Systematic Review of School-Based Interventions to Modify Dietary Behavior: Does Intervention Intensity Impact Effectiveness?

MEGAN RACEY, MSc“ CHARLENE O’BRIEN, BSc² SABRINA DOUGLAS, BSc² OLIVIA MARQUEZ, MSc³ GILLY HENDRIE, PhD⁴
GENEVIEVE NEWTON, DC, PhD⁴

ABSTRACT

BACKGROUND: Owing to the associations between diet and health, it is important that effective health promotion strategies establish healthful eating behaviors from an early age. We reviewed the intensity of school-based interventions aimed to modify dietary behavior in preadolescent and adolescents and related intervention characteristics to effectiveness.

METHODS: Our systematic literature search of 8 databases sought to identify interventions measuring dietary intake in school settings to students aged 9 to 18. We evaluated these studies for effectiveness, intensity, intervention category, and follow-up measures.

RESULTS: Of the 105 interventions 81 were found to be effective immediately postintervention, irrespective of intensity. Studies that were 6 weeks to 5 months in duration, targeted students’ environment or group (alone or in combination), and reached students only in schools were more effective. Only one-fifth of interventions conducted a follow-up measure, and a majority showed a loss of effectiveness from postintervention to follow-up.

CONCLUSIONS: We identified characteristics of effective interventions. These findings may inform the development of future interventions targeting dietary behavior in preadolescents and adolescents in the school-based setting.

Keywords: systematic review; school-based interventions; child and adolescent health; methods and materials of instruction; school health instruction.


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A healthful diet during preadolescence and adolescence promotes optimal health, growth, and cognitive development. Healthy eating habits are also important for the prevention of chronic diseases, such as cancer, later in life.¹ Intake of healthy foods, such as fruit and vegetables and low-fat dairy products, can help students perform better in school, have better digestive health, and maintain a healthy weight.¹ Owing to the clear associations between diet and health, it is important that effective health promotion strategies are utilized to establish healthful eating behaviors from an early age. Therefore, targeting youth during their preadolescent and adolescent stage of development is crucial for them to reap the numerous reported benefits of eating well during this period, and to translate these healthy eating habits into adult behaviors.²³

The school setting has been deemed a viable location for nutrition education interventions. Schools have the potential to reach children of all ages with diverse...
ethnic and socioeconomic backgrounds, and research confirms that nutrition behaviors can be both established and altered in this setting.\textsuperscript{2,3} Previous reviews of school-based interventions have demonstrated a variety of different intervention approaches, including nutrition education, increased availability of healthy foods, free or subsidized food programs, environmental changes, and parental involvement.\textsuperscript{3,5} Whereas these have yielded information regarding intervention approaches, delivery, and measurements (particularly in at-risk populations),\textsuperscript{6} little is known about the relationship between intervention intensity and effectiveness. Evaluation of intervention intensity considers 4 scales, including duration, frequency of contact, level of personalization, and the reach of the strategies, and has been used to evaluate the effectiveness of nutrition interventions.\textsuperscript{7} This information is particularly relevant given the relationship between resource allocation, both financial and otherwise, and intervention intensity.

Following this, the objective of this paper is to present a systematic review and analysis of the intensity of published interventions aimed to modify the dietary behavior of preadolescents and adolescents in a school-based setting. Here, we consider the intensity of dietary interventions in totality as well as within subtypes of different dietary categories. Using this method, we will identify the characteristics of effective interventions, which can be used to inform the development of future school-based interventions targeting dietary behavior in preadolescents and adolescents.

**METHODS**

**Participants**

Interventions delivered directly to adolescents or preadolescents, with preadolescents defined as 9-12 years\textsuperscript{8} and adolescents described as 13-18 years,\textsuperscript{9} were included. If the ages of participants fell outside of this range, the mean age had to be within this range to warrant inclusion. To make this review relevant to the general population, studies that targeted clinical populations, such as obese, malnourished, or lactose-intolerant groups, were excluded.

**Instruments**

The search for literature strictly followed the PRISMA 4-phase flow diagram guidelines.\textsuperscript{10} A list of search terms and databases to search was developed in consultation with a learning and curriculum support specialist and was informed by a recent systematic review.\textsuperscript{7} The search terms used were comprehensive and inclusive (see Appendix S1, Supporting Information). They were categorized under the following 4 headings: Interventions, Nutrition, Population, and Setting. The search included papers published between 1993 and 2015 (March), published in the following databases: ProQuest (41 databases), Web of Science (8 databases, including PubMed), Food & Nutrition Databases, Cochrane Database, Cumulative Index to Nursing and Allied Health Literature, Health and Psychosocial Instruments, Food Agricultural Organization, and CAB direct. Grey literature and reference lists of identified reviews and articles were also searched.

Studies were evaluated based on their effectiveness, using the criteria developed by Hendrie et al.\textsuperscript{7} A study was considered effective if the primary dietary outcome demonstrated a significant change (reported as p \textless .05) in a healthy direction (eg, a study that aimed to increase fruit and vegetable consumption was deemed effective if the intake of fruit and/or vegetables increased). Studies were also evaluated based on their intensity, using a modification of the intensity assessment criteria used by Hendrie et al.\textsuperscript{7}

**Procedure**

Studies were limited to those published in English and were included if they evaluated the effectiveness of an intervention designed to modify dietary intake, with or without a control group. Studies without a control group were included due to the challenges inherent to public health interventions in replicating a controlled environment and recruiting participating groups. Studies were required to conduct some components of the intervention in a school setting.

Interventions were required to include outcomes of modified dietary intake at the group and/or individual level, and dietary intake had to be measured through an objective method (sales data or observed intake) or a robust dietary assessment method (FFQ, 24-hour recall, weighed records). Immediate intervention effectiveness was determined as well as follow-up effectiveness using the same criteria mentioned above. Follow-up was divided into mid- and long-term follow-up, with midterm follow-up defined here as 3 weeks to 4 months postintervention, and long-term follow-up defined as 6 months to 2 years postintervention.

A subsequent overall intensity score was determined by calculating the sum of the 4 components of intensity (out of a possible 20). When required information was not available, an overall intensity score was not calculated. Unfortunately, a lack of reported information resulted in the inability to evaluate fidelity to implementation or dose. Relative to the studies included in the present review, scores greater than 13 were considered as “higher” intensity, 11-12 as “medium” intensity, and 10 or less as “lower” intensity. Evaluated characteristics based on a previous review\textsuperscript{7} included:
1. Duration of intervention: described the length of intervention (scaled relative to interventions included in the review).
2. Frequency of contact with intervention: described the frequency of contact between the participants and the intervention. If the intervention used multiple frequencies of contact points, the most frequent contact was used. If the frequency of contact was not explicitly stated, then the contact points were divided by the duration in order to obtain an average contact frequency.
3. Level of personalization/contact: described the type of contact or level of contact with the intervention.
4. Reach of the strategies: described as the number of settings, such as school, home/parents, or community, used to reach the target population.

The intensity ranking scale was as follows:
- Duration: 1 = <6 weeks, 2 = 6-11 weeks, 3 = 12 weeks—5 months, 4 = 6-12 months, 5 = >12 months.
- Frequency: 1 = annually, 2 = bimonthly to quarterly, 3 = monthly, 4 = weekly, 5 = daily.
- Level of Personalization: 1 = environmental, 2 = large group, 3 = environmental + large group, 4 = large group + individual, 5 = individual OR individual + environmental + group.
- Reach: 1 = one setting, 3 = two settings, 5 = three or more settings.

The number of modified behaviors for each study was assessed in order to keep track of the dietary behaviors that were measured. Only dietary measurements were taken into consideration, although many studies reported other outcomes such as physical activity measurements, body mass index (BMI), ratios, body measurements, or psychological predictors of behavior such as knowledge. Dietary behaviors were defined as those that directly related to eating, such as changes in macronutrient or food group intake. Micronutrient measurements were not included as a modified behavior unless the intervention specifically taught or focused on micronutrient intake (eg, calcium intake in dairy interventions).

Interventions were categorized based on the primary dietary target or the main dietary message of the intervention. Each intervention fit into a single category only. Interventions were defined by the following 4 categories:

1. Fruit and/or vegetable: a focus on increasing fruit and/or vegetable (FV) intake, the benefits of FV, types of FV, ways to eat more FV, etc.
2. General healthy eating: any technique related to general healthy eating in the larger domain of an overall healthy lifestyle such as increasing hydration, decreasing salt intake, increasing FV intake, decreasing fat intake, increasing physical activity, etc. For these interventions, ALL targeted dietary behaviors were considered when evaluating effectiveness of the intervention, focusing mainly on the macronutrient, or food group results.
3. Single food group focus: interventions that focused on modifying intake of a single food or food group, such as decreasing sugar-sweetened beverages, or increasing fish or dairy consumption. Studies in this category sought to modify the intake of fish (N = 1), dairy (N = 6), or sugar-sweetened beverages (N = 5).
4. Single nutrient focus: a specific dietary focus of modifying the intake of a single nutrient. In this review, all of the studies in this category sought to modify lipid intake (N = 7).

The analysis of intervention effectiveness and intensity was performed for all studies as a whole, and as broken down by intervention category. Two researchers independently reviewed all papers, and any discrepancies were discussed and resolved.

Data Analysis
Owing to the heterogeneity in assessment methods and outcomes, such as intake of different foods, macronutrients, or food sales, a meta-analysis was not conducted. Rather, the intensity of interventions was analyzed on the basis of effectiveness. Effective and ineffective studies were compared using two-tailed, unpaired Student’s t-tests. Comparisons were made between each intensity component, including duration, frequency, level of personalization, and reach as well as overall intensity. One-way analysis of variance (ANOVA) was used to compare mean values between each intensity component and overall intensity in effective and ineffective studies in each intervention category, including fruits and vegetables, general healthy eating, single food or food group, and single nutrient. Tukey’s post hoc test was used where indicated by a statistically significant ANOVA. A statistically significant difference was defined as p < .05. All analyses were performed using SPSS version 20.0 (IBM SPSS Statistics, Armonk, NY).

RESULTS
Search Outcomes
Consistent with the PRISMA 4-phase flow diagram, 105 interventions, described in 104 publications, were included in the qualitative synthesis. One published manuscript described the intervention given to 2 distinct populations. These were treated as 2 different interventions. The final PRISMA diagram is shown in Figure 1. Following the screening phase, a total of 248 articles were assessed for eligibility using a full-text analysis, based on the inclusion and exclusion criteria previously described. From this, 144 articles were excluded for the following reasons: clinical
populations (N = 11), lack of dietary intake measure (N = 36), no intervention (N = 24), not school-based (N = 10), lacking full article (N = 25), no English publication available (N = 7), older than 20 years (N = 2), incorrect age range (N = 16), lacking results (N = 5) and duplicates or report of existing study (N = 8). As a result, we included 104 studies describing 105 interventions in the review.

Intervention Intensity Analysis

**Overall intensity.** Of the 105 interventions included in the present review, 81 were effective and 18 were ineffective, and effectiveness for 6 interventions could not be determined due to lack of information. Studies were distributed across the levels of intervention intensity, with 19 studies ranked as low, 29 studies ranked as medium, and 36 studies ranked as high, while for 15 studies intensity could not be determined due to lack of information (see Appendix S1). Interventions in which effectiveness or intensity could not be determined were still included in this review as they met our inclusion criteria and these interventions still contributed scores and completeness to the evaluated categories. Table 1 presents a summary of intensity interventions with known effectiveness, whereas Table 2 presents the mean ± SEM intensity values of effective and ineffective interventions, excluding studies for which effectiveness and overall intensity could not be determined. There were no significant differences between the intensity of effective and ineffective interventions either overall or as broken down by intensity component, including intervention duration, frequency of contact, level of personalization, or reach.

**Nutrition categories.** Table 3 presents the intensity evaluation of studies aiming to modify behavior across different nutrition categories. Interventions in each category were highly effective: fruit and vegetable (N = 33; effective N = 27;11-37 ineffective N = 4;38-41 unknown effectiveness N = 2;42,43), general healthy eating (N = 53; effective N = 41;44-83 ineffective N = 10,84-93 unknown effectiveness N = 2;94,95), single food or food group (N = 12; effective N = 8;96-102 ineffective N = 3;103-105 unknown effectiveness N = 1;106), and single nutrient (N = 7; effective N = 5;107-111 ineffective N = 1;112 unknown effectiveness N = 1;113). Comparing the frequency of effective studies in different categories showed that the mean frequency of interventions in the single food or food group category was significantly higher than for the general healthy eating category (ANOVA p = .04, Tukey’s post hoc test p = .03). There were no other significant differences observed between the intensity of effective and ineffective interventions in different categories or as broken down by intensity component, including intervention duration, frequency of contact, level of personalization, or reach.

### Table 1. Summary of Intensity for Interventions With Known Effectiveness

<table>
<thead>
<tr>
<th>Intensity*</th>
<th>Effective Interventions</th>
<th>Ineffective Interventions</th>
<th>Total Effective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>16</td>
<td>3</td>
<td>19</td>
</tr>
<tr>
<td>Medium</td>
<td>24</td>
<td>5</td>
<td>29</td>
</tr>
<tr>
<td>High</td>
<td>29</td>
<td>7</td>
<td>36</td>
</tr>
<tr>
<td>Unknown</td>
<td>12</td>
<td>3</td>
<td>15</td>
</tr>
</tbody>
</table>

Duration†

| <6 weeks   | 9                       | 4                         | 13              |
| 6-11 weeks | 13                      | 1                         | 14              |
| 12 weeks-5 months | 16                    | 2                         | 18              |
| 6-12 months| 21                      | 6                         | 27              |
| >12 months | 18                      | 4                         | 22              |

Frequency of contact†

| Annually    | —                       | —                         | —               |
| Bimonthly to quarterly | —                     | —                         | —               |
| Monthly     | 7                       | 1                         | 8               |
| Weekly      | 25                      | 7                         | 32              |
| Daily       | 38                      | 7                         | 45              |

Personalization†

| Environmental | 14                      | 3                         | 17              |
| Group         | 20                      | 4                         | 24              |
| Environmental + group | 25                  | 4                         | 29              |

Reach‡

| 1 setting   | 50                      | 9                         | 59              |
| 2 settings  | 29                      | 9                         | 38              |
| 3+ settings | 2                       | 0                         | 2               |

*The total number of interventions with known effectiveness is 99 (81 effective, 18 ineffective). The 6 interventions with unknown effectiveness are not included here.
†Ratings for categories could not always be determined and/or interventions may have more than one delivery method; therefore, total intervention sums are variable.
‡Ratings for delivery methods could not always be determined and/or interventions may have more than one intervention component or duration; therefore, total intervention sums are variable.

**Follow-up measures.** Of the 105 interventions reviewed, 21% or 20% of all interventions, conducted follow-up analysis11,16,25,34,39,43,44,57,72,75,78,86,88,92,94-96,100,103,104,107 (Table 4). Six conducted a midterm- only analysis, 12 conducted a long-term-only analysis, and 3 conducted both a midterm and long-term analysis. Of the studies that were effective immediately postintervention for which follow-up measures were available, 5 maintained effectiveness and 6 were ineffective at later follow-up. Notably, of the 3 studies that conducted both mid- and long-term follow-up, 2 were effective at midterm but not at long-term, and the study that retained a significant measurement of effectiveness at both time points nonetheless showed a decrease from mid- to long-term.

**DISCUSSION**

Our review describes the findings of studies conducted globally, thereby providing an exhaustive
We identified 105 interventions, described in 104 publications, which focused on modifying the dietary intake of preadolescents or adolescents in a school-based setting. Effectiveness was determined for 99 of the interventions, of which ~82% were found to be effective at immediate follow-up (Table 1). This high proportion of effective studies supports results found from a similar systematic review of dietary interventions aimed to increase dairy and calcium intake among younger children (5-12 years), as well as a review of dietary interventions to increase dairy and calcium intake among adolescents (12-18 years). A previous meta-analysis which reviewed school-based interventions also showed high efficacy in reducing obesity rates. Our findings are consistent with previous research that shows that schools are a promising setting for impacting dietary change, although there was a loss of effectiveness across time.

There was variable distribution of interventions across the different levels of intensity, with the majority of interventions being scored as high intensity. A total of 10 points separated the highest and lowest scored intervention intensities, and 15 interventions were not scored because of missing values. Studies that achieved a higher intensity rating scored consistently well across all 4 measures. Based on previous research, we hypothesized that higher intensity interventions would be more effective than interventions with lower intensity; however, the data
did not support this idea. As illustrated in Table 1, more than 80% of interventions irrespective of intensity were effective at immediate follow-up, demonstrating a significant positive change in dietary behavior post-intervention.

Higher intensity studies showed more consistent characteristics than low and medium intensity interventions, including more personalized contact with subjects, longer durations, and more frequent, daily contact with the participants. They also often reached more than just the school environment and involved some home or parental component. Less consistency was observed when looking at medium and lower intensity studies, which were both observed to be very effective, as they scored variably on intensity rankings, except for frequency of contact. Both medium and lower intensity studies were found to have similar frequencies of contact, including both weekly and/or daily intervention visits. They also tended to be conducted in one setting and targeted the students at a lower level of personalization such as environmental or large group. Study duration was one of the main differences between the medium and lower intensity studies, as medium intensity studies tended to be longer in duration than lower intensity studies. Lower intensity studies tended to be less than 6 weeks in duration. Although clear trends were not evident between the intensity rankings, these results demonstrate that higher intensity studies, with more time and resources invested, can be highly effective, but the investment is not always necessary to achieve intervention effectiveness.

When considering the associations between the components of intervention intensity and intervention effectiveness, study duration showed the most consistent findings. Studies between 6 weeks and 5 months in duration appeared to be the most effective, with longer or shorter studies being less likely to result in positive dietary changes. It may be that there is a fine balance between study duration and research visits. Longer studies often had less frequent intervention visits, thus impacting the ability for reinforcement during the study; these interventions may have been too drawn out with not enough visits, reminders, or follow-ups. Shorter studies, of less than 6 weeks, had more frequent visits, but often did not allow enough time for students to make significant changes. It therefore appears that it is necessary to find a study length that allows for an appropriate number of visits, whereas also giving time for changes in behavior to be made.

Another consistent observation related to intervention intensity and effectiveness is that interventions that reached students only in schools were more effective than those with broader reach. Although it is generally accepted that the home, as an additional setting for school-based interventions, is likely to play an important role in the development of habits in children, in the present review, including other reaches such as the home did not necessarily translate to a more effective intervention, possibly due to poor execution of these extended reaches. It is also important to note that while 2 settings, mainly school and home, was still highly effective, in many cases the second setting was not very active and this varied greatly between studies. Parental involvement was often passive in the form of newsletters, homework, or small packages that were meant to involve the parents and promote

Table 3. Intensity Evaluation of Studies in Nutrition Categories Based on Effectiveness*  

<table>
<thead>
<tr>
<th>Nutrition Category</th>
<th># Modified Behaviors</th>
<th>Duration (/5)</th>
<th>Frequency (/5)</th>
<th>Personalization (/5)</th>
<th>Reach (/5)</th>
<th>Overall (/20)</th>
<th>Intensity Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective studies</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit and/or vegetable</td>
<td>NA</td>
<td>3.2</td>
<td>~4.5</td>
<td>26</td>
<td>19</td>
<td>114-120</td>
<td>Medium</td>
</tr>
<tr>
<td>General healthy eating</td>
<td>NA</td>
<td>3.44</td>
<td>42-43</td>
<td>30-32</td>
<td>18</td>
<td>126-127</td>
<td>Medium</td>
</tr>
<tr>
<td>Single food or food group</td>
<td>NA</td>
<td>3.6</td>
<td>5</td>
<td>23-25</td>
<td>15</td>
<td>123-126</td>
<td>Medium</td>
</tr>
<tr>
<td>Single nutrient (fat)</td>
<td>NA</td>
<td>2.75</td>
<td>4.5</td>
<td>38</td>
<td>18-22</td>
<td>135-14</td>
<td>High</td>
</tr>
<tr>
<td>Ineffective studies</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit and/or vegetable</td>
<td>NA</td>
<td>3.3</td>
<td>4</td>
<td>30</td>
<td>20</td>
<td>127</td>
<td>Medium</td>
</tr>
<tr>
<td>General healthy eating</td>
<td>NA</td>
<td>3.8</td>
<td>4.3</td>
<td>34</td>
<td>23</td>
<td>140</td>
<td>High</td>
</tr>
<tr>
<td>Single food or food group</td>
<td>NA</td>
<td>1.3</td>
<td>4.7</td>
<td>3</td>
<td>1.7</td>
<td>107</td>
<td>Medium</td>
</tr>
<tr>
<td>Single nutrient (fat)</td>
<td>NA</td>
<td>4</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>11</td>
<td>Medium</td>
</tr>
<tr>
<td>Studies with unknown effectiveness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit and/or vegetable</td>
<td>NA</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>19</td>
<td>High</td>
</tr>
<tr>
<td>General healthy eating</td>
<td>NA</td>
<td>2.5</td>
<td>40-45</td>
<td>35</td>
<td>2</td>
<td>120-125</td>
<td>Medium</td>
</tr>
<tr>
<td>Single food or food group</td>
<td>NA</td>
<td>4</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>11</td>
<td>Medium</td>
</tr>
<tr>
<td>Single nutrient (fat)</td>
<td>NA</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>12</td>
<td>Medium</td>
</tr>
</tbody>
</table>

NA, not available.

Duration: 1 = < 6 weeks, 2 = 6-11 weeks, 3 = 12 weeks-5 months, 4 = 6-12 months, 5 = >12 months. Frequency: 1 = annually, 2 = bimonthly to quarterly, 3 = monthly, 4 = weekly, 5 = daily. Level of Personalization: 1 = environmental, 2 = large group, 3 = environmental + large group, 4 = large group + individual, 5 = individual OR individual + environmental + group. Reach: 1 = one setting, 2 = two settings, 3 = 3+ settings.

*Mean values for each intensity ranking are presented here.
Table 4. Intensity and Effectiveness of Studies with Mid- and Long-Term Follow-Up

<table>
<thead>
<tr>
<th>Study</th>
<th>Intervention Type</th>
<th>Type of Follow-Up</th>
<th>Effective at Immediate Follow-Up (Yes/No)</th>
<th>Effective at Mid-/Long-Term Follow-Up (Yes/No)</th>
<th>Intervention Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anand et al (2015)</td>
<td>General</td>
<td>Midterm</td>
<td>Yes</td>
<td>Yes at both time points in one group, although decreased from mid- to long-term</td>
<td>Low</td>
</tr>
<tr>
<td>Ansari et al (2015)</td>
<td>General</td>
<td>Both midterm and long-term</td>
<td>Unknown*</td>
<td>Yes</td>
<td>Low</td>
</tr>
<tr>
<td>Ashfield-Watt et al (2008)</td>
<td>Fruit/vegetable</td>
<td>Midterm</td>
<td>Yes</td>
<td>No</td>
<td>Low</td>
</tr>
<tr>
<td>Bere et al (2006)</td>
<td>Fruit/vegetable</td>
<td>Long-term</td>
<td>No</td>
<td>No</td>
<td>Medium</td>
</tr>
<tr>
<td>Bessem et al (2012)</td>
<td>Fruit/vegetable</td>
<td>Long-term</td>
<td>Yes</td>
<td>Yes</td>
<td>Low</td>
</tr>
<tr>
<td>Dawson (2006)</td>
<td>Single nutrient</td>
<td>Midterm</td>
<td>No</td>
<td>No</td>
<td>Medium</td>
</tr>
<tr>
<td>DeVault et al (2009)</td>
<td>Single nutrient</td>
<td>Midterm</td>
<td>Yes</td>
<td>Yes</td>
<td>Medium</td>
</tr>
<tr>
<td>Dewar et al (2013)</td>
<td>General</td>
<td>Long-term</td>
<td>No</td>
<td>No</td>
<td>Medium</td>
</tr>
<tr>
<td>Ezendam et al (2012)</td>
<td>General</td>
<td>Long-term</td>
<td>Yes</td>
<td>No</td>
<td>Unknown</td>
</tr>
<tr>
<td>Fairclough et al (2013)</td>
<td>General</td>
<td>Midterm</td>
<td>No</td>
<td>No</td>
<td>Medium</td>
</tr>
<tr>
<td>Gates et al (2013)</td>
<td>Single food</td>
<td>Long-term</td>
<td>Yes</td>
<td>No</td>
<td>High</td>
</tr>
<tr>
<td>Jemmott et al (2011)</td>
<td>Fruit/vegetable</td>
<td>Long-term (at both 6 months and 1 year)</td>
<td>NA (ongoing)</td>
<td>NA (ongoing) Effective at mid-term but not long-term follow-up</td>
<td>High</td>
</tr>
<tr>
<td>Krolner (2012)</td>
<td>Fruit/vegetable</td>
<td>Long-term</td>
<td>NA (ongoing)</td>
<td>NA (ongoing) Effective at mid-term but not long-term follow-up</td>
<td>High</td>
</tr>
<tr>
<td>Lo et al (2008)</td>
<td>Single food</td>
<td>Both midterm and long-term</td>
<td>No</td>
<td>No</td>
<td>Medium</td>
</tr>
<tr>
<td>Mhas et al (2010)</td>
<td>General</td>
<td>Long-term</td>
<td>Yes</td>
<td>Yes</td>
<td>Unknown</td>
</tr>
<tr>
<td>Neumark-Sztainer et al (2003)</td>
<td>General</td>
<td>Long-Term</td>
<td>No</td>
<td>No</td>
<td>Medium</td>
</tr>
<tr>
<td>Pbert et al (2012)</td>
<td>General</td>
<td>Long-Term</td>
<td>Yes</td>
<td>No</td>
<td>Medium</td>
</tr>
<tr>
<td>Singh et al (2009)</td>
<td>General</td>
<td>Both midterm and long-term</td>
<td>Yes</td>
<td>Effective at mid-term but not long-term follow-up</td>
<td>Unknown</td>
</tr>
<tr>
<td>Smith and Holloman (2011)</td>
<td>Single food</td>
<td>Midterm</td>
<td>Yes</td>
<td>Yes</td>
<td>Medium</td>
</tr>
<tr>
<td>Te Velsk et al (2008)</td>
<td>Fruit/vegetable</td>
<td>Long-term</td>
<td>Yes</td>
<td>No</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

*Study did not perform a measurement immediately postintervention.
†Study measured the decline in dairy consumption from immediate to long-term follow-up, and found a significant decrease.

a supportive home environment; however, few studies actively required parents’ involvement. Whereas it is known that parents, as nutritional gatekeepers, can influence healthy food availability, and support and role model favorable behaviors, it is recommended that when used as part of school-based interventions, parents should be actively involved, rather than voluntary participants, to improve dietary intake in preadolescents and adolescents. Nonetheless, our analytic results show that parental involvement may not improve effectiveness beyond the school setting, perhaps due to unclear expectations and a lack of participation in optional activities. This is consistent with a previous review that suggested parents must be involved actively in the intervention for the home reach to be effective.7

Similar to study duration and reach, the level of intervention personalization appeared to relate to intervention effectiveness. Specifically, interventions that targeted students both as a group and as individuals were less effective than those targeting the environment or group alone or in combination. This was in contrast to our hypothesis, wherein we postulated that more personalized interventions that were tailored to an individual’s specific dietary behavior would be more effective than impersonal, generalized dietary messages. However, these results should be interpreted with caution. First, there were few studies that targeted students at only the level of the group and individual, making it difficult to draw reliable conclusions regarding effectiveness in this group. Second, several of the studies that targeted only the environment provided food to students, which would greatly increase the likelihood of observing a change in dietary behavior immediately postintervention. Unfortunately, most of these studies did not conduct a follow-up after the provision of food was stopped to determine if dietary changes were maintained. Therefore, the relationship between intervention effectiveness and level of personalization is difficult to determine.

It is also difficult to determine the relationship between the frequency of intervention contact and intervention effectiveness. Although monthly contact...
appears to be the most effective, the small number of studies using this frequency limits this finding. Most interventions had weekly or daily frequency of contact and were largely effective, and our analysis suggests that a minimum of monthly contact with the participants should be used in intervention delivery. For shorter studies, weekly or daily contact may be necessary. No studies in the review used a frequency of contact less than monthly, therefore the relationship between infrequent contact and effectiveness is unclear.

The majority of the interventions included in this study were in the Fruit and/or Vegetable (FV) or general healthy eating category, with over 90% showing a positive impact on dietary behavior. Between the FV and general category, the more targeted and direct FV interventions were not more effective than the broad healthy eating interventions, which is in contrast to a previous review of dairy interventions that found that studies focusing on encouraging intake of dairy food or calcium alone were all effective, compared with 55% of studies promoting dairy within the context of a healthy diet. In this review, which focused more broadly on dietary interventions across several categories, there did not appear to be a reduction in effectiveness with dilution of resources across several nutritional targets.

Whereas a high degree of effectiveness was also observed in the single nutrient and single food or food group, these results are limited by the small number of studies, particularly in the ineffective group. However, it can be noted that the single food or food group category was the least effective. This is probably due to the presence of several studies targeting a decrease in consumption of sugar-sweetened beverages; because sugar-sweetened beverages are proportionally the highest consumed beverage by preadolescents and adolescents, it may be more difficult to make significant and meaningful dietary behavior changes.

Although this review found that more than 80% of school-based interventions were successful at modifying dietary behavior immediately post-intervention, we noted a distinct lack of follow-up for the majority of studies. Only 21 studies reported follow-up measures, either midterm (3 weeks to 4 months postintervention) or long-term (6 months to 2 years postintervention), which represents only one fifth of all studies reviewed. This makes it difficult to assess whether the modified dietary behaviors were maintained after the intervention period, which is a concern if food provision was an integral part of the intervention. From the studies that did conduct follow-up, most reported a failure of participants to maintain the changes seen postintervention. Interestingly, in the 3 studies that conducted follow-up at both mid- and long-term, all noticed a loss of effectiveness across time, highlighting the importance of tracking dietary behavior across an extended period with multiple measures. Future studies should address this gap in intervention retention and follow-up with participants to assess long-term, lasting effects of the intervention, as it appears likely that the high degree of effectiveness of published school-based interventions may be misleading, given the tendency of the majority of researchers to only perform measurements immediately following the intervention.

There are limitations that must be considered. Owing to the absence of uniformed reporting or effect size estimates, the definition of effectiveness was based on the significance of results as reported by the study authors. It is acknowledged that statistical significance is related to the assessment method and sample size; however, the approach to determining effectiveness used in this review has been applied elsewhere. The method of determining effectiveness of interventions was limiting to the quality and specificity of the results. Studies were considered effective if they reported a significant change of the primary dietary outcome which is inherently flawed, especially in mixed message studies. This review was also limited by the consideration of multiple dietary focuses, leading to difficulty when comparing the effects of these interventions beyond p-values. Most studies were published in English, which could have created a small bias to North American studies. As an attempt to reduce publication bias, grey literature was searched. Despite these limitations, the methodology of the review is strong and the results show consistency with previous reviews, which is well supported by existing literature.

Overall, interventions that target preadolescents and adolescents in school-based settings to improve dietary habits have been shown to be highly effective, resulting in positive changes in dietary behaviors in the vast majority of studies. However, this review highlights that a significant shortcoming in this body of literature is a lack of follow-up in over 75% of published studies, and demonstrates that positive dietary changes may not be maintained across time. Utilizing an intensity-based scaling of the interventions, the current review found that the school is an effective setting to impact dietary behavior, and highlights specific intervention characteristics such as intervention duration, reach, frequency of contact, and level of personalization that likely contribute to effectiveness. Therefore, these findings may be used to guide successful development of interventions targeting dietary behavior in preadolescents and adolescents in the school-based setting.

**IMPLICATIONS FOR SCHOOL HEALTH**

Our findings support the school as a primary target for nutrition interventions and highlight some characteristics of intervention intensity that relate to effectiveness. To maximize effective dietary change in
students, interventions should be between 6 weeks and 5 months in duration, with a minimum of monthly contact with the participants, and should focus on delivery at the level of the whole class. If interventions aim to include parents in combination with the school-based delivery, then parents should be actively involved in the program, for example, through structured sessions led by a trained facilitator. Increasing the reach of the intervention beyond the school can be effective as community and school partnerships have demonstrated an impact on student nutrition.132 Although it does not appear necessary to administer interventions with a high frequency of contact for a prolonged period of time, it should be acknowledged that there is likely to be a loss of positive behavior change across time, which suggests that maintenance strategies should be explored. A variety of nutritional targets appear to be modifiable in the school environment, allowing messages to be tailored to the specific needs of the student population. Provision of healthy food to students in the school environment is encouraged.

Human Subjects Approval Statement
As a literature review not involving original research on human subjects, this study did not require review by an institutional review board.

REFERENCES
26. Jones AB. The Impact of Participation in the Food Dudes Healthy Eating Program on Dietary Habits in Fourth and Fifth Grade Students in Cache County Utah After One Year [MS ProQuest Dissertations and Theses]. Logan, Utah: Utah State University, 2014.


