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Associations between physical home environmental factors and vegetable consumption among Norwegian 3–5-year-olds: the BRA-study

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Abstract

Objective: First, to explore item pools developed to measure the physical home environment of pre-school children and assess the psychometric properties of these item pools; second, to explore associations between this environment and vegetable consumption among Norwegian 3–5-year-olds.

Design: Data were collected in three steps: (i) a parental web-based questionnaire assessing the child's vegetable intake and factors potentially influencing the child's vegetable consumption; (ii) direct observation of the children's fruit, berry and vegetable intakes at two meals in one day in the kindergarten; and (iii) a parental web-based 24 h recall.

Setting: The target group for this study was pre-school children born in 2010 and 2011, attending public or private kindergartens in the counties of Vestfold and Buskerud, Norway.

Subjects: A total of 633 children participated.

Results: Principal component analysis on the thirteen-item pool assessing availability/accessibility resulted in two factors labelled 'availability at home' and 'accessibility at home', while the eight-item pool assessing barriers resulted in two factors labelled 'serving barriers' and 'purchase barriers'. The psychometric properties of these factors were satisfactory. Linear regression of the associations between vegetable intake and the factors showed generally positive associations with 'availability at home' and 'accessibility at home' and negative associations with 'serving barriers'.

Conclusions: This age group has so far been understudied and there is a need for comparable studies. Our findings highlight the importance of targeting the physical home environment of pre-school children in future interventions as there are important modifiable factors that both promote and hinder vegetable consumption in this environment.

Keywords
Pre-school children
Home environment
Kindergarten
Vegetables
BRA-study

Worldwide, non-communicable diseases such as CVD, cancers, chronic respiratory diseases and diabetes type 2 cause almost 70 % of all deaths[1]. Non-communicable diseases develop slowly over many years; hence promoting a healthy diet early in life may contribute to reduced incidence of these diseases in the long run. Adequate consumption of fruits and vegetables is linked to a reduced risk of some non-communicable diseases[2–4]. Despite the health benefits of diets rich in fruits and vegetables, many countries face a challenge with regard to their population's intake of these food groups[5]. This is also the case in Norway, where the latest national dietary surveys among adults, schoolchildren and pre-school children[6–10] all report low consumption of vegetables. Reasons for inadequate consumption of fruits and vegetables are complex. For example, food preferences play an important role in children's food choices and it is suggested that food preferences are formed by a combination of genetic and environmental factors[11,12]. However, most children can learn to accept foods that are made available to them[13] even though they are not preferred, especially through repeated taste exposure[12,14].

There is evidence of the tracking of dietary intake from childhood to adulthood[15–18]; consequently early childhood represents a critical period for the establishment of dietary habits[15]. In a life course perspective, the home

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environment is acknowledged as the first environment to shape dietary habits and food preferences[19].

According to Rosenkranz and Dzewaltowski[19], factors within the home environment can be characterized as physical factors, sociocultural factors and political/economic factors. A repeated finding across most reviews including school-aged children is that home physical availability and accessibility of fruits and vegetables are strong positive factors for consumption[20–25]. Availability implies that food items are present in the home, while accessibility implies that food items are in a 'ready to eat' form that facilitates their consumption[26]. Furthermore, parental intake, parental modelling and parental encouragement act as important positive sociocultural factors for consumption of fruits and vegetables in that age group[20,22–25]. Finally, as an economic factor, parental socio-economic position is of significance, where low socio-economic position is associated with low fruit and vegetable intake[22,24,25].

There are several distinctions between fruits and vegetables that play an important role when deciding to eat them; for example, sweet-tasting foods such as fruits are generally accepted more easily in childhood than foods containing bitter components such as vegetables[13]. Therefore, Glasson *et al.*[27] recommend treating fruits and vegetables as separate food groups when planning interventions. However, home environmental factors associated with fruit and vegetable consumption are often reported together in previous reviews among school-aged children[20,22,24,25].

Greater understanding of factors that promote or hinder vegetable consumption among young children is desirable. Although there is substantial research in the area of the relationship between childhood diet and parental food practices[28–30] (the sociocultural environment), other aspects of the home environment of pre-school children are relatively unexplored[31]. The present study aimed to address this gap, first by exploring item pools developed to measure the physical home environment of Norwegian pre-school children and assessing the psychometric properties of these item pools, and second by exploring the associations between the physical home environment and vegetable consumption among these children.

Methods

Study design and participants

The BRA-study (an acronym for the Norwegian words *Barnehage* (kindergarten), *gRønnsaker* (vegetables) and *fAmilie* (family)) is an intervention study with an overall aim to improve vegetable intake among pre-school children (aged 3–5 years at baseline) through changing the food environment and dietary practices in the kindergarten and the home. More specifically, the aims are to increase the daily frequency of vegetable intake, to increase the variety of vegetables eaten over a month and to increase the daily amount of vegetables consumed. The target group for the BRA-study is pre-school children born in 2010 and 2011, attending public or private kindergartens in the counties of Vestfold and Buskerud, Norway. All 479 public and private kindergartens in these two counties were invited by letter to participate in the BRA-study. Seventy-three kindergartens chose to participate (response rate 15·2 %). Parents of 1631 children born in 2010–2011 in the seventy-three kindergartens were invited by letter to participate. Parental consent was obtained for 633 children (response rate 38·8 %). Families were allowed to participate with more than one child (forty-five children in the total sample were siblings). The number of participating children in each kindergarten varied from no children up to twenty-three children. For the present study, only data from the baseline surveys among parents and the baseline observation of the children were included.

Design and methods

At baseline, data about the child and the home environment were collected in three steps (Fig. 1) as follows.

1. A parental web-based questionnaire assessing frequency and variety of the child's vegetable intake, as well as factors potentially influencing the child's vegetable consumption was filled in for 439 children (69 % of the 633).
2. Among a sub-sample (*n* 411) of the participating children (65 % of the 633), a direct observation of the children's fruit, berry and vegetable intakes at two meals in one day in the kindergarten was conducted.
3. A parental web-based 24 h recall for assessing the child's intakes of fruits, berries and vegetables was filled in for 470 children (74 % of the 633).

The number of children having data from all three steps was 246.

Step 1: parental web-based questionnaire

In March 2015, all parents of participating children in the BRA-study (*n* 633) received a link to a web-based questionnaire by email. If the family participated with more than one child, parents were instructed to answer separately for each child. One email reminder was sent out to non-responders about 3 weeks after the first email.

The questionnaire was tested in a pilot study with ten mothers. The questionnaire was administered in the same way and under similar conditions as for the main survey; however, the mothers were requested to give feedback to the researchers on questions and items that were not clear to them or felt too sensitive/personal. After the pilot test, six items were revised to increase clarity, one item was deleted due to being too equal to another item and three item pools of totally fifteen items were deleted owing to considerations of the time used to fill in the questionnaire.

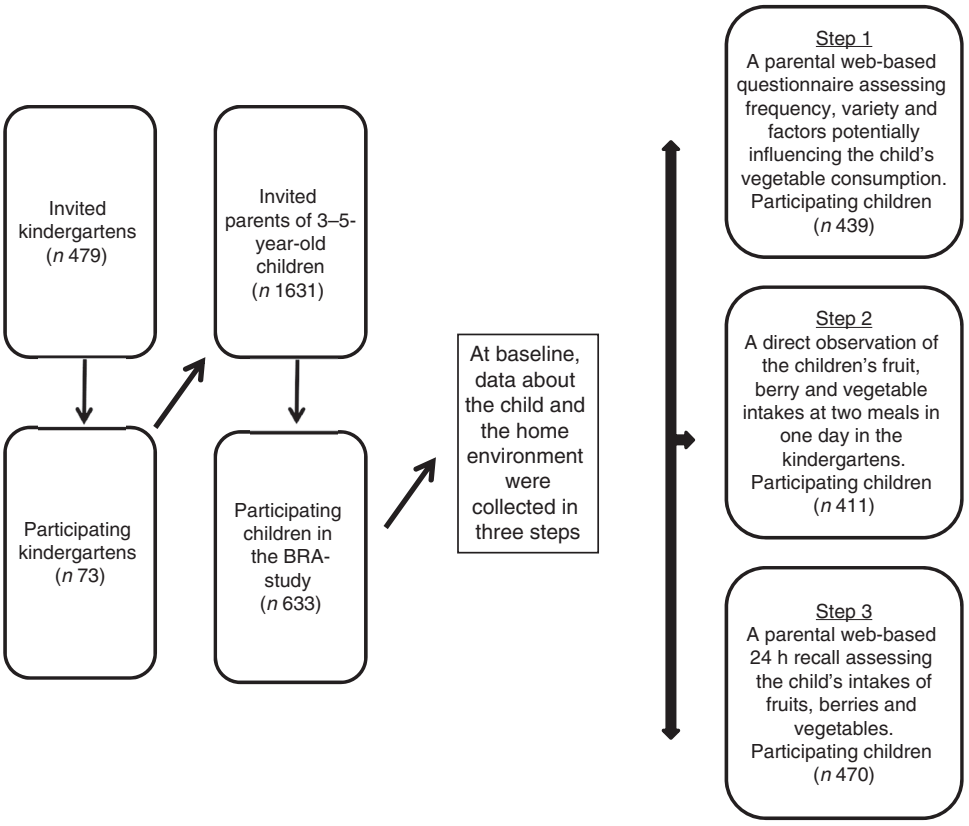

Fig. 1 Flowchart showing recruitment of and data collection from invited and participating 3–5-year-old children in the BRA-study, Vestfold and Buskerud counties, Norway, in total and according to methods used in relation to the home environment at baseline

The final questionnaire included fifty-three questions, divided in two parts. The first part of the questionnaire primarily aimed to measure the usual vegetable intake. Parents were asked to think about the last couple of months, and the frequency and variety of eighteen different types of vegetables were assessed with the question: 'How often does your child eat the following vegetables?' Response alternatives were (times/d in parenthesis) '1–3 times a month' (0·07), '1 time per week' (0·14), '2 times per week' (0·29), '3 times per week' (0·43), '4 times per week' (0·57), '5 times per week' (0·71), '6 times per week' (0·86), 'every day' (1·0) and '2 or more times per day' (2·0). This question was taken from the national dietary survey among Norwegian 2-year-olds[6] mapping total dietary intake. A validation study has been undertaken for that survey, but not for the modified question used in the present study. Pickled and preserved vegetables and potatoes were not included as vegetables in the present study.

The second part of the questionnaire aimed to measure potential factors within the home environment assumed to be related to vegetable intake. In the present paper, only item pools related to the physical factors within the home environment, i.e. the items assessing availability/accessibility and barriers, are presented. The item pool assessing availability/accessibility consisted of thirteen items while the item pool assessing barriers consisted of eight items. The item pools used were composed of modified versions of statements and questions used in previous Norwegian and international studies among children[32–35]. Translation and back-translation of statements and questions available in English were conducted by fluent speakers of the English and Norwegian languages. Responses were given on a 5-point scale ranging from 'totally disagree' (=1) to 'totally agree' (=5), with a neutral midpoint.

The questionnaire also requested information like child gender, child birth year, number of siblings in the household, age of the respondent, respondent's relationship to the child, cohabitant status of the respondent, nationality of the respondent and nationality of the mother/father of the child.

Step 2: direct observation

As part of the baseline data collection, the research team members visited all seventy-three kindergartens in April to June 2015. Direct observation was conducted if the kindergarten had three or more participating children in a department. Each researcher observed one to four children simultaneously, with a maximum of eight children in total from each kindergarten being observed. Preferably, children of mothers with a low educational level were observed and otherwise children were chosen

for observation at random. During observations, the researchers were standing close to tables where the children sat and recorded intakes of fruits, berries and vegetables on an observational form. These foods could be provided by the kindergarten, by the parents or by both the kindergarten and the parents. As children in kindergartens often are offered sliced fruits and vegetables rather than whole pieces, a coloured picture sheet accompanied the observational form to assist researchers in deciding the portion size. The picture sheet contained pictures of nine different shapes like a slice of cucumber, stick of sweet pepper, section of orange, piece of banana, etc. In general, most kindergartens in Norway serve a hot meal for lunch once per week[36]. Therefore, two photograph series with four different portion sizes of a vegetable soup and a vegetable stew were included. After the data collection, the observed portion sizes were converted to grams based on reference weights. The primary source for reference weights was the Norwegian guide on *Weights, Measures and Portion Sizes for Foods*[37]. However, when no reference weight was available, the research team developed a secondary reference by weighing samples of foods according to the shapes of foods observed. In this secondary reference, the number of samples for each shape of food varied; however, a mean weight of three up to thirteen samples for each shape of food was used as standard.

The researchers gave all participating children (*n* 633) a card to take home, which informed about the types of fruits, berries and vegetables served in the child's department on the actual day. Moreover, the card informed parents that they would receive an email from the research team about the 24 h recall (see step 3).

All researchers were trained in observation and all procedures and measurements were conducted according to a standardized protocol.

During data collection there were occasionally options for the researchers to observe the same child/children to assess the inter-rater reliability between pairs of observers. Inter-rater reliability was assessed in sixteen kindergartens, with the first pair of observers observing sixty-six children simultaneously, while the second pair of observers observed twelve children simultaneously. The level of agreement between pairs of observers was estimated by calculating the intra-class correlation. The intra-class correlation for the first pair of observers was 0·96, while for the second pair it was 0·97.

Step 3: parental web-based 24 h recall

In the evening (after 21.00 hours) on the day of the direct observation (step 2), all parents received a link to a web-based 24 h recall by email. If the family participated with more than one child, parents were instructed to answer separately for each child. One email reminder was sent out to non-responders 2 d after the first email.

The 24 h recall was designed to measure the participating child's intakes of fruits, berries and vegetables on the preceding day, with an extra focus on vegetable intake. To ease the reporting, the 24 h was divided in to six eating occasions: breakfast, snack meal 1 (intake after breakfast, but before lunch), lunch, snack meal 2 (intake after lunch but before dinner), dinner and snack meal 3 (intake after dinner and until the child went to bed).

For breakfast, snack meal 1 and snack meal 3, frequencies and amounts of six different types of vegetables were reported. For lunch, snack meal 2 and dinner, frequencies and amounts of six additional types of vegetables were reported. To assist parents in reporting amount of vegetables eaten, a photograph series with four different portion sizes was used. However, photographs of the amount of vegetable were displayed only if the vegetable was reported used. The focus was on everyday intake of vegetables; therefore 24 h recalls reporting on vegetable intake during a weekend day were excluded.

Parents who completed both web-based questionnaires (step 1 and step 3) were entered into a lottery with rewards; two of about 535 € and one of about 1070 €.

Classification of intake of vegetables

The web-based questionnaire (step 1) provided information about frequency and variety of vegetable intake. A vegetable was defined as not used only if the frequency was reported to be 'never'. Due to asking about eighteen different vegetables in the questionnaire, 18 was the maximum variation a child could have in vegetable intake over a month.

Parental ability to recall their child's diet when the child is in childcare may be a limiting factor when using dietary recall methodology among pre-school children[38,39]. Therefore, the amount of vegetables consumed was calculated based on data from the 24 h recall (when at home, step 3) and the direct observation (when in kindergarten, step 2). Hence, only children with data from both step 2 and step 3 were eligible to be included in analyses considering amount of vegetables. In the 24 h recall, the parental reported intake of vegetables at lunch and at snack meal 2 was replaced by the observed vegetable intake in the kindergarten. However, if a child had been picked up from the kindergarten before snack meal 2 (*n* 15), only the lunch meal was replaced in the 24 h recall.

Data analysis

The number of participants included in data analysis varied for the different methods used. For the principal component analysis (PCA), participants included were those with data from the parental web-based questionnaire (step 1, *n* 439). This sample was also eligible to be included in the linear regression analyses; however, due to missing data for covariates (primarily maternal education), the number of participants in the linear

regression analyses for variety and frequency was 395. For the analysis regarding amount of vegetables consumed, participants had to have data from both step 2 and step 3. There were 246 participants with such data; however, twenty-seven were lost due to missing data on covariates (primarily maternal education) and twenty-two were lost due to reporting vegetable intake of a weekend day in the 24 h recall, leaving 197 participants to be included in the analysis concerning amount of vegetables consumed.

PCA was used for exploring factors assumed to be related to vegetable intake. All items asked about in an item pool were entered into PCA. The number of factors retained from the PCA was chosen on the basis of the eigenvalue (explained variance), with the decision criterion of ≥1·0, and the interpretability of the factors. For availability/accessibility, the first two factors were chosen for further analysis. The remaining factors all had eigenvalue less than 1·0, and thus individually explained only a small fraction of the overall variance in the data. To improve the interpretation of the data, the two-factor solution was rotated by varimax rotation. The same pattern as for availability/accessibility was seen for barriers; hence a two-factor solution was chosen for further analysis of this item pool as well.

Items were considered to load on a factor if they had factor loadings >0·3[40]. Items not loading on a factor (factor loading <0·3) were eliminated. Items with high loading on more than one factor were included in the factor where they had the highest loading.

To assess the psychometric properties of the factors derived from the PCA, the internal reliability of the factors was calculated by corrected item–total correlation and Cronbach's alpha (α). Corrected item–total correlation values >0·30 were considered good and values <0·15 were considered unreliable since that would indicate lack of homogeneity of the items within an item pool[41]. Cronbach's α of 0·7 or 0·8 is often classified as an acceptable value[42].

Clustering effects due to kindergartens being the unit of recruitment were checked using the linear mixed-model procedure[43]. The unexplained variance in frequency, variation and amount of vegetables at the kindergarten level was 0 to 1·6 %, which is considered so low that this was not taken into account in the analysis.

Linear regression was applied to study the relationship between variation, frequency and amount of vegetable intake among the 3–5-year-olds and the four new factors derived from the PCA ('availability at home', 'accessibility at home', 'serving barriers' and 'purchase barriers'). For every child a composite score for each of the four factors was created, and this score was further used in linear regression analysis. To be included in the linear regression analysis, participants had to have response on four out of five items within the factor 'availability at home' and likewise for the factor 'accessibility at home'. To be included in the linear regression analysis according to 'serving barriers', participants had to have response on four out of five items, while for 'purchase barriers' participants had to have response on two out of three items.

All models were adjusted for child gender, child birth year and maternal educational level. Maternal and paternal educational level was assessed in the consent form. The educational level was assessed by four pre-coded categories, which were combined into two categories in the analysis: low education (upper secondary school or less) and high education (university college/university). Maternal education was used as an indicator of the socio-economic position of the family as maternal education was reported with fewer missing values compared with paternal education.

Interactions between maternal education and each of the four factors were tested if the associations in the linear regression analysis were significant.

All P values are two-sided, with values <0·05 considered statistically significant. All statistical analyses were performed using the statistical software package IBM® SPSS® Statistics Version 22.0.

Results

Table 1 presents selected characteristics of the children and their parents analysed in PCA. Boys and girls were equally represented, as was child year of birth. Parental respondents were aged between 24 and 60 years, with a mean age of 35·4 (SD 5·1) years. Most of the respondents were the mother of the child, most parents were Norwegians or from other European countries and most had higher education. The sample used in the regression analysis (n 395 and n 197) had the same distribution in characteristics as those presented in Table 1. Descriptive statistics for vegetable intake are also presented in Table 1. According to the reported variation and frequency of vegetable intake, less than 2 % of the children reported consumption to be 'never'. According to observations and the 24 h recall data, results showed that less than 6 % of the children did not consume vegetables at all on the day when observations and recalls were done (data not shown).

Exploration of item pools developed to measure the physical home environment

For the thirteen availability/accessibility items, the two factors derived from PCA were labelled 'availability at home' (five items) and 'accessibility at home' (five items; Table 2), explaining approximately 42 % of the total variance. Three items were not included in the final factor structure as the factor loadings for these items were low (<0·3). These were 'During a meal, I remind my child several times to eat vegetables', 'I serve vegetables I know my child does not like several times a month' and 'I usually

Table 1 Characteristics of 3–5-year-old children and their parents in the BRA-study (*n* 439), Vestfold and Buskerud counties, Norway

Characteristic	*n*	%
Children		
Gender		
Boy	216	49·2
Girl	223	50·8
Year of birth		
2010	229	52·2
2011	210	47·8
County of residence		
Buskerud	161	36·7
Vestfold	278	63·3
Parents		
Age of respondent (years)		
≤30	73	17·0
31–39	271	63·0
≥40	86	20·0
Respondent's relationship to child		
Mother of the child	388	88·4
Father of the child	49	11·2
Stepmother of the child	1	0·2
Female guardian for the child	1	0·2
Cohabitant status of respondent		
Lives with the mother/father of the child	395	90·6
Lives alone	35	8·0
Lives with partner other than the mother/father of the child	6	1·4
Nationality of respondent		
Norwegian	378	86·7
Other nationality	58	13·3
European (*n*)	49	
Nationality of partner of respondent		
Norwegian	368	84·8
Other nationality	66	15·2
European (*n*)	45	
Maternal education		
Low (upper secondary school or less)	116	29·4
High (university college/university)	279	70·6
Paternal education		
Low (upper secondary school or less)	178	46·0
High (university college/university)	209	54·0
Vegetable consumption		
Frequency of vegetable intake (times/d)		
Mean and SD	3·0	1·8
Median	2·9	
Variation in vegetable intake (types/month)		
Mean and SD	10·4	4·3
Median	11·0	
Amount of vegetables (g/d)*		
Mean and SD	118·3	85·6
Median	106·0	

*Total number of children, *n* 197.

serve my child with vegetables'. For the eight barrier items, the two factors derived from PCA explained approximately 57 % of the total variance. The factors were labelled as 'serving barriers' (five items) and 'purchase barriers' (three items). Most items within each of the four new factors had high factor loadings (i.e. ≥0·6).

Table 3 presents the mean values and the psychometric properties of the four factors derived from the PCA. The mean score for 'availability at home' and 'accessibility at home' was high, 4·13 and 3·70 respectively, indicating that most parents partly agreed with the statements included in these factors. The mean score for 'purchase barriers' and 'serving barriers' was low, indicating that most parents partly disagreed with the statements included in these factors.

All values of corrected item–total correlation were 0·36 or above, and all values of Cronbach's α were above 0·7.

Associations between factors of the physical home environment and vegetable consumption

For the factor 'availability at home', there was a significant interaction with maternal education and variation in vegetable intake ($P = 0{\cdot}001$), frequency of vegetable intake ($P = 0{\cdot}015$) and amount of vegetables consumed ($P < 0{\cdot}001$). Every unit increase in the factor 'availability at home' was associated with a higher increase in variation of vegetable intake among children of highly educated mothers compared with children of low-educated mothers (2·7 types/month *v.* 1·2 types/month, respectively; Table 4). The same pattern was observed for frequency of vegetable intake, where children of higher educated mothers had a higher frequency of intake compared with those with lower educated mothers (1·3 times/d *v.* 0·8 times/d, respectively). In opposition, a significantly higher amount of vegetables consumed was observed among those where maternal education was low compared with those where maternal education was high (79·7 g/d *v.* 28·9 g/d, respectively).

Every unit increase in the factor 'accessibility at home' was significantly associated with an increased frequency of vegetable intake, approximately an increase of 2–3 times/week ($P < 0{\cdot}001$), and with an average increase in the amount of vegetables consumed by roughly 17 g/d ($P = 0{\cdot}018$).

Significant associations were also seen for the factor 'serving barriers'. Every unit increase in this factor was associated with a reduction in vegetable variety of about 2 types/month, a reduction in frequency of vegetable intake of about 1 time/d and an average reduction in amount of vegetables consumed of more than 38 g/d (all $P < 0{\cdot}001$). Finally, no significant associations were observed for the factor 'purchase barriers' and vegetable consumption.

Discussion

Presented in the current paper are four distinct factors of the physical home environment of Norwegian 3–5-year-olds, which were labelled 'availability at home', 'accessibility at home', 'serving barriers' and 'purchase barriers'. The psychometric properties of the factors were satisfactory. Associations between factors and vegetable consumption indicated that within the home environment of these Norwegian pre-school children, there are important physical factors that both promote and hinder vegetable consumption.

Table 2 Items and factor loadings* for the factors derived from the principal component analysis reported by parents of 3–5-year-old children in the BRA-study (*n* 439), Vestfold and Buskerud counties, Norway

	F1	F2	F3	F4
Factor: 'Availability at home'				
At home and during a week we usually vary the kinds of vegetables served for dinner	0·80			
At home and during a week we usually vary the preparation method (raw, boiled, etc.) according to the types of vegetables served for dinner	0·78			
At home we usually have vegetables for dinner every day	0·69			
I include vegetables in most meals	0·65			
I cut up vegetables that my child can eat between meals	0·48			
Factor: 'Accessibility at home'				
I usually have more than one kind of vegetables at the table so my child can choose		0·75		
My child usually helps her-/himself to vegetables		0·73		
I usually serve vegetables separately so my child can choose which one he/she wants		0·69		
I place the plate/bowl of vegetables within the reach of my child		0·67		
I send the plate/bowl of vegetables around the table		0·59		
Factor: 'Serving barriers'				
It is difficult to use vegetables in the daily cooking			0·79	
It is too time consuming to cut up vegetables as snack			0·76	
It is too time consuming to use vegetables in the daily cooking			0·72	
I usually forget serving vegetables to my child			0·62	
I do not think my child like vegetables			0·59	
Factor: 'Purchase barriers'				
Vegetables do not look fresh/fine in the store				0·84
Vegetables are too expensive				0·81
Vegetables quickly becomes of poor quality when stored				0·78
Eigenvalue	3·43	1·66	2·87	1·70
Proportion of variance explained (%)	28·62	13·86	35·88	21·25

*Only items with factor loadings >0·3 are displayed.

Table 3 Mean value, standard deviation, corrected item–total correlation (CITC) and Cronbach's alpha (*α*) for the factors derived from the principal component analysis reported by parents of 3–5-year-old children in the BRA-study (*n* 439), Vestfold and Buskerud counties, Norway

	Mean*	SD	CITC	*α*
Factor: 'Availability at home' (*n* 422)	4·13	0·68		0·72
At home and during a week we usually vary the kinds of vegetables served for dinner	4·18	0·92	0·58	
At home and during a week we usually vary the preparation method (raw, boiled, etc.) according to the types of vegetables served for dinner	4·24	0·96	0·59	
At home we usually have vegetables for dinner every day	4·52	0·86	0·48	
I include vegetables in most meals	4·18	1·00	0·46	
I cut up vegetables that my child can eat between meals	3·55	1·20	0·36	
Factor: 'Accessibility at home' (*n* 423)	3·70	0·66		0·74
My child usually helps her-/himself to vegetables	3·35	1·25	0·51	
I usually have more than one kind of vegetables at the table so my child can choose	3·90	1·12	0·61	
I usually serve vegetables separately so my child can choose which one he/she wants	3·51	1·28	0·45	
I place the plate/bowl of vegetables within the reach of my child	4·14	1·03	0·53	
I send the plate/bowl of vegetables around the table	3·53	1·27	0·44	
Factor: 'Serving barriers' (*n* 432)	1·58	0·68		0·73
It is difficult to use vegetables in the daily cooking	1·50	0·94	0·60	
It is too time consuming to cut up vegetables as snack	1·75	1·06	0·58	
It is too time consuming to use vegetables in the daily cooking	1·43	0·81	0·53	
I usually forget serving vegetables to my child	1·55	0·96	0·43	
I do not think my child like vegetables	1·65	1·11	0·37	
Factor: 'Purchase barriers' (*n* 432)	2·59	1·05		0·76
Vegetables do not look fresh/fine in the store	2·26	1·20	0·63	
Vegetables are to expensive	2·76	1·36	0·55	
Vegetables quickly becomes of poor quality when stored	2·75	1·28	0·58	

*Responses were given on 5-point scales ranging from 'totally disagree' (=1) to 'totally agree' (=5), with a neutral midpoint.

Psychometric properties of factors

Most of the items used in the present study were composed of modified versions of statements and questions used in previous Norwegian and international studies among pre-school and school-aged children[32–35], resulting in unknown validity and reliability. The psychometric properties of the factors in the present study were satisfactory, probably indicating suitability for use among children in general. Yet, more studies are needed to verify this. All items correlated with the factor to a good degree

Table 4 Adjusted bivariate associations* between physical home environmental factors and vegetable consumption among 3–5-year-old children in the BRA-study, Vestfold and Buskerud counties, Norway

	Variation in vegetable intake (types/month)†			Frequency of vegetable intake (times/d)†			Amount of vegetables (g/d)‡		
Factor	*B*	95 % CI	*P* value	*B*	95 % CI	*P* value	*B*	95 % CI	*P* value
Availability at home									
Low education§	1·24‖	0·12, 2·36	0·030	0·82‖	0·33, 1·32	0·001	79·7**	48·7, 110·7	<0·001
High education§	2·71¶	2·03, 3·38	<0·001	1·27¶	1·02, 1·52	<0·001	28·9††	9·1, 48·6	0·004
Accessibility at home	0·44	−0·08, 0·96	0·096	0·38	0·17, 0·59	<0·001	17·6	3·0, 32·1	0·018
Serving barriers	−2·02	−2·60, −1·44	<0·001	−0·98	−1·22, −0·75	<0·001	−38·9	−55·5, −22·4	<0·001
Purchase barriers	−0·10	−0·52, 0·33	0·658	−0·15	−0·33, 0·02	0·083	−4·1	−16·4, 8·1	0·509

**B* is adjusted for maternal education, child gender and child birth year.
†Total number of children, *n* 395.
‡Total number of children, *n* 197.
§*B* is adjusted for child gender and child birth year.
‖Total number of children, *n* 116.
¶Total number of children, *n* 279.
**Total number of children, *n* 62.
††Total number of children, *n* 135.

(with the lowest correlation being 0·36)[42]. Additionally, all four factors had acceptable internal consistency, with Cronbach's α values above 0·7. Cronbach's α is sensitive to the number of items included in a scale, with increasing numbers of items in a scale possibly resulting in an increased value[42]. None of the factors in the present study included more than five items, so this has probably not affected the results. Appropriate sample size when conducting PCA has been debated, but it seems reasonable to include a minimum of 300 participants[42]. PCA was conducted on a sample consisting of more than 400 participants; hence the criterion of a large sample size seems fulfilled.

Physical home environment factors positively associated with vegetable consumption

The present study shows that home availability and accessibility are positively associated with vegetable consumption among the 3–5-year-olds. Other studies among pre-school children have also reported positive associations between vegetable intake and availability and accessibility. For example, a study among Australian 4–5-year-olds observed a strong positive association between home availability of vegetables and child intake[31]. In another study focusing on Australian 3–5-year-olds[44], a positive association between fruit and vegetable consumption and home availability and accessibility was found. However, results for the two food groups were reported together and vegetable consumption included intake of potatoes and sweet potatoes. In a study among English 2–5-year-old children[45] no significant association between home availability and vegetable intake was observed. In that study, vegetable intake and availability were both assessed with one question. The authors commented that there was a limited variation in parental response for the question assessing vegetable availability, which may have reduced the explanatory power of that result.

Comparing results across studies is challenging. Associations reported may for example depend on how vegetable intake is estimated, as studies have shown that questionnaires including longer vegetable lists result in higher estimates compared with shorter vegetable lists[46,47]. Further, intake data may represent different time frames as in the present study where the 24 h recall reflects one random weekday, while frequency and variation reflect usual vegetable intake over the last couple of months.

Our results indicate that there are differences in associations according to vegetable consumption when it comes to availability and accessibility, supporting that the two factors should be treated separately. Yet, the item 'I cut up vegetables that my child can eat between meals' had the highest factor loading for the factor 'availability at home' (0·48), while theoretically this item should be included in the factor 'accessibility at home'. However, the factor loading for this item on that factor was only 0·23 (data not shown).

We observed differences in the strength of associations for availability and accessibility according to how vegetable consumption was characterized; this also supports the view that variation, frequency and amount of vegetables are different aspects of the behaviour of vegetable intake and that these aspects might be associated with different factors. As Rasmussen *et al.*[24] point out, increasing variation of vegetables in the home may lead to increased amount consumed, but may be unrelated to increased frequency.

The association between low parental education level and low intake of fruits and vegetables among children is well known[22,24,25]. This was also found in the present paper, where the association between 'availability at home' and variation and frequency of vegetable intake was higher among children of highly educated mothers compared with children of low-educated mothers. However, for the association according to amount of

vegetables, unexpectedly opposite associations were found. It is difficult to point out likely reasons for this finding; one explanation could be differences in the reporting in the 24 h recall between the two educational groups, where the low-educated mothers particularly reported higher intake of vegetables for breakfast compared with high-educated mothers. Such interactions need to be investigated further.

Physical home environment factors negatively associated with vegetable consumption

In the present study every unit increase in the factor 'serving barriers' (e.g. 'It is difficult to use vegetables in the daily cooking') was significantly associated with a reduction in variation, frequency and amount of vegetables consumed, while 'purchase barriers' was not. It might be that purchase barriers included too few items to assess actual purchase barriers, as the PCA resulted in only three items loading on this factor. Moreover, as grocery stores in Norway generally hold high quality on fresh foods such as vegetables, items included might be items that these participants do not worry about. Finally, as this sample consisted mostly of well-educated two-parent families, vegetable prices might not be an issue.

Across studies, scales to measure barriers are unalike and items included may be valued differently according to age, socio-economic position, culture and so on. Among adults, a review of factors associated with fruit and vegetable intake found that six out of nine studies reported a negative association between barriers and fruit and vegetable intake[48]. In the review by Rasmussen *et al.*[24], one out of three studies reported a negative association between barriers and fruit and vegetable intake among 6–18-year-old children. Another review of factors associated with fruit and vegetable consumption in the same age group, including only qualitative studies, found that lack of convenience and price were the most discussed barriers[22]. One study focusing on 5–6-year-old Australian pre-school children found that the factor assessing barriers ('high cost/low preference for fruits and vegetables') was unrelated to vegetable consumption[49]. The authors found this surprising, and reported probable causes for this: 'It may be that by combining two separate constructs, for two separate groups of foods, that is perceptions of cost (for fruit and vegetables) and perceptions of family liking (for fruits and vegetables), into one factor (as suggested by factor analysis), has limited the capacity to describe associations' (p. 1278).

As barriers were assessed by several items and reporting vegetable intake in three different ways, we have extended current knowledge by demonstrating that 'serving barriers' is strongly and negatively associated with vegetable consumption in this sample.

Finally, as discussed earlier, differences between studies may be attributable to methodological differences, ways of assessing factors and ways of assessing vegetable consumption, in addition to subjective decisions made by researches when analysing data.

Strengths and limitations

Strengths of the present study are first of all the age group, which so far has been understudied. Further, as vegetable consumption was assessed in three ways, the associations with factors of the physical home environment present a broad picture of potential relationships. Parental ability to recall their child's diet when the child is in childcare may be a limiting factor[38,39]. This was also supported by the parents in the present study, as more than forty responders of the 24 h recall (step 3) gave feedback regarding difficulties in reporting intake when child was in kindergarten (data not shown). Therefore, to collect a more precise picture of vegetable intake, parental reports were combined with observations by the research staff[50].

Interpretation of findings should also take some limitations into account. First, the data are cross-sectional and although cross-sectional data can demonstrate associations, they cannot be used to determine cause and effect. Further, the participation rate among parents in the present study is lower than participation rates in national dietary surveys among Norwegian pre-school children[6,7,10]; this might have led to a biased sample of those most interested in vegetables. As discussed earlier, low parental education is associated with low intake of fruits and vegetables[22,24,25]. The level of parental education in our sample of participants was higher compared with the national educational level in Norway and this might also have influenced the findings. In Norway, 39 % of men and 55 % of women aged 35–39 years had a high educational level in 2015[51], compared with 54 and 71 %, respectively, in the present study. In addition, to be included in the analyses of amount of vegetables consumed, participants had to have data from two questionnaires and the observations, which might further have led to a biased sample. The significant interaction between 'availability at home' and amount of vegetables consumed surprisingly showed lower amount of vegetables consumed among children of highly educated mothers compared with children of low-educated mothers, and such interactions need to be investigated further.

Conclusion

Exploring item pools developed to measure the physical home environment of Norwegian pre-school children resulted in four factors with satisfactory psychometric properties. The factors 'home availability' and 'home accessibility' were both strongly and positively associated with vegetable consumption. Further, 'serving barriers' was negatively associated with variation, frequency and

amount of vegetables consumed, while 'purchase barriers' was not.

Our findings highlight the importance of targeting the physical home environment of pre-school children in future interventions as there are important modifiable factors that both promote and hinder vegetable consumption in this environment. This age group has so far been understudied and there is a need for comparable studies; hence further research should target these physical home environmental factors when aiming to increase vegetable consumption among pre-school children.

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