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Increasing Children's Vegetable Consumption: Translating a Review of the Evidence Base to Develop Best Practice Guidelines



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Introduction: Dietary guidelines worldwide emphasize the importance of consuming vegetables as part of a healthy diet. Despite this, translating this information into messages for consumers that change behavior has been difficult. There have been population-level social marketing campaigns as well as several smaller campaigns directed specifically toward children, which have demonstrated small increases in consumption. However, achieving meaningful and sustained increases in children's vegetable consumption remains a challenge. This article describes the process of synthesizing the published literature and translating these findings to inform the development of 7 best practice guidelines to increase children's vegetable intake.

Methods: The first step in this process was a systematic review of scientific literature to identify the components of interventions that were associated with successfully increasing vegetable intake. The synthesis of effective intervention components was guided by the Behavior Change Wheel. These scientific findings were translated to guidelines for best practice. This process involved a team of nutrition and behavioral researchers and nutrition practitioners translating the science into actionable advice that could be adopted by a range of stakeholders. The 6 selected stakeholders included long daycare centers, after-hours school care providers, primary schools, industry groups and growers, researchers, and government policy makers. Stakeholders were involved in the development process through surveys and interviews to understand their requirements for resources to support adoption of the best practice guidelines within each setting and within the context of existing practice.

Results: The guidelines center on coordination of effort, with a focus on components such as planning, environmental restructuring, barrier reduction, feedback, and monitoring. In consultation with key stakeholders, a range of resources were developed for each setting to support the implementation of best practice, with the aim of achieving meaningful increases in intake. The resources and tools have been made available at <http://www.vegkit.com.au>.

Conclusions: The translation of knowledge into practice is not traditionally included as part of the research process. Therefore, combining the process of reviewing the science and translating the evidence to stakeholder resources to influence practice in 1 research study is novel, and the study could

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be used to guide future research translation activities within and beyond the field of public health nutrition.

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INTRODUCTION

Vegetables are an important component of a healthy diet, and their adequate consumption is a marker of diet quality owing to their association with reduced risk of chronic diseases.¹ Lifelong food preferences and eating habits, including for vegetables, are formed during the childhood years and track into adolescence and adulthood.² Yet, vegetable intake among children worldwide remains persistently low. For example, Australian children consume about 2 servings of vegetables per day, and only 6% reach the servings recommended in the Australian Dietary Guidelines.³ Similar results have been reported in the U.S.^{4,5} and the United Kingdom.⁶ Therefore, globally, more effective approaches are needed to increase children's consumption of vegetables and reduce the gap between current intake and recommendations.

Dietary guidelines around the world emphasize the importance of consuming vegetables as part of a healthy diet.^{7,8} Despite clarity in these guidelines, translating this information into messages for consumers that change behavior has been challenging. There have been social marketing campaigns such as the Go for 2&5 campaign in Australia and the 5-A-Day type programs in countries such as Canada, Denmark, the U.S., and the United Kingdom, which have reportedly led to increased awareness⁹ but have not increased consumption consistently or by a significant amount.^{9–11} Other European initiatives encouraging fruit and vegetable consumption have been developed; for example, Spain (5aldia.org), France (lesfruitsetlegumesfrais.com), and Germany (5amtag.de) also have versions of 5 serves a day. At a state level in Australia, there are also government-funded programs specifically targeted toward children that have been rolled out. For example, the programs Munch & Move and Crunch&Sip, among others, encourage vegetable consumption in preschool and primary school children.^{12–15} Some have demonstrated small, statistically nonsignificant increases in consumption,¹⁶ but it remains a public health challenge to achieve meaningful and sustained increases in children's vegetable consumption.

The reported effectiveness of interventions that have been evaluated ranges from an increase in consumption

of 0.1 serving per day in school and policy-type studies¹⁷ up to 0.25–0.5 serving of vegetables per day in home and community settings.¹⁸ Sustained or habitual increases in intake appears more difficult to achieve.¹⁹ Therefore, to build on the successful elements of previous interventions, future research needs to better understand the parts of interventions that are working. Literature reviews of interventions have started to critically examine the design features of interventions that might be associated with successful behavior change.^{20–22} Identifying these intervention building blocks may help to support the development of more effective and scalable interventions in the future.²³ It may also help to direct limited funding and resources toward intervention components that are most likely to work. For example, more intensive interventions with higher frequency of contact have been more successful in increasing vegetable intake, and interventions that used behavioral building blocks such as social support, repeated exposure, and staff training have also been effective.¹⁸

In addition to synthesizing the latest scientific evidence, investment into the translation of knowledge directly into professional practice or indirectly through health policy is critical in public health translational research.²⁴ Actively engaging key stakeholders who influence children's dietary intake can help to amplify nutrition messages and potentially help to achieve greater impact. This kind of knowledge translation into practice is not traditionally included as part of the research process. Therefore, this study aimed to describe a novel research translation process, including (1) the critique of contemporary research to determine the components of effective interventions that appear to be associated with increased vegetable intake in children, (2) the translation of these findings into a set of best practice guidelines, and (3) engagement with stakeholders to develop a range of tools and resources to support an increase in children's consumption of vegetables. This study was part of a broader research program, called VegKit (<http://www.vegkit.com.au>), which was funded by Hort Innovation to promote the sales of vegetables. The project aimed to design and develop tools and resources to support stakeholders in increasing children's vegetable intake.

METHODS

Part 1: Synthesis of Primary Evidence by Systematic Review

Criteria for study inclusion. The PRISMA protocol was used to guide the reporting of the review section of this study (Appendix 1, available online). The first step in the process was a review of scientific research studies that built on our previous review¹⁸ to identify the characteristics of interventions associated with successfully increasing children's vegetable intake. A clear search strategy was developed using the Population, Intervention, Comparison, and Outcome framework to describe the inclusion and exclusion criteria (Appendix 2, available online, provides a more detailed Population, Intervention, Comparison, and Outcome). Briefly, studies were included in the review if the interventions were conducted in generally healthy children aged 2–12 years (up to primary school aged) (population of interest). Interventions that were specifically focused on vegetable consumption or fruit and vegetables, healthy eating, or healthy lifestyles delivered to individuals in the home, community, or educational institution or as part of government initiatives were included. Studies that provided food, for example, school lunch programs, were excluded because they would require an overhaul to the provision of food at school, particularly in Australian schools, which do not currently provide formal school lunches (intervention). Prospective studies of any duration evaluating interventions with or without comparison groups were included (comparison). Studies needed to report vegetable consumption in children, separately to fruit, with intake measured at baseline and at a point of follow-up at least 3 months after the initial measurement (outcome).

Search strategy. Four databases (PubMed, Web of Science, Scopus, and PsycINFO) were searched using a predetermined list of keywords and Medical Subject Headings terms. Search terms were grouped under the following 4 headings: Population, for example, *child* and *preschool*; intervention, for example, *campaign*, *education*, and *mobile*; study design, for example, *controlled clinical trial* and *comparative studies*; and outcome, for example, *vegetable consumption* (Appendix 3, available online, provides details of the full search). Research studies published in English between 2014 and 2018 and that met the predefined criteria were included.

Screening and study selection. All results were imported into Endnote, and duplicates were removed. Results were then transferred to Covidence systematic review software²⁵ prior to independent title, abstract,

and full text screening in duplicate by 2 members of the research team using the predefined inclusion and exclusion criteria. There was 97% agreement between reviewers in the title and abstract screening, with conflicts resolved by a third researcher. For full-text review, there was 89% agreement between reviewers, and conflicts were resolved through discussion with 2 other team members.

Corresponding authors of all included studies were contacted through email to request any additional information on the intervention content that may be available. After 2 weeks, a reminder was sent, and researchers were given 2 weeks to respond. Five authors (of 15 studies reviewed) provided additional publications or study websites for analysis.

Study quality. Methodologic quality of all studies was independently scored by 2 researchers using the Effective Public Health Practice Project quality assessment tool for quantitative studies.²⁶ Differences in coding between the 2 researchers (DLB and LKB) were resolved by a third researcher (GAH). This tool has been identified as useful for systematic reviews that evaluate randomized and nonrandomized intervention studies. Eight quality components were scored, including selection bias, study design, confounders, blinding, data collection methods, withdrawals and dropouts, intervention integrity, and analyses. Each section and each study overall were scored as strong, moderate, or weak.

Data extraction and synthesis. Details about the interventions were extracted, including their design, the participants who took part, a description of the intervention, and the outcomes. The behavior change content of the interventions were analyzed by 2 researchers (BW and BJJ) using the Behavior Change Wheel. The Behavior Change Wheel provides a step-by-step framework for designing and evaluating behavior change interventions.²³ The framework can be used to systematically describe parts of interventions under 3 broad categories of (1) understanding the behavior, (2) identifying intervention functions (defined as the "...means by which an intervention can change behaviour"^{23(p106)}), and (3) identifying the context and implementation options for the intervention.²³ Behavior change techniques are then used to describe the techniques used to create the "active component of an intervention designed to change behaviour".^{23(p145)} The techniques are the most used part of the Behavior Change Wheel approach, with several systematic reviews critiquing the techniques used by interventions to better understand how interventions seek to change behavior.^{27–29} There are 93 behavior change techniques

grouped into 16 categories. Examples of categories of techniques include goals and planning, feedback and monitoring, social support, and shaping knowledge.²³ Trained behavioral researchers independently coded the techniques that interventions used (BW and EB) (96% agreement), with differences resolved by discussion.

Owing to the heterogeneity in the study design and how vegetable intake was reported, meta-analysis was not conducted, rather a narrative synthesis of results was conducted. Design features that differentiated effective interventions from ineffective interventions were described and guided the key findings and the development of the best practice guidelines. Effectiveness was defined as a reported statistically significant increase in vegetable intake, either over time for the cohort studies or between groups for controlled trials. The development of the best practice guidelines was informed by the findings of 15 studies included in this review, along with the findings from the previous review.¹⁸

Part 2: Translation of Evidence Into Practice: Development of Stakeholder Resources

The second part of the process involved a team of nutrition and behavioral researchers and nutrition practitioners translating these scientific findings into actionable advice that could be adopted by a range of stakeholders. The social ecological model was used as a guide to identify key stakeholders across the different settings who influence children's eating habits.³⁰ The 6 selected stakeholders included long daycare centers, after-hours school care providers, primary schools, industry groups and growers, researchers, and government policy makers. In the final step of this process, the authors consulted with stakeholders and involved them in the development process through surveys and interviews to understand the resources needed to support adoption of the best practice guidelines within each setting and within the context of existing practice. Stakeholder input was slightly different for each setting. For example, consultation with food industry and policy stakeholders helped to shape the content of the user guides, and it also helped to refine the specific target audience of these user guides. In comparison, interviews with long daycare centers, after-hours school care providers, and primary schools helped to inform the flow of information, its presentation, and format. Drawing on the insights gathered, a range of resources and tools were developed for each setting. A professional editor was used to revise the language from a research tone to one appropriate for each setting. It was important that the resources were useful and complemented existing resources, without duplication. For each of the 6 stakeholder groups, a setting-specific guide of best practice

was developed, except for government policy makers for whom an evidence brief was produced. For all stakeholders, additional tools were developed to support the implementation of the best practice guidelines. For example, in the early learning sector, the tools and resources developed were designed to support long day-care center staff, including management, cooks, and educators. Additional practical tools, such as a Quality Improvement Plan and staff training video, were designed to further support centers. The resources were made freely available on the study website (<http://www.vegkit.com.au>), and usage was assessed periodically through tracking downloads of resources.

RESULTS

Part 1: Synthesis of Primary Evidence

Summary of the studies. The search identified 4,838 records after the removal of duplicates; 248 full-text articles were assessed for eligibility, most excluded on the basis of the outcome reported (i.e., vegetables intake not quantified and reported in isolation), leaving 15 studies that met all the inclusion criteria ([Appendix 4](#), available online). Three studies were rated as strong quality, 5 were rated as moderate, and 7 were rated as weak quality. Five studies were deemed effective at increasing children's vegetable intake, 7 were deemed ineffective, and 3 had mixed findings ([Appendix 5](#), available online).

The most common regions where studies were conducted were the U.S. (5 of 15 studies, 33%) and Europe (4 of 15 studies, 27%). Two studies were conducted in Australia (13%). Almost three quarters of the studies (11 of 15 studies, 73%) were RCTs, 3 (20%) were quasi-experimental, and 1 (7%) was a cohort study. The length of the studies ranged from 3 to 18 months, with active intervention delivery ranging from 1 day to 6 months. Ten studies were community based, and 5 were school-based interventions. Most interventions targeted parents and children together ($n=6$); an additional 2 included teachers as well. Only 1 intervention focused specifically on vegetables; most focused on fruit and vegetables or healthy lifestyles generally ([Appendix 5](#), available online).

The review of literature identified some consistent building blocks that were common to interventions that were effective at increasing children's vegetable intake. Although no single intervention had included all these elements, a greater understanding of the effective elements from past interventions would make a strong foundation for more effective initiatives in the future.

Effective interventions reported an average increased vegetable intake of 30% at the end of the follow-up period, which on the basis of Australian children's current consumption equates to an increase of about half a serving per day. These successful interventions had some consistent design features that were associated with increased vegetable intake (Table 1). Effective studies tended to direct the intervention message toward more than 1 target population—that is, parents and children or teachers, parents, and children—whereas ineffective studies were more likely to deliver intervention messages to only 1 target, commonly targeting children without parent involvement or parents without children's involvement. Effective studies were more likely to be between 6 and 12 weeks in length and have more frequent contact with participants, at least once per week, whereas ineffective studies were more likely to be <6 weeks and have less intensive contact with participants.

All interventions, regardless of effectiveness, targeted the psychological capability as a source of behavior in the Behavior Change Wheel (i.e., knowledge or skills), and most

targeted reflective motivation (i.e., planning and evaluating one's behaviors). The use of social opportunity (i.e., creating a culture that supports change) as a source of behavior was more common in effective studies than in ineffective studies, whereas the use of physical opportunity (i.e., environmental factors that support change) was more common in ineffective than in effective studies.

All studies also used education to increase knowledge and understanding of why eating vegetables is beneficial. Other commonly used intervention functions were training, environmental restructuring, and enablement. Environmental restructuring and enablement, referring to reducing barriers or increasing means to increase opportunity, were more commonly used in effective studies than in ineffective studies.

Goals and planning was the most common category of behavior change techniques used across all interventions. On average, effective interventions used 1 more behavior change technique than ineffective interventions. The most common categories used by effective interventions were goals and planning, shaping

Table 1. Design Features of Interventions That Were Successful at Increasing Children's Vegetable Consumption

Design feature	Description of intervention features	
Nutrition messages	Communicating a clear and consistent message about increasing vegetable consumption	
	Multiple targets	Intervention messages aimed at >1 target audience (e.g., parents and children, parents and teachers) rather than a single audience (e.g., children only)
	Consistent message	Messages were consistent and delivered across multiple settings (e.g., home and school)
Intervention design	Specific focus	Messages were specific, targeting only vegetables or fruits and vegetables rather than general healthy eating or healthy lifestyle
	Being exposed to the nutrition messages enough is important for increasing vegetable consumption	
	Length	Interventions lasted >6 weeks in duration
	Frequency	There was frequent contact with the target participant, at least once a week
Sources of behavior	Evaluation	An evaluation of the program measured the amount of vegetables consumed by children in serves (not just frequency) using a valid measurement tool to get a clear and accurate measure
	The reasons why children do not eat enough vegetables	
	Psychological capability	Lacking knowledge or skills required to eat vegetables, for example, not knowing which vegetables to put into recipes
	Social opportunity	Limited social opportunities to eat vegetables, for example, not having social cues to remind children to eat vegetables
Intervention functions	Reflective motivation	Lacking the ability to plan or evaluate situations to increase vegetable consumption
	Broad categories of ways through which interventions can change behavior	
	Environmental restructuring	Changing the physical or social environment to promote eating vegetables, for example, putting vegetables at the start of a school canteen line
	Education	Increasing the knowledge and understanding of why eating vegetables is beneficial
	Enablement	Reducing barriers that might prevent the consumption of vegetables, for example, reducing the cost of vegetables
	Training	Providing training to increase skills regarding vegetable consumption

Table 2. Behavior Change Techniques Used in Interventions That Were Successful at Increasing Children's Vegetable Consumption

Behavior change techniques	
Techniques associated with more effective intervention	Techniques around goals and planning
	Problem solving to determine the factors that influence behavior and to help identify strategies to overcome them
	Detailed planning of how to implement new behaviors in specific environments
	Ask participants to commit to changing their behaviors
	Ask participants to review and change their goals according to their progress
	Techniques focused on feedback and monitoring
	Providing participants with feedback on how frequently, how well, or for how long they have been performing the desired behavior
	Encouraging participants monitor their own behavior
	Providing feedback on the outcomes of the behavior
Techniques commonly used by interventions	Techniques around shaping knowledge
	Instructions on how to perform the behavior or demonstration of the behavior
	Understanding the consequences of behavior
	Providing information about the health benefits of changing behavior
	Understanding the social and environmental consequences of performing the behavior
	Techniques that restructure the environment in which the behavior occurs
	Changing the physical environment to support the new behavior
	Remove unwanted cues or distraction that create barriers to performing the behavior

knowledge, and natural consequences. More effective interventions used techniques from within goals and planning such as problem solving and goal setting (Table 2). Although not as commonly used, techniques from within the feedback and monitoring category, such as self-monitoring of behavior, also appeared to be associated with intervention effectiveness. The core elements identified from effective interventions formed the basis of a set of 7 best practice guidelines (Figure 1).

Part 2: Stakeholder Resources and Dissemination

The resulting user guide sets out 7 best practice guidelines for long day care that can be adopted in existing programs or used to guide development of new initiatives. The resources for primary schools and out-of-hours school care services provide management and educators with simple vegetable-based snack ideas and the support to track the implementation of new activities. Snack and meal ideas are also provided for school canteens and school food service providers. The guidelines for industry groups and growers focus on product development and marketing opportunities to increase children's vegetable intake. The guidelines have also been developed into resources to support research institutes to design and report on their interventions targeting vegetable intake in children. The guidelines for government policy makers set out the 7 best practice guidelines in a way they can be used in existing

programs or to develop future initiatives. All the guidelines and associated resources can be applied across a range of activities such as design of new nutrition policies or programs, developing evaluation and feedback plans, and identifying opportunities. The resources and tools have been made freely available at <http://www.vegkit.com.au>, and an overview is provided in Appendix 6 (available online).

As an indication of influencing practice, page views and downloads of these resources were aggregated from January 1, 2020 through April 1, 2023, and page views were aggregated through August 15, 2023 (Table 3). The dates for the reporting period differ owing to a change in website management during this period. Generally, the traffic was high to the website. The homepage and long daycare tools and resources page were the most viewed, and the summary infographic of the best practice guidelines and the 7 days of veggie snacks directed toward out-of-school hours care workers were the most downloaded resources during the reporting period. The most downloaded resources were generally the setting-specific, practical resources.

DISCUSSION

This paper is an exemplar of public health translational research describing the process of synthesizing and then transforming scientific knowledge into evidence-based



Figure 1. Evidence-based best practice guidelines for increasing children's vegetable consumption.

tools and resources to influence practice and policy. A strong foundation of scientific evidence was critical in the development of the best practice guidelines and their translation into actionable strategies for different stakeholders. By combining evidence-based strategies associated with success and highlighting the benefits of working collaboratively around a consistent message, the best practice guidelines aim to create greater and more sustained increases in children's vegetable intake. The impact of the resources developed through the process in influencing practice is demonstrated by the high website visitation and downloads reported in the first 3 years of the project.

The systematic literature review that informed the development of guidelines expanded on previous reviews to identify the design features and intervention building blocks that have been associated with successfully increasing children's intake of vegetables. The review applied the Behavior Change Wheel framework²³ to analyze published studies and describe the critical components of effective interventions. Effective interventions

were able to increase children's intake by about 30%, which equates to around half a serving of vegetables per day on the basis of current consumption. An increase of this magnitude is not enough to close the gap between intake and recommendations; however, it is still meaningful, particularly if it could be achieved population wide. We also note that smaller incremental changes could also achieve a meaningful change³¹ if sustained over the longer term and that changes to other areas of children's diets may have flow on effects to improve vegetable intake as well. Translational research aims to translate the best available knowledge and make it useful.³² In this case, the process of translating key research findings into best practice guidelines, accompanied by purposefully designed resources, has the potential to maximize the benefits for the population²⁴ through the collective efforts of a range of stakeholders to implement evidenced informed initiatives.

Changing dietary intake is difficult as eating behaviors tend to be entrenched in a lifestyle pattern, within a multilayer ecosystem that influences what, when, and how

Table 3. Monitoring of Uptake: Most Viewed and Downloaded Resources on the Project Website

Resources	Number of views or downloads
Most viewed website pages from January 1, 2020 to August 15, 2023	
Homepage	23,633
Long day care: tools and resources	18,674
OSHC and schools: tools and resources	5,250
Community and public health: tools and resources	3,518
OSHC and schools: landing page	2,611
Vegetable intake strategic alliance	2,337
Long day care: landing page	1,842
Vegkit – broader project page	1,700
Community and public health: landing page	1,391
Vegetable registry – find vegetable initiatives	1,327
Most downloaded resources from January 1, 2020 to April 1, 2023	
OSHC and schools: 7 days of veggie snacks	1,473
General infographic: best practice guidelines for increasing children’s vegetable intake	1,447
Long day care: sample quality improvement plan	749
Long day care: checklist of simple ideas that work in long day care	745
Long day care: guidelines for increasing children’s vegetable intake	738
Best practice guidelines for increasing children’s vegetable intake	680
Community public health infographic: feeding advice to support young children to learn to eat and enjoy vegetables	444
Public health evidence brief: boosting children’s vegetable intake	263
OSHC: checklist of simple ideas that work in OSHC	205
Public health evidence summary for health practitioners	204
OSHC: best practice guidelines for increasing children’s vegetable intake	203
Schools: checklist of simple ideas that work in schools	86

OSHC, out of school hours care.

much is consumed.^{33,34} The Behavior Change Wheel is a framework designed to unpack behavior change in terms of what is needed to disrupt current habits,²³ and its application in this way to interventions designed to increase children’s vegetable intake is novel. One layer of this ecosystem that interventions must address is why children do not eat enough vegetables in relation to psychological capability (i.e., knowledge), social opportunity, and reflective motivation. Knowledge and motivation are commonly addressed in interventions, but also addressing social opportunities may be a key to success. Social opportunity relates to the cues to remind and support children to eat vegetables more often. This would facilitate greater exposure to vegetables, and evidence suggests that this would lead to greater acceptance.³⁵ Interventions that tried to change the physical or social environments to actively promote vegetable consumption and reduce the barriers that might prevent or inhibit children eating more vegetables appeared most successful.

Behavior change techniques are the core intervention components designed to actively change behavior. It is difficult to untangle the synergistic impacts of multiple techniques, but an emphasis on techniques in goals and planning

and feedback and monitoring appears to be important for success in relation to eating more vegetables. Similar findings have been reported for general healthy eating³⁶ and other health behaviors.^{36,37} The techniques within goals and planning included problem solving with children or their parents to determine the factors that influence what they eat and help to identify strategies to overcome any factors limiting their vegetable intake. It also seems important to include detailed planning of how to implement new behaviors in specific environments and, importantly, review and change goals according to their progress. Effective interventions also directed some of their focus toward providing feedback to participants about how frequently, how well, or for how long they have or have not been achieving the target behavior; they encouraged participants to monitor their own behavior and provided feedback on the outcomes of the behavior.

Parents are a key stakeholder in children’s intake,³⁸ and the home is a primary setting in which children spend time and eat meals. Recently, it was estimated that almost 65% of young Australian children’s vegetable intake is at dinner, a meal that children usually consume at home.³⁹ The authors suggest that families be included in multisetting programs because the scientific evidence

suggests that targeting >1 group (parents and children or teachers, parents, and children) was a key to success. The translation process reported in this study engaged with multiple stakeholders, consistent with other reviews²² and whole-of-community approaches that have been adopted in obesity prevention programs.^{40–42} Similarly, schools in the United Kingdom are taking a whole-of-school approach to children's wellbeing.⁴³ This again links back to consistency of messages across settings, another key finding of this study.

Limitations

This review built on previous reviews to understand the success factors associated with increasing children's vegetable intake. The review was limited to more recently published studies and those published in English. The use of the Behavioral Change Wheel components is a useful approach to consistently capture and describe techniques employed in interventions of different designs, delivered across various settings. However, the taxonomy may obscure some of the intervention details that could provide useful insights for future interventions. By breaking down the intervention, it fails to present the intervention as whole, and it is also likely that the interaction between the techniques is an important part of their success, but this is difficult to ascertain. One other important aspect to understand is the time course of interventions. Some deliver all the content at the start of the intervention, whereas others tended to drip feed information over an extended period. Again, it is a challenge to determine time course from published literature, and it is difficult to know what works best in terms of time course. Further to this, a greater understanding of how to effectively scale successful interventions is also needed.

This evidenced-based translation process was part of a larger project (www.vegkit.com.au) and benefitted from a range of activities, including a stakeholder alliance, media releases, and website that facilitated dissemination. Owing to a change in website management, unfortunately, 4 months of downloaded data were missing. However, downloaded data would suggest that interest in the material developed was high. Although downloads were high (e.g., some out-of-school hours care materials could have reached 18% of Australian primary schools⁴⁴), it is unknown whether and how the recommendations were implemented in practice. More research is needed to explore how such evidence-based resources change practice and have an impact in increasing the intended behavior—in this case, increasing children's vegetable intake.

Implications for Research and Practice

A greater understanding of the intervention building blocks associated with success is important so that newly

designed interventions can be more effective in increasing consumption or that a greater number of interventions are effective in changing behavior. One way to achieve this might be to combine all the components from effective studies together into 1 intervention on the basis of best practice as a recipe for achieving greater behavior change. However, because no published studies identified from the review had done this, the impact of an intervention designed in this way is unknown. It is also possible that the characteristics of effective interventions are different for children of different ages, but this needs to be explored further.

CONCLUSIONS

Children's vegetable intake is below recommended levels, and increasing consumption remains a strong focus for health, nutrition, and obesity prevention initiatives. Multiaudience, multisetting, multitouchpoint interventions with a strong focus on planning, environmental restructuring, barrier reduction, feedback, and monitoring are likely needed to deliver meaningful increases in children's vegetable intake. The unique process described in this study shows how the scientific evidence can be translated into tools and resources to influence practice and policy. The resources have been made available online, and their uptake is monitored through website visitation and download of materials. However, the ultimate goal is that processes such as this lead to the design and delivery of interventions that are effective. Therefore, the process described in this study could be applied to other public health concerns requiring behavior change. Further research to monitor and evaluate the reach and impact of guideline dissemination will also be important to understand the success of this research.

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SUPPLEMENTARY MATERIALS

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REFERENCES

- World Health Organization (WHO). Increasing fruit and vegetable consumption to reduce the risk of noncommunicable diseases. Geneva, Switzerland: WHO; 2019. <https://www.who.int/tools/elena/bbc/fruit-vegetables-ncds>. Published 2019. Accessed October 9.
- Maynard M, Gunnell D, Ness AR, Abraham L, Bates CJ, Blane D. What influences diet in early old age? Prospective and cross-sectional analyses of the Boyd Orr cohort. *Eur J Public Health*. 2006;16(3):316–324. <https://doi.org/10.1093/eurpub/cki167>.
- Mihrshahi S, Myton R, Partridge SR, Esdaile E, Hardy LL, Gale J. Sustained low consumption of fruit and vegetables in Australian children: findings from the Australian National Health Surveys. *Health Promot J Austr*. 2019;30(1):83–87. <https://doi.org/10.1002/hpja.201>.
- Australian health survey: consumption of food groups from the Australian dietary guidelines 2011–12. Australian Bureau of Statistics. <https://www.abs.gov.au/ausstats/abs@.nsf/PrimaryMainFeatures/4364.0.55.012>. Updated June 6, 2018. Accessed March 4, 2019.
- Moore LV, Thompson FE, Demissie Z. Percentage of youth meeting federal fruit and vegetable intake recommendations, Youth Risk Behavior Surveillance System, United States and 33 States, 2013. *J Acad Nutr Diet*. 2017;117(4):545–553.e3. <https://doi.org/10.1016/j.jand.2016.10.012>.
- NatCen social research, Health Survey for England 2017 Children's Health, 2018, UCL. <https://digital.nhs.uk/data-and-information/publications/statistical/health-survey-for-england/2017>. Accessed Dec 10, 2022.
- Eat for Health. Australian dietary guidelines 1-5. Department of Health and Ageing, Australian Government. <https://www.eatforhealth.gov.au/guidelines/australian-dietary-guidelines-1-5>. Accessed November 15, 2019.
- World Health Organization (WHO). Fact sheet: healthy diet. Geneva, Switzerland: WHO; 2020. <https://www.who.int/news-room/fact-sheets/detail/healthy-diet>. Published/Accessed 11 June 2021.
- Civic creative. *Health Claims in Food Advertising*. Sydney, NSW, Australia; 2015. <https://ausveg.com.au/app/data/technical-insights/docs/VG14035.PDF>. Accessed March 15, 2023.
- Woolcott Research, Evaluation of the National Go for 2&5 Campaign, 2007. Accessed 15 March, 2023.
- Rekhy R, McConchie R. Promoting consumption of fruit and vegetables for better health. Have campaigns delivered on the goals? *Appetite*. 2014;79:113–123. <https://doi.org/10.1016/j.appet.2014.04.012>.
- Cancer Council Western Australia. Crunch&Sip. <https://www.crunchandsip.com.au/>. Accessed February 4, 2020.
- Munch & move. Healthy kids. <https://www.healthykids.nsw.gov.au/campaigns-programs/about-munch-move.aspx>. Accessed February 4, 2020.
- Refresh, ed.I. Department of Health. <https://www.refreshedschools.health.wa.gov.au/>. Accessed February 4, 2020.
- Move Well Eat Well. Department of Health and Human Services. <https://www.dhhs.tas.gov.au/mwew>. Accessed February 4, 2020.
- Hardy LL, King L, Kelly B, Farrell L, Howlett S. Munch and Move: evaluation of a preschool healthy eating and movement skill program. *Int J Behav Nutr Phys Act*. 2010;7(1):80. <https://doi.org/10.1186/1479-5868-7-80>.
- Micha R, Karageorgou D, Bakogianni I, et al. Effectiveness of school food environment policies on children's dietary behaviors: a systematic review and meta-analysis. *PLOS ONE*. 2018;13(3):e0194555. <https://doi.org/10.1371/journal.pone.0194555>.
- Hendrie GA, Lease HJ, Bowen J, Baird DL, Cox DN. Strategies to increase children's vegetable intake in home and community settings: a systematic review of literature. *Matern Child Nutr*. 2017;13(1):e12276. <https://doi.org/10.1111/mcn.12276>.
- Hodder RK, Stacey FG, O'Brien KM, et al. Interventions for increasing fruit and vegetable consumption in children aged five years and under. *Cochrane Database Syst Rev*. 2018;1(1):CD008552. <https://doi.org/10.1002/14651858.CD008552.pub7>.
- Nekitsing C, Blundell-Birtill P, Cockcroft JE, Hetherington MM. Systematic review and meta-analysis of strategies to increase vegetable consumption in preschool children aged 2–5 years. *Appetite*. 2018;127:138–154. <https://doi.org/10.1016/j.appet.2018.04.019>.
- Bell LK, Gardner C, Tian EJ, et al. Supporting strategies for enhancing vegetable liking in the early years of life: an umbrella review of systematic reviews. *Am J Clin Nutr*. 2021;113(5):1282–1300. <https://doi.org/10.1093/ajcn/nqaa384>.
- Downs S, Demmler KM. Food environment interventions targeting children and adolescents: a scoping review. *Glob Food Sec*. 2020;27:100403. <https://doi.org/10.1016/j.gfs.2020.100403>.
- Michie S, Atkins L, West R. *The Behaviour Change Wheel: A Guide to Designing Interventions*. Sutton, United Kingdom: Silverback Publishing; 2014. <https://www.behaviourchangewheel.com/>. Accessed April 29, 2024.
- Olgilvie D, Craig P, Griffin S, Macintyre S, Wareham NJ. A translational framework for public health research. *BMC Public Health*. 2009;9:116. <https://doi.org/10.1186/1471-2458-9-116>.
- Covidence- Better. *Systematic Review Management [computer program]*; covidence.org.
- Effective Public Health Practice Project. McMaster University. <https://merst.ca/ephpp/>. Accessed March 8, 2019.
- Vargas-Garcia EJ, Evans CEL, Prestwich A, Sykes-Muskett BJ, Hooson J, Cade JE. Interventions to reduce consumption of sugar-sweetened beverages or increase water intake: evidence from a systematic review and meta-analysis. *Obes Rev*. 2017;18(11):1350–1363. <https://doi.org/10.1111/obr.12580>.
- Golley RK, Hendrie GA, Slater A, Corsini N. Interventions that involve parents to improve children's weight-related nutrition intake and activity patterns – what nutrition and activity targets and behaviour change techniques are associated with intervention effectiveness? *Obes Rev*. 2011;12(2):114–130. <https://doi.org/10.1111/j.1467-789X.2010.00745.x>.
- van der Kruk JJ, Kortekaas F, Lucas C, Jager-Wittenaar H. Obesity: a systematic review on parental involvement in long-term European childhood weight control interventions with a nutritional focus. *Obes Rev*. 2013;14(9):745–760. <https://doi.org/10.1111/obr.12046>.
- Koplan JP, Liverman CT, Kraak VI. Committee on Prevention of Obesity in Children and Youth. Preventing childhood obesity: health in the balance: executive summary. *J Am Diet Assoc*. 2005;105(1):131–138. <https://doi.org/10.1016/j.jada.2004.11.023>.
- Arno A, Thomas S. The efficacy of nudge theory strategies in influencing adult dietary behaviour: a systematic review and meta-analysis. *BMC Public Health*. 2016;16:676. <https://doi.org/10.1186/s12889-016-3272-x>.

32. Narayan KM, Gregg EW, Engelgau MM, et al. Translation research for chronic disease: the case of diabetes. *Diabetes Care*. 2000;23(12):1794–1798. <https://doi.org/10.2337/diacare.23.12.1794>.
33. Story M, Kaphingst KM, Robinson-O'Brien R, Glanz K. Creating healthy food and eating environments: policy and environmental approaches. *Annu Rev Public Health*. 2008;29:253–272. <https://doi.org/10.1146/annurev.publhealth.29.020907.090926>.
34. Chen PJ, Antonelli M. Conceptual models of food choice: influential Factors Related to Foods, Individual Differences, and Society. *Foods*. 2020;9(12):1898. <https://doi.org/10.3390/foods9121898>.
35. Cox DN, Campbell KJ, Cobiac L, et al. Working together to increase Australian children's liking of vegetables: a Position Statement by the Vegetable Intake Strategic Alliance (VISA). *Public Health Nutr*. 2023;26(11):2271–2275. <https://doi.org/10.1017/S1368980023001398>.
36. Michie S, Abraham C, Whittington C, McAteer J, Gupta S. Effective techniques in healthy eating and physical activity interventions: a meta-regression. *Health Psychol*. 2009;28(6):690–701. <https://doi.org/10.1037/a0016136>.
37. Sherrington A, Newham JJ, Bell R, Adamson A, McColl E, Araujo-Soares V. Systematic review and meta-analysis of internet-delivered interventions providing personalized feedback for weight loss in overweight and obese adults. *Obes Rev*. 2016;17(6):541–551. <https://doi.org/10.1111/obr.12396>.
38. Skouteris H, McCabe M, Swinburn B, Newgreen V, Sacher P, Chadwick P. Parental influence and obesity prevention in pre-schoolers: a systematic review of interventions. *Obes Rev*. 2011;12(5):315–328. <https://doi.org/10.1111/j.1467-789X.2010.00751.x>.
39. Rebuli MA, Williams G, James-Martin G, Hendrie GA. Food group intake at self-reported eating occasions across the day: secondary analysis of the Australian National Nutrition survey 2011–2012. *Public Health Nutr*. 2020;23(17):3067–3080. <https://doi.org/10.1017/S1368980020001585>.
40. SA health. OPAL. Government of South Australia. <https://www.sahealth.sa.gov.au/wps/wcm/connect/public+content/sa+health+internet/healthy+living/healthy+communities/local+community/opal/opal>. Updated April 2, 2022. Accessed February 25, 2020.
41. SA Health. *Eat Well Be Active Strategy 2011–16*. <https://catalogue.nla.gov.au/catalog/5716871>. Accessed February 25, 2020.
42. Bell L, Ullah S, Leslie E, et al. Changes in weight status, quality of life and behaviours of South Australian primary school children: results from the Obesity Prevention and Lifestyle (OPAL) community intervention program. *BMC Public Health*. 2019;19(1):1338. <https://doi.org/10.1186/s12889-019-7710-4>.
43. Healthy Schools Healthier Living & Learning. *Guidance for Schools on Developing Emotional Health and Wellbeing*. <https://www.london.gov.uk/what-we-do/health/healthy-schools-london/awards/sites/default/files/EHWPB.pdf>. Accessed February 25, 2020.
44. School numbers. Australian Curriculum Assessment and Reporting Authority (ACARA). <https://www.acara.edu.au/reporting/national-report-on-schooling-in-australia/school-numbers#:~:text=In%20Australia%20in%202022%3A,and%205.4%25%20were%20special%20schools>. Accessed August 15, 2023.