

Taste preferences, liking and other factors related to fruit and vegetable intakes among schoolchildren: results from observational studies

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The present paper explores the relative importance of liking and taste preferences as correlates of fruit and vegetable (FV) intakes among schoolchildren in Europe. The paper first provides an overview of potential determinants of food choice among children and subsequently summarizes the results of two recent observational studies on determinants of FV intakes among school-aged children. It is proposed that taste preferences and liking are important for children's food choices as part of a broader spectrum of nutrition behaviour determinants. Taste preferences and liking are important for motivation to eat certain foods, but social-cultural and physical environmental factors that determine availability and accessibility of foods, as well as nutrition knowledge and abilities should also be considered.

Study 1 shows that children with a positive liking for FV have a greater likelihood to eat fruits (odds ratio (OR) = 1.97) or vegetables (OR = 1.60) every day, while ability and opportunity related factors such as knowledge, self-efficacy, parental influences and accessibility of FV were also associated with likelihood of daily intakes (ORs between 1.16 and 2.75). These results were consistent across different countries in Europe. Study 2 shows that taste preferences were the strongest mediator of gender differences in FV intakes among children; the fact that girls eat more could for a large extent be explained by their stronger taste preferences.

Fruit and vegetables: Taste preferences: Determinants of food choice

Diet and nutrition clearly play a critical role during childhood and adolescent development. First of all, children and adolescents need to cover not only their nutrient and energy needs for maintenance metabolism and physical activities, but also for growth⁽¹⁾. Furthermore, eating habits may be less established in childhood and adolescence, and may therefore be better modifiable⁽²⁾, and food preferences and habits adopted in childhood and adolescence may track to a certain extent into adulthood^(3–5).

Nutritional habits are not in line with recommendations among children and adolescents. Many young people eat not enough fruits and vegetables, too much saturated fat, and more energy than they need⁽⁶⁾. In order to promote more healthful eating, we need to know why children and adolescents eat what they eat^(7,8).

What, when and how much children eat is influenced by a complex, interrelated set of so-called behavioural 'determinants' and successful dietary behaviour change interventions are dependent on the identification of the most *important* and best *changeable* determinants, because intervention strategies, methods and materials need to be selected or developed that are tailored to the target populations and to the most important and best modifiable determinants of behaviour change.

In this paper we will first give a brief overview of different important categories of determinants of food choice and

dietary intake among children and adolescents. Secondly, we will present and discuss the results of two recent observational studies on determinants of fruit and vegetable (FV) intakes that illustrate the relative importance of taste preferences and liking as compared to other potential determinants of FV consumption among school-aged children across Europe⁽⁹⁾.

Determinants of food intake: motivation, ability and opportunity

In affluent countries, most people can generally choose what, when and how much they eat. To induce dietary change, one needs to change people's food choices. Studies on personal determinants of food choice have primarily made use of psychological theories to explain food choice and nutrition behaviours⁽¹⁰⁾. It has, however, been argued that, since children may have less autonomy in making food choices, environmental rather than personal factors may be more important determinants of their nutrition behaviours. More recently, social-ecological models of health behaviour⁽¹¹⁾ have drawn more attention to such environmental influences on nutrition behaviours. A framework proposed by Rothchild⁽¹²⁾ provides a simple, integrative framework to categorise the large and diverse number of potential personal and environmental determinants from various more specific

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behaviour theories. Rothschild identifies three distinct categories of determinants: motivation, ability and opportunity. These categories of determinants are interrelated. For example, in environments with few opportunities for healthful eating, higher motivation and more abilities are needed to maintain a healthful diet.

Motivation

Behavioural decision, motivation or intention have been identified as primary determinants of behaviour⁽¹³⁾. Motivation or intention is influenced by a subjective weighing of expected positive and negative consequences of the behaviour. In general, expectations about short-term outcomes are more important than longer-term outcomes. Taste, satiety and pleasure are short-term consequences of major importance. Taste preferences and liking are regarded as key determinants of food choice⁽¹⁴⁾. People, and young people maybe more so, eat what they like, and disliked foods are avoided⁽²⁾. Certain taste preferences are innate, such as a liking for sweet and salt, and a dislike for bitter and sour. However, taste preferences can be learned and unlearned⁽¹⁵⁾. 'Hunger' or appetite is also a strong motivator to eat. In Maslov's hierarchy of human needs, the need to cover physiological energy requirements, i.e. overcoming hunger, is among the highest human priorities, and the urge to eat and drink when hungry is an inborn trait.

Since eating is primarily a way to cover the basic physiological nutrient requirements and calorie requirements, satiety, i.e. the feeling that energy requirements have successfully been met, is a strong reinforcer for eating specific foods and we therefore quickly learn to like and appreciate energy-dense foods⁽²⁾. Children are therefore 'programmed' to like, or to learn to like, the taste of high-energy, sweet and fatty foods. Nevertheless, many acquire a taste for coffee, tea or beer during childhood and adolescence, which shows that we can even unlearn our innate dislike of bitter.

Some specific types of taste preference learning strategies have been identified. The aforementioned example of learning to like high-energy foods is referred to as 'taste-nutrient learning'. Taste-nutrient learning is an example of operant or instrumental conditioning: a stimulus (eating energy dense, sweet and fatty food) is positively reinforced ('rewarded') by the pleasant feeling of satiety. In the last decades palatable energy-dense foods have become readily available and accessible for most children in western countries. This abundance combined with our innate preference for energy-dense foods may be an important cause for the present-day obesity epidemic. Research shows that high-fat and sugar-rich foods are indeed among the most preferred foods among children and adolescents⁽¹⁶⁾. Most fruits and especially vegetables have low-energy densities, and many vegetables have a somewhat bitter taste. Preferences for these foods are therefore not so easily learned.

Two other food preference-learning strategies are examples of classical conditioning and are referred to as 'taste-taste learning' and 'taste-environment learning'. If a new, unfamiliar, taste is combined with a taste for which a preference already exists, children will more easily learn to like the new taste. For example, children will more easily learn to like the somewhat bitter taste of tea or the sour taste of yoghurt or grapefruit, if these are first served with sugar. Similarly,

a liking for tastes that people are exposed to in pleasant physical or social environments are also learned. Foods first encountered as a child in a friendly, pleasant family environment, may become favourite foods for a lifetime.

A fourth important learning strategy is observational learning or modelling: children learn to like the taste of foods that they see their parents, siblings, friends or other 'important others' eat.

Health related beliefs may also be important. If people are asked about what they find important in their diet and food choice, 'health' usually comes second (or third) after 'taste' (and cost), especially among women⁽¹⁷⁾. Nevertheless, 40% of Americans and 57% of Europeans indicated rarely or never to compromise on taste to improve the healthfulness of their diets⁽¹⁸⁾. This is probably even more likely among children⁽¹⁹⁾.

Motivation and intentions are important determinants of nutrition behaviours, and taste preferences and liking importantly influence motivation to eat. But not all behaviour is intentional, and we not always act on our intentions⁽²⁰⁾. Lack of abilities or lack of environmental opportunities can be important barriers. Environmental cues may also trigger automatic behavioural responses.

Ability

Self-efficacy, or *perceived behavioural control (PBC)*, refers to one's confidence in one's abilities and skills to engage in certain behaviour. PBC is behaviour and context specific. A person can, for example, be confident to be able to eat less fat, but not to increase vegetable intake; and confidence to cut back on fat may be high for regular meals prepared at home, but not for eating out. PBC is strongly related to abilities and skills. Studies in children and adolescents show that food and nutrition-related self-efficacy is associated with healthful food choices and dietary behaviour^(21–23). Skills and abilities are to some extent dependent on practical knowledge. For example, knowing why to eat healthfully, knowing what healthful foods are, and knowing the recommended intake levels may all be conditional for voluntary healthful eating. Although knowledge in itself is unlikely to result in healthful food and nutrition choices – knowledge may be a necessary but insufficient condition for healthy food choice⁽¹⁹⁾ – some recent studies show that knowledge of recommended intake levels of FV was associated with higher intakes in 11-year old school children⁽²³⁾.

Environmental opportunities

Children and adolescents' opportunities to make healthful dietary choices strongly depend on the opportunities their environments have to offer. For example, children's social environment, such as their parents and school staff, importantly influences their range of food choices; their physical environment, such as where they live or go to school, importantly influences what foods are available and accessible to them.

Classifying the food environment

The ANGELO framework⁽²⁴⁾, which was specifically developed to conceptualise health behaviour environments related

to obesity, distinguishes four 'types' of environments: physical, economic, political and socio-cultural. The physical environment refers to availability of healthy and unhealthy choices, such as points-of-purchase for FV and soft drink vending machines in schools. The economic environment refers to the costs related to healthy and unhealthy behaviours, such as the price of soft drinks, FV or energy-dense snacks in school cafeterias. The political environment refers to the rules and regulations that may influence food choice and eating behaviour. Bans on soft drink vending machines in schools, rules on what treats can and cannot be brought to school, as well as family food rules are micro-level political environmental factors. Other examples are national school food policies or national legislation regarding food-marketing efforts aimed at children. The socio-cultural environment refers to the social and cultural subjective and descriptive norms and other social influences such as social support for adoption of health behaviour and social pressure to engage in unhealthy habits.

Evidence for environmental determinants of nutrition behaviours in youth

Child and adolescent dietary behaviour is likely to be strongly influenced by environmental factors, since children may have less autonomy in food choice. From the age of about three years, children's eating behaviour is influenced by their responsiveness to environmental cues, and a variety of family and social factors start to influence children's eating behaviours⁽²⁵⁾. The role of parents and schools is considered to be of particular importance.

Parent and family influences

Parents directly and importantly determine the child's micro-level social, political, physical as well as economical nutrition environments. Eating is a social behaviour, especially for children⁽²⁾, and observing eating behaviours of others, especially parents, influences their own preferences and behaviour. Such modelling of eating behaviours can even result in establishing preferences for foods or substances that are inherently disliked. A recent review of the literature on environmental correlates of nutrition behaviours in youth indicates that children and adolescents' nutrition behaviours are consistently associated with their parents' behaviours⁽²⁶⁾. Parents further influence their offspring's nutrition behaviours by actively encouraging, discouraging or controlling certain behaviours. Restricting children's access to, for example high fat or sugar-rich foods, may encourage rather than discourage preferences for such foods, especially if these same foods are also used to reward children for good behaviour and for celebrations⁽²⁾. However, a study conducted in Belgium indicated that clear restrictive family rules about high fat foods during childhood were associated with healthier food choices in adolescence⁽²⁷⁾, and a recent cross-European study showed that parental demand as well as facilitation to eat FV were associated with higher intake levels in 11 year old children, while 'parental allowance' (i.e. parents allowing children to eat as much as they like), was not^(23,28).

From studies on the association between general parenting styles and children's health behaviours, it appears that authoritative parenting, i.e. a parenting style characterised by

high parental involvement as well as strictness, is associated with more positive health behaviours including higher FV intakes^(29,30), compared to adolescents who reported authoritarian (high strictness, low involvement) or neglectful (low strictness, low involvement) parenting styles.

As a result of these parenting practices and rules, as well as parents' own food preferences and choices, parents influence what foods are available and accessible within the home environment. Availability and accessibility of foods have repeatedly been found to be associated with intake levels in children and adolescents⁽³¹⁾.

Finally, family socio-economic position is important. A recent review of the literature confirmed that low parental education, as well as parental income is associated with less healthful diets in children and adolescents^(32,33).

School influences

A second important setting for children and adolescent nutrition is the school environment. Children spend much time at school; consume a large proportion of their daily intakes there, and schools offer nutrition education as part of the regular curriculum.

Accessibility and availability of foods in schools are important physical environmental factors. In many countries across Europe, schools provide lunch or other foods for the students, with great differences between countries. For example, in Belgium school lunches are offered in a majority of primary and secondary schools. Parents need to pay for their children to have a school lunch, children are allowed to bring their own lunch to school, and the school lunches are not required to meet official dietary guidelines. Most secondary schools do have vending machines and snack food outlets. In The Netherlands, a neighbouring country, school lunches are not offered. In primary schools, children go home for lunch or children need to bring their lunch to school. In secondary schools, adolescents bring their lunch to school, or they can buy lunch in the school a la carte cafeteria. In Sweden and the UK primary and secondary schools do offer free school lunches but while Swedish schools are required to meet official recommended intake levels, nutrition requirements for school lunches in the UK only state that meals in primary schools should contain at least one item from four major food groups (starchy foods; FV; dairy products; meat, fish or alternative protein source) and in secondary school lunches at least two items from each of these groups should be *offered*. Preliminary evidence from the European Pro Children study indicates that school lunches can make a difference; Swedish kids eat more vegetables at school than children from other countries across Europe, and have a relatively high total daily vegetable intake.

Macro-level environment

An important macro-level factor is how foods are marketed to children and adolescents. Children and adolescents are increasingly seen as an important target group for food marketing⁽³⁴⁾. Young people in affluent countries have money to spend themselves, they may also influence food-buying behaviours of their parents, and they are the future adult buyers and consumers. Foods that are most intensively marketed by

means of advertisement and marketing campaign are foods that are high in sugar and fats, and often low in micronutrients. In the US fast food restaurants and soft drink companies spent most on marketing their products. The large portion sizes offered at 'value pricing' (i.e. larger portions cost relatively less), especially in the US, is a marketing strategy that has probably contributed to higher caloric intakes and unnecessary weight gain. Television still is the most important channel for marketing food products, especially for younger children, but food marketing among youth also includes, for example, school-based marketing, Internet advertising, and sponsoring of events. Recent research confirmed that food adverts exposure promotes consumption and that obese children in particular have heightened responsiveness to these food-promotion adverts⁽³⁵⁾.

Although most countries do regard children as a special vulnerable group for television advertising, there are striking differences between countries in rules and regulations for food marketing to children. Only few countries have a complete ban on television advertising for younger children. But most countries (85 % of 73 countries surveyed by the WHO) do have statutory regulations for food television advertising to children; regulations that define, for example, in what ways foods can be promoted at what broadcasting times. The principle underlying many regulations is that advertising may not be misleading. At the ministerial conference on counteracting obesity organised by WHO Europe, all ministers of countries in the European region signed a charter in which they recognized the importance of marketing⁽³⁶⁾.

The relative importance of liking and preferences: evidence from observational studies

To explore how important taste-preferences and liking are as population correlates of food intakes among children two recently published studies on correlates of FV intakes, the Pro Children study and the Fruits and Vegetables Make the Mark study are illustrative^(28,37).

The Pro Children project

A cross-sectional survey was conducted as part of the Pro Children project in nine European countries (Austria, Belgium, Denmark, Iceland, The Netherlands, Norway, Portugal, Spain and Sweden) during October – December 2003.

Schools constituted the sampling unit, and from each country random samples of at least 20 schools and a minimum of 1300 11-year old eligible children were recruited. A participation rate of 90.4 % was reached in the participating schools; mean age was 11.4 years (range 8.8–13.8, SD = 0.48; 79 % of the children was born in 1992). The final sample sizes varied from 1105 for The Netherlands to 2134 for Portugal, with a total sample size of 13 305. A detailed description of the Pro Children project, including the sampling and data collection procedure is given elsewhere^(6,9). All protocols and questionnaires of the Pro Children projects can be accessed at www.prochildren.org

A self-report questionnaire in all applicable languages was developed to measure FV intake, and possible determinants informed by a social-ecological model⁽⁹⁾, a literature review⁽³⁸⁾, focus group interviews with children⁽³⁹⁾, individual

interviews with parents and school staff, and thorough pre-testing as well as a rigorous translation – back translation procedure^(39,40). The questionnaire included questions that were analogous for FV intake on motivational factors such as liking and preferences, and attitudes; ability-related factors such as knowledge of recommended intake levels, self-efficacy and perceived barriers. The questionnaire also included items on opportunity-related factors related to the social-cultural environment: parental and peer modeling, active parental encouragement, parental demands to eat FV, whether parents allow the child to eat as much FV as they like (parental allowances), whether parents actively facilitate FV intake by preparing/cutting FV (parental facilitation) and by giving their children FV to bring to school; and related to the perceived physical environment: availability of FV at home, at school, and at friends' home. An overview of the items, constructs, scaling and psychometrics is reported elsewhere^(40,41). Usual FV intake was measured using a validated food-frequency questionnaire (FFQ)⁽⁴²⁾.

Multilevel logistic regression analysis was used to investigate the associations of daily fruit (dichotomous) intake and daily vegetable intake (dichotomous) with the different motivational, ability and opportunity factors. The predictors were also dichotomized into 0 (negative or neutral, response category < 0.49) or 1 (positive, response category > 0.49)⁽⁴¹⁾. Adjusted odds ratios (OR) and 98 % confidence intervals (CI) were calculated for the total sample, both gender groups and all nine countries separately⁽²⁸⁾.

Differences in daily intake of FV

In the total sample 43.2 % of the children reported to eat fruit every day, 46.1 % reported to eat vegetables every day. A significant gender difference was found for both outcome measures: 47.7 % of the girls and only 38.9 % of the boys reported to eat fruit daily (OR:1.44, 98 % CI:1.33–1.56), while 51.8 % of the girls and 40.5 % of the boys reported to eat vegetables every day (OR:1.58, 98 % CI:1.45–1.71). Significant differences were also found between the nine participating countries ($p < 0.001$). For daily fruit intake, the lowest rates were found in the Nordic countries of Norway, Iceland and Sweden, while the highest proportion of children with daily fruit intake was found in Portugal. For daily vegetable intake, low rates were again found in Norway, Iceland and Spain, and the highest rates were in The Netherlands, Belgium and Portugal.

Correlates of daily FV intakes

For *daily fruit intake*, motivation, ability as well as opportunity factors appeared to be of relevance. Daily fruit intake was more likely to be reported by children with a positive liking for fruit, with a preference for many different fruits and a positive attitude towards fruit intake. Furthermore, daily fruit intake was more likely among children who knew the national recommendation for fruit intake and with positive self-efficacy. In addition, 4 of the 6 social-environmental factors yielded significance. Daily fruit intake was more likely to be reported by children who experienced positive role models, by those with parents who demand them to eat fruit every day, by children with parents who facilitate fruit intake by cutting

up fruit, and by those bringing fruit to school. None of the physical environmental factors was significantly associated with likelihood of daily intake (see Table 1).

Daily vegetable intake was also related to a positive liking of the taste of vegetables, a preference for different vegetables and a positive attitude towards vegetable consumption. Knowing the national guidelines for adequate vegetable intake and a positive self-efficacy to eat vegetables were also significantly associated with daily vegetable intake. All six social-environmental factors were significantly associated with eating vegetables every day. Finally, children who frequently have available vegetables they like at their home were more likely to report daily vegetable consumption.

In country specific analyses a preference for many fruits was significant in 5 out of 9 countries, a liking of the taste of fruit in 3 countries. Regarding ability-related factors, knowledge of the recommendation was significant in all countries, and in 7 countries daily fruit intake was significantly associated with positive self-efficacy. Of the opportunity-related factors, modeling was significant in all countries, bringing fruit to school was significant in 8 of the 9 countries, and parental demand to eat fruit daily was significant in 6 countries.

Liking the taste of vegetables was significantly associated with daily vegetable intake in 6 out of 9 countries, while preference for many vegetables was significant in 8 countries. Among the ability-related factors, self-efficacy and knowledge of recommendations yielded significance in 6 and 5 countries respectively. Parental demand (7 countries) and modeling (5 countries) were the opportunity factors that were positively associated with daily vegetable intake in a majority of countries (see Table 1).

These analyses indicate that liking and preferences are associated with daily intake of FV among school-aged children in Europe. However, other factors related to ability

and opportunity were also important with effect sizes of a similar magnitude as preferences and liking. Effect sizes were in general somewhat larger for fruit intake than for vegetable intake.

Gender differences and liking FV: Fruit and Vegetables Make the Marks (FVMM)

A recent comprehensive review of studies on determinants of children's FV intake stated that gender is among the strongest determinants of adolescents' FV intake⁽³⁸⁾; in 14 of 17 reviewed European studies girls reported to eat more FV than boys. A study was conducted to explore why boys eat less FV than girls and if differences in preferences for these foods explain consumption differences between boys and girls.

This study was part of the FVMM intervention project including 38 randomly selected elementary schools in two Norwegian counties. The pupils within the 20 control schools were used for the study presented here⁽³⁷⁾. Data from survey questionnaires completed in May 2002 and May 2005 were used for the analyses. The questionnaire surveys were completed by the pupils in the classroom in the presence of a trained project worker, within one school-lesson (45 minutes). The FVMM control group is a cohort of 896 pupils (response 84%), of which 813 and 728 respectively participated in the May 2002 (mean age 12.5) and May 2005 (mean age 15.5) surveys and also reported same gender at both surveys.

FV intake was measured with a validated short FFQ comparable to the Pro Children Study⁽⁴³⁾. Potential mediators for the gender differences in intakes were motivation-related (preferences for FV; intention to eat 5-a-day), ability-related (self-efficacy to eat 5-a-day, knowledge about the 5-a-day recommendation) and opportunity-related (accessibility of

Table 1. Odds ratios (ORs¹) and 98% confidence intervals (CI) derived from multilevel logistic regression analyses of the Pro Children Study with daily fruit and vegetable intakes as dependent variables and motivation, ability and opportunity factors as independent variables

	Daily fruit intake (<i>n</i> = 13 168) OR (98% CI)	Daily vegetable intake (<i>n</i> = 11 905) OR (98% CI)
Motivation		
Liking	1.97 (1.52–2.55)	1.60 (1.41–1.80)
Preferences	2.09 (1.79–2.43)	1.46 (1.30–1.63)
Attitudes	1.36 (1.14–1.63)	1.16 (1.03–1.31)
Ability		
Knowledge	2.25 (2.03–2.49)	1.41 (1.26–1.58)
General self-efficacy	0.88 (0.64–1.20)	0.82 (0.68–1.00)
Perceived barriers	1.74 (1.44–2.11)	1.83 (1.65–2.02)
Opportunity		
Social-environment		
Modelling	1.95 (1.74–2.19)	1.43 (1.29–1.60)
Active parental encouragement	0.96 (0.85–1.08)	1.26 (1.12–1.41)
Demand family rule	1.60 (1.42–1.81)	1.50 (1.34–1.68)
Allow family rule	0.85 (0.73–1.00)	1.22 (1.07–1.40)
Family facilitation	1.34 (1.20–1.51)	1.16 (1.03–1.31)
Bring FV to school	2.75 (2.43–3.12)	1.99 (1.68–2.36)
Physical-environment		
Availability at home	1.22 (1.00–1.48)	1.27 (1.12–1.44)
Availability at school	1.00 (0.88–1.13)	1.08 (0.95–1.22)
Availability at friends house	1.07 (0.96–1.19)	1.00 (0.90–1.11)

¹ORs are adjusted for gender, school and country level.

FV at home and modelling). These variables were assessed with one to five statements with response alternatives ranging from 'I fully disagree' to 'I fully agree', except for the knowledge question which had seven response alternatives (for details see⁽⁴⁴⁾). These scales have been analysed showing good reliability⁽⁴⁵⁾.

A variable functions as a mediator when it is associated with the dependent variable (FV intake) and with the independent variable, i.e. the potential distal determinant (gender), and when the association between the independent variable (gender) and the dependent variable (FV intake) becomes non-significant or weakens after controlling for the potential mediator⁽⁴⁶⁾.

All analyses conducted were different mixed models of repeated measures (i.e. both 2002 and 2005 data were included in the same analyses), all adjusting for school and time (survey), using SPSS 14. The analyses carefully tested each of the steps necessary to establish mediation. The proportions mediated by the mediators were calculated by subtracting the adjusted relationship between gender and FV intake (e.g. τ') from the unadjusted (τ), and dividing the sum by the unadjusted value (i.e. $\tau - \tau'/\tau$)⁽⁴⁷⁾.

Girls reported to eat FV more often than boys and reported significantly more positive values for all the potential mediators (see Table 2).

In the single mediation analyses all determinants mediated part of the gender differences, but only adjustment for preferences decreased the gender difference to a level below statistical significance (see Table 3). Preferences alone explained 81% of the gender difference. In the multiple mediation analyses the six mediators together explained 91% of the gender difference, with preferences contributing with the largest amount (25%). In addition, perceived accessibility contributed with 10% of the explanation (data not shown).

Discussion

FV intakes among schoolchildren are associated with preferences and liking, and the differences in intakes between girls and boys is strongly mediated by preferences. However, preferences are certainly not the only potential determinant of intakes. Ability and opportunity related factors such as knowledge, self-efficacy, parental influences and accessibility of FV are also associated with daily intake. These results were consistent across different countries in Europe. Accessibility of FV further mediates gender differences in intakes and recent research indicates that socio-economic differences in schoolchildren's FV intakes are more strongly related to accessibility

Table 2. Gender differences in fruit and vegetable intake and in determinants of intake at the first measurement in 2002

	Items in scale	Range	Boys	Girls	diff.	p-value
FV intake	4	0/40	11.9	14.5	2.6	≤0.001
Accessibility	5	-10/10	3.6	4.9	1.4	≤0.001
Modelling	4	-8/8	2.5	3.1	0.7	≤0.001
Intention	1	-2/2	-0.1	0.2	0.3	0.003
Preferences	4	-8/8	1.3	2.9	1.5	≤0.001
Self-efficacy	3	-14/14	0.1	0.8	0.7	≤0.001
Knowledge	1	0/6	3.5	3.7	0.2	0.008

Table 3. Single mediator analyses: effect of gender on FV intake after adjusting for accessibility, modelling, intention, preferences, self-efficacy OR knowledge

	Models I				
	Potential mediator		Gender		Mediated' ($\tau - \tau'$)/ τ
	β'	$p\beta'$	τ'	$p\tau'$	
Accessibility	0.9	≤0.001	1.3	≤0.001	0.49
Modelling	0.8	≤0.001	2.1	≤0.001	0.20
Intention	1.8	≤0.001	1.8	≤0.001	0.31
Preferences	0.9	≤0.001	0.5	0.19	0.81
Self-efficacy	1.1	≤0.001	1.8	≤0.001	0.30
Knowledge	1.1	≤0.001	2.3	≤0.001	0.10

τ' = difference in FV intake between boys and girls, while adjusting for single potential mediators.

β' = difference in the single potential mediators between boys and girls, while adjusting for FV intake.

Mediated' = proportion of the gender difference in fruit and vegetable intake mediated by the respectively factors.

differences than preference differences (Bere *et al.*, unpublished data).

The fact that liking and preferences were related to likelihood of daily intake of both FV has been found in earlier studies^(22,48-51) and confirms the importance of these motivation-related factors among children. Repeated exposure to many different kinds of FV at early age might be a good strategy to improve liking^(25,52) and increased intakes have been found to be associated with increased liking (Tak *et al.*, unpublished data). Especially parents can promote preferences for FV in such a way. The results indeed confirm earlier studies that show that parental social environmental factors are important for dietary behaviors among school-aged children⁽⁵³⁾. In line with previous research, perceived modeling was a predictor of daily FV intake^(25,50,54-56). Such social learning strategies are also important for learning to like the taste of FV. Next to this rather 'passive' influence of parental modeling, more active parental encouragement and facilitation was also associated with daily intakes.

Knowledge of the prevailing recommendations was positively related to daily FV intake which indicates that teaching these recommendations in primary schools may help to promote daily intake. School and family influences are very important to influence taste preferences and liking of FV and therefore these are ideal settings for interventions.

Positive self-efficacy was another ability-related factor associated with daily FV intake. The literature is inconsistent about the relationship between self-efficacy and FV intake^(22,48,49,55,57), probably due to different possible operationalisations of the self-efficacy construct. Self-efficacy can probably be improved by making FV as available and accessible as possible and thus improve opportunity factors, and the Pro Children Study indicates that bringing FV to school is a good strategy to encourage daily FV intakes.

In the present study only home availability appeared to be a significant physical environmental correlate of daily vegetable consumption but not of daily fruit intake, although the association was close to reaching statistical significance. Earlier studies consistently showed positive associations between availability and FV intakes^(50,51,53,55,57,58).

Bere *et al.* confirmed that gender is a strong correlate of FV intake and additionally showed that the gender difference in FV intake could be explained by differences in preferences and accessibility between boys and girls. That perceived accessibility is higher among girls might be due to the fact that parents raise their daughters in a different way than they raise their sons where foods are concerned, which is also illustrated by observations in the Pro Children study: parents of daughters were more involved in the intervention and participate more often in parental activities than parents of boys (Wind *et al.*, unpublished data). That opportunities for girls to eat FV are better than for boys, might also result in higher motivational factors such as taste preferences. However, from this cross sectional study we cannot conclude on causal relationships between determinants.

The two observational studies and the literature indicate that a wide range of determinants are important in children's FV consumption. However, which determinants of FV are exactly the most important ones is still difficult to answer because determinants are interrelated and form a complex pattern.

Conclusion

The present paper showed that the framework proposed by Rothchild can help to categorize important determinants of FV intake and dietary intake in general. Furthermore, we showed that motivation factors, such as preferences, are among the most important determinants of FV intake among adolescents and that differences in preferences could also explain discrepancies in FV intake levels between boys and girls.

Moreover, opportunities, such as availability and accessibility of FV, are important as well and more research is needed to assess potential moderating roles of availability and/or motivational factors.

Conflict of interest statement

None of the authors has any conflicts of interest to report.

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