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Increasing fruit and vegetable intake among children: comparing long-term effects of a free distribution and a multicomponent program

E. Reinaerts^{1*}, R. Crutzen², M. Candel³, N. K. De Vries⁴ and J. De Nooijer¹

Abstract

The aim of this study was to evaluate and compare the effectiveness of two primary school-based interventions on children's fruit and vegetable (F&V) consumption on the long term (2 years after the start of the interventions). Six primary schools were recruited and randomly assigned to (i) a daily free distribution program for the whole school or (ii) a multicomponent program consisting of a classroom curriculum and parental involvement (without free F&V), and six schools served as controls. Follow-up measurements were conducted at the end of the intervention (Follow-up I) and 1 year later (Follow-up II). Random coefficient analyses for longitudinal data showed that the effects of both interventions did not differ between the two follow-up measurements. The results showed similar effects for the free distribution program and the multicomponent program in increasing children's fruit consumption over time (respectively, 7.2 and 15.2 g day⁻¹). The distribution program also increased children's

vegetable consumption over time (3.25 g day⁻¹), even after repeating the analyses using a pessimistic scenario. Despite the large dropout and its consequences for generalizability of our results, the distribution program is considered as the preferred intervention of the two, and implementation on a larger scale should be investigated.

Introduction

Dutch children consume less fruit and vegetables (F&V) than the recommended 400 g [1], and compared with other European children their consumption is low [2, 3]. Especially, since dietary habits are formed in childhood [4, 5], interventions targeted at increasing young children's F&V consumption are needed. Moreover, children are more open to changes in their dietary pattern [5] than grown-ups or parents for whom their limited consumption of F&V often has become habitual [6].

It is well recognized that the school setting provides many opportunities to improve dietary behaviors such as F&V consumption [7]. In the past decades, several school-based interventions have been developed and most of them have reported small but significant increases in children's F&V consumption, at least on short term (3–12 months after the start of the interventions) [8–10]. The effects of these interventions on the longer term (≥ 2 years after the start of the interventions) are seldom reported [10], but can give important indications about the sustainability of the child's behavior change.

In The Netherlands, initiatives to improve children's F&V consumption have been undertaken,

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including the national Schoolgruitem project [11] and the Pro-children project [12]. Both projects combined a free distribution of F&V at school (twice a week) with other components such as curriculum activities and parental involvement. This design, however, makes it impossible to evaluate the effect of the single components of the interventions. An extensive review of environmental interventions to increase F&V intake recommended that more research into the direct comparison of environment only and multicomponent interventions was necessary in order to establish effective intervention components [9]. Therefore, the Universiteit Maastricht in cooperation with the Local Health Service Noord and Midden Limburg developed and tested two different types of interventions: (i) a daily free F&V distribution program for the whole school and (ii) a multicomponent program, consisting of a classroom curriculum and parental involvement (without free F&V). Both interventions tried to make daily F&V consumption habitual, but used different strategies. The distribution program was developed to create a habit 'unintentionally'. By distributing F&V, the same behavior is frequently and consistently repeated under the same circumstances [13]. Children consumed a free portion of F&V every day at the same time in the classroom. The multicomponent program was used to create a habit 'intentionally' by stimulating respondents to purposefully engage in the desired behavior, both frequently and consistently [13]. Parents and children were stimulated to bring F&V to school every day (frequently and consistently), and similar to the distribution program, a special moment was created to eat the F&V together in the classroom.

A recent evaluation of both interventions showed significant effects on fruit, juice and vegetable (FJV) consumption at the end of the intervention (1 year). The distribution program showed to be more effective than the multicomponent program, especially in increasing vegetable consumption [14]. After 1 year of intervention, both were completely terminated. This means that the free distribution stopped and parents and children were no longer actively stimulated to bring F&V to school.

The purpose of this paper is to explore whether the short-term effects were sustained 1 year after the end of the intervention year. It was expected that the effects would decrease but not disappear completely since both interventions were aimed at creating habitual behavior. Because two different strategies were used to make F&V consumption habitual, we wanted to know whether the two (intervention) strategies differed in sustainability.

Methods

Design and participants

Six schools in The Netherlands were recruited to receive an intervention. These schools were paired, based on ethnic composition because the proportion of foreign students can differ substantially among primary schools. Of each pair, one school was randomly assigned to the distribution condition ($n = 690$ children) and one to the multicomponent condition ($n = 648$), resulting in two intervention groups each consisting of three schools. Six control schools ($n = 1168$) were identified and matched to the intervention schools based on ethnicity and school size. The interventions started in October 2004 and lasted throughout the school year (until June 2005). Both interventions are described in more detail in Reinaerts *et al.* [14]. Informed consent was acquired from parents prior to the study.

Questionnaires were brought home by the children to be completed by one of their parents. At the second follow-up, the oldest children had entered secondary school, so the questionnaires were mailed to their home addresses. Baseline measurements were conducted in October 2004, while the first follow-up was conducted in June 2005 and the second in June 2006.

At baseline, a total of 1739 parents filled out the questionnaire for their child. Of these parents, a total of 940 (54%) also filled out the second one in June 2005 and 436 (25%) filled out all three measurements. All analyses were performed using the parents who filled out the questionnaire on all three measurements.

Measures

The main outcome measures were assessed using a pre-structured food recall and a food frequency questionnaire (FFQ). The pre-structured 24-hour food recall assessed the number of times children consumed food (including fruit or vegetables) the previous day. It aimed to focus parents on the total food intake of the day before and not only F&V to prevent overestimation of F&V consumption. The recall consisted of 16 items, such as 'Did your child eat fruit as a snack between meals' or 'a slice of bread with his/her breakfast'? Parents could indicate whether or not their child consumed the specific item the day before. Only the information on FJV intake (24-hour FJV) was included in the analysis. In The Netherlands, most children go home for lunch or bring their own sandwiches to eat at school. Because no school meals are typically offered, parents should know what their child consumes during school time.

The FFQ (also completed by a parent) was used to assess children's fruit consumption in portions (~80 g) per day, vegetable intake during dinner in grams per day and vegetable snack intake in times per day. Two questions were used to assess children's fruit consumption of 'How many days per week does your child eat fruit?' (1–7 days) and 'How many portions of fruit does your child eat on a day that he or she consumes fruit?' ranging from '1/2 portion a day' to '3 portions a day or more' on a six-point scale. The average consumption of whole fruit (in portions per day) was calculated by multiplying both questions and dividing the result by 7.

The frequency of vegetable intake was measured by three questions, asking how many times per week the child eats (i) cooked or baked vegetables for dinner (including mixed dishes); (ii) mixed dishes such as macaroni and (iii) extra salad, such as lettuce, tomato or other raw vegetables. The number of days that the children consumed cooked vegetables was calculated by subtracting (ii) mixed dishes from (i) cooked or baked vegetables including mixed dishes. Portion size was assessed using photographs of plates filled with different amounts

of cooked vegetables (25, 50, 100 and 150 g) or mixed dishes (75, 150, 300 and 450 g). Parents had to select the photograph that best represented the amount of food that their child usually consumes. According to The Netherlands Nutrition Centre, on average, 33% of a mixed dish consists of vegetables. The amount of extra salad or raw vegetables was calculated by multiplying frequency per week by 35 g (the weight of a small bowl of salad). Finally, the average consumption of vegetables in grams per day was computed by $((\text{the number of days that the children consumed cooked vegetables} \times \text{portion size}) + (\text{the number of days children ate mixed dishes} \times (0.33 \times \text{portion size})) + (\text{the number of days children ate extra salad or raw vegetables} \times 35 \text{ g}))/7$ days. To assess daily intake of 'snack vegetables', we asked how many times per week the child eats vegetables separately as a snack between meals (such as a tomato or a piece of cucumber) or as part of breakfast or lunch (1–7 days), and we divided this by 7.

The FFQ method was used in a similar Dutch project and based on the Pro-children questionnaire that was validated by Haraldsdóttir *et al.* [15].

Demographics of the children included age, sex and ethnicity. The country of birth of both parents assessed ethnicity of the children. Children were classified as 'native' when both parents had been born in The Netherlands and as 'non-native' when one or both parents had been born outside The Netherlands based on the definition used by Statistics Netherlands [16].

Data analyses

Attrition between baseline and the second follow-up (June 2006) was studied by means of multilevel logistic regression analysis with attrition as the dependent variable and child's age, sex and ethnicity, child's F&V consumption at baseline and the intervention factor as predictors. Chi-square tests for proportions and *F*-tests for continuous variables were used to compare baseline characteristics between study groups.

Long-term effectiveness of the interventions was analyzed using random coefficient analyses for

longitudinal data [17], using MLwiN [18]. Separate analyses were performed for each of the outcome measures [24-hour FJV (times per day), fruit (portions per day), vegetable snack (times per day) vegetables (g day^{-1})]. To adjust for dependency in the measurements, a three-level data structure was used in the analysis model, where the three levels were the time of the follow-up measurement (Level 1), pupil (Level 2) and school (Level 3). In all analyses, dummy variables for the distribution and the multicomponent intervention group as main independent variables were included, and the model adjusted for the effects of child's age, ethnicity and baseline value of the outcome measure. Furthermore, all analyses included interactions between time and the dummy indicating the distribution group and between time and the dummy indicating the multicomponent group. All analyses were done following a 'top-down' procedure, i.e. starting with the most elaborate model and successively leaving out the most non-significant effects. Regression coefficients in the model were statistically tested using the likelihood ratio test and the Wald statistic setting significance at $\alpha = 0.05$.

Missing values for individual scale items were substituted by the mean score of all respondents on the item. There were no items that had $>20\%$ missing values. All outcome measures were checked for normality, and as a result of this, fruit consumption (portions per day) and vegetable snack consumption (times per day) were adjusted for positive skewness using square root transformations [$\text{SQRT}(X)$] as described by Tabachnik and Fidell [19].

To quantify the effect of the interventions and give more insight into the practical relevance of the results, the net effect was used, indicating the differences in change in F&V intake between the intervention and control group. Thus, the net effect = (follow-up intake_{intervention} – baseline intake_{intervention}) – (follow-up intake_{control} – baseline intake_{control}). Furthermore, effect sizes (using Δ scores) were calculated for both follow-up measurements following Cohen [20]. However, because these effect measures (net effect and effect size) are calculated using unstandardized mean scores,

no conclusions regarding effectiveness can be drawn from these measures.

Results

Baseline characteristics and dropout analysis

Participant flow from baseline to the second follow-up measurement is presented in Fig. 1. In total, data from 436 parents were available for all three measurements. The mean age of the children was 8 years (SD = 2.2 years), 47% ($n = 206$) were boys and 82% ($n = 357$) were of Dutch origin. Exploratory analyses showed that children in the control group were 0.7 years ($P < 0.05$) older than the children in the multicomponent group and that the distribution of ethnicity among the three groups differed significantly (control versus multicomponent versus distribution: 38 versus 14 versus 48% non-native; $P < 0.001$). Children in the distribution group consumed more vegetable snacks at baseline than children in the control group ($P < 0.05$). To correct for these differences, these factors were included as covariates in all effect analyses.

Multilevel logistic analyses of dropout at first and second follow-up (combined) did reveal some selective dropout. Parents of non-native children (OR = 1.67; 95% CI = 1.16–2.38) dropped out significantly more often (19% native versus 32% non-native). Children of parents who dropped out consumed 0.1 portion less fruit per day (OR = 0.69; 95% CI = 0.69–0.93) at baseline compared with the children whose parents filled out all three surveys. These factors were already included in the model as covariates.

Main outcome measures

Table I shows summary statistics (raw scores; unstandardized) for children's 24-hour FJV consumption (24-hour FJV), fruit, vegetable snack and vegetable consumption at baseline, Follow-up I and Follow-up II. Furthermore, the effects of the distribution program and the multicomponent program across time on the main outcome measures based on the results of the random coefficient

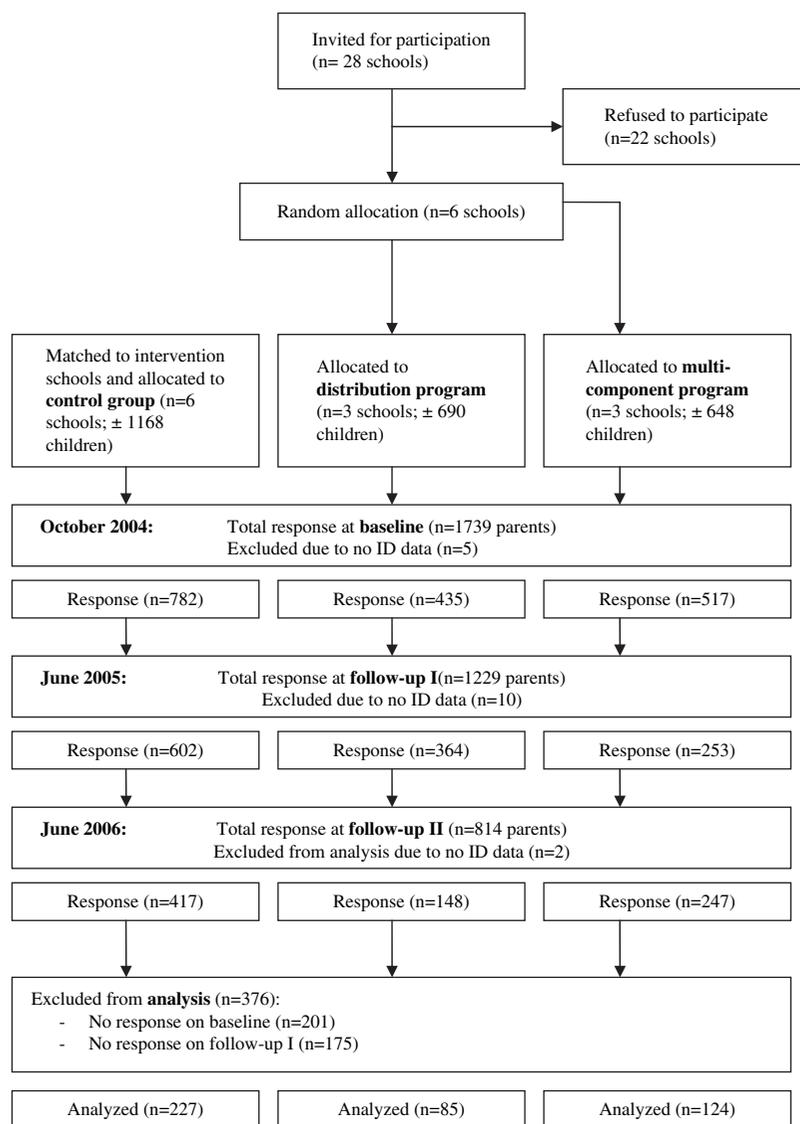


Fig. 1. Flow diagram of the process through the phases of enrollment, intervention allocation, follow-up measurements and data analysis.

analyses are presented. For none of the outcome measures, the interaction between time and intervention condition was significant, indicating that the effect of the intervention did not differ between the two follow-up measurements.

A significant intervention effect of the distribution program compared with the control group ($P <$

0.05) was found on all outcome measures. This means that the distribution program was able to increase all outcome measures and that this effect sustained after the intervention was terminated. Table I shows that at second follow-up, children who received the distribution program had increased their consumption with a net effect of

Table I. Unstandardized means (standard deviation, SD), effect sizes of F&V consumption in both intervention groups and the control group at baseline (October 2004), Follow-up I (June 2005) and Follow-up II (June 2006) and pairwise comparison of intervention effectiveness

	Baseline, mean (SD)	Follow-up I, mean (SD)	Follow-up II, mean (SD)	Net effect		Cohen's <i>d</i>		Pairwise comparison ^a
				Follow- up I	Follow- up II	Follow- up I	Follow- up II	
24-hour FJV (times per day)								
Control (<i>n</i> = 227)	2.63 (1.25)	2.88 (1.16)	2.86 (1.20)					DI, MC > C*
Distribution (<i>n</i> = 85)	2.87 (1.19)	3.38 (1.18)	3.22 (1.13)	0.26	0.13	0.19	0.09	
Multicomponent (<i>n</i> = 124)	2.47 (1.06)	3.10 (1.12)	3.02 (1.29)	0.37	0.32	0.29	0.22	
Fruit (portions per day)								
Control (<i>n</i> = 227)	1.12 (0.68)	1.07 (0.65)	1.03 (0.67)					DI, MC > C*
Distribution (<i>n</i> = 85)	1.25 (0.83)	1.41 (0.83)	1.25 (0.76)	0.21	0.09	0.36	0.15	
Multicomponent (<i>n</i> = 124)	1.08 (0.72)	1.27 (0.70)	1.18 (0.75)	0.14	0.19	0.37	0.29	
Vegetable snack (times per day)								
Control (<i>n</i> = 227)	0.28 (0.25)	0.29 (0.24)	0.29 (0.25)					DI > C, MC*
Distribution (<i>n</i> = 85)	0.32 (0.26)	0.38 (0.28)	0.40 (0.30)	0.05	0.07	0.25	0.29	
Multicomponent (<i>n</i> = 124)	0.22 (0.22)	0.31 (0.29)	0.26 (0.24)	0.08	0.03	0.35	0.12	
Vegetable (g day ⁻¹)								
Control (<i>n</i> = 227)	47.7 (24.1)	46.5 (25.2)	50.1 (21.7)					DI > C, MC*
Distribution (<i>n</i> = 85)	43.6 (22.1)	49.0 (26.5)	49.6 (25.6)	6.45	3.25	0.30	0.14	
Multicomponent (<i>n</i> = 124)	45.2 (25.2)	43.6 (24.7)	48.4 (24.0)	-0.57	0.57	-0.03	0.02	

^aModel: fixed effects were intervention condition, child's age, ethnicity, baseline value of the outcome measure and time (survey). Random effects were added for pupil and school, where pupils were nested in schools. No significant interaction effects between time and intervention condition were found. Therefore, these were not included in the model. * $P < 0.05$; DI, distribution program; MC, multicomponent program; C, control group; >, larger than.

0.13 times FJV on the day prior to data collection ($d = 0.09$), they consumed 0.09 more portions of fruit per day ($d = 0.15$) and 0.07 times more a vegetable snack compared with the control group ($d = 0.29$). A serving of fruit weights on average ~ 80 g, so the consumption of fruit was increased with ~ 7.2 g day⁻¹. Furthermore, the uncorrected data showed that children from the distribution group consumed 3.25 g more vegetables during dinner ($d = 0.14$). The multicomponent program showed significant effects over time in increasing children's 24-hour FJV ($P < 0.05$) and fruit consumption ($P < 0.05$) compared with the control group. At second follow-up, they had increased their consumption with a net effect of 0.32 times FJV ($d = 0.22$) and 0.19 portions (~ 15.2 g) fruit per day ($d = 0.29$) compared with control group. No effects were found for vegetable snack intake and vegetable intake during dinner.

In order to identify the preferred intervention, we compared the distribution and the multicomponent

program by repeating all analyses, using the distribution program as reference. The results of these analyses (Table I) show that the interventions showed similar effects in increasing 24-hour FJV and fruit consumption but that the distribution program also increased vegetable snack intake ($P < 0.05$) and vegetable intake during dinner ($P < 0.01$).

Analyses including dropouts

Unfortunately, a considerable number of parents (75%) withdrew from the study before the second follow-up measurement. Therefore, here could be a risk for informative dropout. This means that whether or not parents dropped out could be dependent on their child's unknown F&V consumption at the first or second follow-up, respectively. To address this problem, we repeated the analyses using a pessimistic scenario, which assumed that all respondents who had missing values did not change their baseline consumption during the intervention period. Therefore, the baseline value (T0) of each

dropped-out respondent was used as a substitute for the missing values on the first (T1) and/or second follow-up (T2). These conservative analyses revealed the same results for both interventions on all outcome measures except for 24-hour FJV consumption and vegetable consumption during dinner. Contrary to the complete-case analyses, the analyses did not show a significant effect of the multicomponent program on 24-hour FJV. Vegetable consumption during dinner was increased by the distribution program, but we only found this effect on the short term (Follow-up I).

For fruit consumption, the significant time by intervention interaction revealed that the effect of both programs decreased over time. However, separate analyses for the first and the second follow-up showed that the effects remained significant at both measurements.

Discussion

The aim of the current study was to evaluate the effects of two school-based interventions aimed at increasing children's F&V intake over time and to identify which of the two interventions was most successful after the intervention had completely stopped. Effectiveness of the interventions was concluded from the results of the random coefficient analyses.

This study indicated that the multicomponent program increased children's 24-hour FJV consumption and fruit consumption over time, and the distribution program increased all outcome measures, but effect sizes were small ($d < 0.2$) to medium ($0.2 < d < 0.5$) according to the criteria of Lipsey [21]. Although the effects on F&V consumption on the second follow-up were smaller compared with the first follow-up, the general lack of intervention by time interactions indicates that the short-term effects of these interventions as reported previously [14] sustained 1 year after terminating the intervention. After comparing both interventions, we must conclude that although both programs showed the same effects regarding 24-hour FJV and fruit consumption over time, the

distribution program also showed an increase in children's vegetable consumption. Although no efforts were made at all to increase consumption at home, the distribution even increased vegetable consumption during dinner. This is especially promising considering that vegetable consumption has been shown to be difficult to change [22] because children tend to accept fruit more easily than vegetables [8, 23]. An explanation for this effect could be that children in the distribution program increased their liking for vegetables because they were probably more frequently exposed to different kinds of vegetables compared with the children who received the multicomponent program. Contrary to the multicomponent program, in which children should bring their own F&V from home, the researchers did make sure that a large variety of F&V was offered in the distribution program. The effects of repeated exposure were previously demonstrated by Wardle *et al.* [24, 25].

Another explanation could be that only in the distribution program the same behavior was repeated frequently and consistently enough to create a habit at least for the outcome measures related to vegetable consumption. The process evaluation of both interventions showed that the multicomponent program was less fully implemented compared with the distribution program [26], which supports the last explanation.

Our results are more or less comparable with those previously reported in similar intervention studies [27, 28], but these studies looked at long-term effectiveness while the distribution component of the interventions was partly continued. The European Pro-children study [28], for example, combined a free distribution of F&V twice a week with a school curriculum. At second follow-up, children reported a net effect of 0.20 times more fruit per day and 0.19 more portions of fruit on the day prior to data collection. Daily frequency of vegetable intake increased with 0.08 times per day [28]. Contrary to the present study, the free distribution was sustained after the intervention period. More in line with our study is the one reported by Bere *et al.* [27] that also found a sustained effect of a free subscription scheme in Norway after

3 years. The estimated long-term effects for F&V consumption were 0.38 portions per day for boys and 0.44 for girls [27]. In this study, a small part of the children still participated in the national (paid) school fruit program the years following the intervention. This mediated the effects partly, but after correcting for the subscription, long-term effects remained significant. Combined with our results, this indicates that a free subscription could be an effective method to increase children's F&V consumption even in the long term. Not only the distribution program seemed to be better able to increase the vegetable consumption compared with the multicomponent program, previous research into implementation of both interventions also concluded that a distribution scheme has more potential to be implemented and sustained at primary schools [26].

Although both interventions showed statistically significant effects for increasing fruit consumption compared with no intervention, it should also be concluded that the net effects were small to medium. The intake of fruit consumption, for example, increased with $\sim 7\text{--}15\text{ g day}^{-1}$. One can wonder whether this increase results in public health benefits and therefore is clinically relevant. According to a Norwegian study reported by Bere *et al.* [27], a lifelong increase of 2.5 g F&V per day is sufficient to make a free distribution during primary school (10 years) cost-effective. To our knowledge, no studies have been conducted that model the health effects of interventions similar to the ones described in this study. However, Veerman *et al.* [29] estimated the health effects of a computer-tailored nutrition education intervention in The Netherlands using epidemiological modeling. In the simulation model, the effects of the intervention were calculated as the difference in pre- and post-test consumption and expressed as the percentage of pre-test consumption. The intervention showed an average increase in F&V intake of 14.1% for weeks after the intervention. Our interventions reached an average increase of F&V intake of 17.5% on short term and 13.8% on longer term, which indicates similar modeled health effects. It was concluded in the simulation study that if the

intervention reached to whole population and the effects were sustained, it could result in a maximum mortality decrease of 0.4–0.7% and save 72–115 life years per 100 000 persons. The healthy life expectancy was estimated to increase by 32.7 days for men and 25.3 days for women [29]. Although our results can only be considered practically relevant if the increased consumption turns out to be a lifelong increase, the fact that the effects remained significant after the termination of the interventions gives some indication of a sustained increase in consumption. Whether this is a lifelong increase remains uncertain. Nevertheless, more research into health effects of these kinds of interventions is needed.

The present study has some important limitations. Although schools were randomly assigned to the intervention conditions, the control schools were matched to the intervention schools based on school size and ethnicity. This resulted unfortunately in differences at baseline regarding ethnicity and baseline consumption levels, which have been controlled for. Because we wanted to include all children who received the interventions into our effect analyses and younger children are limited in their ability to report their own food intake [30], we had to rely on parental reports of the children's F&V intake. However, studies reported that neither parents [31] nor children are reliable reporters of children's food intake [30, 32, 33]. Furthermore, a recent study showed low levels of agreement between child and parental reporting of F&V intake [11]. Therefore, it should be recommended to study effectiveness of interventions by using both parental and child reports. Another important limitation regarding the use of self-reports is that the validity of the results might be threatened as the result of greater social desirability among the parents of the intervention groups compared with the control group [34, 35]. In the absence of a gold standard or an objective F&V measure, we unfortunately had to rely on self-reported data like most studies on dietary behavior.

Using parental reports unfortunately resulted in a large dropout between the baseline measurement and the first and second follow-up. However, in this

study, dropout does not mean that children dropped out of the study by a conscious choice. In this case, it means that parents did not fill in the follow-up measurements. Because reasons for parents for not completing all three surveys were not studied, the generalizability of the results could be threatened. Moreover, since also a limited amount of the schools were willing to participate mostly due to limited time. However, the analyses using a pessimistic scenario by imputing all missing values with the respondent's baseline intake values revealed similar effects for the distribution program (except for long-term effects on vegetable consumption) compared with the complete-case analyses. The multicomponent program only showed significant effects in increasing fruit consumption. Finally, we must address that in our complete-case analyses, children were included who transferred to secondary school after the intervention had ended ($n = 26$ in the control group, 7 in the distribution group and 11 in the multicomponent group, respectively). We believe that the changes in circumstances that these children encounter are of great influence on habitual behavior such as F&V consumption. Considering the small sample sizes of the children who left primary school in our study, we could not look into this more extensively. Further study into the effects of the transition to secondary school is recommended using larger sample sizes.

Despite the limitations of our study, we carefully conclude that both a free distribution program and a multicomponent program can increase children's fruit consumption over time. The distribution program also increased children's vegetable consumption over time, and it is therefore considered as the preferred intervention of the two. In view of these results reported, implementation of a distribution scheme on a larger scale should be investigated.

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Conflict of interest statement

None declared.

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