Cluster randomized controlled trial of a consumer behavior intervention to improve healthy food purchases from online canteens

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ABSTRACT

Background: School canteens represent an opportune setting in which to deliver public health nutrition strategies because of their wide reach and frequent use by children. Online school-canteen ordering systems, where students order and pay for their lunch online, provide an avenue to improve healthy canteen purchases through the application of consumer-behavior strategies that have an impact on purchasing decisions.

Objective: We assessed the efficacy of a consumer-behavior intervention implemented in an online school-canteen ordering system in reducing the energy, saturated fat, sugar, and sodium contents of primary student lunch orders.

Design: A cluster-randomized controlled trial was conducted that involved 2714 students (aged 5–12 y) from 10 primary schools in New South Wales, Australia, who were currently using an online canteen ordering system. Schools were randomized in a 1:1 ratio to receive either the intervention (enhanced system) or the control (standard online ordering only). The intervention included consumer-behavior strategies that were integrated into the online ordering system (targeting menu labeling, healthy food availability, placement, and prompting).

Results: Mean energy (difference: −567.25 kJ; 95% CI: −697.95, −436.55 kJ; $P < 0.001$), saturated fat (difference: −2.37 g; 95% CI: −3.08, −1.67 g; $P < 0.001$), and sodium (difference: −227.56 mg; 95% CI: −334.93, −120.19 mg; $P < 0.001$) contents per student lunch order were significantly lower in the intervention group than in the control group at follow-up. No significant differences were observed for sugar (difference: 1.16 g; 95% CI: −0.50, 2.83 g; $P = 0.17$).

Conclusions: The study provides strong evidence supporting the effectiveness of a consumer-behavior intervention using an existing online canteen infrastructure to improve purchasing behavior from primary school canteens. Such an intervention may represent an appealing policy option as part of a broader government strategy to improve child public health nutrition. This trial was registered at www.anzctr.org.au as ACTRN12616000499482. *Am J Clin Nutr* 2017;106:1311–20.

Keywords: canteen, child diet, child dietary intake, consumer behavior, intervention, nutrition epidemiology and public health, public health nutrition, obesity, school, school canteen

INTRODUCTION

Schools are recommended as a setting to improve childhood nutrition (1) because they provide near-universal access to children in high-income countries (2) and because children can consume ≤40% of their recommended energy intakes for the day during school hours (3). In Australia, as in other countries (4–6), school canteens sell foods and drinks to students during meal and snack breaks and are accessed by ≤95% of children (3). However, the foods that are most frequently purchased from school canteens, such as pies and sausage rolls, pizza products, processed chicken, and hot dogs, are typically high in energy, saturated fat, sugar, and salt (4, 7–9). In addition, school-canteen purchases (compared with foods brought from home) have been estimated to contribute an additional 200 kJ/d to the total energy consumed at school (3).

Evidence from systematic reviews (10, 11) has indicated that strategies to improve the school food environment, such as increasing the availability of healthy foods or limiting the availability of unhealthy foods, are associated with reduced student saturated fat intake with a net effect ranging from −0.9% to −5.2% of energy from saturated fat (10). Furthermore, international

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research within the school setting, as well as in hospitals and restaurants, has suggested that other environmental strategies that are aimed at modifying consumer behavior may increase healthy food choices. These strategies include point-of-purchase nutrition labeling (12, 13), prompting (14), and the placement of menu items [including the order (15), prominence, and access] (16). Despite the potential of these strategies, they are not routinely implemented by schools internationally (17, 18). For example, a recent assessment of the Australian school food environment showed that only 29% of schools had menus that were primarily comprised of healthy foods, 25% of schools prompted healthy foods in meal deals, 43% of schools labeled menus with nutritional information, and 70% of schools placed healthy items in prominent locations (17).

Online canteen ordering systems (henceforth referred to as online canteens), where parents or students order and pay for their lunches online, are increasingly common (19). The online capability of these systems provides a controlled and dynamic infrastructure that enables the implementation of a range of consumer-behavior strategies that can reach large numbers of individuals in real time and at a relatively low cost (20). Despite these aspects, to our knowledge, no previous trials have been conducted on the use of online canteens to deliver consumer-behavior interventions to increase the purchase of healthy foods. In this context, the purpose of this study was to assess the efficacy of a consumer-behavior intervention that was implemented via an online school-canteen ordering system in reducing the energy, saturated fat, sugar, and sodium contents of primary school student lunch orders. We hypothesized that energy, saturated fat, sugar, and sodium contents of lunch orders would be lower in students who were attending schools that were allocated to the intervention relative to those who were attending control schools.

METHODS

Trial design

The study used a parallel-group, cluster-randomized controlled trial design. Schools with an existing online canteen ordering system were randomly assigned to receive either a 2-mo consumer-behavior intervention (enhanced system) or a control (standard online ordering only). The study was prospectively registered with the Australian New Zealand Clinical Trials Registry (www.anzctr.org.au; ACTRN12616000499482) and was approved by the Human Research Ethics Committees of the University of Newcastle (H-2008-0343), Hunter New England Area Health Service (06/07/26/4.04), and the New South Wales Department of Education and Communities (State Education Research Application Process 2012277). The study protocol that was used to conduct this trial was previously published (21).

Subjects and setting

A convenience sample of schools was recruited from New South Wales, Australia, until the required sample of schools consented to participate (n = 10). Recruitment took place from June to September 2016. Schools were eligible to participate if they were a government school, used an online canteen-lunch ordering system from a single provider (henceforth referred to as the provider) for ≥6 mo, processed ≥50 online orders/mo, were not special purpose schools (e.g., catered for students with special needs or juvenile justice), and did not have an externally licensed canteen. All students (grades kindergarten through 6) who placed an online lunch order during the 2-mo baseline-data collection period were included in the study. Student lunch orders in both groups that were preprogrammed to recur before study commencement were excluded because reoccurring orders do not require users to log in and use the ordering system, thereby precluding exposure to the intervention.

Randomization and blinding

After the completion of school recruitment, an independent statistician used a computerized random-number function in the Microsoft Excel program (Microsoft Corp.) to randomize schools to either an intervention or a control group. Randomization was stratified by the socioeconomic status of a school locality (via the school postcode) (22) because evidence has suggested that the healthiness of canteen purchases is associated with a socioeconomic advantage (7). Schools were randomized in a 1:1 (intervention:control) ratio. Separate block sequences of sizes 2 and 4 were used to allocate schools to group within each stratum. Because the final sample size was known before recruitment (n = 10), but the size of each stratum was unknown, the 2 block sequences were generated to also ensure that there were 5 interventions and 5 controls, no matter the combination of sizes of the strata. The study was conducted as an open trial because of the difficulty of blinding users to the changes that were made to the online system. The study statistician who undertook the primary analyses was blinded to the group-allocation variable code.

Intervention

All users (i.e., parents and students) of the online canteen at intervention schools received a 2-mo consumer-behavior intervention that was integrated into the school's existing online canteen ordering system. Online canteen ordering systems allow users (students or a parent on behalf of a student) to login to a website to access the school's lunch menu. Users are able to select, order, and pay for lunch items, which are processed by the canteen and supplied to students during their meal breaks. The intervention was operational from October to December 2016. The intervention sought to encourage consumer purchases of healthier foods and beverages for school lunch orders, i.e., menu items that were lower in energy, saturated fat, sugar, and salt. The intervention incorporated consumer-behavior strategies that have previously been associated with healthier food choices in analogous settings (14, 15, 23) and drew on the principles of choice architecture (24). Consumer-behavior interventions that are based on choice architecture typically require minimal conscious engagement by the consumer and can include the provision of information (prompting, labeling, and feedback); the altering of the physical environment (e.g., altering the placement of products including accessibility, position or proximity, lighting, and decor); or the properties of products or stimuli within an environment (packaging, presentation, and functionality) to cue desirable behavior (21, 24). An overview of the intervention content is provided in **Table 1**. The online canteen provider modified the display of the online ordering system to incorporate the consumer-behavior strategies. Each school's lunch menu was monitored via the provider's website at the start of the intervention and midintervention to identify new menu items

with the online canteen provider modifying the menu, the labels, and positions of any new items to be consistent with the intervention strategies (as outlined in Table 1). Contamination of the intervention between groups was minimized by randomization at the school level and by the provider preventing user access to the intervention by control-group schools.

Control

Online canteen users at schools that were allocated to the control group received the standard online lunch-ordering service only and did not have access to any of the intervention strategies.

Data collection and measures

Primary trial outcomes

The primary trial outcomes were the mean content per student online lunch order of *1*) energy (kilojoules), *2*) saturated fat (grams), *3*) sugar (grams), and *4*) sodium (milligrams). The trial outcomes were based on student purchasing data, which were automatically captured by the online canteen system. The baseline period was from July to September 2016, and the follow-up period was the 2-mo period immediately after intervention commencement (October to December 2016). Trial outcomes were determined with the use of data from all online lunch orders that were placed by a student during the 2-mo baseline and 2-mo follow-up assessment periods for the student cohort. The nutritional profile for each item that was purchased was determined with the use of a menu assessment that was undertaken by a dietitian according to a standardized protocol.

After recruitment, a dietitian contacted each school-canteen manager to request the current menu. Detailed information about each menu item (brand, product name, and serving size for packaged commercial items or the recipe for freshly prepared items) was obtained from each canteen manager via the telephone according to established menu-assessment procedures that have been comprehensively described elsewhere (28, 29).

After the telephone call, the nutritional profile (energy, saturated fat, sugar, and sodium contents) of packaged commercial items were obtained by searching the brand, product name, and serving size in a canteen-product database consisting of >1300 commonly stocked school-canteen items that were developed by the research team (30). If the menu item was not listed in the canteen-product database, the dietitian used a publicly available database of commercial items (Foodswitch 2016; The George Institute) to obtain the nutrition-information panel (31). The nutritional profile (energy, saturated fat, sugar, and sodium contents) for freshly prepared items was obtained by entering the recipe (including the yield, ingredients, and serving size) into a recipe-conversion database (Foodworks version 7; Xyris

TABLE 1
Overview of intervention strategies

Strategy (reference)	Description
Availability[1] (25, 26)	Schools received a comprehensive feedback report including strategies to improve the relative availability of healthy foods. This strategy was based on the NSW[2] Government canteen policy Fresh Tastes @ School whereby foods and beverages that were listed on the canteen menu were classified as red (low in nutritional value), amber (moderate nutritional value), or green (high nutritional value) (27).
Labeling (13)	Each menu item displayed a single, round traffic light label according to Fresh Tastes @ School (27). The menu included information on how to use the label when selecting menu items (e.g., best choice, select carefully, and select occasionally). Healthy (green) menu items that required onsite preparation (e.g., salads, sandwiches, and homemade hot meals) included an appealing description directly under the item name.
Placement (15)	Healthy menu categories (e.g., fruit, sandwiches, and salads) and green items within a category were listed first. Healthy items (green) were listed in the main website display. Amber and red menu items with multiple flavors required users to click or explore the item before the full list of flavors was displayed.
Prompting (14)	When users chose an amber and red hot item, they received a prompt to add a healthy drink (water) or snack (fruit, vegetable, or both) to the lunch order. Healthy food categories (e.g., sandwiches, salad, and fruit) were displayed with a bold font, an image, and a positive food prompt (e.g., "this is a good choice").

[1] This strategy aimed to increase healthy foods and involved providing the school with feedback on how to restrict the availability of unhealthy foods in line with the Fresh Tastes @ School policy (27).
[2] NSW, New South Wales.

Software) (32). If the nutritional profile was unable to be obtained for the commercially packaged item (i.e., was not in the canteen database or Foodswitch database) or freshly prepared item (i.e., insufficient information was provided by the canteen manager), a generic nutrient profile was used that was based on a commercial equivalent present in the canteen-product database. A statistician, who was blind to group allocation, applied the nutritional profile data for each menu item to the student purchasing data to determine the energy, saturated fat, sugar, and sodium contents for each individual order placed.

Secondary trial outcomes

Nutritional quality of student online lunch purchases. The nutritional quality of lunch purchases was determined as follows: *1*) the mean percentage of energy per student online lunch order was derived from saturated fat and sugar; the conversion of saturated fat and sugar to energy was based on internationally accepted conversion factors of 37 and 17 kJ/g, respectively (33); and *2*) the mean proportion per student of all online lunch items that were purchased and classified as green (high nutritional value) and red (low nutritional value) as classified by a dietitian according to the New South Wales government school-canteen policy Fresh Tastes @ School criteria (27).

Revenue. As a potential adverse outcome of the intervention, revenue data that were automatically collected by the online canteen were extracted for analysis. The mean weekly online canteen revenue throughout the baseline period (July to September 2016) and follow-up period (October to December 2016) was compared between groups.

Other data: school and user characteristics

School-level data (e.g., school size, year range, and postcode) were obtained from the Department of Education MySchool website (34). Information regarding the school's *1*) type of canteen operation [parents and citizens run or school run] and *2*) staffing (paid or unpaid) were obtained via a computer-assisted telephone interview with a canteen manager. Information regarding user characteristics, including the student grade, was automatically collected by the online canteen system. Furthermore, the frequency of online canteen use by each user was calculated on the basis of the number of orders placed within the data-collection periods.

Process measures

Acceptability of the intervention. During the telephone call to canteen managers, subjects in the intervention group (n = 5) reported whether they showed the intervention components (e.g., labeling and overall menu design) and frequency of contact from the research team acceptable by using a 4-point Likert scale that ranged from strongly agree to strongly disagree.

Availability of menu items. The intervention encouraged canteen managers to modify the items that were available for sale at their canteens after feedback regarding the menu-item classification (red, green, or amber). To describe change in menu composition that resulted from this intervention strategy, the proportion of *1*) green items and *2*) red items that were available on the menu were assessed at baseline and immediately after intervention completion.

User engagement with the intervention. As a description of user engagement with the intervention, the time that was taken to place the online order and the device that was used to place the order (mobile telephone or tablet compared with a personal computer) were automatically collected by the online canteen system.

Sample size

The sample-size calculation was conducted on the basis of estimated changes in energy intake between groups at which a reduction of a defined magnitude was required to accrue a health benefit at the population level (35). Specifically, a reduction of 192–300 kJ energy/d was estimated to offset overweight in children (35) and, in doing so, to reduce population level risk of chronic disease. Sample-size estimates were conducted with the use of standard t tests on the basis of an effective sample size of 84.6/group. The effective sample size was calculated by dividing the group size by the design effect (6.15). With the assumptions that 104 students/school would place ≥1 online lunch order over the data-collection period (B Morgan, Flexischools, personal communication, 2015) and a standard student lunch order would contain a mean ± SD of 1729 ± 700 kJ (L Wolfenden, unpublished results, 2015) with an intraclass correlation coefficient of 0.05, the participation of 10 schools (5 schools/arm) in the trial would enable the detection of an ∼300-kJ difference between groups at follow-up with 80% power at the 0.05 significance level.

Statistics

All statistical tests were performed with the use of SAS version 9.3 statistical software (SAS Institute Inc.) by a statistician who was blinded to the group-allocation variable code. All outcome data were assessed by comparing between-group differences from all online lunch orders that were placed by a student during the 2-mo follow-up and analyzed via an intention-to-treat approach. All outcomes were assessed with the use of separate linear mixed models. The mixed models were adjusted for clustering at the school level and repeated measures (i.e., students placing multiple orders within the period) and controlled for baseline values. The school was a random-effect component of the model. The unit of analysis for the primary trial outcomes (mean energy, sodium, saturated fat, and sugar contents) and secondary trial outcomes, including the mean percentages of energy derived from *1*) sugar and *2*) saturated fat, was the student lunch order (whereby a lunch order could contain multiple items), and the analysis used data from all online lunch orders that were placed by a student during the 2-mo baseline and 2-mo follow-up data-collection periods. The outcomes relating to the proportion of lunch items that were *1*) green and *2*) red were calculated by tallying the total number of individual lunch items that were purchased by a student over the data-collection period and determining the percentages of those items that were *1*) green and *2*) red. The unit of analysis for revenue was the school. The primary trial outcome was assessed under an intention-to-treat framework with the use of multiple imputation for missing data at follow-up as recommended by White et al. (36) via the MI procedure (SAS Institute Inc.) in the SAS software. In addition, a complete case analysis was performed with the use of data of participants with canteen purchases that were made at both baseline and follow-up (without imputation). As specified a priori, subgroup analyses were performed to examine interactions between the experimental group allocation and the following subgroups: *1*) frequency of canteen use, whereby high users ordered ≥1 time/wk, and low users ordered <1 time/wk (37); and *2*)

student grade, whereby students in grades kindergarten through 2 were one subgroup and students in grades 3–6 were the second subgroup.

RESULTS

Figure 1 illustrates the flow of participants through the trial. A total of 2714 participants placed an online lunch order during the 2-mo baseline period (n = 1144 in the intervention group; n = 1570 in the control group). The characteristics of the intervention and control groups were similar (**Table 2**). At baseline, a total of 19,081 student lunch orders were placed with a mean of 2 items and 1556 kJ energy, 4.9 g saturated fat, 557 mg Na, and 15.8 g sugar. At the end of the 2-mo follow-up, outcome data were available for 936 intervention participants (82%) and for 1435 control participants (91%). Participants in the intervention group were significantly more likely to be lost to follow-up than were those in the control; however, there were no significant differences between the 2 groups being lost to follow-up by grade, frequency of use, or baseline nutrition (mean energy, saturated fat, sugar, and sodium).

Primary outcomes

Under an intention-to-treat framework with the use of imputation for missing data, at follow-up, the mean contents per student lunch order in energy (difference: −567.25 kJ; $P < 0.001$), saturated fat (difference: −2.37 g; $P < 0.001$), and sodium (difference: −227.56 mg; $P < 0.001$) were significantly lower in the intervention group than in the control group after controlling for baseline values and clustering. The effects were similar in the complete case analysis. The mean sugar content per student lunch order in the intervention group was not significantly different (difference: 1.16 g; $P = 0.17$) than that in control group at follow-up with or without imputation (**Table 3**).

Secondary outcomes

The impact of the intervention on secondary outcomes is presented in Table 3.

Nutritional quality of student online lunch purchases

The mean percentage of energy per student online lunch order that was derived from saturated fat was significantly lower in the intervention group than in the control group at follow-up (9.32% compared with 10.69%, respectively; $P < 0.001$). The mean percentage of energy per student lunch order that was derived from sugar was significantly higher in the intervention group than in the control group at follow-up (37.82% compared with 18.38%, respectively; $P < 0.001$). The mean proportion per student of all online lunch items purchased that were green was significantly higher (51.21% compared with 37.93%; $P < 0.001$), and the mean proportion of purchased items that were classified

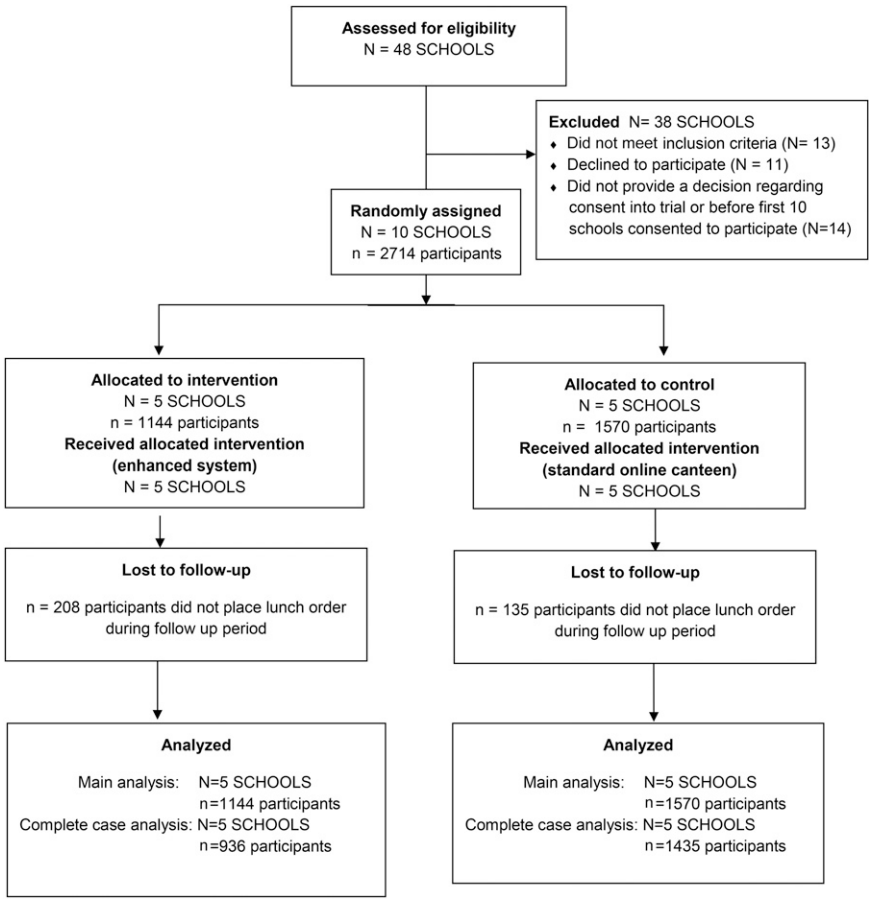

FIGURE 1 Participant flow through the trial and analyzed for the primary outcome. Data were analyzed with the use of separate linear mixed models with adjustment for baseline values and clustering at the school level. Main findings are reported via an intention-to-treat analysis with multiple imputation.

TABLE 2
Baseline characteristics of schools and participants by group

	Intervention (n = 5 schools)	Control (n = 5 schools)
School characteristic		
Enrollment,[1] n	613 ± 125	562 ± 136
Socioeconomic status,[2] n (%)		
Least advantaged	3 (60)	2 (40)
Most advantaged	2 (40)	3 (60)
Type of canteen operation, P&C[3] run, n (%)	5 (100)	5 (100)
Type of manager, n (%)		
Paid	5 (100)	4 (80)
Volunteer	0 (0)	1 (20)
Operation, d/wk, n (%)		
3–4	2 (40)	0 (0)
5	3 (60)	5 (100)
User characteristic		
Participants, n	1144	1570
Grade of student, n (%)		
Infant (grades kindergarten–2)	563 (49)	709 (45)
Primary (grades 3–6)	581 (51)	861 (55)
Frequency of use,[4] n (%)		
High (≥1 occasion/wk)	358 (31)	586 (37)
Low (<1 occasion/wk)	786 (69)	984 (3)

[1] Values are means ± SDs.
[2] Status was determined based on the postcode of the school locality and the Socio-Economic Indexes for Areas 2011.
[3] P&C canteens are managed and operated by the school's parent representative body. P&C, parents and citizens.
[4] Frequency of use was based on baseline characteristics of users.

as red was significantly lower (1.21% compared with 11.11%; $P < 0.001$) in the intervention group than in the control group, respectively, at follow-up.

Revenue

There was no significant difference in the mean weekly online canteen revenue in intervention schools than in control schools at follow-up [difference: −62.33 AU$ (–49.77 US$); $P = 0.41$].

Subgroup analysis

The subgroup analysis of the comparison of low and high users of the online canteen showed that the subgroup-by–experimental group interaction was significant for mean energy ($P = 0.007$), mean saturated fat ($P = 0.03$), and mean sodium ($P = 0.01$) (**Table 4**). There were no other significant subgroup interactions.

Process data

Intervention acceptability

The telephone contact as part of the intervention (i.e., to collect information about unclassified menu items) was rated as acceptable (strongly agreed or agreed) by all 5 canteen managers. All 5 canteen managers agreed or strongly agreed that they would recommend the intervention to others.

Availability of menu items

The mean proportion of green items on the menu increased for intervention schools (baseline: 42.4%; follow-up: 49.4%) compared with for control schools (baseline: 51.4%; follow-up: 51.8%). The proportion of red items on the menu decreased for intervention schools (baseline: 7.2%; follow-up: 1.8%) compared with for control schools, which had no change (baseline: 4.8%; follow-up: 4.8%).

User engagement

The mean length of time that was spent being engaged with the intervention was 5.5 min, with 44% of online lunch orders in the intervention group being placed via a personal computer compared with 56% that were placed via a mobile device.

DISCUSSION

To our knowledge, this is the first randomized controlled trial to examine the efficacy of a consumer-behavior intervention that was implemented in an online school-canteen ordering system in reducing the energy, saturated fat, sugar, and sodium contents of primary student lunch orders. The study showed that the mean energy, saturated fat, and sodium contents per student lunch order were significantly lower in subjects who were allocated to the intervention than in those who were allocated to the control. Encouragingly, such improvements were reported without any evidence of an adverse impact on the canteen revenue. Because of the increasing prevalence of online food-ordering systems in schools and the frequency of web-based food ordering more generally, such findings highlight the potential public-health merit of the integration of consumer-behavior interventions into these systems.

The size of the intervention effect, which was equivalent to a reduction of 572 kJ energy, 2.38 g saturated fat, and 230 mg Na per student lunch order was larger than that observed in previous trials of school-based interventions to improve child diets (25, 38, 39). The effect of this magnitude could make an important contribution to improving public health nutrition and population weight gain particularly because of the potential for web-based interventions to be delivered at scale to large numbers of schools

TABLE 3
Impact of intervention on primary and secondary outcomes in intervention and control groups at follow-up controlling for baseline values[1]

					Intervention compared with control at follow-up[2]			
	Baseline		Follow-up		Complete case analysis[3]		Multiple imputation analysis[4]	
Variable	Intervention (n = 1144)	Control (n = 1570)	Intervention (n = 936)	Control (n = 1435)	Difference	P	Difference	P
Primary outcome								
Student								
Energy, kJ	1678.73 ± 595.61	1567.38 ± 630.97	1103.83 ± 542.96	1564.88 ± 602.88	−572.18 (−739.26, −405.10)	<0.001	−567.25 (−697.95, −436.55)	<0.001
Saturated fat, g	5.40 ± 3.13	5.05 ± 2.94	2.87 ± 1.73	4.84 ± 2.71	−2.38 (−3.27, −1.49)	<0.001	−2.37 (−3.08, −1.67)	<0.001
Sugar, g	17.23 ± 11.26	16.39 ± 11.59	18.19 ± 10.44	16.42 ± 12.63	1.17 (−0.99, −3.34)	0.25	1.16 (−0.50, 2.83)	0.17
Sodium, mg	653.83 ± 281.81	534.91 ± 313.61	399.89 ± 307.86	526.54 ± 295.79	−230.66 (−368.85, −92.47)	0.005	−227.56 (−334.93, −120.19)	<0.001
Secondary outcome								
Student, % of energy								
From saturated fat	11.50 ± 4.13	11.11 ± 4.48	9.32 ± 4.72	10.69 ± 4.16	−1.76 (−3.00, −0.53)	0.01	−1.77 (−2.73, −0.82)	<0.001
From sugar	18.66 ± 13.97	17.62 ± 11.21	37.82 ± 24.89	18.38 ± 12.49	19.98 (11.85, 28.11)	<0.001	19.82 (13.92, 25.71)	<0.001
Item, %								
Student lunch orders items that were green	26.61 ± 27.08	35.86 ± 27.87	51.21 ± 36.94	37.93 ± 27.06	21.61 (11.47, 31.74)	0.001	21.47 (13.83, 29.11)	<0.001
Student lunch orders items that were red	8.75 ± 18.45	12.93 ± 18.97	1.21 ± 8.02	11.11 ± 16.48	−7.36 (−12.42, −2.30)	0.01	−7.52 (−11.33, −3.71)	<0.001
School								
Revenue per school, AU$/wk	987.89 ± 381.14	1701.64 ± 1364.18	990.20 ± 315.94	1766.29 ± 1426.91	-62.33 (−212.36, 87.68)	0.41	—	—

[1] Values are means ± SDs unless otherwise indicated. Data were analyzed with the use of separate linear mixed models that were adjusted for baseline values and clustering at the school level.
[2] All values are means (95% CIs).
[3] Data were from participants who made canteen purchases at both baseline and follow up (without imputation).
[4] All available data with imputation for data missing at follow-up were used.

TABLE 4
Impact of intervention on primary trial outcomes by subgroups at follow-up after adjustment for baseline values and controlling for clustering within schools[1]

	Baseline		Follow-up		Intervention compared with control at follow-up[2]	
Variable per student lunch order	Intervention (n = 1144)	Control (n = 1570)	Intervention (n = 936)	Control (n = 1435)	Difference	P
Energy, kJ						
Student grade						0.36
Kindergarten–2	1603.59 ± 544.33	1544.36 ± 586.81	1071.58 ± 515.83	1541.78 ± 603.55	−551.72 (−725.90, −377.54)	
3–6	1751.55 ± 633.42	1586.35 ± 664.88	1136.78 ± 568.01	1583.84 ± 602.05	−590.63 (−764.08, −417.18)	
Frequency of use						0.007
Low	1729.22 ± 637.74	1604.54 ± 626.18	1094.98 ± 568.59	1605.40 ± 625.32	−627.32 (−793.88, −460.75)	
High	1567.88 ± 472.82	1505.00 ± 634.60	1119.14 ± 495.97	1504.62 ± 563.02	−479.59 (−652.81, −306.38)	
Saturated fat, g						
Student grade						0.08
Kindergarten–2	5.20 ± 2.90	4.91 ± 2.77	2.84 ± 1.67	4.69 ± 2.68	−2.21 (−3.13, −1.30)	
3–6	5.60 ± 3.33	5.17 ± 3.07	2.90 ± 1.78	4.96 ± 2.72	−2.54 (−3.45, −1.63)	
Frequency of use						0.03
Low	5.70 ± 3.47	5.21 ± 2.99	2.91 ± 1.85	5.00 ± 2.80	2.55 (−3.44, −1.66)	
High	4.76 ± 2.10	4.79 ± 2.84	2.80 ± 1.49	4.60 ± 2.55	−2.11 (−3.02, −1.20)	
Sugar, g						
Student grade						0.29
Kindergarten–2	17.26 ± 10.87	16.83 ± 11.16	18.04 ± 10.09	16.99 ± 13.38	0.74 (−1.60, 3.09)	
3–6	17.20 ± 11.64	16.02 ± 11.93	18.35 ± 10.79	15.95 ± 11.97	1.58 (−0.74, 3.91)	
Frequency of use						0.88
Low	17.73 ± 11.88	17.10 ± 11.79	19.15 ± 10.84	17.25 ± 13.49	1.11 (−1.15, 3.37)	
High	16.13 ± 9.71	15.19 ± 11.15	16.54 ± 9.50	15.19 ± 11.14	1.23 (−1.19, 3.65)	
Sodium, mg						
Student grade						0.07
Kindergarten–2	632.96 ± 273.67	525.16 ± 292.89	398.81 ± 309.69	511.73 ± 284.80	−209.16 (−349.63, −68.69)	
3–6	674.05 ± 288.28	542.94 ± 329.65	400.99 ± 306.30	538.70 ± 304.15	−250.80 (−391.06, −110.54)	
Frequency of use						0.01
Low	674.21 ± 299.81	550.15 ± 314.14	383.10 ± 320.42	539.46 ± 303.25	−254.74 (−390.91, −118.56)	
High	609.08 ± 231.73	509.33 ± 311.32	428.92 ± 282.94	507.33 ± 283.50	−189.31 (−327.50, −51.12)	

[1] Values are means ± SDs unless otherwise indicated. Frequency of use was based on baseline characteristics of users whereby high use was defined as ≥1 occasion/wk, and low use was defined as <1 occasion/wk.
[2] All values are means (95% CIs). Data were analyzed after adjustment for baseline values and clustering within schools and represent subgroup-by–experimental group interactions ($P < 0.05$).

and users at a relatively low cost. However, the mean percentage of energy from sugar significantly increased in the intervention group compared with in the control group. As a relative measure, increases in energy from sugar may be expected because of the reductions that were observed in total energy and the percentage of energy from saturated fat. In future interventions, a greater emphasis toward the promotion of healthy foods, such as vegetables, over those with natural occurring sugars, such as fruit and some dairy products, may be warranted.

Significant group interactions by the frequency of online canteen use suggested that the effects of the intervention may be greatest in individuals who less frequently ordered from the canteen. The finding may reflect that the purchasing behaviors of frequent users are more habitual and, thus, more resilient to consumer behavior-change strategies. Further research is required to examine this hypothesis and to identify strategies that may best have an impact on routine behaviors. Nonetheless, significant improvements in foods that were purchased by students in interventions schools were reported for both high and low users and for infant and primary school–aged children, thereby suggesting that, although the magnitude of an effect may differ, the intervention has a broad beneficial impact across these population groups.

The study findings should be considered in the context of the trial methods. The strengths of this study include the experimental design, objective data collection, central random assignment to groups, allocation concealment, and blinding. However, there are a number of limitations of this study. First, the generalizability of the findings may be limited because a convenience sample of 10 schools with relatively large student enrollments was included. Encouragingly, there were no differences in school or user demographics at baseline with schools evenly distributed by socioeconomic status, student grade, and use. Furthermore, the trial tested a complex public health intervention and was not designed to assess the independent effects of individual strategies that were used in the intervention. Nonetheless, optimizing the effects of such interventions requires an understanding of the contribution of specific intervention strategies toward improving the nutritional quality of the foods purchased. Therefore, the use of factorial designs in future research is warranted to help identify the most effective combinations of intervention strategies.

Although there were no significant differences in the characteristics of subjects who were lost to follow-up, the trial had greater study attrition from the intervention than from the control. It is possible that factors other than those measures at baseline may have differed significantly in intervention and control group participants who did not provide follow-up data. The decision to exclude recurring lunch orders post hoc was also a limitation. However, reoccurring orders represented only 3% of all purchases through the online system. Furthermore, a post hoc analysis undertaken by the study team indicated that the inclusion of reoccurring orders in the outcome analysis would not have changed the significance of the trial outcomes. Finally, we did not adjust the α value for the analysis to adjust for multiple significance testing of the primary trial outcome. However, doing so would not have altered the trial conclusions because all significant P values were <0.001.

In conclusion, notwithstanding the trial limitations, the study provides strong evidence supporting the effectiveness of a consumer-behavior intervention using an existing online canteen infrastructure to improve purchasing behavior from primary school canteens. The findings of this research may represent an appealing policy option as part of a broader government strategy to improve child public health nutrition and reduce future chronic disease.

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