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1 **Abstract**

2 *Objective:* To systematically review the literature and map published studies on 4-8
3 year olds intake of discretionary choices against an ecological framework (ANalysis
4 Grid for Environments Linked to Obesity: ANGELO).

5 *Design:* Articles were identified through database searches (PubMed, PyscINFO®,
6 Web of Science) in February and March 2014 and hand-searching reference lists.
7 Studies were assessed for methodological quality and mapped against the ANGELO
8 framework by environment size (macro and micro setting) and type (physical,
9 economic, **policy, socio-cultural** influences).

10 *Setting:* Studies were conducted in the USA (*n* 18), Australia (*n* 6), the UK (*n* 3), the
11 Netherlands (*n* 3), Belgium (*n* 1), Germany (*n* 1) and Turkey (*n* 1).

12 *Subjects:* Children aged between 4-8 years, or parents/other caregivers.

13 *Results:* Thirty-three studies met the review criteria (observational *n* 23, interventions
14 *n* 10). Home was the most frequently studied setting (67% of exposures/strategies),
15 with the majority of these studies targeting family policy-type influences (e.g. child
16 feeding practices, television regulation). Few studies were undertaken in government
17 (5.5%) or community (11%) settings, or examined economic-type influences (0%). Of
18 the intervention studies only four were categorised as effective.

19 *Conclusions:* This review is novel in its focus on mapping observational and
20 intervention studies across a range of settings. It highlights the urgent need for high
21 quality research to inform interventions that directly tackle the factors influencing
22 children's excess intake of discretionary choices. Interventions that assist in
23 optimising a range of environmental influences will enhance the impact of future
24 public health interventions to improve child diet quality.

25

26 **Keywords:** discretionary choices, children, review, ecological, environments, diet
27 quality, energy-dense nutrient-poor, solid fats, added sugar, sugar-sweetened
28 beverages

29

30 **Introduction**

31

32 Consumers globally are exposed to an abundance of energy-dense, nutrient-poor
33 foods and beverages, which can be referred to as ‘discretionary foods’ or
34 ‘discretionary choices’⁽¹⁻⁵⁾. Examples of such foods are sugar-sweetened beverages,
35 processed meats, fried foods, pastries and cakes. The Australian dietary guidelines
36 recommend limiting intake of (discretionary) foods containing saturated fat, added
37 sugar, salt and alcohol which are not required as part of a dietary pattern that
38 promotes health and wellbeing⁽⁵⁾.

39

40 Over consumption of discretionary choices is associated with increased risk of obesity,
41 cardiovascular disease, type 2 diabetes, some cancers and dental caries⁽⁵⁾. The risk of
42 these chronic conditions and related dietary patterns begin in childhood and track into
43 adult life^(5, 6). This is of particular concern given the sizable chronic disease burden
44 and high rates of obesity across the lifespan⁽⁷⁾. Overconsumption of discretionary
45 choices can also displace core foods (fruit, vegetables, dairy, lean meats, whole
46 grains) from the diet, further increasing risk of nutrient deficiencies, obesity and
47 chronic disease^(8, 9).

48

49 National intake data across the western world shows the majority of children are not
50 meeting the recommended intakes of core foods and are over consuming discretionary
51 choices⁽¹⁰⁻¹³⁾. According to US data 99.9% of 4-8 year old children are consuming
52 above the maximum recommended energy allowance from discretionary choices⁽¹⁰⁾.
53 This statistic aligns with Australian data, which shows consumption of discretionary
54 choices currently contribute about 36% of children’s energy intake, with intakes
55 increasing with age from 30.2% in 2-3 year olds, to 37.5% in 4-8 year olds^(11, 12).
56 Early childhood is an opportune time to intervene to moderate intake of discretionary
57 choices and potentially increase core foods to establish healthier dietary patterns.

58

59 Individual and environmental factors influence food provision to, and dietary intake
60 of, young children (Table 1)^(14, 15). A key environmental change across the ages of 4-8
61 years is the transition from home or childcare to formal education settings (preschool,
62 junior primary school)⁽¹⁶⁾. While starting school widens children’s environmental
63 influences^(15, 16), they still rely predominately on their caregivers for food provision,
64 and the home setting remains an important environment influencing food intake.

65 Creating supportive eating environments to minimise children’s intake of

66 discretionary choices, in all settings where children spend their time, will enhance the
67 impact and sustainability of nutrition promotion and obesity prevention efforts.

68

69 Discretionary choices have received little direct attention in the paediatric nutrition
70 literature. To date, the literature has instead focused on general healthy eating
71 interventions for obesity prevention and management⁽¹⁷⁻¹⁹⁾, or nutrition promotion
72 interventions targeting fruit and vegetable intake⁽²⁰⁾. Children's exposure to food
73 marketing is one area where there is some evidence of an association with
74 discretionary choices intake⁽²¹⁾; however, more research is needed to understand the
75 factors that influence children's intakes of these nutritionally poor foods, and identify
76 other targets for intervention.

77

78 This review aims to identify and map the range of environmental predictors that
79 influence children's intake of discretionary choices. The review will focus on
80 observational and intervention studies targeting children 4-8 years or their caregivers,
81 with a clear focus on discretionary choices, measuring child intake of these foods
82 directly or via proxy. The review objectives are:

- 83 1. To identify and map the current literature on predictors of 4-8 year old
84 children's intake of discretionary choices using an ecological framework.
- 85 2. To provide recommendations for the 'next steps' of future research by
86 highlighting gaps in the current body of evidence.

87

88

89 **Methods**

90

91 **A systematic review process was implemented to identify original published studies**
92 **meeting the below inclusion criteria⁽²²⁾. Studies were then critiqued and synthesised to**
93 **answer the review objectives.** No publication date limit was set to access all literature
94 published in English, meeting the **review inclusion** criteria.

95

96 ***Inclusion and exclusion criteria***

97 **Population**

98 Healthy children, with an age range or mean age between 4-7.9 years, or their
99 parents/other caregivers (e.g. grandparents, educators). Clinical samples were
100 excluded (e.g. anaemia, cystic fibrosis, diabetes).

101

102 Predictors (intervention or comparator)

103 All correlates modifiable in a nutrition promotion context were included (e.g. child
104 feeding practices, hours of television use). Descriptive studies or studies focusing on
105 non-modifiable correlates (e.g. age, ethnicity) were excluded. Studies that focused on
106 overweight/obesity management were excluded as the focus of this review was on
107 broader public health diet quality and obesity prevention.

108

109 Outcome measures

110 *Primary*: children's intake (or proxy) of discretionary food or beverages, or related
111 components (i.e. energy, saturated fat, sugar or sodium). Proxy measures included
112 availability (e.g. food access, parent intake), provision (e.g. parenting control),
113 preferences (e.g. child requests), behaviour (e.g. meal pattern, child feeding practices),
114 and purchasing (e.g. receipts).

115

116 *Secondary*: Secondary outcomes included knowledge/attitudes/beliefs of child or
117 carer. Studies with a secondary outcome were only included if they also contained at
118 least one primary outcome measure.

119

120 Study design and type

121 To capture the **breadth** of work on discretionary choices, observational and
122 intervention studies conducted in any of the settings outlined in Table 1 were included.
123 Non-human (e.g. animal model, laboratory), methodological (e.g. food record tool,
124 protocol only), and non-primary studies (e.g. review papers, commentary) were
125 excluded.

126

127 ***Search strategy and selection process***

128 Search terms were combined under the following headings:

- 129 1. Population (e.g. child* or preschool), and
- 130 2. Intervention (e.g. "nutrition education" or "behaviour change" or "dietary
131 intake" or "eating pattern*"), and

132 3. Outcomes (e.g. “energy-dense” or “non-core food” or “high calories” or
133 “sugar-sweetened beverages” or “fast food” or “saturated fat” or “added sugar”
134 or “salt” or “energy intake”)

135 4. Limits applied: English

136 Terms were trialled in PubMed. PubMed, PsycINFO[®] and Web of Science were
137 systematically searched in February (PubMed, PsycINFO[®]) and March (Web of
138 Science) 2014, and citations identified from other sources (Figure 1). Title, abstract
139 and full text screening was completed by two reviewers; in cases of uncertainty, a
140 third reviewer was consulted and consensus reached.

141

142

143 ***Data extraction***

144 Data extracted included: study details (identification, site, setting, study design, study
145 duration, participants), discretionary choices targeted, exposure/intervention strategies,
146 environmental influences, outcome assessment method, key results and quality
147 assessment tool score. To ensure consistency of data extracted 10% of studies were
148 rechecked by the single reviewer. Due to the heterogeneity in the design,
149 exposures/strategies and outcomes of included studies, a meta-analysis was not
150 undertaken. **Statistical significance (of $p < 0.05$) was used to guide the review narrative.**
151 Results are presented in a narrative summary, with overall direction and confidence of
152 the association of the study findings summarised using the following symbols:
153 significant negative association, --; non-significant negative association, -; null
154 association, 0; non-significant positive association, +; significant positive association,
155 ++; inconsistent associations, ~ (Table 3 and 4). **Non-significant findings were
156 highlighted to examine whether consistent effect sizes (direction) were present across
157 studies and to consider where an increase in sample size or better study design may
158 have achieved statistical significance.**

159

160 ***Study quality***

161 A single reviewer assessed study quality using the standardised Effective Public
162 Health Practice Project (EPHPP) Quality Assessment Tool⁽²³⁾. The tool scores study
163 quality (strong, moderate, weak) across six areas: selection bias, study design,
164 confounders, blinding, data collection methods, withdrawals and drop-outs⁽²³⁾. An
165 overall quality rating is assigned: strong (four strong ratings and no weak ratings),

166 moderate (less than four strong ratings and one weak rating) or weak (two or more
167 weak ratings)⁽²³⁾. In an assessment of 213 quality assessment tools, this tool was
168 identified as useful for systematic reviews that evaluate randomized and non-
169 randomized intervention studies⁽²⁴⁾. To enable comparison of study quality across
170 study design, the tool was adapted to allow for use with observational studies, as well
171 as interventions. Adaptions to the tool included description of covariates rather than
172 difference between groups prior to interventions, and adjustments for cross-sectional
173 design with no dropouts and one data collection time point.

174

175 ***Mapping of environmental influence***

176 Observational study correlates were termed ‘exposures’, and intervention strategies
177 were termed ‘strategies’. Study exposures/strategies were mapped using the ANalysis
178 Grid for Environments Linked to Obesity (ANGELO), an ecological framework
179 which identifies a range of environment sizes (i.e. **macro and micro setting**) and
180 environment types (e.g. physical, economic, policy, socio-cultural) that likely
181 influence children's discretionary choice intake, and has been described elsewhere in
182 detail⁽¹⁵⁾. A coding system was developed in order to systematically assign a type of
183 exposure/strategy to one of the ANGELO framework environments. **A single**
184 **reviewer hand coded exposures/strategies using Table 1, any uncertainties by the**
185 **reviewer were discussed with all reviewers. Where one study included multiple**
186 **exposures/strategies all relevant codes were applied. To simplify the coding process**
187 **using the ANGELO framework only the primary environment type and size of the**
188 **exposure/strategy was coded.** For example frequency of meals consumed away from
189 home (termed meal pattern) was coded as a socio-cultural influence within the
190 community. Another example is kilojoule labelling of food outlet menus, which was
191 coded as a policy influence within the government setting.

192

193

194 **Results**

195

196 Thirty-three studies met the review criteria (Figure 1). Over half of studies were based
197 in the USA (n 18)^(2, 3, 25-40) or Australia (n 6)⁽⁴¹⁻⁴⁶⁾. Twenty-three were cross-sectional,
198 observational studies^(1, 2, 25-35, 41-43, 47-53)(Supplementary Table 1), with an average

199 sample size of 563 (range 41⁽³¹⁾-2074⁽⁵⁰⁾). There were ten interventions (randomised
200 controlled trials $n = 8$ ^(3, 36, 38, 39, 44-46, 54), case controlled trial $n = 1$ ⁽³⁷⁾, cohort $n = 1$ ⁽⁴⁰⁾;
201 Supplementary Table 2), with an average sample size of 210 participants (range
202 29⁽³⁸⁾-560⁽⁴⁶⁾). No studies rated high in methodological quality. Several potential
203 sources of bias, including participant selection, study design and data collection
204 methods were common across study design. However, intervention studies were more
205 likely to rate highly (60% moderate, 40% weak), compared with observational studies
206 (4% moderate, 96% weak).

207

208 *Ecological mapping of studies*

209 For each study, the exposure variables (in observational studies) or strategies (in
210 intervention studies) were coded and mapped against the ANGELO framework (Table
211 2). In total 55 exposures/strategies were mapped, which included 39 exposures from
212 23 observational studies and 16 strategies from 10 intervention studies.

213

214 Studies were mapped against environmental size (i.e. **macro and micro** setting). There
215 were few studies within the government setting, with only three intervention
216 strategies⁽³⁶⁻³⁸⁾ and no observational exposures evaluated in this setting. Most studies
217 were undertaken within the home setting (37 exposures or strategies/out of 55),
218 primarily in observational studies (31/37). Majority of research within educational
219 institutions has been from intervention studies; seven strategies^(3, 39, 46, 54) were
220 identified compared to two exposures from observational studies⁽⁵³⁾. A total of six
221 exposures have been examined within the community setting, all from observational
222 research^(26, 27, 29, 41, 48, 51).

223

224 Studies were also mapped by environment type (i.e. physical, economic, policy,
225 socio-cultural) by study design. Within observational studies, policy-type exposures
226 were most common (17/39), followed by physical (12/39) and socio-cultural (10/39).
227 No economic-type exposures were included in any observational studies. Within
228 interventions, physical (6/16) and policy-type (6/16) strategies were most common.
229 Again, economic strategies were not included in any interventions targeting children's
230 discretionary choices intake.

231

232 *Ecological view: Summary of the relationships in observational studies*

233 Table 3 summarises the results of observational studies by environmental size and
234 type (Table 3). Six observational studies were conducted within the community
235 setting, five focussed on discretionary choices as a whole and one on sugar-sweetened
236 beverages only. Five observational studies focused on meal patterns (socio-cultural
237 influence), of which three reported a significant positive relationship with
238 discretionary choices intake^(27, 29, 41). That is higher frequency of meals or snacks
239 consumed out of the home (e.g. fast food, restaurant, home of friends/relatives) were
240 significantly associated with higher intake of discretionary choices^(27, 29, 41). One
241 community-based observational study focussed on food availability (physical
242 influence) and reported no relationship between availability of discretionary choices
243 within the community and children's intake⁽⁴⁸⁾.

244

245 There was one observational study within the educational setting, which reported
246 greater food availability (physical influence) was significantly associated with higher
247 intakes of discretionary choices⁽⁵³⁾. This study also reported the absence of a nutrition
248 policy was associated with higher intakes of discretionary choices, though the result
249 did not reach statistical significance⁽⁵³⁾.

250

251 Nineteen observational studies measured exposures within the home setting, 14 of
252 which focussed on discretionary foods as a whole, with two targeting snacks, two
253 with a nutrient focus, and one focusing only on sugar-sweetened beverages. Within
254 the home setting, 16 studies examined policy-type exposures, primarily relating to
255 child feeding practices. Four studies found higher levels of parental control (pressure)
256 was related to higher children's intake of discretionary choices^(28, 30, 42, 47). In all four
257 of these studies, more than three discretionary choices were measured. Some studies
258 also noted higher parental **monitoring**, a desired feeding practice, were associated
259 with lower intake of discretionary choices^(2, 27, 28, 30, 47, 52). Other policy-type studies in
260 the home focussed on television regulation targeting various discretionary choices^{(1, 25,}
261 ^{27, 31, 32, 34)}. Of these studies four out of six found higher discretionary choice intake
262 was significantly associated with higher television use^(27, 31, 32, 34). Television access
263 (physical influence) was also observed in the home in nine studies, with six targeting
264 a range of discretionary choices. Higher access to televisions within the home was
265 associated with significantly higher intake of discretionary choices, in five of the
266 studies^(27, 31, 32, 34, 42).

267

268 *Ecological view: Summary of association from intervention studies*

269 Intervention studies were also categorised by environmental size and type (Table 4).

270 Three intervention were conducted within the government setting, two focussed on

271 nutrition labelling, specifically fast food menu labelling (policy influence), and

272 targeted single discretionary food items (e.g. fast food) rather than a variety of

273 discretionary choices⁽³⁶⁻³⁸⁾. One study reported a significant, negative relationship

274 between the policy strategy and intake, that is the introduction of the policy was

275 associated with a significant reduction in children's fast food intake⁽³⁶⁾. One

276 intervention focussed on food reformulation (physical influence) and reported

277 negative, but non-significant, association with children's snack food intake⁽³⁸⁾.

278

279 Four interventions were set within educational institutions, and three targeted socio-

280 cultural influences (e.g. teacher or parent beliefs and attitudes, influence of peers),

281 two examined policy strategies (e.g. nutrition policy), and two included physical (e.g.

282 food availability) strategies^(3, 39, 46, 54). These strategies tended to focus on a smaller

283 number of discretionary choices, such as snack food, sweet snacks or confectionary^{(3,}

284 ^{39, 54)}. Two (of four) studies within educational institutions reported a significant

285 reduction in discretionary choices intake, both included policy and socio-cultural

286 strategies^(39, 46).

287

288 Three studies were conducted within the home, all included elements of addressing

289 the physical influence of discretionary choices availability^(40, 44, 45). All reported

290 favourable results towards a reduction in children's intake of these foods^(40, 44, 45);

291 however, only one study reported a significant reduction in discretionary choices⁽⁴⁰⁾.

292 This study focussed on food substitution but was limited to specific discretionary

293 foods, for example replacing sugar-sweetened beverages for water or low fat milk⁽⁴⁰⁾.

294

295

296 **Discussion**

297

298 This review evaluated the observational and intervention literature to map the current

299 evidence targeting a reduction in children's intake of discretionary choices. This aim

300 was focussed on children aged 4-8 years due to the expanding environmental
301 influences present during the transition to formal education⁽¹⁶⁾.
302
303 This review identified only 33 studies across the wide range of settings which could
304 potentially influence children's discretionary choices intake. This was surprising given
305 the health and diet quality concerns regarding discretionary choices⁽⁵⁾. When
306 compared with the breadth of literature regarding improving child diet quality through
307 increasing fruit and vegetable intake, it is clear that ways to moderate children's intake
308 of discretionary choices is an understudied area, requiring further research investment
309 ⁽²⁰⁾. For example a recent systematic review of interventions promoting fruit and
310 vegetables in schools identified 27 interventions, compared with the four
311 interventions targeting discretionary choices included in this review⁽⁵⁵⁾. The mapping
312 process undertaken in the present review also highlighted the gap in economic-type
313 influences (such as discretionary choice cost-related initiatives, e.g. government sales
314 tax on discretionary choices) across all settings, with no studies in this area to date.
315 Economic-type influences consequently require consideration in further research, in
316 particular due to the potential for economic strategies at a population level to result in
317 a wide reduction in intakes of discretionary choices. An example in the government
318 setting is a tax on discretionary choices, with revenue raised from the tax redirected
319 into health initiatives or subsidising healthy foods⁽⁵⁶⁾. Within the home setting
320 economic strategies could be to highlight the costs of packaged or takeaway foods,
321 which could reduce the approximately 30% of the weekly home food budget spent on
322 takeaway type foods (e.g. restaurants, clubs, fast food, takeaway)⁽⁵⁷⁾.
323
324 The frequency of meals away from home, a community-based socio-cultural influence,
325 was significantly associated with higher children's intake of discretionary choices
326 (60% of studies)^(26, 27, 29, 41). This highlights an opportunity for interventions to
327 evaluate strategies to support parents at times when meals are consumed away from
328 home. For example, healthy options guide or skills-based resources of nutritious foods
329 to take when likely to consume foods away from home. Perhaps this contrasts with
330 the higher time investment of planning home food availability by the food purchasing
331 process that may mediate consumption, making it easier to limit discretionary choices
332 in the home. Progress in this area will help to support parents to reduce their child's
333 intake of discretionary choices by providing strategies to choose healthy options when

334 consuming meals away from home, and would further be enhanced by increasing the
335 availability of healthy meal options.

336

337 Within the home environment, when observing child feeding practices, there was a
338 trend towards higher parental control linked with higher children's intake of
339 discretionary choices; however, this was only significant in four out of nine studies^{(28,}
340 ^{30, 42, 47)}. The numerous definitions and measures used to describe this feeding practice
341 may have weakened this association, and requires further investigation using
342 standardised measures. Parental monitoring (i.e. monitoring of children's dietary
343 intake) on the other hand was significantly associated with higher children's intake of
344 discretionary choices in majority of studies measuring this exposure^(2, 27, 28, 30, 47, 52).
345 These child feeding approaches are in line with those first described by Satter⁽⁵⁸⁾
346 where the parent's role is to provide a range of healthy choices and the child's role is
347 to decide which and how much of these foods they will consume. These findings
348 again highlight an important role parents' play in this setting. It would be of interest
349 to further explore changes in these practices in future interventions.

350

351 Higher children's intake of discretionary choices was also associated with more
352 frequent television use^(27, 31, 32, 34). This association could be influenced by food
353 advertising or through the habits associated with screen time activities (e.g. snacking),
354 or a combination⁽²¹⁾. Though there has been extensive advocacy work to reduce food
355 advertising during children's television viewing times^(59, 60), changes in home policies
356 regarding television use is another possible solution. Based on the findings of the
357 included studies, a change in parents' television viewing rules (policies) is likely to
358 reduce children's intake of discretionary choices, as well as to support National
359 guidelines regarding such sedentary activities⁽⁶¹⁾.

360

361 Observational and intervention studies in the government setting are lacking.
362 Although there have only been three interventions, these are of particular interest
363 given the ability for enablers at this level to have a greater influence and reach to all
364 groups within the community (e.g. difficult to engage and vulnerable populations)⁽¹⁵⁾.
365 Government strategies would also support other settings by facilitating healthy
366 options to become easy choices for consumers. Two of the three interventions to date
367 evaluated kilojoule labelling of fast food menus, one finding a significant reduction in

368 kilojoules ordered^(36, 37). However, a key consideration is the use of a simulated
369 environment, which brings to question if these findings would remain in a practice
370 setting (i.e. when child requests for discretionary choices may influence purchasing).

371

372 Intervention strategies in the education setting, such as information workshops
373 (including consequences of discretionary choice intake) targeting either parent or
374 teacher attitudes and beliefs led to significantly reduced children's intake or exposure
375 to discretionary choices^(39, 46). This sociocultural influence may therefore impact on
376 discretionary choices provision outside the area of child feeding practices (not
377 included in these interventions). Of note both interventions targeted attitudes and
378 beliefs in combination with other strategies (e.g. implementation of a nutrition policy).
379 This warrants further investigation to see if these findings are replicated when studied
380 alone, or if they are only a complementary strategy.

381

382 Our ecological mapping found most of studies focus on the home environment,
383 specifically assessing the impact of policy (e.g. family rules) or physical influences
384 (e.g. television access) on the provision of discretionary choices. The vast majority of
385 these studies are observational in nature, and although such observational studies have
386 been published since the 1970's⁽⁴⁰⁾, to date very few interventional studies evaluating
387 strategies have been performed^(31, 40, 44, 45). Further interventional research is therefore
388 required to provide evidence to support parents who are primarily responsible for the
389 provision of discretionary choices in this setting. For example numerous observational
390 studies have found children who watch more television are provided with more
391 discretionary choices^(25-27, 31-33, 42), yet we are lacking the evidence from interventions
392 to implement strategies in public health nutrition initiatives in this area.

393

394 It is important to note that discretionary choices encompass more than single
395 groupings, such as sugar-sweetened beverages or fast foods. From this review it
396 appears targeting the whole discretionary choices group in interventions may be
397 perceived as too challenging, with only three (out of ten) interventions addressing a
398 larger portion of this group. Comparatively, approximately three quarters of
399 observational studies included numerous discretionary choices. This is a key example
400 where intervention design could be strengthened, as strategies would be more likely to

401 produce the same findings when implemented in practice, when controlling for
402 changes within the discretionary choices group.

403

404 A key review strength was utilising the ecological approach with a broad search and
405 outcome inclusion to examine the scope of current literature and identify implications
406 for further research. Reviewer error/bias was minimised by the use of two reviewers
407 when possible. When not, a consultative approach with two experienced reviewers
408 was used. Quality of this review was also strengthened by the use of a validated
409 critical appraisal tool and the PRISMA checklist for systematic review reporting^(23, 62).

410

411 This review is not without limitations. Firstly, only a small body of lower quality
412 evidence was available. The variety of outcome measures, discretionary choices
413 targeted and range of exposures and strategies explored did lend this review to a
414 heterogeneous sample. It was therefore not possible to conduct a meta-analysis. It did,
415 however, support the ecological mapping and guidance for future research. The
416 sample heterogeneity and limited detail reported in original studies also restricted the
417 ability to report collective magnitudes of intervention effects. For this reason, only
418 qualitative comparisons were included.

419

420 Reporting bias within data collection is a risk, even with the aid of validated and
421 reliable tools. The discretionary choices focus minimised the effect of under-reporting
422 bias on findings presented. Reporting bias was also reduced in several interventions
423 using objective experimenter observations where blinding was not possible. As this
424 review was limited to published information, due to limited resources, publication
425 bias may have affected the quality of assessment with several quality areas rated
426 unknown. Although outside of the scope of this review, it is possible there is a body
427 of practiced-based evidence that would add to the findings presented.

428

429 In order to enhance the literature in the area, and to take steps towards reducing
430 children's intake of discretionary choices, several recommendations have been
431 formulated. More high quality research is required across the ecological framework,
432 but in particular in the gaps identified as noted earlier. In addition, studies that focus
433 on multiple levels of influence would provide valuable insight to interrelated factors
434 within different settings and environment types. Modelling these multiple influences

435 in interventions will also assist in the application of these findings to practice. To
436 support strengthening the quality of future studies, researchers should report findings
437 in line with STROBE or CONSORT statements, for the relevant study design^(63, 64).
438 To give confidence in findings, prospective longitudinal research designs with
439 appropriate adjustment for confounders (e.g. parental education, socioeconomic status,
440 family structure, weight status) should be utilised.

441

442

443 **Conclusion**

444

445 The ecological mapping of the literature in this review has provided a clear, practical
446 view of the evidence to date relevant to public health nutrition. Although far more
447 research is needed before seeing an influence in public health nutrition practice, this
448 review highlights a step in the right direction, with studies now starting to focus on
449 discretionary choices. **This review makes a key contribution to public health nutrition
450 research by identifying the gaps in the literature to ensure future studies address the
451 areas of greatest unmet need. Additionally, this paper will guide the focus of future
452 interventions to develop multi-target initiatives to make healthy options the easy
453 choices (i.e. through government and economic-type influences) and create a change
454 in culture in order to reduce provision of discretionary choices.** It is essential research
455 continues to explore predictors and potential strategies in this young age group, in
456 order to intervene early and start making meaningful changes to improve diet quality.

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458

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Figure captions

Figure 1: PRISMA Statement Flow Diagram indicating number of studies included at each phase of the review

Table 1: Environmental influences on children’s dietary intake according to ANalysis Grid for Environments Linked to Obesity framework*

		Environment Size			
		Macro indirect influence on children’s intake	Home (e.g. home, family)	Educational Institution (e.g. school, childcare)	Community (e.g. locations outside of the home)
Environmental Type	Physical what is available, access	Product reformulation (e.g. low kJ alternatives)	Television access	Food provided by the setting (e.g. lunch program)	Location and density of fast food outlets within neighbourhood
	Economic what are the costs	Government sales tax and price changes	Family food budgeting approach Costs of packaged and takeaway foods	Canteen or vending machine revenue	Council planning regarding the development of fast food outlets vs fresh produce
	Policy what are the “rules”	Nutrition (kJ) labelling in food outlets	Child feeding practices (e.g. control, monitoring, restriction)	School nutrition policies re: lunchboxes, celebrations, fundraising	Sporting club policies re: nutrition and sport
	Socio-cultural what are the attitudes and beliefs	Marketing tactics (e.g. popular characters)	Parental attitudes and beliefs	Peer role modelling and influences	Meal pattern (e.g. frequency of meals away from home)

* Adapted from Swinburn, Egger & Raza⁽¹²⁾

Table 2: Spread of Current Literature (Observational and Intervention Studies) by ANalysis Grid for Environments Linked to Obesity Framework (Environment Size and Type)*

		Environment Size				
		Macro		Micro		
		Government	Home	Educational Institution	Community	Total
Observational (71% exposures measured)						
Environment Type	Physical	-	10†	1	1	12
	Economic	-	-	-	-	-
	Policy	-	16	1	-	17
	Socio-cultural	-	5	-	5	10
	Total	-	31	2	6	39
Intervention (29% strategies evaluated)						
Environment Type	Physical	1	3	2	-	6
	Economic	-	-	-	-	-
	Policy	2	2	2	-	6
	Socio-cultural	-	1	3	-	4
	Total	3	6	7	-	16

* Studies may investigate multiple exposures or strategies; therefore one study may represent multiple environments.

† Number of studies including the exposure or strategy

Table 3: Summary of observational studies targeting children’s discretionary choices intake

Reference, country, study design, quality*	ANGELO Framework (environment size and type)	Discretionary choices targeted	Results summary†
Micro: Community			
Ayala et al. (2008) ⁽²⁹⁾ USA Cross sectional Weak	Sociocultural: Meal pattern (higher frequency of meals away from home)	DC‡	++
Buck et al. (2013) ⁽⁴⁸⁾ Germany Cross sectional Weak	Physical: Food availability (higher DC availability within community)	DC	0
Erinsho et al. (2012) ^{(26)a} USA Cross sectional Weak	Socio-cultural: Meal pattern	DC	+
Kerr et al. (2010) ⁽⁵¹⁾ Ireland Cross sectional Weak	Socio-cultural: Meal pattern	DC	~
Lopez et al. (2012) ^{(27)b} USA Cross sectional Weak	Socio-cultural: Meal pattern	SSB§	++
Spurrier et al. (2008) ^{(41)c} Australia Cross sectional Weak	Socio-cultural: Meal pattern	DC	++
Micro: Educational Institution			
Vereecken et al. (2008) ⁽⁵³⁾ Belgium Cross sectional Weak	Physical: Food availability Policy: Nutrition policy	DC	+
Micro: Home			
Aguirre et al. (2012) ⁽²⁸⁾	Policy: Child feeding practices (higher control and restriction and lower)	DC	++

USA Cross sectional Weak	monitoring)		
Aktas Arnas (2006) ⁽¹⁾ Turkey Cross sectional Weak	Physical: TV access (higher child TV viewing) Policy: TV regulation (higher parental regulation of child TV viewing)	DC	0
Andaya et al. (2011) ⁽²⁵⁾ USA Cross sectional Weak	Physical: TV access Policy: Meal pattern, TV regulation Sociocultural: Meal time structure (higher frequency of snacking)	Soda/soft drink, savoury snacks	~
Arredondo et al. (2006) ⁽³⁰⁾ USA Cross sectional Weak	Policy: Child feeding practices	DC	~
Brown et al. (2008) ⁽⁴⁷⁾ UK Cross sectional Weak	Policy: Child feeding practices	DC	~
Campbell et al. (2006) ⁽⁴²⁾ Australia Cross sectional Weak	Physical: Food availability, TV access Policy: Child feeding practices Sociocultural: Meal time structure	DC	++
Campbell et al. (2010) ⁽⁴³⁾ Australia Cross sectional Moderate	Sociocultural: Parental beliefs / attitudes (higher positive DC related beliefs)	DC	0
Erinsho et al. (2012) ^{(26)a} USA Cross sectional Weak	Physical: Food availability, TV access	DC	+
Galst et al. (1976) ⁽³¹⁾ USA Cross sectional Weak	Physical: TV access Policy: TV regulation, Parenting (higher positive parenting practices)	DC	++

Gubbels et al. (2011) ⁽⁵⁰⁾ Netherlands Cross sectional Weak	Policy: Meal pattern	DC	0
Gubbels et al. (2012) ⁽⁴⁹⁾ Netherlands Cross sectional Weak	Policy: Child feeding practices	Energy, sugar	+
Islar et al. (1987) ⁽³²⁾ USA Cross sectional Weak	Physical: TV access Policy: TV regulation, Parenting	DC	++
Lopez et al. (2012) ^{(27)b} USA Cross sectional Weak	Physical: TV access Policy: Child feeding practices, TV regulation	SSB	~
Murashima et al. (2012) ⁽²⁾ USA Cross sectional Weak	Policy: Child feeding practices	DC	~
Ogden et al. (2006) ⁽⁵²⁾ UK Cross sectional Weak	Policy: Child feeding practices	DC	~
Spurrier et al. (2008) ^{(41)c} Australia Cross sectional Weak	Physical: Food availability, TV access Policy: Child feeding practices Socio-cultural: Meal time structure	DC	~
Tabak (2011) ⁽³³⁾ USA Cross sectional Weak	Policy: Child feeding practices Socio-cultural: Meal time structure	DC	~
Taras et al. (1989) ⁽³⁴⁾ USA Cross sectional Weak	Physical: TV access Policy: TV regulation	Energy, saturated fat, sugar, salt	~

Wroten et al. (2012) ⁽³⁵⁾ USA Cross sectional Weak	Physical: Food availability	Sweet and savory snacks	++
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ANGELO, ANalysis Grid **for** Environments Linked to Obesity; DC, discretionary choices; SSB, sugar-sweetened beverages; TV, television

* Study methodology quality assessed using the Effective Public Health Practice Project Quality Assessment Tool, with an overall quality rating is assigned: strong (four strong ratings and no weak ratings), moderate (less than four strong ratings and one weak rating) or weak (two or more weak ratings)⁽¹⁹⁾

† Direction and confidence of the association will be summarised using the following symbols: significant negative association, --; non-significant negative association, - null association, 0; non-significant positive association, +; significant positive association, ++; inconsistent associations, ~.

‡ Includes more than three discretionary food choices

§ Includes soft drinks, energy drinks, fruit juice and other flavoured drinks

| Includes salty and high fat snacks, potato chips and other savoury/packaged snacks

| Includes confectionary, cakes, biscuits, and other sweet snacks

^{a, b, c} One study covered multiple environmental sizes

Table 4: Summary of intervention studies targeting children's discretionary choices intake

Reference, country, study design, quality*	ANGELO Framework (environment size and type)	Discretionary choices targeted	Results summary†
Macro: Government			
Birch et al. (1993) ⁽³⁸⁾ USA RCT Weak	Physical: Food reformulation (reduction in DC associated nutrients)	Sweet‡ and savoury snacks§	-
Stutts et al. (2011) ⁽³⁷⁾ USA RCT Weak	Policy: Nutrition labelling (addition of DC associated nutrient labelling)	Fast food	-
Tandon et al. (2010) ⁽³⁶⁾ USA RCT Moderate	Policy: Nutrition labelling	Fast food	--
Micro: Educational Institution			
Acran et al. (2013) ⁽³⁹⁾ USA RCT Moderate	Policy: Teacher classroom food-related practices (reduction in behaviours using DC) Sociocultural: Teacher beliefs (increase in positive DC related beliefs)	Candy, fast food, SSB	--
Bevelander et al. (2012) ⁽⁵⁴⁾ Netherlands RCT Moderate	Socio-cultural: Peer influence (positive peer modelling)	Sweet snack	0
Musher-Eizenman et al. (2010) ⁽³⁾ USA RCT Moderate	Physical: Food availability	Snack food	-
Zask et al. (2012) ⁽⁴⁶⁾ Australia RCT Weak	Physical: Food availability Policy: Nutrition policy Socio-cultural: Parental knowledge/attitudes/beliefs	DC	--
Micro: Home			
Dickin et al. (2013) ⁽⁴⁰⁾	Physical: Food availability/ SSB substitution water, low fat milk	SSB, fast food	--

USA
Cohort
Weak

Duncanson et al. (2013) ⁽⁴⁴⁾ Australia RCT Moderate	Physical: Food availability Policy: Child feeding practices	DC	-
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Fletcher et al. (2013) ⁽⁴⁵⁾ Australia RCT Moderate	Physical: Food availability Policy: Child feeding practices Sociocultural: Meal time structure	DC	-
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ANGELO, ANalysis Grid **for** Environments Linked to Obesity; RCT, randomised **controlled** trial; SSB, sugar-sweetened beverages; DC, discretionary choices

* Study methodology quality assessed using the Effective Public Health Practice Project Quality Assessment Tool, with an overall quality rating is assigned: strong (four strong ratings and no weak ratings), moderate (less than four strong ratings and one weak rating) or weak (two or more weak ratings)⁽¹⁹⁾

† Direction and confidence of the association will be summarised using the following symbols: significant negative association, --; non-significant negative association, - null association, 0; non-significant positive association, +; significant positive association, ++; inconsistent associations, ~.

‡ Includes confectionary, cakes, biscuits, and other sweet snacks

§ Includes salty and high fat snacks, potato chips and other savoury/packaged snacks

| Includes soft drinks, energy drinks, fruit juice and other flavoured drinks

| Includes more than three discretionary food choices

