation of numeric results within individual countries and comparisons between countries should be done with care. However, the available data strongly suggest that intakes of SFA and PUFA in children and adolescent are generally not optimal, and should be improved in many parts of the world.

Suggestions for future research

Data on dietary fatty acid intake in children and adolescents are lacking for many countries worldwide, particularly those in developing regions. Adequate intake data should be collected in these countries, particularly because many are undergoing rapid changes, i.e. towards more affluent lifestyles and diets that have adverse health effects. Data from national dietary surveys with representative population sampling, using a weighed food record or multiple 24 h recall, should be applied to measure current intakes at the population level[20–22]. As well as intakes of fat and fatty acids, intakes of other dietary components that affect CVD risk, such as types of carbohydrates and Na intake, need to be assessed in children.

Official quantitative international recommendations on fat and fatty acid intakes for children are needed to help public health organisations and health influencers to develop policies for improving fatty acid intake in this age group. Moreover, future research is needed to establish to what extent improvement of dietary fatty acid intake in childhood translates into lower CHD risk in later life.

In conclusion, the available data consistently indicate that in many parts of the world children and adolescents have SFA intakes that are higher and PUFA intakes that are lower than intake levels recommended by the WHO for the prevention of chronic diseases. Public health initiatives should focus on improving the fatty acid composition of the diet starting early in childhood.

Acknowledgements

Collection of fatty acid intake data in Mexico was supported by Unilever Netherlands B.V. All the authors are employees of Unilever. Unilever markets food products made of vegetable oils, including margarines and dressings. R. K. H. and S. J. M. O. designed the study concept and R. K. H. searched and collected the data. All authors were involved in interpretation of the data and preparation of the manuscript. The authors would like to thank Peter van Bruggen for statistical input, and other Unilever colleagues who helped identify dietary data sources for specific countries.

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