



NOVA

University of Newcastle Research Online

nova.newcastle.edu.au

Nathan, N., Wiggers, J. Wyse, R. et al. Factors associated with the implementation of a vegetable and fruit program in a population of Australian elementary schools. *Health Education Research*, Vol. 32, Issue 2, Pages 197-205 (2017)

Available from: <https://doi.org/10.1093/her/cyx038>

This is a pre-copyedited, author-produced version of an article accepted for publication in the journal of *Health Education Research* following peer review. The version of record N. Nathan, J. Wiggers, R. Wyse, C. M. Williams, R. Sutherland, S. L. Yoong, C. Lecathelinis, L. Wolfenden; Factors associated with the implementation of a vegetable and fruit program in a population of Australian elementary schools, *Health Education Research*, Volume 32, Issue 2, 1 April 2017, Pages 197–205, is available online at: <https://doi.org/10.1093/her/cyx038>

Accessed from: <http://hdl.handle.net/1959.13/1389784>

1 **Title:**

2 Factors associated with the implementation of a vegetable and fruit program in a population
3 of Australian elementary schools.

4
5 **Authors:**

6 Nathan N^{*1,2,3,4}, Wiggers J^{1,2,3,4}, Wyse R^{1,2,3,4}, Williams C.M^{1,2,3,4}, Sutherland R^{1,2,3,4}, Yoong
7 SL^{1,2,3,4}, Lecathelinais C¹, Wolfenden L^{1,2,3,4}

- 8
9 1. Hunter New England Population Health, Hunter New England Area Health Service,
10 Newcastle; Locked Bag No. 10 Wallsend NSW 2287 Australia
11 2. School of Medicine and Public Health, The University of Newcastle, Newcastle NSW
12 2308, Australia
13 3. Priority Research Centre for Health Behaviour, The University of Newcastle, Newcastle
14 NSW 2308, Australia
15 4. Hunter Medical Research Institute, Newcastle NSW 2300, Australia

16
17 **Running title:**

18 Implementation of a vegetable and fruit program

19
20 **Corresponding author**

21 Nicole Nathan, Program Manager, Hunter New England Population Health Locked Bag No.
22 10, Wallsend NSW 2287, AUSTRALIA. Tel: +61 2 49246 257 Fax: +61 2 4924 6209 Email:
23 Nicole.Nathan@hnehealth.nsw.gov.au

24
25 **Key words**

26 Schools, implementation, vegetables, fruit, theoretical framework

27
28 **Word count: 3422**

29

30 **ABSTRACT**

31

32 Implementation of vegetable and fruit programs in schools is less than optimal. This study
33 aimed to identify, using a theoretical framework, factors associated with implementation of a
34 school vegetable and fruit program; that provides a time in class for children to consume a
35 piece of vegetable or fruit they have brought from home. Three hundred and three randomly
36 selected school principals across the state of New South Wales, Australia responded to a 25-
37 minute telephone survey. Principals were asked if their school had implemented a vegetable
38 and fruit program, and which of 12 factors from Damschroder's Consolidated Framework for
39 Implementation Research had facilitated or impeded implementation. Multiple logistic
40 regression models examined the association between such factors and program
41 implementation. Seventy-eight per cent of schools had a vegetable and fruit program. Schools
42 were significantly more likely to implement the program if the principal believed that: the
43 program was effective (OR 2.97; $p < 0.02$); they had sufficient resources to implement the
44 program (OR=4.22; $p < 0.0001$); the program would not be difficult to implement (OR=10.16;
45 $p < 0.0001$); and that the program was as important as other school priorities (OR=2.45;
46 $p < 0.02$). Realising the intended benefits of vegetable and fruit programs requires widespread
47 implementation by schools. Consideration of principal beliefs about the program
48 effectiveness, resources, difficulty and relative importance in program implementation
49 strategies appear key to increasing program implementation.

50 **INTRODUCTION.**

51 Internationally, most children fail to consume adequate quantities of vegetables and fruit [1].
52 For example studies in the United States [2], United Kingdom [3] and Australia [4] have
53 found that between 70-80% of children aged 5-18 years do not eat the recommended serves
54 of vegetables (that is between 2½-5 serves) or fruit (that is between 1-2 serves). Adequate
55 childhood consumption of vegetables and fruit is essential for healthy growth and
56 development [5] and is hypothesized to protect against infections [6] and respiratory illnesses
57 [7]. Furthermore, dietary habits established in childhood track into adulthood [8] reducing the
58 risk of future obesity and chronic disease [1]. Accordingly, the implementation of population-
59 based initiatives such as supportive environments, policies or programmes that increase
60 vegetable and fruit intake by children is a recognised public health priority [9].

61
62 Schools represent an appropriate setting to increase children's intake of vegetables and fruit
63 as they provide almost universal access to children over an extended period of time [10], and
64 are recommended settings to address the health and well-being of children [11]. Interventions
65 in this setting have been found to modestly improve student consumption of vegetables and
66 fruit [1]. While school-based vegetable and fruit initiatives have been conducted in a number
67 of countries including the United States [12], United Kingdom [13], Norway [14], New
68 Zealand [15], where governments have provided free or subsidised vegetables and fruit to
69 children, and Australia [16], where children are encouraged to bring vegetables and fruit from
70 home to consume in class, implementation of such initiatives by schools is less than optimal,
71 and has been suggested in some studies to vary according to school size, rurality and level of
72 disadvantage [17]. For example, after more than a decade only 57% of eligible Norwegian
73 elementary schools are reportedly registered for the subsidised fruit scheme [14], and with
74 only 30% of children participating in the scheme [18]. In 2010 a representative random

75 sample of over 600 elementary schools in the United States found that only 25% of public
76 elementary schools were participating in a program that provided reimbursement to lower
77 socio-economic schools offering fresh vegetables and fruit to students during the school day
78 [12]. Similarly, a 2010 study found that only 40% of Australian elementary schools were
79 implementing, to the recommended level (that is in at least 80% of classes every school day),
80 a government endorsed program that promoted children's consumption of a piece of
81 vegetable or fruit, that they have brought from home, during class time [17].

82

83 For the potential public health benefits of school vegetable and fruit programs to be realised,
84 implementation across the population of schools is necessary. Theoretical frameworks
85 suggest that there is a need to consider a range of factors that may support or impede the
86 implementation of programs in community settings if program implementation is to be
87 maximised [19]. The Consolidated Framework for Implementation Research (CFIR)
88 developed by Damschroder et al [20] is one such framework which provides a comprehensive
89 taxonomy of constructs from multiple disciplines including psychology and organizational
90 change that have been reported to influence program implementation. The CFIR constructs
91 identifies 37 constructs, grouped into five domains which include: intervention characteristics
92 (e.g. cost, perceived complexity, ease of implementation); outer setting factors (e.g. external
93 policies, and peer behaviour), inner setting factors (e.g. alignment with organisational values,
94 and access to information and support); characteristics of the individuals involved (e.g. their
95 knowledge, attitudes and self-efficacy); and the process of implementation (e.g. planning).

96

97 A limited number of primary research studies have comprehensively evaluated the factors
98 associated with schools' implementation of vegetable and fruit programs. One study of a
99 vegetable and fruit intervention implemented in Danish secondary schools [21] found that

100 those schools that had a food policy and that had teachers and students who valued the
101 program had higher rates of implementation than those without such characteristics.
102 Conversely, a study within Australian elementary schools found no association between a
103 school having a written school policy and implementation of a vegetable and fruit program
104 [17]. However, the study found a significant association between program implementation
105 and having teachers trained in delivery of the program. The CATCH Eat Smart School
106 Nutrition Program conducted in The United States, that sought to improve the preparation,
107 production and promotion of elementary schools food service through the implementation of
108 East Smart guidelines, found that the percentage of guidelines implemented was not
109 associated with the number of training sessions school food service staff had attended, but
110 was associated with their perceived utility and satisfaction with program guidelines [22].
111 Furthermore, other studies have identified that the uptake of school vegetable and fruit
112 programs is associated with other school characteristics, such as number of students and
113 socio-economic and geographic characteristics. For example the 2015 study by Aarestrup et
114 al [21] which examined the implementation of the Boost trial in 20 Danish schools, found
115 that smaller schools, with fewer families of lower socio-economic background were more
116 likely to consistently deliver the intervention at a high level. Similarly, the 2011 study by
117 Nathan et al [17], which surveyed 384 Australian elementary school principals found that
118 small schools, rural schools and schools from lower socio-economic areas were more likely
119 to implement the recommended vegetable and fruit program. Despite providing an indication
120 of the association between some school characteristics and school implementation of
121 vegetable and fruit programs, no single study has reported on such associations across a
122 broad range of characteristics. In the absence of such information it limits the development of
123 interventions to maximise school implementation of such programs and subsequently our
124 understanding of how successful interventions achieve their impact.

125 To address this evidence gap, a study was undertaken to determine the factors associated with
126 the implementation of a vegetable and fruit program in Australian schools, using a
127 comprehensive implementation theoretical framework. The study further sought to identify if
128 school characteristics such as size, rurality and level of disadvantage was associated with
129 these factors.

130

131 **Policy context**

132 In 2005, the Australian Government recommended all elementary schools provide a time in
133 class for children to consume a piece of vegetable or fruit that they have brought from home.
134 A program, *Crunch&Sip*® was made available to facilitate the implementation of such a
135 vegetable and fruit break [16]. *Crunch&Sip*® encouraged schools to develop a school policy
136 regarding the implementation of a vegetable and fruit break in class time; the implementation
137 of such breaks; teaching and learning materials to reinforce related nutrition messages; and
138 promotion of the program to teachers, students and parents. Since 2007 the New South Wales
139 state government encouraged school implementation of *Crunch&Sip*® and offered, through a
140 nongovernment organization [24] access to information-based support via a website and
141 newsletters [23]. In 2010, the state government established the Healthy Children’s initiative,
142 to support schools to implement policies and programs to promote both healthy eating and
143 physical activity, *Crunch&Sip*® being one of these programs, and developed formal
144 implementation performance targets and monitoring systems for each [24].

145

146 **METHODS**

147

148 **Ethical approval**

149 Approval to conduct this study was obtained from Hunter New England (HNE) Local Health
150 District Human Research Ethics Committee (no. 06/07/26/4.04), and relevant school ethics
151 committees.

152

153 **Design and setting**

154 A cross sectional survey of elementary schools was conducted across the state of New South
155 Wales (NSW), Australia. NSW has a population of approximately 863,000 children aged
156 between 5 and 14 years and over 2200 elementary and central schools [25].

157

158 **Participants and recruitment**

159 A database of all NSW Government and non-Government (Catholic and Independent)
160 elementary schools (that is those that cater for children aged five to twelve years of age) and
161 central schools (that is those that cater for children aged five to eighteen years of age)
162 (hereafter referred to as ‘elementary schools’) was generated from school lists provided on
163 the websites of the Department of Education, the Catholic Education Commission and the
164 Association of Independent schools. Special purpose schools (such as juvenile justice
165 schools, hospital schools or school serving students with special needs) were excluded. From
166 this database, a representative random sample of 476 (approximately 20%) eligible schools,
167 stratified by school type and location, was drawn. Principals of schools within the sample
168 were sent an information letter inviting them to participate in the study. Two weeks following
169 mailing of the invitation, principals were telephoned by a trained research assistant, who
170 confirmed school eligibility and sought participant consent.

171

172 **Data collection**

173 A 25-min Computer-Assisted Telephone Interview was conducted with consenting principals
174 or their nominated delegate (hereafter referred to as principals). The survey was conducted
175 from March to August 2014. Principals from central schools were asked to report on
176 activities relevant to elementary school age classes (5–12 years) only.

177

178 **Measures**

179 Principals were asked a range of questions regarding the characteristics of their school and to
180 assess the level of implementation of the vegetable and fruit program in their school and the
181 factors associated with implementation of the vegetable and fruit program. Specifically this
182 included;

183

184 *School and principal characteristics*

185 During the telephone interview, principals were asked to report the number of students
186 attending the school and to provide some demographic data including their role in the school,
187 how long they have been in that role and their years of teaching experience. School type
188 (Government, non-Government Catholic or non-Government Independent) and the postcode
189 of the locality of the school were obtained from school websites.

190

191 *School implementation of a vegetable and fruit program*

192 Implementation of a vegetable and fruit break in class time was used as the measure of
193 program implementation. Using a validated measure [26], principals were asked to report if
194 their school had implemented specific breaks to allow children to eat vegetables or fruit
195 during class time ('yes - all classes', 'yes - some classes', 'no classes', 'don't know').

196 Principals who reported that 'yes - some classes' at their school had a vegetable and fruit

197 break were then asked to estimate the percentage of classes that had such breaks. Principals

198 were also asked to indicate the number of days per week such breaks were usually
199 implemented. Consistent with criteria indicated in the *Crunch&Sip*® program [27], schools
200 were classified as implementing the vegetable and fruit program if they indicated having a
201 vegetable and fruit break in at least 80% of classes every school day.

202

203 *Factors associated with school implementation of the Crunch&Sip*® program

204 To identify the factors associated with implementation of a vegetable and fruit program,
205 survey items were developed based upon the Consolidated Framework for Implementation
206 Research (CFIR) by Damschroder et al [20]. The CFIR recommends that only constructs
207 relevant to the study context, intervention and setting be used [20]. For the current study,
208 twelve survey items were developed to measure the constructs that could either promote or
209 impede the implementation of a vegetable and fruit program (Table 2). All principals were
210 read a description of the *Crunch&Sip*® program and, consistent with scales used to assess the
211 significance of a CFIR domain on implementation, asked the extent to which they agreed
212 with each of the 12 statements regarding its implementation in their school (on a 5-point
213 Likert scale strongly agree - strongly disagree) (Table 2).

214

215 **Analyses**

216 All analyses were conducted using the statistical package SAS Version 9.2 (SAS Institute
217 Inc., Cary, NC, USA). Descriptive statistics were used to describe school and principal
218 characteristics. Schools were dichotomised based on school type: Government or non-
219 Government (Catholic and Independent) schools. The reported number of enrolled students in
220 each school was used to categorise schools as: ‘small schools’ (1–159 students); ‘medium
221 schools’ (160–450 students) or ‘large schools’ (451+ students). School postcodes were also
222 used to categorise the school’s locality as either ‘rural’ (those schools in outer regional,

223 remote and very remote areas) or ‘urban’ (those in regional cities and inner regional areas)
224 based upon the Accessibility/Remoteness Index of Australia (ARIA) [28]. Schools with
225 postcodes ranked in the top 50% of NSW postcodes based on the Socio-Economic Indexes
226 For Areas (SEIFA) [29] Index of Relative Socio-economic were categorised as schools in
227 ‘higher socio-economic areas’, while those in the lower 50% were categorized as schools in
228 ‘lower socio-economic areas’.

229

230 Whilst the use of the 5-point likert scale was intended to assess the significance of a CFIR
231 domain on implementation, for ease of interpretation of logistic regression results responses
232 to the items regarding principal agreement with each of the implementation factors were
233 collapsed into two groups; ‘Agree’ (strongly agree, agree) and ‘Disagree’ (neutral, disagree,
234 strongly disagree). Three survey items were reverse coded (i.e. phrased in the semantically
235 opposite direction). For the purposes of analysis and interpretation, these were converted to
236 the same format as the other questions, where agreement with the statement was considered
237 to facilitate implementation. Separate logistic regression analyses were initially performed to
238 examine univariate associations between each of the 12 implementation factors (independent
239 variables) and principal report of whether the school had implemented a vegetable and fruit
240 break (dependent variable), with schools not having implemented such a break being the
241 reference group. Implementation factors that were shown to be associated in such analyses
242 (p-value < 0.25) were subsequently included in a backwards multiple logistic regression
243 model to examine which implementation factors were independently associated with school
244 implementation of a vegetable and fruit break, controlling for school characteristics (school
245 size, rurality or level of disadvantage). An interaction term was included for each
246 implementation factor and each school characteristic.

247

248 **RESULTS**

249

250 **Sample and school characteristics**

251 Of the 476 schools invited to participate in the survey, 17 could not be contacted (3.6%), 156
252 refused to participate (32.7%), and 303 (63.7%) participated in the survey. Characteristics of
253 participating schools are shown in Table 1. Of the survey participants, most (76%) were
254 Principals, with 6% Acting Principals and 6% Deputy or Assistant Principals, with an
255 average of 299 months (SD = 114 months) teaching experience, and an average of 54 months
256 (SD = 54 months) experience in their current role. Survey participants were significantly
257 more likely than non-participants to come from Government schools (79% vs 63%, $p < 0.01$),
258 rural schools (31% vs 16%, $p < 0.01$) and schools in lower socio-economic areas (66% vs
259 50%, $p < 0.01$).

260

261 **INSERT TABLE 1 HERE**

262

263 *School implementation of a vegetable and fruit break*

264 Seventy-eight percent of schools reported that they were implementing a vegetable and fruit
265 break on 5 days per week in at least 80% of classes.

266

267 *Factors associated with school implementation of vegetable and fruit break.*

268 Univariate regression analyses found that all implementation factors were associated with the
269 implementation of a vegetable and fruit break (Table 2). The multiple logistic regression
270 analysis showed that, four of the twelve-implementation factors were significantly associated
271 with the implementation of a vegetable and fruit program (Table 2). Principals who agreed
272 that: there is evidence that the Crunch&Sip® program increases student consumption of

273 vegetables and fruit (OR=2.97; 95% CI 1.27- 6.97; $p= 0.0121$); their school had sufficient
274 resources to implement the Crunch&Sip® program (e.g. money, time) (OR=4.22; 95% CI
275 1.81- 9.85; $p=0.0009$) were significantly more likely to have implemented a vegetable and
276 fruit break. Principals who agreed that the Crunch&Sip® program would be difficult for
277 schools to implement (OR=10.16; 95% CI 4.38- 23.54; $p<.0001$), or who agreed that
278 implementing the Crunch&Sip® program is far less important than other priorities within the
279 school (OR=2.45; 95% CI 1.21- 4.95; $p=0.0129$) were significantly less likely to be
280 implementing a vegetable and fruit program. No significant interactions ($p< 0 .01$) were
281 found between implementation factors and school characteristics (size, rurality, or level of
282 disadvantage).

283

284

INSERT TABLE 2 HERE

285

286 **DISCUSSION**

287 Using the Consolidated Framework for Implementation Research (CFIR) this study sought to
288 identify the independent associations between a range of constructs and schools’
289 implementation of a vegetable and fruit program in Australian elementary schools.
290 Independent associations were observed between the implementation of the vegetable and
291 fruit program and four implementation factors: strength of evidence; complexity; relative
292 priority and available resources. The observed associations did not differ according to school
293 size, rurality or level of disadvantage.

294

295 No previous studies have used a theoretical framework to comprehensively examine the
296 association between a range of theoretically determined implementation factors and schools’
297 implementation of a vegetable and fruit program. Nonetheless, the findings of this study are

298 consistent with other studies of school nutrition programs, which have highlighted the
299 importance of minimising program complexity [30, 31]. The CFIR suggests that the
300 perceived “complexity” of an initiative, which includes; the range and number of tasks, the
301 time to do the tasks and the degree to which the task is a departure from routine practice
302 contributes to the likelihood of implementation. Given schools routinely report a “crowded
303 curriculum” as a barrier to implementing health promotion programs [17], developing an
304 intervention that is simple, well-defined and that can be embedded into routine school
305 practice is recommended in order to facilitate implementation in this setting.

306

307 However, unlike other studies [32-34], which suggest program costs and adaptability are
308 important factors for consideration when implementing school nutrition programs these
309 factors were not identified as significant factors influencing program implementation in this
310 study. Furthermore, these findings are not consistent with a study of 215 Australian childcare
311 managers which, using the CFIR, found that readily available external support was
312 significantly associated with implementation of healthy eating and physical activity policies
313 and practices in early childcare services. The inconsistency of the findings across studies may
314 reflect differing jurisdictional, setting or program contextual issues, which have been
315 suggested to influence program implementation [35].

316

317 The findings that the implementation of the vegetable and fruit break was associated with
318 principal’s perception that the program is evidence based and relevant to the school priorities
319 highlights the importance of communicating the benefits and relevance of school vegetable
320 and fruit programs to school principals and staff. According to the CFIR stakeholders’
321 opinion of the quality or validity of the strength of evidence can be influenced by published
322 literature, data from pilot studies and anecdotal stories from colleagues. Using relevant school

323 education departments or opinion leaders [26, 34] or training [22] may represent strategies for
324 addressing these determinants. Engagement of school staff during program development is
325 suggested to be particularly important in ensuring that a program is aligned with school
326 priorities [34]. Previous research suggests that such engagement with end-users is not
327 widespread in the development and reporting of child obesity prevention programs generally
328 [36] thereby limiting the intended benefits of programs for children.

329

330 This study found principal's reported commitment of school resources was associated with
331 program implementation. As inadequate resources are commonly reported as a barrier to
332 school implementation of health promotion initiatives [37], strategies to secure principals'
333 commitment of time, resources or personnel may need to be considered during initial
334 engagement discussions with schools. Memorandums of understandings or integration of
335 programs into school management plans have been used successfully in previous trials [26] to
336 ensure school commitments and support implementation of vegetable and fruit breaks.

337

338 The study findings should be considered in light of its design characteristics. First, a strength
339 of the study is the use of a large representative sample of schools drawn from the population
340 of all schools in the state, enhancing the generalisability of its findings. However, the extent
341 to which the findings are applicable to other jurisdictions is unknown. Second, the study used
342 a self-report measure of vegetable and fruit breaks in schools, and of the extent of
343 implementation of such breaks. It is considered the inherent inaccuracy of self-report
344 measurement was limited by the use of a validated measure of vegetable and fruit programs
345 in this study [26]. Third, given single items were used to assess the CFIR constructs the
346 psychometric properties of the tool used in the study are unknown, therefore future studies
347 should aim to validate these measures. Finally given the cross-sectional nature of the study

348 these findings may only be considered associations, and thus future prospective intervention
349 studies are warranted to determine if strategies to address the four factors associated with the
350 implementation of a vegetable and fruit break identified in this study are effective in
351 increasing the likelihood of schools' implementation of vegetable and fruit breaks.

352

353 Despite these limitations, the study provides an important contribution to the field of
354 implementation science, as it provides policy makers and practitioners with practical
355 information to use in the design of interventions to support schools' implementation of
356 vegetable and fruit programs. Future research examining how interventions impact on these
357 constructs for example through mediation analyses would represent a considerable
358 opportunity for implementation scientists to better understand intervention mechanisms.

359

360 **FUNDING**

361 This work was supported by infrastructure support from the Hunter Medical Research
362 Institute (HMRI), The University of Newcastle and Hunter New England Population Health.
363 LW is supported by an NHMRC Early Career Fellowship. SY is supported by a Heart
364 Foundation Postdoctoral Fellowship (100547).

365

366 **ACKNOWLEDGEMENTS**

367 The authors would also like to acknowledge and thank the survey respondents of
368 participating schools.

369

370 **CONFLICT OF INTEREST**

371 The authors declared no potential conflicts of interest with respect to the research, authorship,
372 and/or publication of this article.

373

374

375 **REFERENCES**

- 376 1. Evans, C.E., et al., *Systematic review and meta-analysis of school-based interventions*
 377 *to improve daily fruit and vegetable intake in children aged 5 to 12 y.* American
 378 *Journal of Clinical Nutrition*, 2012. **96**: p. 889–901.
- 379 2. Centres for Disease Control and Prevention. *Children eating more fruit, but fruit and*
 380 *vegetable intake still too low.* 2014 [24th August 2015]; Available from:
 381 <http://www.cdc.gov/media/releases/2014/p0805-fruits-vegetables.html>.
- 382 3. The NHS Information Centre and Lifestyles Statistics, *Statistics on obesity, physical*
 383 *activity and diet: England, 2013* The Health and Social Care Information Centre,
 384 Editor. 2014.
- 385 4. Australian Bureau of Statistics. *43640DO013_20112012 Australian Health Survey:*
 386 *First Results, 2011–12 — Australia.* 2012 [22nd November 2015]; Available from:
 387 [http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4364.0.55.0012011-](http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4364.0.55.0012011-12?OpenDocument)
 388 [12?OpenDocument](http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4364.0.55.0012011-12?OpenDocument).
- 389 5. National Health and Medical Research Council, *Australian Dietary Guidelines,*
 390 National Health and Medical Research Council, Editor. 2013, Australian Government:
 391 Canberra.
- 392 6. Slavin, J.L. and B. Lloyd, *Health Benefits of Fruits and Vegetables.* *Advances in*
 393 *Nutrition: An International Review Journal*, 2012. **3**(4): p. 506-516.
- 394 7. Seyedrezazadeh, E., et al., *Fruit and vegetable intake and risk of wheezing and*
 395 *asthma: a systematic review and meta-analysis.* *Nutrition Reviews*, 2014. **72**(7): p.
 396 411-428.
- 397 8. Kaikkonen, J.E., et al., *Does childhood nutrition influence adult cardiovascular*
 398 *disease risk?--insights from the Young Finns Study.* *Ann Med*, 2013. **45**(2): p. 120-8.
- 399 9. World Health Organisation, *Population-based approaches to childhood obesity*
 400 *prevention.* 2012: Geneva, Switzerland.
- 401 10. Carter, M. and B. Swinburn, *Measuring the 'obesogenic' food environment in New*
 402 *Zealand primary schools.* *Health Promotion International* 2004. **19**(1): p. 15-20.
- 403 11. World Health Organisation, *School Policy Framework: Implementation of the WHO*
 404 *Global Strategy on Diet, Physical Activity and Health,* in *WHO Library Cataloguing-*
 405 *in-Publication Data.* 2008, World Health Organisation: Geneva, Switzerland. p. 1-48.
- 406 12. Ohri-Vachaspati, P., L. Turner, and F.J. Chaloupka, *Fresh Fruit and Vegetable*
 407 *Program Participation in Elementary Schools in the United States and Availability of*
 408 *Fruits and Vegetables in School Lunch Meals.* *Journal of the Academy Of Nutrition*
 409 *And Dietetics*, 2012. **112**(6): p. 921-926.
- 410 13. Teeman, D., et al., *The third evaluation of the school fruit and vegetable scheme.*
 411 2010, National Foundation for Educational Research & University of Leeds.
- 412 14. Bere, E., M.B. Veierbd, and K.-I. Klepp, *The Norwegian School Fruit Programme:*
 413 *evaluating paid vs. no-cost subscriptions.* *Preventive Medicine* 2005. **41** p. 463-470.
- 414 15. Boyd, S., et al., *Taking a bite of the apple: The implementation of Fruit in Schools*
 415 *(Healthy Futures evaluation report to the Ministry of Health)* 2007, New Zealand
 416 Council for Educational Research: Wellington.
- 417 16. NSW Ministry of Health. *Crunch&Sip.* 2015 [cited 2015 28th August]; Available
 418 from: <http://www.healthykids.nsw.gov.au/campaigns-programs/crunch-sip.aspx>.
- 419 17. Nathan, N., et al., *Vegetable and Fruit Breaks in Australian Primary Schools:*
 420 *prevalence, attitudes, barriers and implementation strategies.* *Health Education*
 421 *Research*, 2011. **76**: p. 722-731.

- 422 18. Øvrum, A. and E. Bere, *Evaluating free school fruit: results from a natural*
423 *experiment in Norway with representative data*. Public Health Nutrition, 2013. **17**(6):
424 p. 1224–1231.
- 425 19. Nilsen, P., *Making sense of implementation theories, models and frameworks*.
426 Implement Sci, 2015. **10**: p. 53.
- 427 20. Damschroder, L.J., et al., *Fostering implementation of health services research*
428 *findings into practice: a consolidated framework for advancing implementation*
429 *science*. Implementation Science, 2009. **4**(1): p. 50.
- 430 21. Aarestrup, A.K., et al., *Implementation of strategies to increase adolescents' access to*
431 *fruit and vegetables at school: process evaluation findings from the Boost study*.
432 BMC Public Health, 2015. **15**(86).
- 433 22. Mccullum-Gomez, C., et al., *Factors Influencing Implementation of the Coordinated*
434 *Approach to Child Health (CATCH) Eat Smart School Nutrition Program in Texas*.
435 Journal of the American Dietetic Association, 2006. **106**: p. 2039-2044.
- 436 23. Wiggers J, et al., *Good for Kids, Good for Life 2006-2010 Evaluation Report.*, NSW
437 Ministry of Health, Editor. 2013, NSW Ministry of Health: Sydney.
- 438 24. Farrell L, et al., *Applying a performance monitoring framework to increase reach and*
439 *adoption of children's healthy eating and physical activity programs*. . Public Health
440 Research & Practice, 2014. **25**(1).
- 441 25. Australian Bureau of Statistics (ABS), *Australian Demographic Statistics, Population*
442 *Estimates by Age and Sex, New South Wales by Geographical Classification, cat. no*
443 *3235.0*, ABS, Editor. 2009: Canberra.
- 444 26. Nathan, N., et al., *Effectiveness of a multi-strategy intervention in increasing the*
445 *implementation of vegetable and fruit breaks by Australian primary schools: a non-*
446 *randomised controlled trial*. BMC Public Health, 2012. **12**(651).
- 447 27. Government of Western Australia Department of Health. *Crunch&Sip®*. 2015 [25th
448 July 2015]; Available from: <http://www.crunchandsip.com.au/what-is-crunchsip/>.
- 449 28. Australian Bureau of Statistics (ABS), *Statistical Geography Volume 1- Australian*
450 *Standard Geographical Classification (ASGC). Cat. no 1216.0*. 2006, Commonwealth
451 of Australia: Canberra.
- 452 29. Australian Bureau of Statistics (ABS), *Technical Paper: Census of Population and*
453 *Housing: Socio-Economic Indexes For Australia (SEIFA). Cat. no 2039.0.55.001*
454 *2001*, Commonwealth of Australia: Canberra.
- 455 30. Nanney, M.S., et al., *Awareness and adoption of a nationally disseminated dietary*
456 *curriculum*. Am J Health Behav, 2007. **31**(1): p. 64-73.
- 457 31. Bounds, W., M.F. Nettles, and J.T. Johnson, *Recess Before Lunch Programs in*
458 *Elementary Schools: Perceptions and Practices of School Professionals*. The Journal
459 of Child Nutrition and Management, 2009. **33**(1).
- 460 32. Levine, E., et al., *The Team Nutrition Pilot Study: Lessons Learned from*
461 *Implementing a Comprehensive School-Based Intervention*. Journal of Nutrition
462 Education and Behaviour, 2002. **34**(2): p. 109-116.
- 463 33. Hoelscher, D., et al., *Dissemination and adoption of the Child and Adolescent Trial*
464 *for Cardiovascular Health (CATCH): a case study in Texas*. Journal of Public Health
465 Management and Practice, 2001. **7**(2): p. 90-100.
- 466 34. Franks, A.L., et al., *School-based Programs: Lessons Learned from CATCH, Planet*
467 *Health, and Not-On-Tobacco*. Preventing Chronic Disease: Public Health Research,
468 Practice and Policy, 2007. **4**(2).
- 469 35. Glasgow, R.E. and D. Chambers, *Developing robust, sustainable, implementation*
470 *systems using rigorous, rapid and relevant science*. Clin Transl Sci, 2012. **5**(1): p. 48-
471 55.

- 472 36. Wolfenden L, et al., *How useful are systematic reviews of child obesity interventions.*
473 *Obesity Reviews*, 2010. **11**: p. 159-165.
- 474 37. Lister-Sharp, D., et al., *Health promoting schools and health promotion in schools:*
475 *two systematic reviews.* *Health Technology Assessment*, 1999. **3**(22): p. 1-207.
476

477

Table 1: Participating School Characteristics

Characteristics of participating schools	N	%
All schools	303	
School type^a		
Government	239	79
Non-Government	64	21
School size^b		
Small	123	41
Medium	127	42
Large	52	17
ARIA^c		
Rural	93	31
Urban	210	69
SEIFA^d		
Low	201	66
High	102	34

^aSchool type (non-Government)= Catholic and Independent schools.

^bsmall schools=1–159 students; medium schools= 160–450 students; large schools= 451+ students.

^cARIA= Accessibility/Remoteness Index of Australia

^dSEIFA= Socio-Economic Indexes For Areas (SEIFA)

Table 2: Association between implementation factors and school implementation of a vegetable and fruit program.

CFIR Domain	CFIR Construct	Survey Item: Implementation Factor	Response Category [#]	Implementing VF break (Daily in 80% of classrooms n=235 (%))	Univariate Analysis: Unadjusted OR [95% CI]	p-value	Multivariate analysis: Adjusted OR [95% CI]	p-value
Characteristics of the intervention	Evidence strength & quality	There is convincing evidence that the <i>Crunch&Sip</i> ® program increases student consumption of vegetables and fruit.	Agree	219 (93)	7.96 (3.92-16.14)	<.0001	2.97 (1.27-6.97)	0.0121
			Disagree	16 (7)	1.0		1.0	
	Adaptability	The <i>Crunch&Sip</i> ® program can be easily adapted to fit in with schools routines.	Agree	223 (95)	12.24 (5.74-26.10)	<.0001		
			Disagree	12 (5)	1.0			
	Complexity	The <i>Crunch&Sip</i> ® program would be difficult for schools to implement.	Agree	14 (6)	1.0	<.0001	1.0	<.0001*
			Disagree	221 (94)	12.46 (6.06- 25.65)		10.16 (4.38- 23.54)	
	Cost	Implementing the <i>Crunch&Sip</i> ® program would be costly for schools.	Agree	36 (15)	1.0	<.0001		
			Disagree	199 (85)	4.91 (2.71-8.90)			

CFIR Domain	CFIR Construct	Survey Item: Implementation Factor	Response Category [#]	Implementing VF break (Daily in 80% of classrooms n=235 (%))	Univariate Analysis: Unadjusted OR [95% CI]	p-value	Multivariate analysis: Adjusted OR [95% CI]	p-value
Outer Setting	External Policies	My education department recommends that schools implement the <i>Crunch&Sip</i> ® program.	Agree	153 (65)	2.83 (1.63-4.94)	0.0002		
			Disagree	82 (35)	1.0			
Inner Setting	Compatibility	The <i>Crunch&Sip</i> ® program is consistent with the philosophy and ethos of our school.	Agree	224 (95)	6.79 (3.00-15.36)	<.0001		
			Disagree	11 (5)	1.0			
	Relative priority	Relative to other priorities in my schools, implementing the <i>Crunch&Sip</i> ® program is far less important.	Agree	82 (35)	1.0	<.0001	1.0	0.0129*
			Disagree	153 (65)	4.79 (2.49-8.05)		2.45 (1.21- 4.95)	
	Organisational incentives & Rewards	Implementing the <i>Crunch&Sip</i> ® program enhances the reputation of a school	Agree	159 (68)	3.84(2.17-6.77)	<.0001		
			Disagree	76 (32)	1.0			
	Available	My School has dedicated	Agree	125 (53)	7.45	<.0001	4.22 (1.81- 9.85)	0.0009*

CFIR Domain	CFIR Construct	Survey Item: Implementation Factor	Response Category [#]	Implementing VF break (Daily in 80% of classrooms n=235 (%))	Univariate Analysis: Unadjusted OR [95% CI]	p-value	Multivariate analysis: Adjusted OR [95% CI]	p-value
	Resources	substantial resources (e.g. money, time) to implement the <i>Crunch&Sip</i> ® program.	Disagree	110 (47)	1.0		1.0	
	Access to information & knowledge	External support is readily available to help schools implement the <i>Crunch&Sip</i> ® program.	Agree	157 (67)	3.94 (2.23-6.97)	<.0001		
			Disagree	78 (33)	1.0			
Individuals	Knowledge and beliefs about the intervention	I believe it is important to implement the <i>Crunch&Sip</i> ® program	Agree	219 (93)	10.18(5.06- 20.48)	<.0001		
			Disagree	16 (7)	1.0			
Process	Planning	The <i>Crunch&Sip</i> ® program is included within our school management plan.	Agree	88 (37)	7.54(2.92-19.47)	<.0001		
			Disagree	147 (63)	1.0			

[#] Agree consists of those reporting agree and strongly disagree; *p significant ≤ 0.05