

Does the distribution frequency matter? A subgroup specific analysis of the effectiveness of the EU School Fruit and Vegetable Scheme in Germany comparing twice and thrice weekly deliveries

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Abstract

Objective: The present study aimed to examine the effectiveness of two different implementation forms of the EU School Fruit and Vegetable Scheme (SFVS).

Design: A quasi-experimental design was applied including a thrice as well as a twice weekly intervention group. Repeated 24 h dietary recalls were used to measure children's fruit and vegetable (F&V) intake. Effects were analysed on days with and without F&V deliveries using hierarchical linear regression models.

Setting: Twelve primary schools in North Rhine-Westphalia, Germany.

Subjects: Third and fourth graders (n 664).

Results: Average daily F&V intake at pre-intervention was 0.84 frequencies in the thrice weekly intervention group, 0.90 frequencies in the twice weekly intervention group and 1.25 frequencies in the control group. Providing children thrice weekly with F&V increased children's F&V intake on average by 0.96 ($P < 0.001$) frequencies/d. The effects were higher on days with (1.07; $P < 0.001$) than on days without (0.75; $P < 0.001$) F&V deliveries. Distributing F&V twice weekly resulted in an increase of 0.75 ($P < 0.001$) frequencies/d on average, again with higher effects on days with (1.30; $P < 0.001$) than without (0.48; $P < 0.003$) F&V deliveries. Subgroup analysis revealed some indications for differential effectiveness only in the twice weekly intervention group.

Conclusions: The SFVS with thrice or twice weekly deliveries of F&V led to a significant increase in children's F&V intake on days with and without deliveries. The latter might provide an indication of positive long-term effects of the scheme. The scheme shows equal efficiency for almost all subgroups.

Keywords

Children
Intervention study
Fruit and vegetable
Hierarchical linear modelling

Since childhood obesity has increased continuously in the past resulting in high prevalence rates in Europe and many other regions in the world^(1,2), changing dietary habits has become a public health goal. Even through the latest trends in childhood obesity show flattening in north-western Europe and first indications for stagnation in Germany, prevalence rates remain at a high level^(3,4). As eating habits established in childhood are likely to track into adulthood^(5,6), improving dietary habits during early youth seems to be a promising prevention strategy^(7–9) and might reduce subsequent disease risk and health-care costs of obesity, which have become a serious concern^(10,11).

Empirical studies and literature reviews document that successful prevention strategies should be broad-based and well-integrated into children's lives^(12,13). Accordingly, the school setting is a natural fit for anti-obesity programmes and particularly effective when a multisector and

bottom-up approach is applied^(14–16). Increasing the intake of fruits and vegetables (F&V) has been shown to reduce long-term risk for obesity among adults, as incorporating them in the diet can reduce energy density, promote satiety and decrease energy intake^(17–20), and is therefore one key element of many prevention strategies. The objective of increasing F&V intake also addresses the issue that children's average consumption level of these food items is still below the recommended intake^(21,22). The effectiveness of various school-based interventions programmes aimed at promoting F&V intake has been previously summarized^(23,24). It was concluded that most schemes were successful in increasing F&V intake of children. In these reviews, also intervention approaches providing children with free or subsidized F&V were shown to be effective. These findings confirm those of previous empirical investigations in that accessibility and

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availability are considered to be strong predictors of children's F&V consumption⁽²⁵⁾. Also more recent studies found that availability of F&V at home mediated children's F&V intake^(26,27). Additionally, research indicates that repeated exposure to a food is capable of increasing one's willingness to consume it⁽²⁸⁾. Experimental studies with infants and children have provided strong evidence for the efficacy of exposure in increasing liking as well as intake of unfamiliar foods and drinks^(29–32). Availability as well as repeated exposure and thus increasing provision of healthy food choices in schools are therefore promising obesity prevention measures at the community level^(13,33).

Against this background, the EU launched a School Fruit and Vegetables Scheme (SFVS) which provides children with free F&V and thus encourages good eating habits in young people. The exact implementation of the scheme at national level is left to the member states but has to be based on national or regional strategies⁽³⁴⁾. In North Rhine-Westphalia (NRW), the largest German federal state by population, the SFVS was launched towards the end of the 2009/10 academic year. Since its introduction, the number of schools participating in the scheme has increased continuously. The expansion was made possible due to an increase in the budget allocated to the programme and the reduction in the distribution frequency of F&V deliveries from daily to thrice weekly^(35,36). In the school year 2012/13, when the present data were collected, the total budget for the SFVS NRW was 5 million Euro, with 50% being financed from federal state resources of NRW and 50% by EU funds⁽³⁷⁾. The effectiveness of the SFVS NRW in terms of increasing children's F&V intake was evaluated during the first year of implementation in 2010/11 by Methner *et al.*⁽³⁸⁾, confirming the success of daily F&V deliveries in increasing children's F&V intake. However, since then there has been a reduction in F&V deliveries and this current implementation form with only thrice weekly deliveries has not been evaluated in the specific context of the SFVS NRW before. Thus, the question arises whether thrice weekly F&V deliveries are sufficiently frequent to positively influence the dietary behaviour of children. Based on the assumption of a given budget, moreover, only a further reduction in F&V distribution frequency, namely to twice weekly F&V deliveries, will allow more schools' participation in the future. Thus, a closer look should also be taken at the effects of twice weekly F&V deliveries. With thrice as well as twice weekly F&V deliveries, it is expected that during one school week days without provision of F&V will occur which have not been present before in NRW. This new situation raises the question whether effects that might be observed on days with F&V deliveries are also verifiable on days without those deliveries. The latter would provide a first indication of the potential existence of long-term effects of the scheme, due to an increase in F&V intake in the absence of F&V deliveries. Finally, it seems important to investigate whether subgroups (e.g. boys *v.* girls,

low *v.* high SES) are affected differently by both implementation forms, as it has been shown that F&V intake is particularly low in boys and children with a low socioeconomic status (SES)^(21,22,39).

Accordingly, the aim of the present study was to examine whether providing children F&V thrice or twice weekly within the scope of the SFVS NRW is effective in increasing F&V intake of participating children and relevant subgroups. Additionally, the study aims to give a first indication of possible long-term effects, by looking at the effects on days without F&V deliveries.

Methodology

Study design and data collection

The study used a quasi-experimental design with a pre-intervention and post-intervention survey conducted among the same primary-school children (third and fourth grade, aged between 7 and 10 years at pre-intervention) before and after one year of participation in the SFVS NRW. Data were collected at the beginning and end of the 2012/13 school year. Overall, four schools with a thrice and four schools with a twice weekly distribution frequency of F&V, as well as four schools not participating in the SFVS NRW (control schools), were included in the evaluation study. The four schools with a thrice weekly distribution frequency were selected from schools which successfully applied for the admission in the programme in the 2012/13 academic year.* The four schools with a twice weekly distribution frequency were chosen out of the group of schools which applied for the admission in the programme, but were initially rejected. Criteria for inclusion were social and regional criteria as well as the concept of accompanying nutrition education measures to be established by the schools in the case of acceptance⁽³⁷⁾. The four control schools were schools that had never applied for admission in the SFVS NRW. Selection criteria for all schools included in the study were their spatial proximity and accessibility for the research team as well as their size. The latter implied that schools considered for the study had to have at least two parallel classes in each grade to ensure a sufficient sample size. In schools with more than two classes in the third and fourth grade, respectively, classes were selected based on class teachers' willingness to participate in the survey. In total four classes of each school participated in the survey, resulting in forty-eight classes with 664 children included in the analysis. The study was carried out with the support of the Ministry for Climate Protection, Environment, Agriculture, Conservation and Consumer Protection of the State of North Rhine-Westphalia (MKULNV).† Furthermore,

* Selected by the MKULNV according to the EU framework⁽⁴⁰⁾.

† The MKULNV provided access to the names of all schools that had applied for participation in the SFVS including those which were initially rejected.

data handling was approved by the data protection officer of the University of Bonn.

Survey instruments

The F&V intake of children was recorded in three repeated 24 h dietary recalls before as well as after one year of participation in the SFVS NRW, respectively. At both time points, the children completed a paper-and-pencil questionnaire as a class exercise, supervised by the research team at the first day of data collection. Using words and pictures, children were encouraged to recall the previous day and to describe the foods and drinks they consumed. For the analysis, all F&V consumed over the course of the day were added up, using predefined coding strategies. At post-intervention, F&V provided at school were included if children indicated that they have eaten F&V at school. Aspects of validity, reliability and sensitivity to change of this measurement were tested during the development of the questionnaire in the UK⁽⁴¹⁾. Furthermore, the version used in our survey has been adapted to the German school system and was successfully applied in the first evaluation study of the SFVS NRW carried out by Methner *et al.*⁽³⁸⁾. To ensure high data quality, manual data entry was done twice and inter-coder reliability was checked using Holsti's inter-coder reliability test which yielded an average inter-coder reliability score of 0.99. Only questionnaires of children who filled in at least two 24 h dietary recalls at pre- and post-intervention were included in the analysis. Applying this strategy resulted in a sample size of 783 children. Reasonability of answers of these children was investigated carefully by outlier detection via boxplot analysis at school level. We defined outliers as values that were more than $1.5 \times$ interquartile range below the first quartile or more than $1.5 \times$ interquartile range above the third quartile. Following this definition fifty-three children were excluded from the analysis, resulting in a sample size of 730 children. We assessed SES by written questionnaires addressed to parents who filled in the survey at home on a voluntary basis. Children were assigned to low, middle or high SES applying the Brandenburger Social Index⁽⁴²⁾. Written informed consent was obtained from all parents of included children. To be able to control for difference in SES, we had to exclude children with missing information on SES, due to missing information in the parent questionnaire, resulting in a final sample size of 664 children nested in forty-eight classes.

Statistical analyses

Differences between intervention groups with respect to demographic variables (proportion of children with low, middle and high SES, of third and fourth graders, of girls and boys, of children who eat lunch at home or at school) were analysed using χ^2 tests. We used hierarchical linear regression models according to Raudenbush and Bryk⁽⁴³⁾ to determine whether there were differences in F&V

intake change from the first measurement period (pre-intervention) to the post-intervention period (post-intervention) between control and intervention groups. We developed a four-step sequential modelling approach and fitted three-level models with days (level 1) nested in children (level 2), nested in classes (level 3). With only twelve schools in the sample we decided upon class as the highest level and treated the intervention variable as a class variable, given that the intervention was administered in classes. We refrained from adding dummy variables for schools because this would have resulted in a model with a very large number of additional fixed effects parameters (eleven main effects plus all interaction terms with the lower-level predictors). Bell *et al.*⁽⁴⁴⁾ have shown for two-level models that a very small sample size (of 10 units) at the highest level can lead to a bias in fixed effects and, more importantly, is related to a very low power to detect non-zero fixed effects. However, to account for possible school differences in composition of children, we decided to include child- and class-level covariates, namely SES, gender and grade (explained in more detail below).

Model I was the 'empty' model without any explanatory variables besides a dummy variable (*Period*) for the post-intervention period (post=1), which allows to partition the total variance in children's F&V intake level into a variance between classes, children and time periods. The outcome Y_{tij} at level 1 refers to the F&V intake (measured via 24 h recalls) on day t of child i in class j :

Level 1 (days):

$$Y_{tij} = \pi_{0ij} + \pi_{1ij} \cdot \text{Period}_{tij} + e_{tij} \quad (1)$$

Level 2 (children):

$$\pi_{0ij} = \beta_{00j} + r_{0ij} \quad (2)$$

$$\pi_{1ij} = \beta_{10j} + r_{1ij} \quad (3)$$

Level 3 (classes):

$$\beta_{00j} = \gamma_{000} + u_{00j} \quad (4)$$

$$\beta_{10j} = \gamma_{100} + u_{10j} \quad (5)$$

Model II examined general intervention effects by adding a dummy-coded group membership variable for both intervention groups (control group=0). As the intervention was implemented on the class level, the intervention group variables were class variables and added as predictors in the level-3 equations. Accordingly, the level-1 and level-2 equations were the same as in Model I, while the level-3 equations were:

Level 3 (classes):

$$\beta_{00j} = \gamma_{000} + \gamma_{001} \cdot \text{Int.thrice}_j + \gamma_{002} \cdot \text{Int.twice}_j + u_{00j} \quad (6)$$

$$\beta_{10j} = \gamma_{100} + \gamma_{101} \cdot \text{Int.thrice}_j + \gamma_{102} \cdot \text{Int.twice}_j + u_{10j} \quad (7)$$

For an increase in F&V intake, due to the intervention, we expect γ_{101} and γ_{102} – that is, the mean differences between the groups (intervention group minus control group) with respect to the differences between the periods (intervention period minus control period) – to be significantly larger than zero⁽⁴⁵⁾.

Model III additionally included level-2 covariates to control for compositional effects on the class level (e.g. clustering of children of high SES within a certain class). On the child level (level 2), a dummy variable capturing whether the children usually eat lunch at school (=0) or at home (=1), gender (boys=0, girls=1), and a dummy variable for low SES and middle SES, respectively, with high SES as the reference group (=0), were considered as covariates and centred around the grand mean. Centring a level-2 (child-level) dummy variable around the grand mean yields level-3 (class) coefficients that can be interpreted as adjusted outcome means⁽⁴⁶⁾. Additionally, grade (third grade = -0.5, fourth grade = +0.5) was included at the class level (level 3) as an effect-coded covariate in each of the two level-3 equations, so that it can be tested whether group differences in F&V intake change exist beyond grade effects. The model equations were:

Level 1 (days):

$$Y_{ij} = \pi_{0ij} + \pi_{1ij} \cdot \text{Period}_{ij} + e_{ij} \quad (8)$$

Level 2 (children):

$$\pi_{0ij} = \beta_{00j} + \beta_{01j} \cdot \text{Lunch}_{ij} + \beta_{02j} \cdot \text{Gender}_{ij} + \beta_{03j} \cdot \text{SES.low}_{ij} + \beta_{04j} \cdot \text{SES.middle}_{ij} + r_{0ij} \quad (9)$$

$$\pi_{1ij} = \beta_{10j} + \beta_{11j} \cdot \text{Lunch}_{ij} + \beta_{12j} \cdot \text{Gender}_{ij} + \beta_{13j} \cdot \text{SES.low}_{ij} + \beta_{14j} \cdot \text{SES.middle}_{ij} + r_{1ij} \quad (10)$$

Level 3 (classes):

$$\beta_{00j} = \gamma_{000} + \gamma_{001} \cdot \text{Int.thrice}_j + \gamma_{002} \cdot \text{Int.twice}_j + \gamma_{003} \cdot \text{Grade}_j + u_{00j} \quad (11)$$

$$\beta_{01j} = \gamma_{010} + u_{01j} \quad (12)$$

$$\beta_{02j} = \gamma_{020} + u_{02j} \quad (13)$$

$$\beta_{03j} = \gamma_{030} + u_{03j} \quad (14)$$

$$\beta_{04j} = \gamma_{040} + u_{04j} \quad (15)$$

$$\beta_{10j} = \gamma_{100} + \gamma_{101} \cdot \text{Int.thrice}_j + \gamma_{102} \cdot \text{Int.twice}_j + \gamma_{103} \cdot \text{Grade}_j + u_{10j} \quad (16)$$

$$\beta_{11j} = \gamma_{110} + u_{11j} \quad (17)$$

$$\beta_{12j} = \gamma_{120} + u_{12j} \quad (18)$$

$$\beta_{13j} = \gamma_{130} + u_{13j} \quad (19)$$

$$\beta_{14j} = \gamma_{140} + u_{14j} \quad (20)$$

For each of the covariates, the deviance statistic was used to test which parameter should be included as a

random effect⁽⁴⁷⁾. Only significant random slopes were retained in the final model.

In Model III, the level-3 coefficients that capture the intervention effects on the change in F&V intake from pre- to post-intervention (i.e. γ_{101} and γ_{102}) can be interpreted in the following way: γ_{101} (γ_{102}) represents the mean difference between the thrice (twice) weekly intervention group and the control group with respect to the difference between the intervention and the control period, adjusted for differences in the proportion of compared groups (i.e. girls, children with low/middle SES, children who eat lunch at home) across classes. Grade was effect-coded so that the meaning of the estimated scores for the control group (i.e. γ_{000} , the pre-intervention scores, and γ_{100} , the pre – post difference scores) does not change from Model II to Model III.

Additionally, we explored whether subgroups were affected differently by the school F&V intervention (i.e. differential effectiveness of the intervention). To do that, we examined the cross-level interactions by adding the intervention group variables to each of the concerned level-3 equations (e.g. to examine whether children usually eating in the school canteen were affected differently by the school F&V intervention, group membership variables were added to equations (12) and (17)). This analysis was done in a stepwise procedure. First, the cross-level interaction with each covariate was tested one after another. Second, significant cross-level interactions were combined in one model to scrutinize the unique contribution of each interaction term. Due to the explorative character of this analysis, we accepted a significance level of 10% for this part of our analysis.

Finally, we tested whether the two intervention groups (twice *v.* thrice weekly deliveries) differed with respect to the increase in F&V intake from pre- to post-intervention by analysing the data of the two intervention groups only (i.e. Model II was adapted so that only one dummy variable for twice *v.* thrice weekly intervention was included at level 3).

All analyses described above were carried out (i) jointly for days with and without F&V deliveries, (ii) for days with and (iii) for days without F&V deliveries. Children in schools with a thrice weekly distribution frequency filled in the 24 h dietary recall for two days with and one day without F&V deliveries, whereas children in schools with the twice weekly distribution frequency filled in the 24 h recall for one day with and two days without F&V deliveries, respectively. This allowed us to evaluate both the overall effect in the two intervention groups considering the differences in distribution frequency of school F&V, as well as differences in effects between days with and without F&V deliveries. Consequently, at pre-intervention for the control and both intervention groups and at post-intervention for the control group, the analysis was always based on three 24 h dietary recalls. This also holds in the case of the joint analysis of days with and without F&V

deliveries for both intervention groups at post-intervention. However, for the analysis of days with F&V deliveries we considered at post-intervention only the respective days with F&V deliveries (two 24 h dietary recalls in the case of schools with thrice weekly deliveries, one 24 h dietary recalls in the case of schools with thrice weekly deliveries). Analogously, for studying the impact of the SFVS on days without F&V deliveries we considered at post-intervention only the respective days without F&V deliveries (one 24 h dietary recall in the case of schools with thrice weekly deliveries, two 24 h dietary recalls in the case of schools with thrice weekly deliveries).

Results

Characteristics of children

The final sample consisted of 664 primary-school children, who filled in two or more 24 h dietary recalls for the pre- and post-intervention measurement, respectively, without missing values for the considered control variables. Demographic characteristics of the three groups (children in twice/thrice weekly intervention groups and control group) are summarized in Table 1. Groups did not show significant differences regarding grade and gender, but did so with respect to SES and the proportion of children usually eating lunch at home. The proportion of children with high SES was higher in the control group than in the intervention groups. Furthermore, children with low SES were over-represented in the intervention group with the thrice weekly school F&V deliveries. The proportion of children eating lunch at home was lowest in the control group and highest in the thrice weekly intervention group. The identified differences between the groups clearly show the need for controlling for potential confounders in the following analysis.

Overall intervention effect of school fruit and vegetable deliveries

Results of the series of hierarchical linear regression models analysing the overall intervention effect on daily F&V intake of children are presented in Table 2. The empty model (Model I) showed that, on average, children's daily F&V intake frequency increased by 0.59 (γ_{100}) from 1.00 (γ_{000}) at pre-intervention to 1.59 at post-intervention. To explain this increase by the school F&V intervention, dummy-coded group membership variables were added to the two level-3 (classes) equations. Intervention groups differed significantly in the mean pre-intervention scores, with an average daily F&V intake frequency of 1.25 in the control group (γ_{000}), 0.84 ($\gamma_{000} + \gamma_{001}$) in the thrice weekly intervention group and 0.90 ($\gamma_{000} + \gamma_{002}$) in the twice weekly intervention group. That is, the control group had a higher average F&V intake before the intervention. With respect to the change in daily F&V intake from pre- to post-intervention, the intervention groups showed higher increases than the control group: children in the control group did not significantly increase their daily F&V intake frequency ($\gamma_{100} = 0.03$, $P = 0.789$). The thrice weekly intervention group's increase was significantly larger than the control group's increase (by $\gamma_{101} = 0.96$). That is, the thrice weekly intervention group increased their F&V intake by 0.99 ($\gamma_{100} + \gamma_{101}$), from 0.84 frequencies/d at pre-intervention to 1.83 frequencies/d at post-intervention. In a similar vein, the twice weekly intervention group's increase was significantly larger than the control group's increase (by $\gamma_{102} = 0.75$). That is, the twice weekly intervention group increased their F&V intake by 0.78 frequencies/d ($\gamma_{100} + \gamma_{102}$), from 0.90 frequencies/d at pre-intervention to 1.68 frequencies/d at post-intervention. Adding the group membership dummy variables to the level-3 equations in Model II reduced the variance of the level-3 residuals of slopes for period (u_{10j}).

Table 1 Demographic characteristics of the study sample at pre-intervention: third and fourth grade children (n 664) from twelve primary schools in North Rhine-Westphalia, Germany, beginning of the 2012/13 school year

	Thrice weekly (total N 183)		Twice weekly (total N 250)		Control (total N 231)		χ^2	P value	df
	n	%	n	%	n	%			
Grade									
3rd grade	83	45.4	127	50.8	128	55.4			
4th grade	100	54.6	123	49.2	103	44.6	4.13	0.127	2
Gender									
Girl	100	54.6	124	49.6	101	43.7			
Boy	83	45.4	126	50.4	130	56.3	4.94	0.084	2
Lunch at home									
Yes	133	72.7	136	54.4	110	47.6			
No	50	27.3	114	45.6	121	52.4	27.35	0.000	2
SES*									
Low	74	40.4	39	15.6	19	8.2			
Middle	52	28.4	63	25.2	55	23.8	84.86	0.000	4
High	57	31.1	148	59.2	157	68.0			

SES, socio-economic status.

*Brandenburger Social Index of Böhm *et al.*⁽⁴²⁾.

Table 2 Overall intervention effect of fruit and vegetable (F&V) deliveries of the European School Fruit Scheme in North Rhine-Westphalia, Germany, on the F&V intake of third and fourth grade children (*n* 664) from twelve primary schools, beginning to the end of the 2012/13 school year

	Fixed part						Random part		
	Coef.	Est.	SE	<i>t</i>	<i>P</i> value	df	Coef.	Var.	<i>P</i> value
Model I									
Intercept	γ_{000}	1.00	0.05	16.80	<0.001	47	u_{00j}	0.13	<0.001
For period slope									
Intercept	γ_{100}	0.59	0.09	6.88	<0.001	47	u_{10j}	0.28	<0.001
Model II									
Intercept	γ_{000}	1.25	0.09	13.62	<0.001	45	u_{00j}	0.09	<0.001
Thrice weekly intervention	γ_{001}	-0.41	0.13	-3.05	0.004	45			
Twice weekly intervention	γ_{002}	-0.35	0.13	-2.69	0.01	45			
For period slope									
Intercept	γ_{100}	0.03	0.10	0.30	0.767	45	u_{10j}	0.11	<0.001
Thrice weekly intervention	γ_{101}	0.96	0.15	6.34	<0.001	45			
Twice weekly intervention	γ_{102}	0.75	0.15	5.15	<0.001	45			
Model III									
Intercept	γ_{000}	1.20	0.08	14.75	<0.001	44	u_{00j}	0.08	<0.001
Thrice weekly intervention	γ_{001}	-0.29	0.12	-2.40	0.021	44			
Twice weekly intervention	γ_{002}	-0.31	0.11	-2.83	0.007	44			
Grade	γ_{003}	-0.38	0.09	-4.12	<0.001	44			
Lunch at home	γ_{010}	-0.31	0.06	-5.26	<0.001	513			
Gender	γ_{020}	0.32	0.06	5.58	<0.001	513			
Low SES	γ_{030}	-0.18	0.08	-2.18	0.03	513			
Middle SES	γ_{040}	-0.19	0.07	-2.75	0.006	513			
For period slope									
Intercept	γ_{100}	0.03	0.10	0.27	0.789	44	u_{10j}	0.10	<0.001
Thrice weekly intervention	γ_{101}	0.99	0.15	6.70	<0.001	44			
Twice weekly intervention	γ_{102}	0.77	0.14	5.71	<0.001	44			
Grade	γ_{103}	0.17	0.11	1.47	0.148	513			
Lunch at home	γ_{110}	0.12	0.08	1.46	0.145	513			
Gender	γ_{120}	0.16	0.09	1.76	0.085	47	u_{12j}	0.10	0.021
Low SES	γ_{130}	-0.10	0.11	-0.92	0.358	513			
Middle SES	γ_{140}	0.01	0.09	0.11	0.913	513			

Coef., coefficient; Est., estimate, Var., variance components; SES, socio-economic status.

The variance of the level-1 residual (e_{ij}) was estimated to be 1.08 in all models. The variance of the level-2 residual of intercepts (r_{0j}) was 0.20 in Models I and II and 0.14 in Model III. The variance of the level-2 residual of slopes for period (r_{1j}) was 0.20 in Models I and II and 0.17 in Model III.

As a measure of effect size for the effect of group membership on change in F&V intake, we calculated the proportional reduction in level-3 variance of slopes for period when the two group dummy variables were added to the model⁽⁴⁷⁾, resulting in a quasi- R^2 of 61.80%, which can be considered a large effect.

In Model III, we added the grand-mean-centred child-level covariates (SES, gender, lunch at home) on level 2 (children) as well as effect-coded grade on level 3 (classes). The results can be found in the lower part of Table 2. By adding the child-level covariates grand-mean-centred, differences between classes with respect to compositional effects (i.e. proportion of girls, children with low/middle SES, children who eat lunch at home) are adjusted for. The results of Model III showed that the overall effectiveness of the school F&V intervention was confirmed when controlling for compositional effects and for grade. In this model, slopes for gender were treated as random (u_{12j}). The adjusted F&V intake scores at pre-intervention and the adjusted F&V intake change scores (i.e. the expected scores with respect to the proportion of girls, of children with low/middle SES and of children who eat lunch at home being identical across classes) can be calculated from the

fixed effects in Model III, as explained above. The 'main effects' of the control variables in this model (gender, SES, lunch at home, grade) represent mean differences with respect to the intercept (i.e. effects on pre-intervention scores). The results revealed that children who usually eat lunch at home, children from homes with low and middle SES as well as in fourth grade had a significantly lower intake score at pre-intervention compared with their reference group. Girls showed significantly higher F&V intake scores at pre-intervention than boys.

Moreover, in a separate model that extends Model III, we explored whether the school F&V intervention affected subgroups of children differently. To do so, we examined the cross-level interactions between the group membership variables on level 3 and each child-level covariate on level 2. This analysis revealed that the twice weekly intervention group's increase in F&V intake was 0.31 frequencies/d lower for children who usually eat lunch at home compared with children who eat lunch at school ($P=0.085$; see online supplementary material, Supplemental Table 1). For the thrice weekly intervention group, the coefficient was also negative (-0.22) but non-significant ($P=0.297$). No other cross-level interaction reached significance.

Intervention effect on days with school fruit and vegetable deliveries

Besides the overall intervention effect, we were also interested in the effectiveness of the SFVS in increasing children's F&V intake on days with and without school F&V deliveries. The effect on days with F&V deliveries can be interpreted as a direct effect due to the increase in F&V availability in schools (structural prevention), whereas an increase in F&V intake on days without school F&V deliveries might be considered a first indication of possible long-term effects of the SFVS. Table 3 presents the results of the series of hierarchical linear regression models in which only the days with F&V deliveries were included for the intervention groups in the post-intervention period. The empty model (Model I) showed that, on average, children's F&V intake frequency increased by 0.79 (γ_{100}) from 1.00 (γ_{000}) at pre-intervention to 1.79 at post-intervention on days with school F&V deliveries. As can be seen in Table 3 (Model II), on school F&V days the thrice weekly intervention group's increase was significantly larger than the control group's increase (by $\gamma_{101} = 1.07$). That is, the thrice weekly intervention group increased their F&V intake by 1.10 ($\gamma_{100} + \gamma_{101}$)

frequencies/d, from 0.84 frequencies/d at pre-intervention to 1.94 frequencies/d at post-intervention. In a similar vein, the twice weekly intervention group's increase was significantly larger than the control group's intake (by $\gamma_{102} = 1.30$). That is, the twice weekly intervention group increased their F&V intake by 1.33 ($\gamma_{100} + \gamma_{102}$) frequencies/d, from 0.90 frequencies/d at pre-intervention to 2.23 frequencies/d at post-intervention. The effect size for the effect of group membership on change in F&V intake (i.e. quasi- R^2 for the reduction in level-3 variance of slopes for period) was 70.58%. Adjusting for differences between classes with respect to level-2 (children) compositional effects (gender, SES, lunch at home) and controlling for grade (on level 3) in Model III confirmed the overall effectiveness of the school F&V intervention on school F&V days (see Table 3). Comparing Tables 2 and 3 reveals that the intervention effect in the twice as well as the thrice weekly intervention group was considerably higher on days with school F&V deliveries compared with the effect considering days with and without F&V deliveries.

Again, as an extension of Model III, we explored whether subgroups of children were affected differently by the school F&V intervention focusing this time on school F&V

Table 3 Intervention effect on days with fruit and vegetable (F&V) deliveries of the European School Fruit Scheme in North Rhine-Westphalia, Germany, on the F&V intake of third and fourth grade children (*n* 664) from twelve primary schools, beginning to the end of the 2012/13 school year

	Fixed part						Random part		
	Coef.	Est.	SE	<i>t</i>	<i>P</i> value	df	Coef.	Var.	<i>P</i> value
Model I									
Intercept	γ_{000}	1.00	0.06	16.84	<0.001	47	u_{00j}	0.13	<0.001
For period slope									
Intercept	γ_{100}	0.79	0.11	7.21	<0.001	47	u_{10j}	0.47	<0.001
Model II									
Intercept	γ_{000}	1.25	0.09	13.63	<0.001	45	u_{00j}	0.09	<0.001
Thrice weekly intervention	γ_{001}	-0.41	0.13	-3.06	0.004	45			
Twice weekly intervention	γ_{002}	-0.35	0.13	-2.70	0.01	45			
For period slope									
Intercept	γ_{100}	0.03	0.11	0.26	0.799	45	u_{10j}	0.14	<0.001
Thrice weekly intervention	γ_{101}	1.07	0.17	6.27	<0.001	45			
Twice weekly intervention	γ_{102}	1.30	0.17	7.68	<0.001	45			
Model III									
Intercept	γ_{000}	1.21	0.08	14.65	<0.001	44	u_{00j}	0.08	<0.001
Thrice weekly intervention	γ_{001}	-0.30	0.12	-2.43	0.019	44			
Twice weekly intervention	γ_{002}	-0.32	0.11	-2.82	0.007	44			
Grade	γ_{003}	-0.37	0.10	-3.92	<0.001	44			
Lunch at home	γ_{010}	-0.31	0.06	-5.26	<0.001	513			
Gender	γ_{020}	0.31	0.06	5.57	<0.001	513			
Low SES	γ_{030}	-0.18	0.08	-2.18	0.03	513			
Middle SES	γ_{040}	-0.19	0.07	-2.75	0.006	513			
For period slope									
Intercept	γ_{100}	0.03	0.11	0.25	0.805	44	u_{10j}	0.13	<0.001
Thrice weekly intervention	γ_{101}	1.09	0.17	6.32	<0.001	44			
Twice weekly intervention	γ_{102}	1.31	0.17	7.95	<0.001	44			
Grade	γ_{103}	0.19	0.14	1.36	0.181	44			
Lunch at home	γ_{110}	0.11	0.09	1.16	0.248	513			
Gender	γ_{120}	0.15	0.11	1.37	0.177	47	u_{12j}	0.21	<0.001
Low SES	γ_{130}	-0.14	0.12	-1.11	0.268	513			
Middle SES	γ_{140}	-0.05	0.10	-0.45	0.652	513			

Coef., coefficient; Est., estimate; Var., variance components; SES, socio-economic status. The variance of the level-1 residual (e_{ij}) was estimated to be 0.94 in all models. The variance of the level-2 residual of intercepts (r_{0ij}) was 0.24 in Models I and II and 0.19 in Model III. The variance of the level-2 residual of slopes for period (r_{1ij}) was 0.36 in Models I and II and 0.30 in Model III.

days only. This analysis revealed that on days with school F&V deliveries, the twice weekly intervention group's increase in F&V intake was 0.40 frequencies/d lower for children who usually eat lunch at home than for children who eat lunch at school ($P=0.062$) and 0.44 frequencies/d lower for children with middle SES ($P=0.079$) compared with children with high SES (see online supplementary material, Supplemental Table 2). For the thrice weekly intervention group, the corresponding coefficients were also negative but non-significant (lunch at home: -0.15 , $P=0.519$; middle SES: -0.14 , $P=0.595$).

Intervention effect on days without school fruit and vegetable deliveries

Table 4 presents the results of the series of hierarchical linear regression models in which only the days without F&V deliveries were included for the post-intervention period. The empty model (Model I) showed that on average children's F&V intake frequency on days without school F&V deliveries increased by 0.41 (γ_{100}) from 1.00 (γ_{000}) at pre-intervention to 1.41 at post-intervention, and thus considerably less than if all days are considered (0.59;

see Table 2). As can be seen from Table 4 (Model II), on days without school F&V deliveries, the thrice weekly intervention group's increase was significantly larger than the control group's increase (by $\gamma_{101}=0.75$). That is, the thrice weekly intervention group increased their F&V intake by 0.78 ($\gamma_{100}+\gamma_{101}$) frequencies/d, from 0.85 frequencies/d at pre-intervention to 1.63 frequencies/d at post-intervention. In a similar vein, the twice weekly intervention group's increase was significantly larger than the control group's intake (by $\gamma_{102}=0.48$). That is, the twice weekly intervention group increased their F&V intake by 0.51 ($\gamma_{100}+\gamma_{102}$) frequencies/d, from 0.91 frequencies/d at pre-intervention to 1.42 frequencies/d at post-intervention. The proportional reduction in level-3 variance of slopes for period (u_{10j}) was 45.47%. Adjusting for level-2 (lunch, gender, SES) and level-3 (grade) covariates as described above confirmed the stability of the results and changed the corresponding coefficients (γ_{101} and γ_{102}) only slightly (Table 4, Model III).

Regarding the effect on days without school F&V deliveries, additional exploratory analyses revealed no subgroups that benefited more or less from participation in

Table 4 Intervention effect on days without fruit and vegetable (F&V) deliveries of the European School Fruit Scheme in North Rhine-Westphalia, Germany, on the F&V intake of third and fourth grade children ($n=664$) from twelve primary schools, beginning to the end of the 2012/13 school year

	Fixed part						Random part		
	Coef.	Est.	SE	<i>t</i>	<i>P</i> value	df	Coef.	Var.	<i>P</i> value
Model I									
Intercept	γ_{000}	1.00	0.06	16.82	<0.001	47	u_{00j}	0.13	<0.001
For period slope									
Intercept	γ_{100}	0.41	0.08	5.22	<0.001	47	u_{10j}	0.21	<0.001
Model II									
Intercept	γ_{000}	1.25	0.09	13.61	<0.001	45	u_{00j}	0.09	<0.001
Thrice weekly intervention	γ_{001}	-0.40	0.13	-3.03	0.004	45			
Twice weekly intervention	γ_{002}	-0.34	0.13	-2.68	0.01	45			
For period slope									
Intercept	γ_{100}	0.03	0.11	0.29	0.777	45	u_{10j}	0.11	<0.001
Thrice weekly intervention	γ_{101}	0.75	0.17	4.53	<0.001	45			
Twice weekly intervention	γ_{102}	0.48	0.15	3.16	0.003	45			
Model III									
Intercept	γ_{000}	1.20	0.08	14.78	<0.001	44	u_{00j}	0.08	<0.001
Thrice weekly intervention	γ_{001}	-0.29	0.12	-2.42	0.02	44			
Twice weekly intervention	γ_{002}	-0.31	0.11	-2.79	0.008	44			
Grade	γ_{003}	-0.36	0.09	-3.84	<0.001	44			
Lunch at home	γ_{010}	-0.31	0.06	-5.25	<0.001	513			
Gender	γ_{020}	0.32	0.06	5.59	<0.001	513			
Low SES	γ_{030}	-0.18	0.08	-2.25	0.025	513			
Middle SES	γ_{040}	-0.19	0.07	-2.81	0.005	513			
For period slope									
Intercept	γ_{100}	0.03	0.10	0.32	0.754	44	u_{10j}	0.10	<0.001
Thrice weekly intervention	γ_{101}	0.76	0.16	4.70	<0.001	44			
Twice weekly intervention	γ_{102}	0.50	0.14	3.60	<0.001	44			
Grade	γ_{103}	0.23	0.12	1.90	0.064	44			
Lunch at home	γ_{110}	0.14	0.09	1.57	0.117	513			
Gender	γ_{120}	0.18	0.09	1.90	0.063	47	u_{12j}	0.10	0.046
Low SES	γ_{130}	-0.09	0.12	-0.71	0.478	513			
Middle SES	γ_{140}	0.07	0.10	0.70	0.482	513			

Coef., coefficient; Est., estimate; Var., variance components; SES, socio-economic status. The variance of the level-1 residual (e_{ij}) was estimated to be 0.89 in Model I and Model II and 0.90 in Model III. The variance of the level-2 residual of intercepts (r_{0ij}) was 0.26 in Models I and II and 0.20 in Model III. The variance of the level-2 residual of slopes for period (r_{1ij}) was 0.34 in Models I and II and 0.30 in Model III.

the programme. That is, no significant cross-level interactions were found.

Comparison of the effectiveness of different distribution frequencies of school fruit and vegetable deliveries

As presented in Tables 2 to 4, school F&V deliveries at a frequency of thrice as well as twice weekly significantly increased daily F&V intake of children participating in the SFVS compared with the control group on days with and without school F&V deliveries. Additionally, we aimed to test whether the two intervention groups (twice *v.* thrice weekly deliveries) differed with respect to the increase in F&V intake from pre- to post-intervention. The results showed that the two intervention groups did not differ with respect to the F&V increase over time (overall effect: $P=0.207$; effect on days with school F&V deliveries: $P=0.274$; effect on days without school F&V deliveries: $P=0.151$; see online supplementary material, Supplemental Tables 3–5).

Discussion

The data demonstrate that the current implementation of the SFVS NRW with thrice weekly F&V deliveries as well as an adjustment to a twice weekly delivery is successful in increasing children's daily F&V intake. Thus, our results underline the effectiveness of increased availability and repeated exposure in mediating the dietary behaviour of participating children, as theory and previous empirical research have suggested^(25,48–50).

A systematic review of published and unpublished studies identified fifteen studies focusing on interventions designed to increase F&V intake of 5- to 18-year-old children and adolescents. Of those none revealed a detrimental effect on F&V intake while ten of the studies found a significant effect on children's F&V intake ranging from 0.3 to 0.99 servings/d⁽⁵¹⁾. Thus, our estimates of 0.96 frequencies/d for the thrice weekly intervention group and 0.75 frequencies/d for the twice weekly intervention group are in line with previous research. Considering that intervention approaches vary greatly between studies and that we used F&V frequencies rather than servings to quantify the effect on F&V intake, our findings are most comparable to the results of Methner *et al.*⁽³⁸⁾. Those authors carried out the first evaluation study of the SFVS NRW and found an overall effect of 0.77 frequencies/d. Obviously, our results show a slightly greater effect compared with the estimates of Methner *et al.*⁽³⁸⁾, even though the authors investigated the effectiveness of the SFVS NRW with daily F&V deliveries. As our study used three repeated 24 h dietary recalls instead of only one as in Methner *et al.*'s study⁽³⁸⁾, a possible explanation for the small differences could be that the potential for recall bias was lower in our study. Additionally, the study by Methner

et al.⁽³⁸⁾ was carried out in the first year of SFVS NRW. Guidelines and support for schools in implementing nutrition education programmes have improved considerably in the subsequent years and likely increased the application of those measures in the participating schools. This argument is supported by other studies showing that multicomponent programmes are more effective in changing dietary behaviour of children than single measures^(51,52).

Interestingly, both types of interventions (twice and thrice weekly F&V deliveries) investigated in our study showed a similar increase in F&V intake from pre- to post-intervention and evidence for differential effectiveness was low. In contrast, an earlier evaluation study of the SFVS arrived at the conclusion that a distribution frequency of one to two times weekly is insufficient⁽⁵³⁾. Against this background, our results should be interpreted with caution in order to avoid premature conclusions. Besides subgroup analysis of the covariates included in our study, further analysis should also consider potential moderators of F&V intake such as personal and social determinants. The latter have been shown to influence F&V intake of children^(25,54,55) and therefore might also moderate the effect of the SFVS NRW, even though determinants of F&V intake have not often been studied in the context of moderation effects⁽⁵⁶⁾. Differentiating the results according to days with and without school F&V deliveries revealed that on days with F&V deliveries children in the twice weekly intervention group who usually eat lunch at school tended to benefit more from the F&V deliveries compared with children who usually eat lunch at home. This result clearly shows a first indication for differential effectiveness and is most probably attributable to the fact that, as stated by school principals, leftovers of F&V in the twice weekly intervention group are distributed to children in the school canteen at lunch time. This interpretation is also supported by our finding that on days without school F&V deliveries eating lunch at school had no effect on children's increase in F&V intake. As those children eating lunch at school showed a higher F&V intake at pre-intervention, this result may not be desired by the initiators of the SFVS NRW, because it advantages children with a higher initial F&V intake. Nevertheless, the appropriateness of this practice depends strongly on the nutritional value of food provided in the specific school canteen, which at present varies considerably across different schools in Germany⁽⁵⁷⁾. Besides these findings, additional exploratory analyses provided little evidence for the existence of differential effects of the SFVS NRW with respect to class and child characteristics. This holds particularly true for grade and gender. Also SES showed no significant interaction effect in the overall model, a result which is in line with previous research analysing the effects of the SFVS NRW⁽³⁸⁾. Exclusively investigating the effect of the SFVS NRW on days with F&V deliveries revealed that children with a middle SES in the twice

weekly intervention group benefit less from the scheme compared with those with a high SES. A similar effect was not detected for children with a middle SES, thus an interpretation of this result proves to be difficult. Regarding the thrice weekly intervention group not even low evidence for differential effectiveness was found, meaning that there were no subgroups benefiting more from the school F&V deliveries. This can be positively interpreted, but it also implies that it was not possible to give special support to subgroups, such as boys or children from homes with low SES who are known to eat less F&V^(58,59) and had significantly lower pre-intervention scores in our study as well. However, this is not to say that these subgroups did not benefit from the programme.

Overall our results indicate that particularly the thrice weekly F&V deliveries are an effective instrument for increasing the F&V intake of all children participating in the SFVS NRW. It therefore seems likely that the SFVS has relative advantages compared with other measures aiming to improve the dietary habits of the population. For example, previous research has indicated that high-risk approaches such as dietary advice typically widen socio-economic inequalities⁽⁶⁰⁾. This also seems to be true in general for interventions that require individuals to use a high level of agency to benefit⁽⁶¹⁾. In contrast, those that require fewer agencies are considered to be more effective because they reach broader segments of society⁽⁶²⁾.

Our results also indicate that the SFVS NRW was successful in increasing F&V intake of children on days without F&V deliveries. Regarding the thrice weekly intervention group, this result was not surprising, as school principals stated in interviews that they distribute the delivered F&V over the whole school week. This also implies that the effect in the thrice weekly intervention group on days without F&V deliveries should be interpreted with caution, as it likely not indicates long-term effects, but rather reflects the increase in F&V availability due to the F&V leftovers from the previous day. Remarkable, however, is that children of the twice weekly intervention group increased their F&V intake on days without school F&V deliveries to a comparable degree. As mentioned before, school principals of all four schools in this group clearly stated that they provide the F&V only on two fixed days during one school week. Hence, these findings provide first evidence that the SFVS NRW can have a sustainable effect on children's dietary behaviour apart from the direct effect of F&V deliveries. Nevertheless, it should be noted that F&V intake of children increased considerably more on days with school F&V deliveries, supporting the importance of accessibility and availability as predictors for F&V intake^(23–25).

In conclusion, even though there might be some determinants which have not yet been taken into account in terms of differential effectiveness, from the present state of analysis, the SFVS NRW reaches all considered subgroups, a result which holds particularly true for the thrice

weekly implementation form and represents an advantage over many other strategies aiming to improve dietary behaviour. However, it should be noted that a clear limitation of our study is the non-randomization of schools to the study groups. Although differences between the groups were controlled by including respective variables as covariates and by applying a statistical method which best fits the data structure, there might be some other factors not addressed in our analysis. For example, the intensity and quality of accompanying measures could have had an influence on the effectiveness of both implementation forms and might be different between the study groups. However, regarding the selection criterion 'nutrition education measures', all schools are obliged to implement respective measures once entering the programme. Thus, this holds for schools originally selected by the ministry as well as those that were later included due to our study. We are therefore confident that this criterion will not influence our findings. Additionally, a pre-post design where subjects are not randomly assigned to groups is most common in evaluation research^(63,64). In terms of limitations, it should be also mentioned that measuring dietary intake is always a challenge and requires validated and reliable instruments. We addressed this issue by selecting an existing and validated 24 h dietary recall proven to be reliable for the specific age group of our sample and used before in the context of evaluating the effect of the SFS NRW^(38,41). We also tried to reduce the potential for recall bias by using three instead of only one 24 h dietary recall at pre- and post-intervention. However, two 24 h dietary recalls at each time point were filled in by the children in the absence of the research team. Although teachers were given specific instructions on how to guide children while completing the questionnaire, we can neither completely exclude that teachers influenced children's answers nor that some children had problems to remember the foods and drinks eaten on the previous day. However, as instruments and respondents did not change from pre- to post-intervention, we expect high comparability of pre- and post-intervention measurements.

Conclusions

Our results clearly indicate that the current implementation of the SFVS NRW of providing children thrice weekly with school F&V deliveries is successful in increasing children's F&V intake. The findings also suggest that the impact of the SFVS NRW in its present form does not discriminate subgroups of children. This, however, also implies that those groups known to have a low intake level of F&V, such as boys or children from homes with a low SES, are not specifically supported by the programme. Reducing the distribution frequency of F&V to twice weekly deliveries is, according to the first findings presented here, similarly effective in positively influencing children's F&V intake, but there is also some evidence that this implementation form would advantage children eating

lunch in the school canteen. The findings also show that children's F&V intake increases significantly on days without F&V deliveries. This result provides a first indication of the positive long-term effects of the scheme.

Assuming a given budget, the twice weekly implementation would allow to provide more children with F&V in school. However, a recommendation for one or the other implementation needs to consider the potential discriminating effect as well as the longer-term impact of both intervention types and thus should be based on further research.

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Supplementary material

To view supplementary material for this article, please visit <https://doi.org/10.1017/S1368980017003949>

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