RESEARCH
Original Research

A Randomized Controlled Trial of the Food Dudes Program: Tangible Rewards Are More Effective Than Social Rewards for Increasing Short- and Long-Term Fruit and Vegetable Consumption

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ABSTRACT

Background Despite many health benefits, children do not consume enough fruits and vegetables (F/V). The Food Dudes program increases in-school F/V consumption, but the cost of prizes might be an adoption barrier.

Objective Our aim was to compare the effects of the Food Dudes program when prizes vs praise are used to reward F/V consumption.

Design We conducted a randomized controlled trial with three groups (ie, prize, praise, and control). Schools were randomly assigned to groups while approximately equating the percentage of students qualifying for free or reduced-price lunch. F/V consumption (lunch-tray photos) was assessed twice at pre-intervention and once after phase I, phase II, and at 6 months post-intervention, spanning approximately 11 months overall.

Participants/setting In total, 2,292 students attending six elementary schools participated, with 882, 640, and 770 in the prize, praise, and control groups, respectively.

Intervention The Food Dudes program was implemented over 4.5 months in all but the control schools. Two Food Dudes schools implemented the program with tangible prizes contingent on individual students' F/V consumption (prize group); two schools implemented Food Dudes using teacher praise instead of prizes (praise group). Follow-up data were collected 6 months post-intervention.

Main outcome measure F/V consumption was assessed by digital imaging of lunch trays.

Statistical analysis performed Linear mixed-effects modeling, including sex, grade, and baseline consumption as covariates, was performed.

Results Students attending the Food Dudes schools consumed more F/V than control schools after phase I, with larger differences in prize schools (92% difference) than praise schools (50% difference). After phase II, Food Dudes schools consumed 46% more F/V than control schools, with no difference between prize and praise schools. At 6-month follow-up, only prize schools consumed more F/V than control schools (0.12 cups more per child, 42.9% difference).

Conclusions Social praise proved an inadequate substitute for tangible prizes within the Food Dudes program. Program-related increases in F/V consumption decreased after the intervention, underscoring the need to develop low-cost, long-term interventions to maintain and make habitual consumption of recommended levels of F/V.
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CONSUMING A DIET RICH IN FRUITS AND VEGETABLES (F/V) decreases the risk of developing hypertension, coronary heart disease, some types of cancer, and stroke,[1] yet most children and adolescents do not consume the recommended daily amounts.[2,3] Various types of school-based interventions aimed at increasing children's F/V consumption have been evaluated but have yielded mixed results. Evans and colleagues[4] reported that simply providing F/V produces no lasting improvement in healthy eating, and multicomponent interventions produce the best effects.

One multicomponent intervention that has shown the most consistent increases in children's in-school F/V consumption is the Food Dudes program.[5-8] The Food Dudes program uses role modeling, repeated tasting, and rewards delivered contingent on consumption of a criterion amount

of F/V. Figure 1 shows the baseline and intervention phases of the Food Dudes program, as well as intervention components and the individuals responsible for implementing each component. The Food Dudes program typically increases fruit (27% to 164% increases) and vegetable (32% to 51% increases) consumption during the 4-month intervention period. Two long-term evaluations of Food Dudes have been conducted.[6,9] At a 12-month follow-up, Horne and colleagues[6] showed that consumption of fruits, vegetables, and juice (combined) increased by 73% above baseline levels, and Upton and colleagues[9] reported at the same follow-up interval that F/V consumption fell below baseline levels.

Lowe[10] suggested that poor program implementation fidelity might be responsible for the latter outcomes. That is, if teachers did not implement the Food Dudes program as designed, good long-term outcomes should not be expected. Neither the Horne and colleagues[6] nor the Upton and colleagues[9] studies measured implementation fidelity, but the weak effects of Food Dudes during the implementation phase of the latter study (a modest 14% increase in F/V consumption) offer reason to question their implementation fidelity and to be skeptical that their long-term results are representative of Food Dudes. One rationale for conducting the current study was to evaluate the relationship between fidelity of implementing the Food Dudes program and its long-term effects on F/V consumption.

A second rationale was to evaluate the effects of Food Dudes when the tangible rewards are replaced with social praise from teachers. The cost of tangible rewards may be an adoption barrier to schools, despite concerns about students' healthy eating, so evaluating the efficacy of a less-expensive version of Food Dudes was of interest. One well-controlled study[11] reported that tangible rewards and praise increased vegetable consumption at a 3-month follow-up relative to a control group. Although tangible rewards produced about twice the effect of social praise (not a statistically significant difference), the fact that praise maintained elevated long-term vegetable consumption suggests that this model of rewarding F/V consumption in schools could prove to be a cost-effective approach to improving public health.

A randomized controlled trial was conducted in which incentive type (tangible reward vs praise) was compared with a no-treatment control. Based on previous research, tangible rewards and praise were hypothesized to increase F/V consumption relative to a control condition, with tangible prizes being more effective incentives than praise. A secondary hypothesis was that at follow-up, both incentive groups would consume significantly more F/V than the control group.

METHODS

Participants and Setting

Participant recruitment began in early 2011. All students attending one of six public elementary schools in a single, suburban school district in northern Utah during the 2011/2012 academic year (including those bringing lunch from home) were invited and eligible to participate in all study phases. The district was composed of 49% female students. Approximately 91% of all students were white, 8% were Hispanic/Latino, 8% were American Indian, 1% African American, and 1% Asian (school district records permitted caregivers to select more than one race or ethnicity for each student, thus percentages sum to >100%.). Required sample size was calculated via a power analysis for cluster-randomized designs. A passive, opt-out consent provided to students' parents/guardians yielded a minimum of 92% participation (range=92% to 97%, n=2,292), with 29, 26, and 69 students opting out of participation in the prize, praise, and control groups, respectively. All teachers (n=63) agreed to participate in the implementation fidelity analyses and were assured anonymity. The research protocol, including the passive-

Phase	F/V[a] served	Component (implemented by)[b]
Naturalistic Baseline	Typical school menu/home lunch	None
Default-Provision Baseline	FD[c]-targeted F/V	Default Provision to encourage repeated tasting (researchers)
Phase I	FD-targeted F/V	Default Provision (researchers) FD media to provide role models (teachers) Rewards as F/V consumption incentives (teachers)
Phase II	Typical school menu/home lunch	Wall chart to encourage student self-monitoring (teachers) Rewards (teachers)
Follow-up	Typical school menu/home lunch	None

[a]F/V=fruits and vegetables.

[b]Indicates who implemented the indicated component of the Food Dudes Program.

[c]FD=Food Dudes.

Figure 1. Description of each baseline and intervention phase of the Food Dudes program, including whether the fruits and vegetables (F/V) served were from the typical school-lunch menu or were F/V selections that were served by default to each child and targeted for consumption by the Food Dudes program.

consent procedure, was reviewed and approved by the Institutional Review Board at Utah State University.

Schools were randomly assigned to one of three groups (two schools per group) and matched for the percentage of students qualifying for free-or-reduced lunch (a measure of socioeconomic status). Researchers completed group assignment by randomly drawing each school's assignment from a hat. No programmatic changes were made after the trial commenced.

Materials

Student identification numbers were printed on 1.5×6.7-cm white adhesive labels and placed on lunch trays for child identification in lunch-tray photos. Photos were taken with handheld digital cameras (Canon Power Shot SD 1300 IS). Portions of F/V were served in plastic cups (2 to 4 oz). Food Dudes media (videos, letters) were obtained from Food Dudes Health Ltd (Cheshire, UK). Teachers used a custom website to access these media. Self-inking stamps were used to place marks on students' hands to indicate consumption of a whole portion of fruits and/or vegetables in the cafeteria. Tangible rewards used in the prize group were small toys or gadgets (eg, notepad, whistle, etc); 64% of the prizes were branded with the Food Dudes' logo. The 46×61-cm wall charts used for self-reported F/V consumption were posted on classroom walls. The wall charts contained a grid with separate rows for the name of each child in the class. Columns corresponded to days on which children consumed F/V. The placement of "goal" cells in each row indicated the number of days of F/V consumption required to earn a reward (prize or praise), which increased each time a reward was obtained.

Procedure

Teacher Training. Before the start of the study, a research assistant experienced in implementing the Food Dudes program conducted a training session with teachers for program procedures. Training materials provided by Food Dudes Health Ltd were discussed and distributed.

Phased Roll Out. The program was rolled out sequentially into five schools in the fall 2011 semester and the sixth school at the start of the spring 2012 semester. The order of roll out was randomly determined: praise school 1, prize school 1, control school 1, praise school 2, control school 2, prize school 2. A mean of 11 days separated the start dates for each school and no menu changes were made throughout the school year.

Naturalistic Baseline (All Groups; Days 1 to 3). During the Naturalistic Baseline, the cafeteria adhered to the preplanned menu following the US National School Lunch Program guidelines. The data collected in this phase served as the pre-intervention comparison for phase II, when the F/Vs served were those on the schools' normal menu. Observers took top-down pictures of individual lunch trays before lunch as students exited the serving line, and a second picture was taken after lunch was eaten.[12] Observers also monitored children during lunch to ensure that they consumed only their own lunch. Photos were taken of both school- and home-lunch consumption; students were asked to display their lunch with no items overlapping before the photo being taken. Photos were later coded for F/V consumption; see Data Preparation section. There were no programmed consequences (ie, rewards or praise) for F/V consumption during this phase.

Default-Provision Baseline (All Groups; Days 4 to 7). During the Default-Provision Baseline, volume-measured servings of F/V (henceforth, targeted F/V) were provided by default to every participant, including students who brought lunch from home. Data collected in this phase served as the comparison for phase I, when study-provided F/Vs were served. First- and second-graders received $^1/_4$-cup servings each of the targeted F/V, and third- through fifth-graders received $^1/_3$-cup servings. A different targeted F/V pairing was provided each day (a serving each of apples and black bean salad, pineapple and carrots, grapes and cucumber, oranges and blanched broccoli). Pre– and post–lunch-tray photo data were collected as during the Naturalistic Baseline phase. There were no programmed consequences for F/V consumption.

Phase I (Days 8 to 23). ***Prize group.*** During phase I, teachers showed Food Dudes video episodes and read Food Dudes letters according to the schedule provided by Food Dudes Health Ltd. In the cafeteria, default provisions of the same targeted F/Vs from the preceding phase were served on a rotating basis (4 times each) throughout the 16 days of phase I. Bite-sized tasting portions were served on days 8 to 11, two tablespoons of targeted F/V were served on days 12 to 15, $^1/_4$ cup of targeted F/V were served on days 16 to 19, and full portions ($^1/_4$ or $^1/_3$ cup, depending on grade) were served on days 20 to 23. The gradually increasing portion size is a deviation from the Food Dudes procedure of transitioning from 4 days of tasting-sized portions to 12 days of full-sized portions. This procedure change was based on a pilot study in which children struggled to consume full portions after 4 days of tasting-sized portions.[8]

When students accepted the portions of F/V, they received the appropriate pre-consumption hand stamps. Research assistants identified students who consumed all of their targeted F/V and gave them the appropriate post-consumption hand stamps. After lunch, classroom teachers provided a prize to each child who had all four hand stamps. During the final 4 days of phase I, pre- and post-tray photo data were collected as mentioned.

Praise group. All procedures were identical to those used in the prize group except that teachers rewarded F/V consumption with praise. Teachers were instructed to praise the behavior of individual students and were given autonomy to do so in a way that felt natural and genuine.

Control group. No intervention was provided during phase I, but F/V consumption was measured during the final 4 days, as in the other groups.

Phase II (Days 24 to 93/96). ***Prize group.*** During phase II, the cafeteria served school lunch as in the Naturalistic Baseline phase. Research assistants provided hand stamps in the cafeteria 1 day per week. Otherwise, students

self-reported daily F/V consumption after lunch on their classroom's wall chart. When students completed all cells up to and including the premarked goal cell, teachers delivered a prize in accord with the sequence provided by Food Dudes Health Ltd. During the final 3 days of phase II, lunch-tray photo data were collected as mentioned.

Praise group. All procedures were as in the prize schools except that when a wall-chart goal was met, teachers provided praise instead of a prize.

Control group. Lunch-tray photo data were collected on the final 3 days of phase II.

Follow-Up (All Groups). Follow-up lunch-tray data were collected over 3 days in all schools approximately 6 months after the end of phase II in the 2012/2013 school year. Procedures were identical to those used in the Naturalistic Baseline phase. F/V consumption for students who had matriculated into the sixth grade was evaluated in the middle school cafeteria following the same procedures. No consequences were provided for taking or consuming F/V.

Assessing Implementation Fidelity. Two types of fidelity data were collected in phase I: Food Dudes media use (antecedent) and reward delivery (consequence). Antecedent implementation fidelity was tracked automatically by the customized study website from which teachers accessed the Food Dudes media. The website recorded the dates and times each teacher accessed each media file. The proportion of accessed media (number of letters and videos accessed divided by the total number of letters and videos available) served as the metric of antecedent fidelity. In the prize schools, a research assistant visited teachers weekly during teachers' free periods to assess consequence fidelity and to obtain self-reports of teachers' current level of stress on a 5-point Likert scale (1=none, 3=moderate, 5=high). The number of prizes delivered was recorded during phase I and compared with the number of the teacher's students who consumed full portions of F/V (the latter obtained from the lunch-tray photo data). Errors of omission (failing to deliver an earned prize) and commission (delivering an unearned prize) were treated identically. Proportion of errors (ie, omission and commission errors divided by prize events) was calculated during the course of phase I, and teachers were coded for fidelity on a 1 to 5 scale, where $\leq$20% fidelity=1 and $>$80% fidelity=5. For praise schools, research assistants visited teachers on the same schedule and asked them to self-report the number of days (of the past 5 days) that they delivered praise to deserving students and their current level of stress. Consequence fidelity was converted to the same 1 to 5 scale using the same percentage cutoffs. During these observations and monthly in phase II, teachers in both groups were asked to rate their current opinion of the Food Dudes program (1=very negative, 3=neutral, 5=very positive).

Data Preparation. Two trained observers blinded to study group and phase independently coded each pre– and post–lunch-tray photo, recording the amount of each F/V consumed. Mixed F/V items (eg, vegetable soup) were not included in the analysis. The scale used ranged from 0 to 1 cups in 0.13-cup increments (two child-bite–sized pieces of fruit or vegetable). Observers estimated both targeted (researcher provided) and nontargeted (student selected) F/V consumption using this visual estimation system. The mean of the two estimations was taken as the final estimate. If the first two observers did not obtain agreement within 0.13-cup of each other, a third observer (blinded as above) coded the photo pair. If this third observer's estimation did not match either of the other two, a registered dietitian nutritionist coded the photo pair to make the final estimation. The fourth observer was needed for 5% of the estimations.

Statistical Analyses

Descriptive statistics for demographic characteristics (Table 1), children's F/V consumption, and teacher's implementation fidelity were calculated by group and period of measurement (including means, standard deviations [SD], and percentages). The F/V consumption of students who ate school lunch and those who brought lunch from home were combined for statistical analyses.

The effects of group (prize, praise, or control) on F/V consumption were examined using 12 linear mixed-effects models: one model for each outcome measure, including fruits, vegetables, or combined F/V consumption at phase I controlling for Default-Provision Baseline consumption, phase II controlling for Naturalistic Baseline consumption, follow-up controlling for Naturalistic Baseline consumption, and follow-up controlling for Default-Provision Baseline consumption. Because students were clustered within classrooms at their respective schools, the mixed-effects models used classroom as a random (slope) effect. School was not included as an additional cluster variable because the intervention was school-based and synonymous with treatment group. To adjust for baseline differences, level of F/V consumption at the corresponding baseline periods (as noted here) served as a predictor variable in each model. Group membership (prize, praise, and control), grade level, and sex were also included as predictors in each model. Older students (grades 3 to 5) comprised $>$50% of each group. In addition, the following differences emerged among the groups: the prize group had a larger percentage of older participants (58.2% in grades 3 to 5, as compared with 54.3% in the praise and 56.2% in the control groups; χ^2=18.67; $P<0.001$) and significantly fewer participants in the praise group, whose sex was unknown (3.0%, as compared with 9.0% for the prize and 10.1% for the control groups; χ^2=27.93; $P<0.001$). Two-way interactions between group and both sex and grade level were also evaluated in each model.

The effects of implementation fidelity on F/V consumption were examined within a second set of 12 models. The models were identical to those above except that the control group was excluded because there were no implementation fidelity data for this group and both antecedent fidelity (ie, showing videos and reading letters) and consequence fidelity (ie, delivering rewards correctly) were added as predictor variables. Nonsignificant main effects (eg, antecedent fidelity) were dropped from the model. Two- and three-way interactions among group and all significant predictor variables were evaluated. Predictors beyond grade and sex were only included in the table if they were significant as a main effect or part of a significant interaction.

Table 1. Baseline demographic characteristics of 2,257 elementary school students participating in a Food Dudes healthy eating program evaluation[a]

	Group					
	Prize (n=852)		Praise (n=635)		Control (n=770)	
Variable	n	%	n	%	n	%
Grade						
1 to 2	356	41.8	290	45.7	337	43.8
3 to 5	496	58.2	345	54.3	433	56.2
Sex						
Male	381	44.7	316	49.8	352	45.7
Female	395	46.3	300	47.2	341	44.2
Unknown	76	9.0	19	3.0	77	10.1
Qualified for free or reduced lunch	337	39.6	254	40.0	391	50.8
Opted out of study	29	3.4	26	4.1	69	9.0

[a]Participants attended six different schools, two of which were randomly assigned to a group that delivered prizes for fruit and vegetable consumption as part of the Food Dudes program, two of which were assigned to a group that provided teacher praise for fruit and vegetable consumption as part of the Food Dudes program, and the final two were assigned to a no-intervention control group.

Due to the large sample size, several interactions were statistically significant, yet were deemed to be of no clinical significance, defined as <.05 units change (or <.05 of 1 cup of F/V consumption). Therefore, interactions without clinical significance were not interpreted in the results, although they are presented in the Tables. Competing or nested models (eg, removing a predictor variable, removing an interaction term, models with and without random intercepts and slopes) were evaluated using a likelihood ratio test to compare the two models in question; if no statistically significant difference was observed between the fit of the two models, the more parsimonious model was retained.

For each mixed-effects model, a measure of model fit (R^2) was computed, which represents the squared correlation between the observed and predicted values of each model. Assumptions of linearity, normality, and homoscedasticity for mixed-effects models are somewhat similar to other generalized linear models and are often best evaluated using residual plots. For example, the assumption of normality was evaluated by plotting the residuals in a quantile–quantile plot against the normal distribution and visually inspecting them for departures from normality. The assumption of linearity was examined by plotting the observed vs the predicted values of each outcome using a scatterplot and checking for a nonlinear trend across the range of plotting space. The assumption of homoscedasticity was assessed by plotting the residuals against the predicted values of the dependent variables, as well as each predictor variable using a scatterplot and checking for any discernible patterns across the range of the plotting space. These plots can also be used to determine whether there are outliers beyond ±2 SD. Using these methods, we did not identify any problems with any the stated assumptions of the mixed-effects models computed in this study. R software (version 3.0.2, 2013, R Core Team) was used to run the mixed-effects models and create the residual plots.

Finally, teachers' opinion of the Food Dudes program was examined with a 2 (prize vs praise group)×2 (phase I vs II) repeated-measures analysis of variance conducted in IBM SPSS Statistics for Windows, version 22.0 (2013, IBM Corp). Each teacher's opinion was averaged separately for phase I and phase II and subsequently analyzed.

RESULTS

Baseline demographics of each group are shown in Table 1. Table 2 presents the mean amounts of F/V consumed by each group at phase I, phase II, and follow-up. All graphical and in-text descriptions of results are based on the predicted values generated by each model, adjusted for baseline consumption level.

Phase I

Table 3 shows that fruits, vegetables, and combined F/V consumption were significantly higher in the prize group than both the praise and control groups. The left panel of Figure 2 shows between-group mean comparisons for each food type. Across groups, combined F/V consumption increased by 0.21 cups (control vs praise), 0.32 cups (control vs prize), and 0.11 cups (praise vs prize). In addition, there were significant grade (older students consumed more F/V than younger students) and sex (female students consumed more F/V than male students) effects. Variance in F/V consumption accounted for by all predictor variables ranged from 37% to 46% (R^2 values in Table 3).

The interaction between group and consequence implementation fidelity on F/V consumption in Phase 1 was significant (Table 4). Delivering rewarding consequences with higher fidelity positively impacted F/V-consumption outcomes in the prize schools but not in the praise schools.

Phase II

Table 3 and the middle panel of Figure 2 show that fruit consumption was significantly higher in the prize group than the praise and control groups at the end of phase II. In

Table 2. Fruit and vegetable consumption among 2,292 elementary school children participating in a randomized trial using the Food Dudes program, 2011/2012

	Group								
	Prize			Praise			Control		
Phase	F[a]	V[b]	F/V[c]	F	V	F/V	F	V	F/V
Naturalistic Baseline[d]									
n[e]	853	853	853	635	635	635	771	771	771
Mean	0.23	0.11	0.35	0.24	0.23	0.47	0.25	0.13	0.38
SE[f]	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Median	0.17	0.00	0.25	0.20	0.08	0.38	0.17	0.00	0.31
Default-Provision Baseline[g]									
n	849	849	849	637	637	637	754	754	754
Mean	0.32	0.21	0.53	0.25	0.19	0.44	0.28	0.23	0.36
SE	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01
Median	0.28	0.15	0.47	0.19	0.11	0.38	0.24	0.12	0.41
Phase I[h]									
n	836	836	836	597	597	597	731	731	731
Mean	0.39	0.34	0.73	0.30	0.27	0.57	0.25	0.13	0.38
SE	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Median	0.37	0.32	0.70	0.27	0.24	0.53	0.23	0.11	0.35
Phase II[i]									
n	797	797	821	530	530	530	745	745	745
Mean	0.24	0.13	0.38	0.20	0.17	0.38	0.18	0.07	0.26
SE	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Median	0.23	0.11	0.30	0.19	0.14	0.35	0.16	0.05	0.23
Follow-up[j]									
n	671	671	671	555	555	555	668	668	668
Mean	0.27	0.12	0.40	0.22	0.07	0.29	0.21	0.07	0.28
SE	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Median	0.27	0.12	0.38	0.22	0.06	0.28	0.20	0.06	0.27

[a]F=fruit.
[b]V=vegetables.
[c]F/V=combined fruit and vegetables.
[d]F/V served in the cafeteria were those offered according to the usual school lunch menu. Before- and after-lunch photos were taken of children's lunch trays and these were used to estimate F/V consumption.
[e]Sample size values decrease across phases due to participant school transfers and missing child observations.
[f]SE=standard error.
[g]A fruit and vegetable not offered on the usual school lunch menu was served by default to every child. Tray photos were obtained as in the prior baseline.
[h]Default servings of F/V continued for 3 weeks while children watched Food Dudes videos in the classroom and obtained rewards for consuming F/V.
[i]No default servings of F/V, no Food Dudes videos, and a gradual reduction in the frequency of rewarding F/V consumption.
[j]Six months after phase II concluded, lunch-tray photo assessments of F/V consumption were collected.

addition, vegetable and combined F/V consumption were significantly higher than control-group levels in both intervention groups, with no significant difference between the intervention groups. Between groups, combined F/V consumption increased by 0.12 cups (control vs praise and control vs prize). A sex effect (females consumed more vegetables and combined F/V than males) was evident, but there was no grade-level effect. Variance in F/V consumption accounted for by all predictor variables ranged from 13% to 25%.

Table 4 shows that consequence implementation fidelity in phase I significantly affected F/V consumption in phase II. The nature of the interaction was as in phase I: high levels of reward implementation fidelity increased F/V consumption in the prize schools, but not in the praise schools. In phase II, when considering fruit consumption, there was a significant interaction between group and teachers' self-reported levels of stress. The direction of the interaction was opposite when considering vegetable and F/V consumption, so no clear

Table 3. Fruit and vegetable (F/V) consumption at phases I, II, and follow-up, as a function of prize, praise, and control group membership, adjusting for baseline consumption, in a randomized trial using the Food Dudes program, 2011/2012

	Fruits		Vegetables		F/V	
	Estimator[a]	95% CI[a]	Estimator	95% CI	Estimator	95% CI
Phase I[b]						
Intercept	0.06	0.04 to 0.09	0.01	−0.02 to 0.03	0.06	0.03 to 0.10
Group (control vs praise)	0.07*	0.04 to 0.09	0.14*	0.12 to 0.17	0.21*	0.17 to 0.25
Group (control vs prize)	0.12*	0.09 to 0.14	0.20*	0.18 to 0.22	0.32*	0.28 to 0.35
Group (praise vs prize)	0.05*	0.02 to 0.08	0.05*	0.04 to 0.08	0.11*	0.07 to 0.15
Grade (1 to 2 vs 3 to 5)	0.05*	0.03 to 0.07	0.06*	0.04 to 0.07	0.09*	0.06 to 0.13
Sex (male vs unknown)	0.02	−0.01 to 0.05	0.06*	0.02 to 0.09	0.07*	0.03 to 0.13
Sex (male vs female)	0.02*	0.00 to 0.04	0.03*	0.02 to 0.05	0.05*	0.02 to 0.07
Default-Provision Baseline Consumption	0.52*	0.49 to 0.56	0.39*	0.35 to 0.42	0.50*	0.46 to 0.53
R^2	0.37		0.38		0.46	
Phase II[c]						
Intercept	0.12	0.09 to 0.15	0.07	0.04 to 0.11	0.12	0.08 to 0.15
Group (control vs praise)	−0.01	−0.05 to 0.02	0.06*	0.03 to 0.10	0.08*	0.03 to 0.12
Group (control vs prize)	0.07*	0.04 to 0.10	0.06*	0.03 to 0.09	0.13*	0.09 to 0.17
Group (praise vs prize)	0.05*	0.02 to 0.08	0.01	−0.03 to 0.03	0.01	0.01 to 0.10
Grade (1 to 2 vs 3 to 5)	−0.01	−0.03 to 0.02	0.02	−0.01 to 0.04	0.01	−0.03 to 0.04
Sex (male vs unknown)	−0.01	−0.05 to 0.04	−0.02	−0.05 to 0.02	−0.02	−0.07 to 0.04
Sex (male vs female)	0.01	−0.01 to 0.03	0.03*	0.01 to 0.05	0.04*	0.01 to 0.07
Naturalistic Baseline Consumption	0.31*	0.27 to 0.35	0.33*	0.29 to 0.36	0.33*	0.29 to 0.37
R^2	0.13		0.25		0.18	
Follow-up[d]						
Intercept	0.12	0.10 to 0.18	0.01	−0.01 to 0.03	0.14	0.08 to 0.18
Group (control vs praise)	0.02	−0.06 to 0.03	−0.01	−0.01 to 0.03	−0.01	−0.05 to 0.06
Group (control vs prize)	0.06*	0.02 to 0.10	0.05*	0.03 to 0.07	0.12*	0.07 to 0.17
Group (praise vs prize)	0.05*	0.01 to 0.09	0.07*	0.05 to 0.09	0.13*	0.07 to 0.18
Grade (1 to 2 vs 3 to 5)	0.01	−0.03 to 0.03	0.02*	0.01 to 0.03	0.01	−0.03 to 0.05
Sex (male vs unknown)	−0.06	−0.14 to 0.03	0.01	−0.04 to 0.06	−0.04	−0.15 to 0.07
Sex (male vs female)	0.03*	0.01 to 0.05	0.04*	0.03 to 0.05	0.06*	0.04 to 0.09
Naturalistic Baseline Consumption	0.26*	0.22 to 0.30	0.13*	0.11 to 0.16	0.26*	0.22 to 0.29
R^2	0.20		0.16		0.24	

[a]Estimators and CIs are the β-coefficients from a linear mixed-effects model.
[b]A fruit and vegetable not offered on the usual school lunch menu was served by default to every child for 3 weeks. Children in the prize schools watched Food Dudes videos in the classroom and obtained prizes for consuming F/V. Children in the praise schools did the same but were rewarded for F/V consumption with teacher praise. Children in the control schools were served the same F/V by default but no intervention was implemented.
[c]No default servings of F/V, no Food Dudes videos, and a gradual reduction in the frequency of rewarding F/V consumption in the Food Dudes prize and praise schools.
[d]Six months after phase II concluded, lunch-tray photo assessments of F/V consumption were collected.
*Indicates statistical significance, $P<0.05$.

relation is revealed. Variance in F/V consumption accounted for by all predictor variables ranged from 14% to 28%.

The analysis of teacher's opinion of the Food Dudes program revealed a significant main effect of phase ($F[1,43]=11.464$; $P<0.01$) and a phase×group interaction ($F[1,43]=8.541$; $P<0.01$). Prize-group teachers' opinion of the Food Dudes program declined from a mean of 4.02 (SD=0.57) in phase I to 3.29 (SD=0.95) in phase II, and praise-group teachers' opinion of Food Dudes did not change from phase I (3.61 [SD=0.81]) to phase II (3.56 [SD=0.88]).

Follow-Up

Although separate models were constructed that controlled for consumption at each baseline (Naturalistic and Default

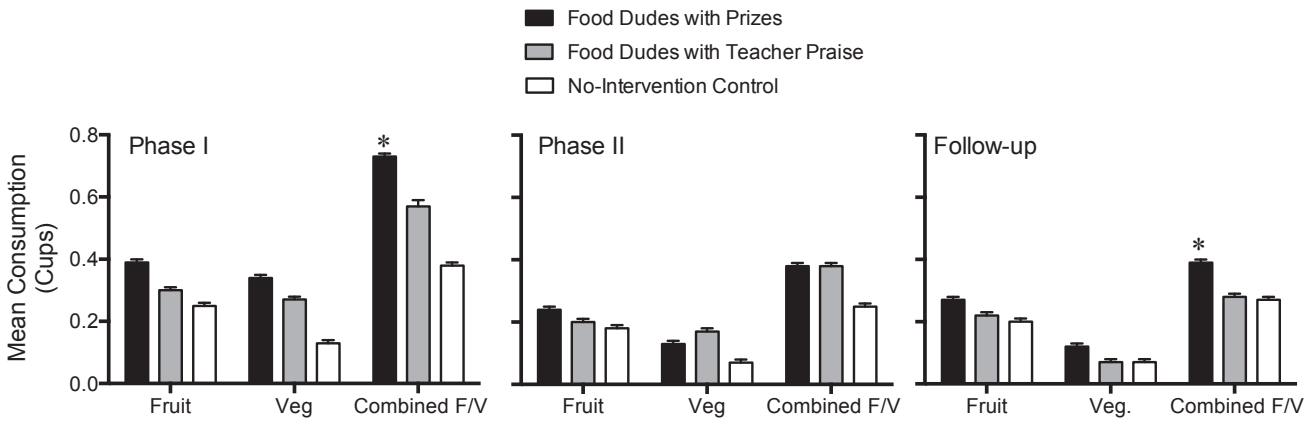

Figure 2. Fruits, vegetables, and combined fruit and vegetable (F/V) consumption among elementary school children participating in a randomized trial using the Food Dudes Program (n=2,292) across phase I[a], phase II[b], and follow-up[c] for prize schools, praise schools, and control schools. *Prize>praise and control; $P<0.05$. In phase I, students earned a prize or praise (depending on group) for criterion F/V consumption each day. [b]In phase II, students earned a prize or praise for criterion F/V consumption after increasing numbers of days. [c]During follow-up, there were no consequences for F/V consumption.

Provision), the models were extremely similar, so Tables 3 and 4 show only data from the models that controlled for Naturalistic Baseline consumption. The right panel of Figure 2 shows that the prize group consumed significantly more of each food than the praise and control groups, which were not significantly different from each other. Across groups, combined F/V consumption increased by 0.12 cups (control vs prize) and 0.11 cups (praise vs prize). There the same sex and grade effects were observed. No interactions achieved an interpretable level of significance. Variance in F/V consumption accounted for by all predictor variables ranged from 16% to 24%.

DISCUSSION

When the Food Dudes program was implemented as designed, with tangible rewards delivered for F/V consumption, children consumed a mean of 92% more F/V during the intensive first 3 weeks (phase I) than did children attending control schools; this amounted to a mean difference of 0.35 cups more F/V consumed per child per day, an outcome comparable with other published Food Dudes studies.[5-8] The intervention was significantly less effective in phase I for the praise group (who received verbal praise) than the prize group (who received tangible prizes). Nonetheless, children in the praise schools consumed a mean of 50% more F/V than children attending control schools (0.19 cups more F/V). When F/V consumption was reassessed approximately 4 months later at the end of phase II, both intervention groups (mean=0.38 cups) consumed a mean of 0.12 cups more F/V than the control group (mean=0.26), representing 46.2% more consumption (see Table 2; calculated as [0.38−0.26]/0.26). At 6-month follow-up, only the Prize group (mean=0.40) consumed 0.12 more cups of F/V than the control group (mean=0.28), representing 42.9% more consumption (see Table 2; calculated as [0.40−0.28]/0.28); whereas the praise group was not different (mean=0.29). Thus, when considering long-term effects, teacher praise proved not to be an adequate substitute for tangible rewards within the Food Dudes program.

It is important to note that F/V consumption decreased in the control schools by a mean of 0.10 cups (26%) during the course of the study; a similar decrease was observed in the praise schools at the 6-month follow-up (a mean decrease of 0.18 cups, a 38% decline from pre−Food Dudes levels). The schools that implemented Food Dudes with tangible rewards avoided these decreases (a mean 0.05 cups more F/V consumed at follow-up relative to baseline, a 14% difference); this counteractive effect is of practical significance.

The factors influencing the decreases in F/V consumption in the praise and control groups are unclear. One possibility is that reactivity to the cafeteria data-collection procedures elevated F/V consumption at baseline but not at follow-up. Reactivity occurs when behavior is altered because it is being observed.[13] Because adults were taking pictures of student identification−labeled lunch trays, students might have anticipated that consequences (beneficial or detrimental) would be delivered based on their lunchtime consumption. Because students in US schools are provided with information about the health benefits of F/V and are encouraged to consume these foods daily, they might have deduced that F/V consumption was important to these adults. When no consequences for F/V consumption occurred (control schools) or when consequences had been suspended many months earlier (praise and prize schools), the reactivity-related increase in F/V consumption ceased, returning consumption at follow-up to true baseline levels. If this account is correct, then children attending the prize schools increased their F/V consumption at follow-up much more than reported here (because the baseline level of consumption was inflated by reactivity). Future researchers might avoid the possibility of these putative reactivity effects either by developing less-intrusive procedures for quantifying F/V consumption, or by conducting longer-duration baseline observations (reactivity effects tend to decrease with continued observations).[13]

An examination of the effects of consequence fidelity showed that delivering tangible rewards as programmed increased fruit consumption. This finding supports Lowe's[10] hypothesis that implementing the Food Dudes program with

Table 4. Implementation fidelity: Fruit and vegetable (F/V) consumption at phases I, II, and follow up as a function of prize and praise group membership only, adjusting for baseline consumption in a randomized trial using the Food Dudes program, 2011/2012

	Fruits		Vegetables		F/V	
	Estimator[a]	95% CI[a]	Estimator	95% CI	Estimator	95% CI
Phase I[b]						
Intercept	0.20	0.14 to 0.25	0.15	0.12 to 0.17	0.42	0.19 to 0.65
Group (praise vs prize)	−0.10*	−0.18 to −0.02	0.06*	0.03 to 0.08	−0.45*	−0.80 to −0.10
Reward fidelity	−0.02	−0.03 to 0.00	—	—	−0.05	−0.13 to 0.02
Stress	—[c]	—	—	—	−0.03	−0.10 to 0.00
Group×reward fidelity	0.05*	0.03 to 0.08	—	—	0.18*	0.08 to 0.29
Group×stress	—	—	—	—	0.13*	0.01 to 0.26
Reward fidelity×stress	—	—	—	—	0.01	−0.01 to 0.03
Group×reward fidelity×stress	—	—	—	—	−0.04*	−0.08 to −0.01
Grade (1 to 2 vs 3 to 5)	0.02	−0.01 to 0.05	0.06*	0.03 to 0.08	0.07*	0.03 to 0.11
Sex (male vs unknown)	0.01	−0.04 to 0.05	0.08*	0.03 to 0.13	0.07	−0.01 to 0.14
Sex (male vs female)	0.03*	0.01 to 0.05	0.04*	0.02 to 0.06	0.06*	0.03 to 0.10
Default-Provision Baseline Consumption	0.45*	0.40 to 0.49	0.37*	0.32 to 0.40	0.45*	0.41 to 0.49
R^2	0.31		0.27		0.37	
Phase II[d]						
Intercept	−0.44	−1.13 to 0.25	0.21	−0.01 to 0.43	0.42	0.20 to 0.64
Group (praise vs prize)	0.62	−0.09 to 1.33	−0.30	−0.64 to 0.04	−0.47*	−0.80 to −0.14
Stress	0.29*	0.02 to 0.55	0.07	−0.17 to 0.03	−0.07	−0.17 to 0.02
Opinion	0.17	0.00 to 0.34	—	—	—	—
Reward fidelity	−0.02	−0.04 to 0.00	−0.08*	−0.15 to -0.01	−0.11*	−0.18 to −0.03
Group×reward fidelity	0.04*	0.01 to 0.07	0.13*	0.01 to 0.24	0.21*	0.10 to 0.32
Group×stress	−0.34*	−0.61 to −0.06	0.14	−0.02 to 0.30	0.19*	0.04 to 0.35
Group×opinion	−0.17*	−0.35 to 0.01	—	—	—	—
Stress×opinion	−0.08*	−0.15 to −0.01	—	—	—	—
Reward fidelity×stress	—	—	0.04*	0.01 to 0.07	0.03	−0.01 to 0.07
Group×stress×opinion	0.09*	0.01 to 0.16	—	—	—	—
Group×reward fidelity×stress	—	—	−0.06*	−0.11 to −0.01	−0.08*	−0.13 to -0.02
Grade (1 to 2 vs 3 to 5)	−0.02	−0.05 to 0.01	0.03	−0.02 to 0.07	0.01	−0.04 to 0.04
Sex (male vs unknown)	−0.01	−0.06 to 0.05	−0.02	−0.08 to 0.03	−0.05	−0.13 to 0.03
Sex (male vs female)	0.01	−0.02 to 0.04	0.04*	0.02 to 0.07	0.05*	0.01 to 0.09
Naturalistic Baseline Consumption	0.34*	0.28 to 0.39	0.35*	0.30 to 0.39	0.35*	0.30 to 0.39
R^2	0.14		0.28		0.16	
Follow-up[e]						
Intercept	0.13	0.09 to 0.18	−0.02	−0.07 to 0.03	0.12	0.06 to 0.18
Group (praise vs prize)	0.05*	0.01 to 0.09	0.13*	0.07 to 0.19	0.13*	0.07 to 0.18
Stress	—	—	0.01	−0.01 to 0.03	—	—
Group×stress	—	—	−0.03*	−0.06 to -0.01	—	—
Grade (1 to 2 vs 3 to 5)	0.01	−0.03 to 0.05	0.02	−0.01 to 0.04	0.02	−0.03 to 0.08

(*continued on next page*)

Table 4. Implementation fidelity: Fruit and vegetable (F/V) consumption at phases I, II, and follow up as a function of prize and praise group membership only, adjusting for baseline consumption in a randomized trial using the Food Dudes program, 2011/2012 (*continued*)

	Fruits		Vegetables		F/V	
	Estimator[a]	95% CI[a]	Estimator	95% CI	Estimator	95% CI
Sex (male vs unknown)	−0.13	−0.27 to 0.01	−0.03	−0.11 to 0.06	−0.14*	−0.31 to 0.03
Sex (male vs female)	0.04*	0.01 to 0.06	0.04*	0.03 to 0.06	0.07*	0.04 to 0.10
Naturalistic Baseline Consumption	0.26*	0.20 to 0.31	0.13*	0.10 to 0.16	0.26*	0.21 to 0.30
R^2	0.18		0.17		0.23	

[a]Estimators and CIs are the β-coefficients from a linear mixed-effects model.
[b]A fruit and vegetable not offered on the usual school lunch menu was served by default to every child for 3 weeks. Children in the prize schools watched Food Dudes videos in the classroom and obtained prizes for consuming F/V. Children in the praise schools did the same but were rewarded for F/V consumption with teacher praise. Children in the control schools were served the same F/V by default but no intervention was implemented.
[c]Predictors beyond grade and sex were only included if they were significant as a main effect or part of a significant interaction.
[d]No default servings of F/V, no Food Dudes videos, and a gradual reduction in the frequency of rewarding F/V consumption in the Food Dudes prize and praise schools.
[e]Six months after phase II concluded, lunch-tray photo assessments of F/V consumption were collected.
*Indicates statistical significance, $P<0.05$.

inadequate fidelity may be responsible for poor outcomes in studies of this program (specifically, those reported by Upton and colleagues[9]).

Prize-school teachers' opinion of the Food Dudes program significantly decreased from phase I to phase II. Teachers raised concerns about the time needed to manage the tangible-reward system, time that was taken away from academic instruction, and some teachers objected philosophically to giving prizes. This finding might be unique to the way Food Dudes was implemented in these US schools. When Food Dudes was implemented in Europe, teachers observe their children eating F/V at snack-time and deliver prizes at this noninstructional time. In these US schools, teachers did not see their children engaged in healthy eating and were asked to allocate academic time to deliver prizes.

Limitations

We note six limitations of the present study. First, the extent to which the current findings might generalize to other schools is unknown. Second, the delay between the consumption of F/V and the acquisition of the reward might have decreased the efficacy of Food Dudes. As just mentioned, when the Food Dudes program is implemented in European schools, F/V are most often consumed in the classroom and teachers provide tangible rewards soon after the F/V is consumed.[5-7] In US schools, F/V are eaten in the cafeteria and delivering prizes or praise in that setting was deemed impractical. This procedural change from how Food Dudes is typically implemented introduced a delay between consuming F/V and obtaining the reward. Because delayed rewards are discounted in value relative to immediate rewards,[14] this modification of Food Dudes might have decreased its efficacy relative to past evaluations of Food Dudes. Future research should explore the effects of this delay to reinforcement on children's F/V consumption and feasible ways to decrease these delays in a school-cafeteria setting.

Third, in phase II, students self-reported their F/V consumption, and this information was used when delivering rewarding consequences. Self-report may be prone to overreporting inaccuracies due to the social desirability bias[15] or children's motivation to receive rewards. As a result, children may have received undeserved phase II rewards, an outcome that would be expected to reduce the efficacy of the Food Dudes program. Observations suggest that teachers' declining opinions of the Food Dudes Prize intervention in phase II may be related to students overreporting F/V consumption on the wall chart.

Fourth, the quality of the praise provided and fidelity with which praise was implemented are difficult to judge because data regarding these events rely on teacher self-reports. Fifth, in the praise schools, teachers were given no formal training on how to effectively praise F/V consumption of their students. It is possible that praise-school outcomes could be improved by such training. Finally, the Food Dudes protocol aims to increase total F/V consumption and physical health, but F/V consumption at home and physical health measures were not taken. Therefore, no conclusions can be drawn about the effects of the intervention on F/V consumption outside of school, and whether this might have impacted measures of physical health (eg, body mass index; calculated as kg/m^2).

Detrimental Effects of Rewards

Some researchers have outlined negative effects associated with the use of tangible incentives, indicating that these extrinsic motivators decrease individuals' drive, or intrinsic motivation, to engage in certain behaviors.[16] This phenomenon, sometimes referred to as the overjustification effect, is observed when a behavior that is reinforced with tangible incentives decreases below unreinforced levels when incentives are no longer provided. This effect is only observed in individuals who demonstrate some initial intrinsic motivation to engage in the target behavior before rewards are delivered.[17]

In the prize group, when tangible incentives were no longer delivered, the overjustification effect was not observed; F/V consumption did not decrease below baseline

levels at either the end of phase II or follow-up. When combined with the other active components of the Food Dudes program (repeated tasting and role modeling[18]) tangible incentives did not produce either momentary or lasting negative effects on intrinsic motivation to consume F/V.

Dissemination of Incentive-Based Interventions

Although arranging tangible incentives within the Food Dudes program produced significant increases in F/V consumption, the material (videos, supporting materials, and prizes costing $12.50 per child) and labor costs of the program might be a barrier to adoption in US schools. Hoffman and colleagues[19] increased F/V consumption for 2 years using inexpensive stickers, but teachers were required to monitor consumption and deliver stickers in the cafeteria daily, a labor cost that may be a barrier to adoption.

Using incentives to maintain F/V consumption for the long periods of time needed to impact habit formation[20] will require a low-cost, low-labor approach. Some evidence suggests that virtual rewards embedded in a game-based intervention can increase F/V consumption.[21,22] In these studies, when the school met its daily F/V consumption goal, fictional characters in a game narrative made progress toward their goal of capturing a band of villains. Virtual rewards minimize material costs, and labor costs were reduced by using a waste-based performance-monitoring system. The significant increases in F/V consumption in both studies are encouraging.

CONCLUSIONS

The Food Dudes program, when implemented with tangible prizes, increased F/V consumption during its implementation and at a 6-month follow-up. Substituting teacher praise for prizes tended to produce smaller increases during the program and produced no lasting benefits. Implementation fidelity proved to be important when delivering prizes, and prizes did not decrease F/V consumption below baseline levels when they were discontinued. Although there are material- and labor-cost issues that need to be addressed, the current findings support the use of incentives as an effective approach to improving children's F/V consumption at school.

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STATEMENT OF POTENTIAL CONFLICT OF INTEREST

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