Fruit and vegetable intakes, sources and contribution to total diet, in very young children (1–4 years): the Irish National Pre-School Nutrition Survey

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Abstract

Although the importance of fruit and vegetable (F&V) intakes in the prevention of chronic diseases is well established, there are limited data on intakes in very young children. This paper estimates F&V intakes and sources and the contribution to the total diet using data from the National Pre-School Nutrition Survey, a nationally representative sample (n=500) of Irish children aged 1–4 years. A 4-day weighed food record was used to collect food intake data. Of 1652 food-codes consumed, 740 had a fruit/vegetable component. The percentage of edible fruit and/or vegetables in each food-code was calculated. Intakes (g/d), sources (g/d) and the contribution of F&Vs to the weight of the total diet (%) were estimated, split by age. All children consumed F&V. Intakes of total fruit, in particular fruit juice, increased with age. The contribution to total fruit intake was discrete fruit (47–56% range across age), 100% fruit juice, smoothies and pureés (32–45%) and fruit in composite dishes (7–13%). Total vegetable intake comprised of discrete vegetables (48–62% range across age) and vegetables in composite dishes (38–52%). F&V contributed on average 20% (15% fruit; 5% vegetables) to the weight of the total diet and was<10% in 61 children (12%). F&V contributed 50% of vitamin C, 53% of β-carotene, 34% of dietary fibre and 42% of non-milk extrinsic sugar intakes from the total diet. F&Vs are important components of the diet of Irish pre-school children; however, some aspects of F&V intake patterns could be improved in this age-group.

Key words: children; fruit; vegetables; juice; dietary intake; survey; guidelines; pre-school; composite dishes

Introduction

Early childhood is a pivotal time in the development of food preferences and as such an opportunity to foster the development of healthy eating practices. Fruit and vegetable intakes play an important role in the prevention of chronic diseases [1] and obesity [2] and to halt the escalating prevalence of both, fruit and vegetable consumption should be encouraged from an early age. There are however limited data on fruit and vegetable intakes in very young children.

The beneficial role of both quantity and variety of fruit and vegetable intake has been acknowledged in disease prevention in adults [3]. There are also unresolved questions as to the health outcomes associated with fruit juice intake [4; 5; 6] and concerns about sugar intake including that from fruit [7; 8]. Thus, it is important to characterise fruit and vegetable intake by identifying the dietary sources and estimating the contribution to nutrient intakes.

Currently, there are no established quantitative guidelines for fruit and vegetable intakes for very young children in Ireland or in many other countries. However there are number of evidence based resources available including “The Infant and Toddler Forum” [9]. It is generally acknowledged that due to the volume that a young child can consume, 400g a day or 5 (80g) portions per day, the guideline for those aged ≥5years in Ireland [10; 11] and the WHO population goal [1], is not appropriate. Evaluating the proportion of the diet that is comprised of fruit and vegetables in very young children could inform whether public health intervention such as the development of an age specific guideline is necessary. The aim was to estimate fruit and vegetable intakes and identify the sources and contribution to the total diet in Irish preschool children aged 1–4 years using data from the National Pre-School Nutrition Survey (NPNS).

Methodology

Survey design and population

The National Pre-School Nutrition Survey (NPNS), a nationally representative dietary survey, was carried out by the Irish Universities Nutrition Alliance between October 2010 and September 2011 to establish a database of habitual food and drink consumption in a representative sample of Irish children aged 1–4 years.

500 (boys 251, girls 249) pre-school children, aged 12 to 59 months inclusive, were recruited from a database of children compiled by 'eumom' (an Irish parenting resource; www.eumom.ie) or from randomly selected childcare facilities in selected locations. While this facilitated a representative sample of the population of the Republic of Ireland with regard to age, sex and residential location, the sample contained a higher proportion of children of professional workers and a lower proportion of children of skilled manual workers than the general population [12].

Children and their families were visited in their own home by a research nutritionist. 4-day weighed food records were used to collect food intake data. Training in completion of the food record was given to primary care-givers and a brief set of instructions on a laminated sheet was provided to accompany the child and food record when in the care of others. The food records benefited from a large amount of researcher/participant interaction allowing for detailed training of the participants and clarification of recorded data where necessary. All participants completed records over a continuous four day period, including at least one weekend day. Food intake data were converted to nutrient intakes using UK and Irish food composition data [13; 14].

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and ethical approval was obtained from the Clinical Research Ethics Committee of the Cork Teaching Hospitals, University College Cork. Written informed consent was obtained from parents/guardians. A detailed description of the survey methodology is available at www.iuna.net.

Fruit & vegetable intake

1652 different food-codes were consumed on the NPNS, of these 740 had a fruit and/or vegetable component. These included discrete fruit and vegetables and fruit and vegetables contained in composite foods and dishes. The percentage of fruit and/or vegetables in each of these food-codes was estimated using standard recipes from the UK food composition database [(14)], and from participants' food diaries, and manufacturers' product information. Calculations were included to remove inedible or un-consumed portions e.g. cores, uneaten peel. The effects of concentration, e.g. in the case of tomato purée, were also accounted for.

Vegetables included: the edible parts of plants commonly consumed as vegetables; foods used as vegetables such as green pulses and sprouts, fresh sweetcorn; botanical fruits used as vegetables, such as tomatoes, peppers or cucumbers and; mushrooms and seaweed. Cereals, potatoes and other tubers, as well as dry pulses, were not considered as vegetables. Fruits included the edible part of all fruits that were fresh, canned, frozen and dried, unless they were classified as vegetables. Fruits with high energy content, such as avocados and olives were included as fruit. In calculating the fruit and/or vegetable proportion of composite foods and dishes, all dishes/foods with a fruit and/or vegetable component regardless of nutritional profile of the dish/food were included.

Statistical analysis

Intakes (g/d) and sources (g/d) were described for the total population and for consumers only using mean, median, standard deviation (SD) and % consumers. Intakes from major sources were stratified by age and the association with age assessed using ANOVA. Associations were considered significant at $p<0.05$.

Intakes and sources were further disaggregated by age and are presented for the total population and for consumers only (Online Supporting Material Tables 1 & 2).

The contribution of fruit and vegetable intake to the weight of the total diet (total weight of all food and beverages in the diet) was estimated separately as the contribution of: all sources (g); discrete vegetables (g); discrete fruit (g); vegetables in composite foods and dishes (g); and fruit in composite foods and dishes (g), to the total weight of the diet (g). These were expressed as percentages and reported for the total population and by age.

We estimated the proportion of children with contributions of fruit and vegetables to the weight of the total diet at 4 levels: <10%; ≥10% and <20%; ≥20% and <30%; and >30%. As the weight of fruit juice contributes disproportionately to the weight of total fruit and vegetables the proportion of children in each category of percent contribution was calculated both including fruit and vegetables from all sources and limiting the contribution of 100% fruit juice to total fruit and vegetable intake to 1 portion per day [(50-120 ml) [15]. As food and beverage intake data were weighed and subsequently reported in grams, a 1:1 conversion of ml to g was assumed.

Using age appropriate portion sizes for individual fresh fruits and vegetables, dried fruit and fruit juice(derived from medians of intakes, mostly weighed) (range 14-124g) [15], we estimated the mean±SD daily intake of portions of fruit and vegetables consumed from: all sources of fruit and vegetables; and all sources of fruit and vegetables limiting the

contribution of 100% juice to 1 portion. We reported these for the total population and by age.

The contribution fruit and vegetable intakes made to intake of key nutrients were estimated as mean daily intake and % contribution of total dietary intake for: total sugar, non-milk extrinsic sugars (NMES), dietary fibre, potassium, folate, vitamin C and β-carotene.

Results

The daily intake of fruit and vegetables in the total population and in consumers only, from all sources and disaggregated by source, are displayed in Table 1. All pre-school children consumed fruit and vegetables during the four survey days. Mean daily intake of fruit and vegetables from all sources was 247±124 g/d. There were more consumers of fruit (98%) than of vegetables (90%). The largest proportion (70%) of total fruit and vegetable intake (247 g/d) came from discrete fruit intake (171 g/d).

There were no differences in intakes by sex (p=0.303). Intakes of total fruit were positively associated with age (p<0.001) but there was no significant association between vegetable intake and age (p=0.184) (Table 2). Higher intakes of total fruit in older children were largely explained by higher intakes of 100% fruit juice, smoothies and purees (Table 2). This was driven by a threefold higher intake of 100% fruit juice in those age 4 years (77±99 g/d) versus those age 1 year (23±50 g/d) (Online Supporting Material Table 1).

The sources of total fruit intake were: discrete fruit excluding 100% fruit juice, smoothies and pureés (48–56% contribution to total fruit, range of contribution across age) of which bananas (14–19%) and apples (7–13%) contributed the most; 100% fruit juice, smoothies and pureés (32–45%) and; fruit in composite foods and dishes (7–13%) of which beverages contributed the most (48-63%). Total vegetable intake comprised of discrete vegetables (48–62% contribution to total vegetables, range of contribution across age) of which peas, beans and lentils (11–16%) and carrots (9–15%) contributed the most and; vegetables in composite foods and dishes (38–52%) of which meat based dishes (15–30%) contributed the most (Table 2 & further disaggregation in Online Supporting Material Table 1).

Trends observed for intakes and sources by age in the total population were similar when examined in consumers only (Online Supporting Material Table 2).

159 Fruit and vegetables contributed 20% (fruit: 15%, vegetables: 5%) of the weight of the total
160 diet (Figure 1). This did not vary significantly with age. The ratio of the contribution of
161 discrete fruit and vegetables to fruit and vegetables in composite foods and dishes varied with
162 age, with older children consuming more discrete fruit and vegetables (Figure 1).

163 Of the 500 children, 61 had fruit and vegetable intakes that contributed <10% of the weight
164 of the total diet, 224 had intakes that contributed ≥10% and <20%, 148 had intakes that
165 contributed ≥20% and <30% and 67 had intakes that contributed ≥30%. Limiting the
166 contribution of 100% fruit juice to total fruit and vegetable intake to 1 portion per day most
167 affected the number of children categorised as having contributions ≥30%. After applying the
168 limitation, 64 children had fruit and vegetable intakes that contributed <10% of the weight of
169 the total diet, 243 had intakes that contributed ≥10% and <20%, 151 had intakes that
170 contributed ≥20% and <30% and 42 had intakes that contributed ≥30%.

171 The mean daily intake in the total population was 4.7±2.2 portions of fruit and vegetables and
172 4.5±2.0 portions when the contribution of juice was limited to 1 portion per day. Mean daily
173 intake of portions differed by age ($p \leq 0.001$ when including all juice and when limiting juice).
174 Children aged 1 year consumed the most portions per day (mean±SD, 5.5±2.6 when
175 including all juice and 5.3±2.3 when limiting juice) and children aged 4 years consumed the
176 least (mean±SD, 4.3±1.8 when including all juice and 4.1±1.7 when limiting juice).

177 Fruit and vegetable intakes contributed 32% (24g/d) of total sugar, 42% (24g/d) of NMES,
178 34% (4.1g/d) of dietary fibre, 25% (449mg/d) of potassium, 18% (30µg/d) of folate, 50%
179 (43mg/d) of vitamin C and 53% (1225µg/d) of β-carotene daily intakes.

Discussion

Summary of findings

In this nationally representative survey of pre-school children aged 1-4 years, fruit and vegetables were important foods, contributing 20% of the weight of the total diet and consumed by all children during the four days surveyed. Discrete fruit intake was the largest contributor to total fruit and vegetable intakes. Total fruit intake was higher in older children, largely driven by higher intakes of 100% fruit juice. Vegetable intakes contributed only 5% of the total weight of the diet and 10% of children consumed no vegetables during the four survey days. Composite foods and dishes were important sources of vegetables particularly in younger children in whom they contributed 52% of total vegetable intake. Mean portion intake was 4.7 portions per day. 12% of children had what could be considered a very low (<10%) contribution of fruit and vegetable intake to the weight of the total diet. F&Vs were an important source of nutrients in particular vitamin C (50% of mean daily intake), β-carotene (53%) and dietary fibre (34%) intakes. They also contributed 42% of non-milk extrinsic sugar daily intakes.

Results in context

To compare our findings directly with those from other studies is difficult as we have included fruit and vegetables in composite dishes, excluded inedible portions and included calculations for concentration and cooking losses. These are methodologies not routinely included in studies as they require a detailed level of data collection that is often not available. Some general comparisons can be made with surveys from the UK and US.

In the UK National Diet and Nutrition Survey mean intakes in 1.5-3 year olds were 106g/d for fruit, 114 g/d for fruit juice, 22 g/d for salad and raw vegetables and 48 g/d for cooked

vegetables including those from composite dishes, totalling a crude mean of 290 g/d [16]. This is similar to the mean intakes of total fruit and vegetables in the current study of 247 g/d.. The Feeding Infants and Toddlers Study (FITS) reported that a substantial proportion of US children do not consume any fruit or vegetables in a given day [17]. In contrast, all children in the current study consumed fruit and/or vegetables. This difference may be explained by methodological difference as FITS is based on one 24-hour recall and only included discrete fruit and vegetable intakes.

Contribution of composite foods and dishes

The importance of composite foods and dishes in the estimation of fruit and vegetable intakes has been highlighted previously, albeit in adults [18; 19]. Our study has shown that inclusion of the contribution of composite foods and dishes is particularly important for estimating vegetables intakes in this age-group as 38-52% (range across age) of their vegetable intake was from this source. The contribution of composite foods and dishes should be included in estimating intakes for other analyses. If it is not feasible to disaggregate composite food-codes, the percentages reported here could be applied. Without accounting for this important source, intakes may be underestimated by as much as 52% in this age-group. Thus composite foods and dishes should also be considered if generating guidelines for consumption.

Fruit and vegetable dietary patterns and guidelines

It is difficult to interpret what contribution to diet fruit and vegetable intake should make in very young children. Currently Irish food based dietary guidelines pertaining to fruit and vegetable intake are for those aged 5 years and more [10; 11]. Other countries similarly have a gap between breast/bottle feeding and weaning advice for infants and the availability of food based dietary guidelines. For example the *eatwell* plate in the United Kingdom is also aimed at those over the age of 5 years [20]. Some countries have established guidelines including

227 Australia who recommend 2-3 servings of vegetables and legumes and 0.5 servings of fruit
228 for boys and girls aged 1-2 years and 2.5 and 1 servings respectively for 2-3 years olds[21].

229 To inform whether the development of age specific fruit and vegetable guidelines or public
230 health interventions for fruit and vegetable intake in pre-school children are necessary we
231 carried out a number of observational analyses. Areas we noted for improvement included the
232 contribution of fruit juice to total fruit intake, the proportionally lower vegetable intakes than
233 fruit intakes, and the very low intakes of fruit and vegetables (<10% weight) and 0 g/d
234 intakes of vegetables in a sub-group of the population.

235 Pre-school age is an important time for establishing good dietary behaviours to carry forward
236 into later life [22]. Previous evaluation of discrete fruit and vegetables in Irish school-age
237 children has shown that pre-school children have a higher intake and less reliance on fruit
238 juice than older children and teenagers [23]. Our more detailed observations compounded this
239 finding and also provided further insight as to the evolution of dietary patterns in this age-
240 group. The greater dependence on fruit juice as a source of fruit with increasing age noted for
241 older children, was already evident in pre-school children. In pre-school children the total
242 fruit and vegetable intake excluding fruit juice increased with age as did the percentage of the
243 total diet comprised of fruit and vegetable. This suggests that the decline in intake of fruit and
244 vegetables coincides with starting school, marking this as a point for targeted intervention.
245 The mean intake of the pre-school population was 4.7 portions a day. This is encouraging as
246 currently the Irish child and teenager [23], and adult [24] populations need to double their intakes
247 to meet the 5-a-day fruit and vegetable intake recommendations [1].

248 *Fruit juice*

249 There is mixed evidence for the nutritional benefits of consuming fruit juice. In this
250 nationally representative survey of very young children 100% fruit juice was a large

contributor to vitamin C intakes, second only to discrete fruit intakes (data not shown). Fruit juice has also been highlighted as the largest contributor to vitamin C intake in older UK children's diets [16]. However fruit juice is also a source of free sugar, and limiting the consumption of free sugars is recommended for optimum health [25; 26]. The benefits of replacing fruit juice with whole fruit in terms of increasing fibre intake and decreasing energy intake have also been shown using data from children in the US [27].

The association of fruit juice intake with health outcomes is also as of yet inconclusive. For example, higher intake of 100% fruit juice has been associated with higher risk of incident type 2 diabetes [5] but a null association has also been reported [28]. The associations of fruit juice intake and the risk of the metabolic syndrome and obesity [29], and blood pressure [30] have also been investigated but there is currently insufficient evidence from which to draw conclusions.

100% fruit juice was a large contributor to total fruit intakes in this age-group and its contribution increased substantially with age. However, even in the oldest children, the mean intake was 77 g/d. Intakes at this level are unlikely to negatively impact on health outcomes although the rapid increase in consumption of 100% fruit juice with age may be of concern. Until a definitive conclusion is made as to the role of fruit juice in the diet, communication of the nutritional benefits of whole fruit instead of fruit juice consumption in this age-group would be pragmatic.

Reporting bias

The data are self-reported and are thus susceptible to reporting bias. Under-reporting food and energy intakes is of particular concern in this context as there are noted implications of under-reporting for the development of food-based dietary guidelines [31]. However as the focus in these analyses is fruit and vegetable intakes, perceived "healthy" foods, the social biases associated with food reporting are more likely to bias towards to over-reporting not under-reporting. The high level of researcher/participant interaction may have eliminated much misreporting due to forgetting foods, poor or incorrect descriptions of foods and through encouraging compliance. The use of weighed records likely reduced inaccurate estimation of portion sizes. However, researcher/participant interaction and weighing increases participant burden which can introduce its own biases.

Strengths and limitations

The main strengths of this study are the national representativeness of the sample, the detailed prospective dietary intake data and the comprehensiveness of the estimation of fruit and vegetable intakes. A limitation of this work is that we used the weight of all food and beverages for the weight of the total diet. This may have led to children with high intakes of liquid-like-foods and beverages having lower estimated percent contribution of fruit and vegetables to the total diet. However as there was no difference in the weight of the total diet across the four groups of level of contribution of fruit and vegetables, this was considered a justified approach.

Conclusions

Fruit and vegetables are important components of the diet of Irish pre-school children. They were eaten by all children, mean intakes were >4 portions per day, they contributed 20% of

293 the weight of the total pre-school diet and were important sources of dietary fibre, β-carotene
294 and vitamin C. Some aspects of fruit and vegetable intakes in pre-school children could be
295 improved and would benefit from targeted public health interventions. These include low
296 vegetable intakes overall, increasing dependence on fruit juice with age and, very low intakes
297 of both fruit and vegetables in a sub-group of the population.

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301 **Author Contribution**

302 LO'C conceived the research question, generated the fruit and vegetable intake data, analysed
303 the data and wrote the manuscript. JW contributed to the contents and writing of the
304 manuscript and is the study co-ordinator. AF gave critical input to the manuscript and is a
305 principal investigator of the National Pre-School Nutrition Survey. All authors approved the
306 final version of the manuscript.

307 **Conflict of Interests**

308 None

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Table 1 Daily intake (g/day) of fruit and vegetables in Irish pre-school children aged 1-4 years (n=500)

	Total population			Consumers only			
	Mean	Median			Mean	Median	
	g	g	S.D.	%	g	g	S.D.
All sources	247	231	124	100	247	231	124
Discrete vegetables	32	24	30	89	35	28	30
Peas, bean & lentils	8	1	13	52	16	11	14
Onions, peppers, squashes & other vegetables	7	0	12	50	14	10	14
Carrots	7	0	11	50	14	10	13
Green vegetables (including green beans)	5	0	10	39	13	9	12
Salad vegetables	2	0	7	19	13	11	10
Tinned & jarred vegetables	1	0	4	10	11	8	9
Sweet potatoes	1	0	6	3	29	22	25
Fresh herbs	0	0	0	2	1	1	1
Discrete fruit	171	147	117	98	175	150	115
Fruit juices (100% juice)	51	8	78	52	98	71	84
Bananas	30	24	30	71	42	37	28
Fruit purées & smoothies (100% fruit)	22	0	44	31	69	50	53
Apples	21	12	28	62	34	26	30
Citrus fruits	11	0	22	36	31	23	29
Berries	11	0	22	37	29	21	28
Grapes	10	0	18	38	25	19	21
Kiwi, melons, pineapples, plums & other fruit	8	0	20	25	31	21	31
Pears	5	0	14	19	26	20	20
Dried fruit	3	0	6	32	10	8	7
Tinned fruit	1	0	3	6	11	11	8
Vegetables in composite foods & dishes	26	18	25	90	29	22	24
Meat & meat products/dishes	13	7	17	67	19	14	18
Soups, sauces & miscellaneous foods	5	0	12	32	16	11	18
Vegetable dishes	3	0	10	20	17	13	17
Grains, rice, pasta & savouries	3	0	7	36	9	5	9
Fish & fish dishes	1	0	4	8	10	8	8
Breads & rolls	0	0	1	7	3	2	4
Eggs & egg dishes	0	0	1	1	8	7	5
Potato dishes	0	0	0	2	2	1	2
Fruit in composite foods & dishes	19	9	37	98	19	9	37
Beverages	11	2	36	64	17	5	44
Fruited yoghurt	4	3	4	9	4	3	4
Confectionary & preserves	1	0	3	50	3	2	4
Fruit dishes	1	0	8	3	37	29	37
Ice-creams & chilled desserts	1	0	3	9	7	5	7
Biscuits, cakes & pastries	1	0	2	21	3	1	3
Breakfast cereals	0	0	2	13	3	1	5
Sauces	0	0	1	1	7	6	8

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Table 2 Daily intakes & sources of fruit and vegetables in Irish pre-school children aged 1-4 years by age (n=500)

	Age 1 year (n=126)	Age 2 years (n=124)	Age 3 years (n=126)	Age 4 years (n=124)	*p*-value*
	MDI, g/d (% contribution)				
Total vegetables	**63**	**53**	**53**	**61**	0.184
Discrete vegetables		30 (48)	28 (53)	31 (58)	38 (62)
Vegetables in composite foods & dishes		33 (52)	25 (47)	22 (42)	23 (38)
Total Fruit	**151**	**185**	**209**	**213**	0.000
Discrete fruit	84 (56)	102 (55)	105 (50)	102 (48)	0.000
100% fruit juice, smoothie, purée	48 (32)	61 (33)	86 (41)	96 (45)	0.002
Fruit in composite foods & dishes	19 (12)	22 (12)	18 (9)	15 (7)	0.504

* As calculated using ANOVA

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Table 3 Contribution of fruit and vegetable intake to daily intake of key nutrients in Irish pre-school children aged 1-4 years by age (n=500)

		MDI		% contribution to total dietary intake	
		Mean	SD	Mean	SD
Total sugars	g/d	24.0	13.9	31.5	14.8
Non-milk extrinsic sugars	g/d	24.0	13.8	42.4	17.7
Dietary fibre	g/d	4.1	2.4	33.9	14.6
Potassium	mg/d	449	243	25	12
Folate	µg/d	30	23	18	12
Vitamin C	mg/d	43	35	50	26
β-carotene	µg/d	1225	1668	53	33

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Disaggregated by age:

	Age 1 year (n=126)	Age 2 years (n=124)	Age 3 years (n=126)	Age 4 years (n=124)
	% of total diet			
Total fruit & vegetables	17.8	19.1	21.4	21.3
Discrete vegetables	*2.5*	*2.2*	*2.5*	*2.9*
Discrete fruit	*11.0*	*13.1*	*15.5*	*15.5*
Vegetables in composite foods & dishes	*2.8*	*2.0*	*1.8*	*1.8*
Fruit in composite foods & dishes	*1.5*	*1.8*	*1.6*	*1.1*
Remainder of diet	82.2	80.9	78.6	78.7

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