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**Lifestyle weight management programmes for children: a  
systematic review using Qualitative Comparative Analysis to  
identify critical pathways to effectiveness**

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**Abstract**

This study aimed to identify critical features of successful lifestyle weight management interventions for overweight children (0-11 years).

Eleven qualitative UK-based studies examining children's, parents' and providers' perspectives and experiences of programmes were synthesised to identify components felt to be critical. Studies for this views synthesis were identified from existing reviews and an update of one review's search, which was run in December 2015. The identified components were then explored in a synthesis of intervention evaluations (five 'most effective' and 15 'least effective') conducted in western Europe, North America, Australia or New Zealand. The intervention evaluations were identified from existing reviews and an update of one review's search, which was run in March 2016. This evaluation synthesis was carried out using Qualitative Comparative Analysis.

Three important mechanisms were present in all the most effective interventions but absent in all the least effective: 1/ showing families how to change: a) providing child physical activity sessions, b) delivering practical behaviour change strategy sessions, c) providing calorie intake advice; 2/ ensuring all the family are on board: a) delivering discussion/education sessions for both children and parents, b) delivering child-friendly sessions, c) aiming to change behaviours across the whole family; 3/ enabling social support for both parents and children by delivering both child group sessions and parent group sessions.

To conclude, programmes should ensure the whole family is on board the programme, that parents and children can receive social support and are not just told what to change, but shown how.

## Introduction

Overweight and obese children face many immediate and long term health risks (1, 2). Lifestyle weight management programmes (WMPs) aim to improve nutrition and increase physical activity. There has been extensive research examining the impact of these programmes on children, including systematic reviews (3-10). These provide robust evidence that WMPs for children can be effective, at least immediately post-intervention, though results vary and study quality can be low (3-5).

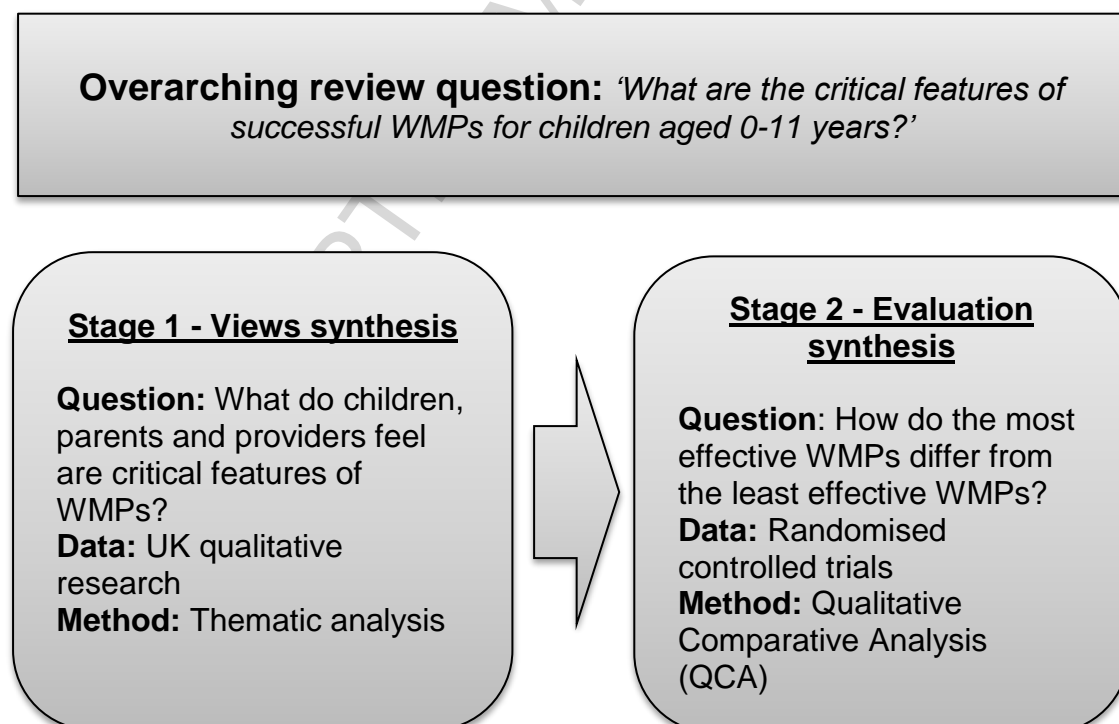
The National Institute for Health and Care Excellence (NICE) guidance on lifestyle weight management programmes for overweight or obese children and young people recommends a focus on diet and physical activity, reducing sedentary time and behaviour change strategies for the child and family (11). However there lacks specific guidance on *how* to deliver these components. Interventions aiming to change diet and/or physical activity behaviours, such as WMPs, are social interventions characterised by complexity. They tend to have multiple, interacting, flexible components, and their effects can be moderated by many factors, including their context, how they are delivered and the characteristics of the people targeted and those involved in service delivery (12). Those that have been evaluated tend to vary in terms of content and the contexts of their delivery however the reporting of interventions' content and their contexts has generally been poor (13-15). As such, the existing sound but high-level guidance and review findings need to be complemented by more fine-grained evidence about the critical features of such interventions. This paper presents findings from a mixed method evidence synthesis using qualitative comparative analysis (QCA), specifically designed to identify the critical features of successful lifestyle weight management interventions for early years and primary-school-aged children (0 - 11 years old).

## Methods

In this mixed method evidence synthesis, a ‘views synthesis’ of UK-based qualitative research with children, parents and providers was used to identify programme components to explore in an ‘evaluation synthesis’ using Qualitative Comparative Analysis (QCA) (see figure 1). QCA enables the identification of configurations of features that are (or are not) present when an intervention has been successful (or not) in obtaining a desired outcome (16). The evaluation synthesis QCA explored differences in the programme characteristics of those interventions found to be most and least effective, in terms of reductions in body mass index (BMI)z scores months (BMIz scores are measures of BMI scores adjusted for age and sex, according to a reference population (17)).

Figure 1 here

Figure 1: Review methods



Since the child weight management literature has been reviewed extensively, we sought studies from existing reviews (3-6, 8, 18-21) as well as updating two reviews' searches (4, 8). Studies were screened for inclusion by pairs of researchers (KS, RR, HB) according to pre-defined criteria (see table 1). For more details about the methods used to identify studies, see supplementary file 1.

*Table 1 here*

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Table 1: Inclusion and exclusion criteria

Criteria	Specification for views synthesis	Specification for trials synthesis
<i>Inclusion</i>		
1. Population	<ul style="list-style-type: none"> <li>• <b>Children</b> (<math>\leq 11</math> years) who had experience of a WMP for children; or</li> <li>• <b>Parents or carers</b> who had experience of a WMP for children aged <math>\leq 11</math> years; or</li> <li>• <b>Service providers</b> who had delivered a WMP for children aged <math>\leq 11</math> years.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Children</b> (<math>\leq 11</math> years) all of whom are classified as overweight or obese.</li> </ul>
2. Study type	<ul style="list-style-type: none"> <li>• Qualitative study of views, perceptions or beliefs</li> </ul>	<ul style="list-style-type: none"> <li>• Randomised controlled trial</li> </ul>
3. Intervention	<ul style="list-style-type: none"> <li>• WMP for children aged <math>\leq 11</math> years.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Targeted at younger children (<math>\leq 11</math> years) or their parents or carers;</b> and</li> <li>• <b>Contained multiple components</b> (addressing diet, physical activity and strategies for behaviour change); and</li> <li>• Included a <b>parental involvement</b> component.</li> </ul>
4. Comparison		<ul style="list-style-type: none"> <li>• Control group or minimal intervention</li> </ul>
5. Outcome	Views about WMPs for children aged $\leq 11$ years.	<ul style="list-style-type: none"> <li>• BMIz or BMI percentile; and</li> <li>• Followed-up for at least 12 months after baseline/randomisation.</li> </ul>

Criteria	Specification for views synthesis	Specification for trials synthesis
6. Country	<ul style="list-style-type: none"> <li>UK</li> </ul>	<ul style="list-style-type: none"> <li>Those with a high degree of applicability to a UK setting (Western Europe, North America, Australia and New Zealand)</li> </ul>
7. Language	<ul style="list-style-type: none"> <li>English only</li> </ul>	<ul style="list-style-type: none"> <li>English only</li> </ul>
8. Publication date	<ul style="list-style-type: none"> <li>Published in or since 1990</li> </ul>	<ul style="list-style-type: none"> <li>Published in or since 1990</li> </ul>
<b>Exclusion</b>		
9. Document type	<ul style="list-style-type: none"> <li>Conference abstracts or posters</li> <li>Reviews of reviews, though the reference lists were searched for primary studies</li> </ul>	<ul style="list-style-type: none"> <li>Conference abstracts or posters</li> <li>Reviews of reviews, though the reference lists were searched for primary studies</li> </ul>
10. Quality and data	<ul style="list-style-type: none"> <li>Study with a poor description of the methods (full report screening only)</li> <li>Studies with little data on experience with WMP (full report screening only)</li> </ul>	



Thematic analysis (22) guided our inductive line-by-line coding (23) of views studies, which aimed to capture descriptive themes about WMP features. The descriptive themes were organised into higher-order analytical themes that 'went beyond' the original findings of the studies (22). Three researchers conducted the views synthesis (KS, RR, HB). Data were extracted by at least two researchers for each of the studies, with all three researchers working together to identify and agree on the descriptive themes, and to confirm their conceptual coherence.

Included trials were ranked according to the mean difference in BMIz between intervention and control arms at 12 months follow-up. We compared 'most effective' interventions; those achieving a difference of at least -0.25; and 'least effective' interventions - those with a mean difference of -0.05 or less. The cut off of -0.25 for 'most effective' interventions was selected, since this was the minimum reduction that has been found to be associated with improvements in health risk factors in adolescents; there remains a lack of evidence for younger children (24). For 'least effective' interventions, -0.05 was selected as this a clear distinction between moderately effective and least effective interventions. Similar to MSDO/MDSO (most similar, different outcome/most different, similar outcome) designs (25) we excluded moderately effective interventions to enhance our ability to differentiate between success and failure; and thus detect the critical features of successful WMPs.

The views synthesis structured the QCA in three ways. First, to extract information about the features of the selected WMPs, we developed a coding framework based on the findings of the views synthesis, as well as other features of the intervention and evaluation. Second, we developed QCA models by considering the analytical themes derived from the views synthesis. Having identified three key mechanisms of change in the views synthesis we developed three models, each incorporating related features that form part of the broader mechanism. Third, we used the views synthesis to help interpret the QCA results. This mirrored our previous work on weight management programmes for adults (Melendez-Torres et al., in preparation; Sutcliffe et al, in preparation).

Trial quality was assessed according to Cochrane guidance (26) although one criterion, risk of bias due to selective reporting of outcomes, was excluded since this review focused on one outcome measure which had to be reported in order for a study to be included.

Data on WMP features were extracted from studies by two researchers (KS, HB), using a framework based on the findings of the views synthesis, as well as other descriptive features of the intervention and evaluation. These 'other' features included standard intervention and evaluation descriptors (e.g. frequency of sessions, eligibility criteria), as well as features that the researchers felt might be pertinent based on prior experience (e.g. calorie intake was included, since this was identified as important in a previous review of adult weight management programmes) (27). Based on the data extractions, a binary code was then applied to each feature. At both the data extraction and coding stage, the two researchers first worked independently and then compared their work to reach a consensus.

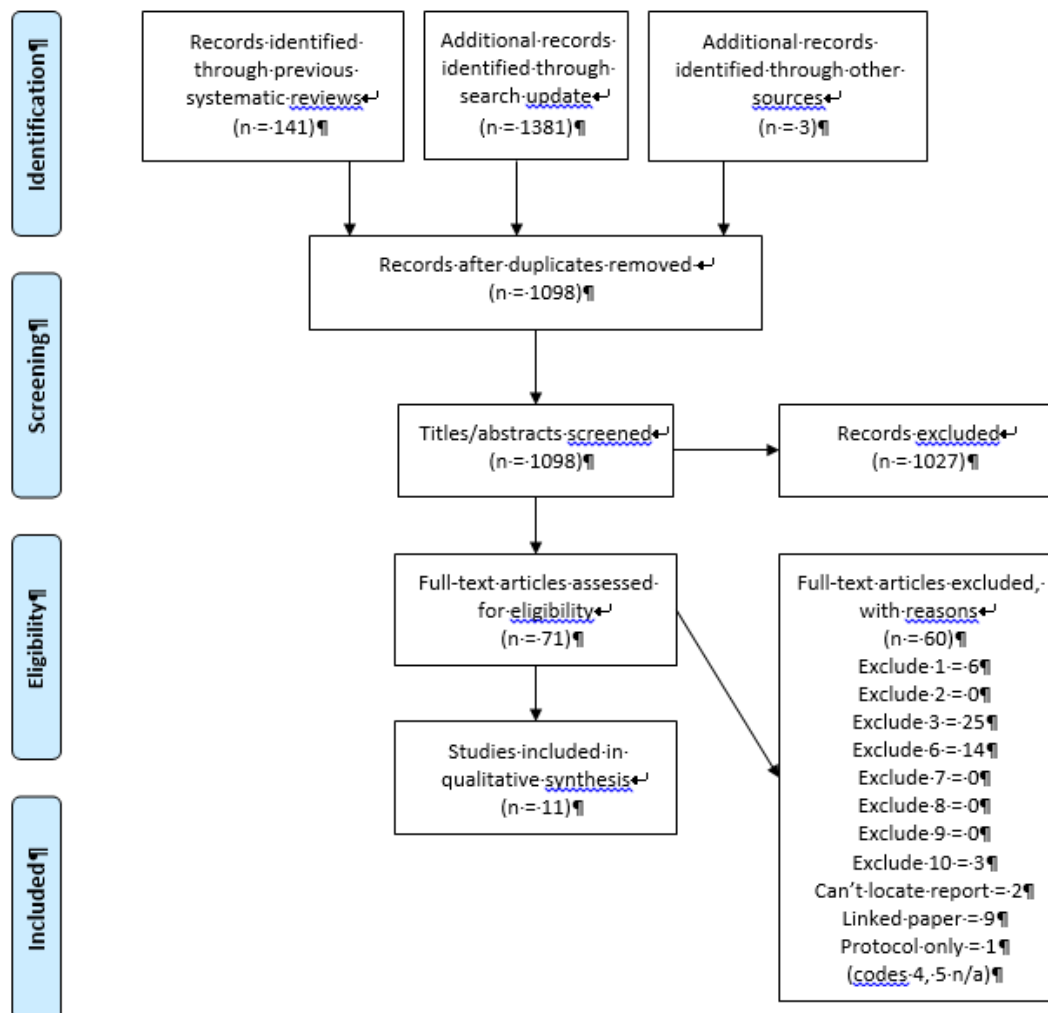
Using the freely available 'Kirq' software (28) we employed QCA to identify combinations of WMP features associated with most effective or least effective interventions. QCA enables the identification of configurations of intervention and contextual features that together form pathways to high effectiveness or, conversely, to low effectiveness (16). The logic of QCA is based on configurational causation; that is, how do different intervention characteristics combine to form the conditions necessary for an outcome to occur? We followed the six QCA steps described by Thomas et al. (16). For more details about our methods, see supplementary file 1.

## Results

### Description of studies

In total, 1098 references were screened for the views synthesis and 1617 references were screened for the trials synthesis (for details of the flow of studies included in the review, see figure 2). Eleven studies, presented in 19 papers, were included in the views synthesis (29-39) and 20 intervention evaluations, reported in 17 trials (40-56), were included in the evaluation synthesis.

Figure 2 here



Eight views studies captured perspectives from children, ten captured parents' perspectives, and four captured providers' views (see table 2). The WMPs discussed in the views studies varied in terms of duration, frequency, target population and content, with most involving regular group sessions and physical activity provision; but some involving individual appointments and no activity (see supplementary file 2, table 1, for more details about the included views studies).

*Table 2 here*

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Table 2: Overview of included views studies

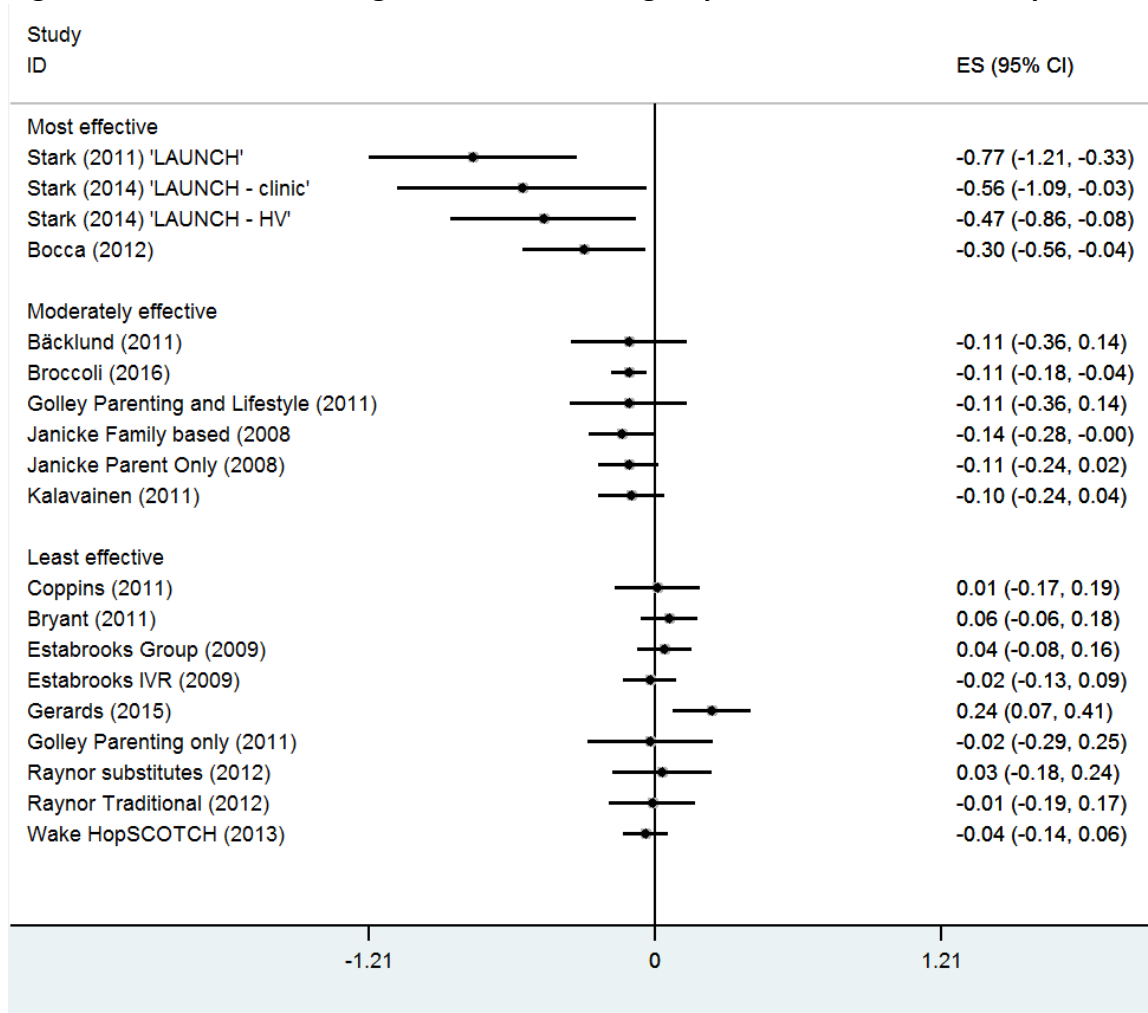
Ref no.	Study	Weight management programmes			Type	Number of participants			Child's gender	Additional information
		Name	Provider	Target age		Chil dren	Parents /carers	Provi ders	% female	
(29)	Lewis et al. (2014)	Un-named	community	6-16	Group-based	58	-	-	50%	39 children were aged 6-11 years, of which 19 were male
(30, 57)	Lucas et al. (2014)	"MEND"	community	7-13	Group-based	31	33	29	45%	22 children interviewed were attending the programme, 9 were siblings.
(31)	Newson et al. (2013)	Un-named	NHS	5-15	Group-based	-	14	-	Ns	
(32)	Owen et al. (2009)	Un-named	NHS	5-18	Individual family	11*	21	-	55%	2 children aged 5-10 years; 9 aged 11-18 years
(33)	Pittson (2013)	"Y W8?"	NHS	8-13	Group-based	-	6	-	-	Parents interviewed: 5 children were female; 2 male. Mean age of completers: 10.6 years
(34, 58)	Robertson (2009)	"Families for Health"	community	7-11	Group-based	18*	13	1	72%	Children's group interviews age range 7-13 years. Included 2 'normal' BMI siblings who attended the programme.
(35)	Staniford et al. (2011)	"MEND"	community	7-13	Group-based	10	7	9	70%	Participants include those both pre-treatment and post-treatment
(36, 59, 60)	Stewart et al. (2008)	Un-named	NHS	5-11	Individual family	-	17	-	53%	8 parents received intervention; 9 were in the control arm. 8 had 5-8 year olds; 9 had 9-11 year olds
(37)	Trigwell et al. (2011)	"GOALS"	community	5-13	Group-based	13*	9	-	62%	Nine families with 13 children participating were involved in qualitative data collection.
(38)	Visram et al. (2013)	"Balance It!"	NHS	4-17	Individual family	17*	20+**	16	45%	Five aged 8 yrs or younger, seven 9-12 yr olds, eight 13+ yr olds
(39, 61, 62)	Watson (2012)	"GOALS"	community	5-13		39	34	-	51%	

\* Limited children's views presented, \*\* Unclear number of parent participants

For the evaluation synthesis, a forest plot was produced to visually present the difference in BMIz change between the intervention group and the control group at 12 months follow up (figure 3); however only 19 interventions were presented since the information to calculate confidence intervals was unavailable for 11 (table 3 contains the data for all 30). Five interventions met the criteria for classification as 'most effective' and 15 as 'least effective' (see table 3). Five of the least effective interventions showed greater reduction in BMIz at 12 months in the control group than in the intervention group, suggesting a possible harmful intervention effect. Interventions varied widely, for example, in terms of the target population, frequency, duration, delivery mode and content. Study quality varied, with studies meeting between zero and five of six criteria for low risk of bias; however there was no substantial difference in quality between the most and least effective interventions (see supplementary file 2, table 2, for more details about the included intervention evaluations).

*Figure 3 here*

*Table 3 here*

**Figure 3: Difference in change in BMIz between groups at 12 months follow up\***

\*Several interventions (n=11) were unable to be presented in this forest plot since the information to calculate confidence intervals was unavailable.

Table 3: Overview of intervention contexts and outcomes (n=20)

	Refer ence	First study author and year (intervention arm)	BMIz difference *	BMIz reference population used	Country of study	Age & BMI eligibility criteria
<b>Most effective interventions</b>	(50)	Stark 2011	-0.77	USA 2000	USA	2-5 years, BMI 95-99th
	(56)	Weigel 2008	-0.60	Germany 2001	Germany	7-15 years, BMI >90th
	(49)	Stark 2014 (LAUNCH- clinic)	-0.56	USA 2000	USA	2-5 years, 95-99th
	(49)	Stark 2014 (LAUNCH – HV)	-0.47	USA 2000	USA	2-5 years, 95-99 <sup>th</sup>
	(40) (63)	Bocca 2012	-0.30	The Netherlands 1996/7	The Netherlands	3-5 years, BMI-z >1.1
<b>Mid-effect interventions</b>	(64)	Resnicow 2015 (provider plus RD)	-0.18	USA 2011**	USA	2-8 years, BMI 85-97th
	(64)	Resnicow 2015 (provider- only)	-0.14	USA 2011**	USA	2-8 years, BMI 85-97th
	(65) (66, 67)	Janicke 2008 (family- based)	-0.14	n/s	USA	8-14 years, BMI >85th
	(65) (66, 67)	Janicke 2008 (parent-only)	-0.11	n/s	USA	8-14 years, BMI >85th
	(68) (69)	Broccoli 2016	-0.11	n/s	Italy	4-7 years, BMI 85-94 <sup>th</sup>
	(70) (71, 72)	Backlund 2011	-0.11	Sweden 2000	Sweden	8-12 years, age- and gender- adjusted BMI of $\geq 25\text{kg/m}^2$
	(73) (14, 45)	Golley 2007 (Triple P + lifestyle education)	-0.11	UK 1990	Australia	6-9 years, overweight or obese according to IOTF but BMIz $\leq 3.5$



	Refer ence	First study author and year (intervention arm)	BMIz difference *	BMIz reference population used	Country of study	Age & BMI eligibility criteria
	(74)	Taylor 2015	-0.11	USA 2000	New Zealand	4-8 years, BMI $\geq$ 85th
	(75) (76)	Kalavainen 2011	-0.10	UK 1996	Finland	7-9 years, weight for height 120-200%
	(77)	Lochrie 2013	-0.10	n/s	USA	8-11 years, with BMI $\geq$ 85th
<b>Least effective interventions</b>	(52)	Taveras 2011	-0.05	n/s	USA	2-6.9yrs, BMI $\geq$ 95th percentile or BMI 85 <sup>th</sup> to 95th percentile if $\geq$ 1 parent was overweight (BMI $\geq$ 25)
	(51) (78)	Taveras 2015	-0.05	USA 2000	USA	6-12 years, BMI $\geq$ 90 <sup>th</sup>
	(55) (79, 80)	Wake 2013	-0.05	n/s	Australia	3-10 years, BMI $>$ 95 <sup>th</sup>
	(53) (81)	Van Grieken 2014	-0.04	n/s	The Netherlands	5 years; overweight but not obese
	(46) (82)	Hughes 2008	-0.04	UK 1990	UK	5-11 years, BMI $\geq$ 98 <sup>th</sup>
	(43)	Estabrooks 2009 (FC-IVR)	-0.02	USA 2000	USA	8-12 years, BMI $>$ 85 <sup>th</sup>
	(73) (14, 45)	Golley 2007 (parenting only)	-0.02	UK 1990	Australia	6-9 years, overweight or obese according to IOTF but BMIz $\leq$ 3.5
	(47)	McCallum 2006	-0.02	UK 1990	Australia	5-9 years, classified as overweight/mildly obese according to IOTF
	(48)	Raynor 2012 (traditional)	-0.01	USA 2000	USA	4-9 years, BMI $\geq$ 85 <sup>th</sup>
	(42)	Coppins 2011	-0.01	UK 1990	UK	6-14 years, BMI $>$ 91 <sup>st</sup> centile

	Refer ence	First study author and year (intervention arm)	BMiz difference *	BMiz reference population used	Country of study	Age & BMI eligibility criteria
	(54)	Wake 2009	0.02	USA 2000	Australia	5-9 years classified as overweight/mildly obese according to IOTF but BMiz $\leq 3.0$
	(48)	Raynor 2012 (substitutes)	0.03	USA 2000	USA	4-9 years, BMI $\geq 85^{\text{th}}$
	(43)	Estabrooks 2009 (FC- group)	0.04	USA 2000	USA	8-12 years; BMI $> 85^{\text{th}}$
	(41) (83)	Bryant 2011	0.06	UK 1990	UK	8-16 years; BMI $> 98^{\text{th}}$
	(44)	Gerards 2015	0.24	The Netherlands 1996/7	The Netherlands	4-8 years, overweight or obese

\* Mean difference in the change in BMiz at 12 months between intervention and control group

\*\* BMiz calculated by study team based on BMI percentile. BMI percentile calculated using CDC BMI percentile calculator 2011

**Views synthesis: what did those involved think about WMPs?**

Analysis of children's, parents' and providers' views revealed three key WMP features that were felt to be necessary for successful weight management. These supported the development of the skills, confidence and resilience perceived by participants to be critical. The three features were:

- 1) **practical experiences**, which were exemplified by showing participants *how* to change, rather than just telling them what to change
- 2) **family involvement**, which was exemplified by creating a shared understanding and a healthy home environment; and
- 3) **social support**, which was exemplified by creating a safe space in which to gain confidence and skills.

There did not appear to be differences in the viewpoints of children, parents and providers, although not all studies included all stakeholders nor covered all the themes. For example, children, parents and providers all appreciated a broader, more holistic approach rather than a focus just on weight loss (although only 4/8 child-focused studies covered this, and only 3 of the 4 provider studies). Table 4 below provides an overview of the three themes.

*Table 4 here*

Table 4: Summary of findings on the views of children, parents and providers

Theme	Example view
<p><b>1. Learning <i>how to change</i>:</b> Practical experiences that show you how to change, not only telling you what to change</p> <p><i>“It wasn’t just like ‘you need to do more exercise and you need to eat better’ – it actually taught us like how to” child (39) p181</i></p>	
<p>Practical experiences, as opposed to didactic information giving, were valued:-</p> <p>Practical <b>physical activity</b> sessions were widely and emphatically praised for giving children confidence and enabling them to experience enjoyment of being active.</p> <p>Practical and interactive <b>healthy eating sessions</b> were also highly valued such as cooking or tasting foods, and visual approaches, e.g. to illustrate portion size.</p> <p><b>Practical health behaviour change</b> strategies such as goals, monitoring or parenting skills, were also felt to be helpful.</p>	<p><i>“The team games were good. Boost their confidence to join in with their mates. Cause some of these kids are really isolated so they need team sports to encourage them to join in” Parent, (33) p177</i></p> <p><i>“The portion sizes [session] was very good. We are eating way too much of everything and need to cut down.” Parent, (34) (p455)</i></p> <p><i>“The best bit I liked was making the bread.” Child, (34) (p326)</i></p> <p><i>“The challenge charts you gave us, he loved it, loved it. Yeah he absolutely thought that was brilliant, and it was competition cause his brother joined in” Parent (33) (p176)</i></p>

Theme	Example view
<p><b>2. Getting all the family 'on-board':</b> Shared understanding and a healthy home environment</p> <p><i>"They've got to have the support of the others in the family otherwise it's almost impossible" Health professional (35) p238</i></p>	
<p>One <b>key impediment</b> to change was felt to be <b>other family members</b> both within the home and in relation to extended family and friends. Engaging the wider family was felt to enable:-</p> <p>Shared <b>understanding</b> across family members</p> <p><b>Shared responsibility</b> for making changes</p> <p>The creation of a <b>healthy home environment</b></p>	<p><i>'Providers valued the active involvement of parents and carers and saw a family approach as crucial: "I think that's key... because if you don't change the parents, then nothing changes at home..." Provider (30) p7</i></p> <p><i>"how can I tell her "this is what you need to do" if she's not seeing me do it" Parent (39) p118</i></p> <p><i>"children are more aware nowadays, none of us like being told to do things and so it was like forming a partnership and it worked" parent (36) p166</i></p> <p><i>"at home we've had different fruit in our house in our fruit bowl and we've had less chocolate" child (39) p124</i></p>

Theme	Example view
<p><b>3. Social support:</b> a safe space with similar others in which to gain confidence and skills</p> <p><i>“finding out you weren’t alone in this [...] having an open forum to say my kid does that too, cause you feel so guilty” Parent (33) p177</i></p>	
<p>Families were emphatic about <b>group sessions</b> which provided a <b>positive contrast</b> to experiences of prejudice and bullying.</p>	<p><i>“Coming here with other children similar to himself and getting to speak to other parents dealing with like the same issues is really helpful for us.” Parent (35) p236</i></p> <p><i>“I found them fun because I was surrounded by different people who were in the situation that I was in” Child (female) (30) p8</i></p>
<p>In particular group sessions were described as having a <b>positive impact on children’s confidence</b>, which was described as <b>fundamental to both initiation and maintenance</b> of health behaviour changes.</p>	<p><i>“I think I’m glad I stayed at it because I’ve made more friends and confidence has built up a bit...and it’s easier to talk to people because they don’t tell you to go away or you know ‘you’re not fit to be with us because so and so and how you look’ but they actually go ‘oh hi, how are you today? And ‘do you want to come and join us’ ....” child (39) p123</i></p>
<p><b>Skilled providers</b> helped to create positive group experiences</p>	<p><i>“They’re friendly and kind, and they boost your confidence.” Child (29) p1222</i></p>

**Evaluation synthesis: which combinations of characteristics created pathways to least/most effectiveness?**

The QCA explored the association between the three features identified in the views synthesis through the development, testing and refinement of three models.

**Model 1. Showing families *how to change*.** This model intended to address *how* to deliver the three key elements of programme content in a lifestyle WMP: healthy eating, physical activity and behaviour change.

This model included three conditions: a) provision of **physical activity sessions** for children; b) delivery of three or more **practical behaviour change strategy** sessions; and c) **advice on calorie intake**. The first two conditions reflect key themes from the views synthesis around practical support and guidance. For some conditions, such as practical behaviour change strategies, it was clear that intensity was important. However there was insufficient evidence to specify exactly what the minimum intensity should be; only that when less than a certain number of sessions were included (in this case two or fewer), this was insufficient. Hence for some conditions, such as practical behaviour change sessions, we have specified 'x or more' sessions. The final condition was the only condition in the models that emerged as part our assessment of the intervention descriptions for each study rather than from the views synthesis. Whilst the importance of this component was not underscored by the views of children, parents and providers, evidence from our previous review on adult weight management had identified calorie goals as a critical feature of WMPs (Melendez et al., in press; Sutcliffe et al, in press).

All three conditions were present in all five most effective interventions (see table 5). That is to say, a critical pathway to effectiveness is to include all three of these components in a WMP. Conversely, inclusion of only one of these features, or disregarding all of them, formed a critical pathway to least effectiveness. Our analyses were completely consistent; that is, each pathway either included all most effective or all least effective trials.

Because QCA is a 'small-n' analysis method, observations are unlikely to

include all possible combinations of conditions. These combinations are called 'logical remainders' - possible configurations for which we did not have any studies in our dataset. We hypothesise that all four logical remainders would lead to low effectiveness, since the presence of all three conditions appears to be necessary for higher effectiveness.

*Table 5 here*

**Table 5: Configurations represented in the three QCA models**

Conditions in model			No. most effective interventions	No. least effective interventions
<b><i>1. How to change model</i></b>				
<b>Child physical activity sessions</b>	<b>3+ practical behaviour change strategy sessions</b>	<b>Calorie intake advice</b>		
Absent	Absent	Absent	0	9
Absent	Present	Absent	0	4
Present	Absent	Absent	0	2
Present	Present	Present	5	0
<i>Absent</i>	<i>Absent</i>	<i>Present</i>	<i>0*</i>	<i>0*</i>
<i>Absent</i>	<i>Present</i>	<i>Present</i>	<i>0*</i>	<i>0*</i>
<i>Present</i>	<i>Absent</i>	<i>Present</i>	<i>0*</i>	<i>0*</i>
<i>Present</i>	<i>Present</i>	<i>Absent</i>	<i>0*</i>	<i>0*</i>



Conditions in model	No. most effective interventions	No. least effective interventions
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### ***2. All family on board model***

<b>Child-friendly sessions</b>	<b>Aim to change behaviour of the whole family</b>	<b>3+ education/discussion sessions for children and for parents</b>		
Absent	Absent	Absent	0	1
Absent	Present	Absent	0	5
Absent	Present	Present	0	5
Present	Absent	Absent	0	1
Present	Absent	Present	0	2
Present	Present	Absent	0	1
Present	Present	Present	5	0
<i>Absent</i>	<i>Absent</i>	<i>Present</i>	<i>0*</i>	<i>0*</i>

### ***3. Social support model***

<b>Child group sessions</b>	<b>3+ parent group sessions</b>			
Absent	Absent		0	9
Absent	Present		0	4
Present	Absent		0	2
Present	Present		5	0

*\*logical remainders*

Model 2. Efforts to ensure **all the family are on board**. This model included three conditions: a) delivering **child-friendly** sessions, b) delivering three or more **discussion/education sessions for both children and parents**, and c) **aiming to change behaviours across the whole family** rather than just the participating child. The first condition reflects the need to engage the child in the WMP, for example by ensuring that materials and activities are accessible and appealing for children. Interventions were coded as child-friendly if they delivered child-only sessions, or mentioned using materials aimed at children or attempting to engage the child. The second condition addresses a need for a shared understanding of the programme by different family members. The third condition reflects the finding from the views synthesis that addressing the habits of the whole family and encouraging a healthy home environment are needed to support behaviour change in the child targeted by the programme.

As in the previous model, the presence of all three conditions in an intervention formed a critical pathway to effectiveness (see Table 5). In contrast, critical pathways to least effectiveness were characterised by the inclusion of only one, two or none of these three conditions. All pathways were completely consistent. We hypothesised that the one logical remainder would lead to low effectiveness, since other interventions with just one of the conditions in this model were least effective.

Model 3. WMPs which enable **social support** for both parents and children. This model built on a key theme from the views synthesis: that social support from similar others, for both parents and children, played a crucial role in successful weight management. Social support fostered motivation to attend WMPs and increased confidence and self-esteem, which in turn supported families' adoption of healthier behaviours. This model contained two conditions: a) **group sessions specifically for children**; and b) three or more **group sessions specifically for parents**. The presence of both these conditions formed a pathway to high effectiveness; the absence of either or both formed pathways to least effectiveness (see table 5). The included interventions represented all four possible configurations; there were therefore no logical remainders. Analyses were completely consistent.

Table 6 presents a summary of the findings.

*Table 6 here*

ACCEPTED MANUSCRIPT

**Table 6: Summary of overall findings**

Critical feature	Components	Example programme content
Showing families how to change	<ul style="list-style-type: none"> <li>Physical activity sessions for children</li> </ul>	“lessons on physical activity (alternating swimming and indoor sports)” (56) p372
	<ul style="list-style-type: none"> <li>3+ sessions on practical behaviour change strategies</li> </ul>	“[Parents] were also taught stimulus control strategies, such as setting up the food environment to encourage healthy eating by eliminating high calorie/low nutrient foods and having fruits and vegetables in the home.” (50) p135
	<ul style="list-style-type: none"> <li>Advice on calorie intake</li> </ul>	“a normocaloric diet was advised based on the required daily intake for this age group” (40) p1110
Getting all the family on board	<ul style="list-style-type: none"> <li>Designed to be child friendly</li> </ul>	“Children were seen concurrently in a group format. They received nutrition education through games and art activities, tried new foods during a structured meal, and completed 15 min of moderate to vigorous activity.” (50) P135

	<ul style="list-style-type: none"> <li>• Aimed to change behaviour of the whole family</li> </ul>	“Parents were taught to change family attitudes toward healthy eating and physical activity...”(40) p1110
	<ul style="list-style-type: none"> <li>• 3+ discussion/ education sessions for children and for parents</li> </ul>	“12 weekly sessions, alternating between group-based clinic sessions (parent and child concurrent groups), and individual home visits” (49) p1003
Social support	<ul style="list-style-type: none"> <li>• Sessions for groups of children</li> </ul>	“Motor skills were taught, and sessions were aimed at having fun during exercise, thereby improving the child’s well being.” (40) p1110
	<ul style="list-style-type: none"> <li>• 3+ group sessions for parents</li> </ul>	“Parental support was provided separately at monthly meetings and feedback discussions of up to 2 hours” (56) p371

Once the QCA had been conducted and the combinations of conditions identified that were associated with the most and the least effective interventions, the ten mid-effect interventions (i.e. those achieving  $\leq 0.25$  change in BMIz compared to controls but greater than  $-0.05$  change) were then assessed according to these criteria (64, 65, 68, 70, 73-75, 77) (two trials had two included intervention arms) (see supplementary file 2 for details of these intervention evaluations). This was to identify whether any interventions should, according to the QCA findings, be in either the most or the least effective set. This added a further layer of robustness to the findings by further testing the validity of our analysis, as well as potentially highlighting additional conditions that may be of relevance that had not previously been considered. We hypothesised that moderately effective interventions would likely be characterised by some but not all of the pathways to effectiveness for the above models.

As expected, we found that none were characterised by pathways to effectiveness for all three models. Five interventions were characterised by pathways to most effectiveness with regards to the all family on-board and the social support models, but by pathways to least effectiveness with regards to the 'how to change' model (65, 70, 73, 75, 77) (Janicke et al.'s family-based intervention arm). The remaining five were characterised by pathways to least effectiveness with regard to all three models (64, 65, 68, 74) (Janicke's parent-only intervention arm; both intervention arms in Resnicow et al.).

## Discussion

This analysis identified three key mechanisms within which conditions could form pathways to effectiveness: showing families how to change, ensuring all the family are on board and enabling social support for parents and children. Conditions related to these mechanisms formed pathways to most effectiveness, and their absence (or partial absence) was associated with least effective interventions.

Whilst our findings must be considered developmental rather than conclusive, as we cannot be certain that we have been able to identify *all* critical features

of child WMPs, concurrence with the broad recommendations of the NICE guidance (11) and the findings of existing systematic reviews (3-6, 9, 10, 20, 84-91) underscores their validity. Moreover, whilst further work may help to refine and build on the theories presented, the particular value of this methodological approach is that it was able to offer a more nuanced understanding about mechanisms and programme features that appear to be important. For all three aspects of programmes (physical activity, healthy eating and behaviour change), practical approaches were critical. For example, rather than simply advising that more physical activity should be undertaken, all of the most effective programmes included the delivery of sessions where children participated in physical activities together. Physical activity sessions were found to be vital for giving children both skills and confidence in, as well as enjoyment of, physical activity.

Others have also concluded that programmes should target the whole family, rather than the child or parent only (5, 87). Our analysis found that not only was it important to involve both parent and child, but that programmes should focus on changing the behaviours of the whole family rather than the target child alone. Involving both parent and child – so they both have some ownership of the behavioural changes and both develop confidence and skills. Furthermore, as demonstrated in the third model, involving both would provide them with access to peer social support. Focusing on the whole family would be more likely to lead to a change in the home environment e.g. foods available at home. A review by Cislak et al. confirmed that family behaviours, such as whether parents and siblings ate lots of healthy or unhealthy foods, were associated with children's food intake (92).

The context within which overweight children and their families live, can help to hypothesise explanations for some of the findings. The views synthesis highlighted a context of bullying and stigma that has also been noted in other studies (93, 94). Social support for children may therefore be critical; whilst parents require support in their role as parental authority and role model, as well as having responsibility for shaping the home environment.

### Strengths and limitations

The QCA method complements the overarching findings from meta-analyses by making use of the inherent variance in intervention content, context and outcomes to answer a different question to that posed by previous reviews, i.e. rather than 'what works, on average', this review aimed to explore the critical features of WMPs for children to understand the mechanisms through which interventions have the impact that they do.

In addition, there are several strengths arising from our methods that enable us to have confidence in our findings. Firstly, the QCA was underpinned by the experiential evidence that emerged from the views synthesis; it therefore adds face validity in relation to what children, parents and providers have said about their experiences of WMPs. Secondly, we conducted two analyses for each model, in order to examine not only pathways to most effective interventions to identify how to maximise effectiveness, but also pathways to least effective interventions to identify WMP approaches and components to avoid. This was crucial given the limited number of most effective studies. Finally, our findings concur with previous reviews, but offer more fine-grained evidence than is possible through a meta-analysis. Nevertheless, there were limitations of this analysis, particularly related to the studies included.

As with any review, this analysis was limited by the evidence-base available. Notably, there was a lack of views studies and few trials relating to pre-school WMPs. Furthermore, the quality of the studies and their associated intervention descriptions were often poor and few interventions met the criteria for 'most effective'. These limitations have been noted previously (3, 4, 6, 11). Nevertheless, the qualitative evidence focused on the same age group as most of the studies in the least effective set. A further strength of the analysis was that the evidence from the sets of most and least effective interventions mirror each other (i.e. where least effective interventions were characterised by the absence of certain conditions, most effective interventions were characterised by their presence). As such, it seems that the findings could apply to both pre-school and primary-school aged children.



We recommend that future primary research explores the mechanisms by which provider-set energy goals may have an impact within WMPs and what role, if any, negotiated goals should play and what intensity of different activities is most effective. Our study findings support the research recommendations set out in the NICE guidance, i.e. the use of BMIz as a standardised outcome measure, a minimum follow-up period of 12 months post-baseline, qualitative process evaluations and more research targeting pre-school children (11). Finally, we recommend that intervention evaluations improve their intervention descriptions, for example using the TIDieR checklist (95).

### **Conclusion**

This analysis identified three key mechanisms perceived by children, parents and providers to support health behaviour change and found that these were fostered by most effective interventions and were not fostered by least effective interventions. Thus, future service provision should aim to ensure that families are not just told what to change but *shown how* to change, that the whole family is on board with the programme, and that there are opportunities for parents and children to receive social support.

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### Highlights

- Child lifestyle weight management programme features identified as important were:
- 1/ Showing families how to change
- 2/ Ensuring all the family are on board
- 3/ Enabling social support for both parents and children

ACCEPTED MANUSCRIPT