Social influence in childhood obesity interventions: a systematic review

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Social influence in childhood obesity interventions: a systematic review

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³ Center for Health Promotion & Disease Prevention, Gillings School of Public Health, University of North Carolina at Chapel Hill, Chapel Hill, NC, United States of America

Summary
The objective of this study is to understand the pathways through which social influence at the family level moderates the impact of childhood obesity interventions. We conducted a systematic review of obesity interventions in which parents’ behaviors are targeted to change children’s obesity outcomes, due to the potential social and environmental influence of parents on the nutrition and physical activity behaviors of children. PubMed (1966-2013) and the Web of Science (1900-2013) were searched, and 32 studies satisfied our inclusion criteria. Results for existing mechanisms that moderate parents’ influence on children’s behavior are discussed, and a causal pathway diagram is developed to map out social influence mechanisms that affect childhood obesity. We provide health professionals and researchers with recommendations for leveraging family-based social influence mechanisms to increase the efficacy of obesity intervention programs.

Keywords: social influence, childhood obesity, weight-related behaviors, family-based intervention.

Abbreviations
MQRS: methodological quality rating scale
**Introduction**

Despite substantial efforts and much research, childhood obesity continues to be a significant public health concern. Beyond the biological and genetic causes of obesity, a growing consensus among researchers (e.g., [1-5]) points to the significant role of social factors in weight-related behaviors. A variety of weight-related behaviors associated with eating patterns, sedentary life style and physical activity (e.g., [6-9]) can be influenced by social norms, family environments, and relationships [2]. Such influences have been shown to impact individuals' body weight [10, 11]. For instance, a study by Dowda *et al.* [12] suggests that youths between the age of 8 and 16 years who have at least one overweight parent are more likely to be overweight compared with youths who do not have an overweight parent. Christakis and Fowler [4] estimate that an obese sibling or spouse can increase the probability of becoming obese by 40% and 37%, respectively. Reviewing studies on the role of social influence in the obesity epidemic, Hammond [2] concludes that social influence is an important area of continued research and is promising for informing intervention design.

Although some obesity interventions leverage social influences to enhance their effectiveness, there is much room for designing interventions that better leverage social influence to impact weight-related behaviors. For example, Bahr *et al.* [10] argue that inefficacy of obesity interventions is partially due to the fact that overweight and obese individuals are usually considered in isolation from their surrounding social context. However, teasing out the effect of social influence from other influences on behavior is complicated, as the majority of obesity interventions that leverage social influence also have a direct effect on weight-related behavior.

In this study, we review parent-based social influence mechanisms in obesity interventions in the family setting. We specifically focus on the family setting because: 1) family relationships represent psychologically close ties in a shared environment and have significant potential to influence obesity [13-15]; and 2) the family setting is ripe for observing social influence mechanisms in action and their potential impact on weight-related behaviors [16]. In this context, we focus on social influence that captures how children’s weight-related opinions, emotions, and behaviors are influenced by parents. For instance, parents can significantly impact children’s health behaviors through modeling of behaviors, rewarding desirable behaviors, and providing concrete resources to support certain behaviors, among others [17, 18]. Moreover, to avoid confounding the mechanisms of social influence with other influence pathways in obesity interventions, we focus on studies that leverage a specific kind of family social influence, targeting parents to help with children’s weight-related outcomes rather than intervening directly with the children.

**Methods**

**Search strategy**

We conducted a systematic review to study the effects and potential mechanisms of parent-based influence in obesity interventions in the family setting. We reviewed only those studies involving an intervention directed at parents with outcomes addressing children’s eating and physical activity behaviors. This design limits the review to studies that capture only social influence of parents without confounding the direct effect of the intervention on children’s behavior. We looked for relevant papers in public health and social science journals listed in PubMed and the Web of Science. Search terms included: (family or family-based or parents or parent-focused or parent-led or family members) and (weight or overweight or obesity) and (intervention or trial or treatment or prevention), and any variation of those key terms.
Inclusion/exclusion criteria
Peer-reviewed full-text papers written in English and published from the inception of PubMed (1966) and the Web of Science (1900) to the end of 2013 were included. The inclusion and exclusion criteria were fully specified in the review protocol before conducting the review. Papers had to include an obesity intervention (prevention or treatment) directly targeting parents to influence the weight outcomes of children (e.g., intervening with parents with the distal goal of influencing children’s weight status). Papers were excluded if they did not report weight and/or weight-related behavior outcomes for children; were not randomized trials; were reviews or meta-analyses; did not target family interactions; involved medications or medical procedures, individuals with eating disorders, or individuals in institutional settings.

Data extraction
Two reviewers independently performed data extraction to provide a detailed understanding of the interventions and their impacts. Data extraction was performed in two phases. In Phase 1, data was extracted based on the PICOT framework (participants, intervention, comparison, outcome, and time) [19]. In addition to PICOT variables, study objectives, country of study, participants’ age, family members directly/indirectly targeted, and key findings were extracted from each paper. The researchers also coded for whether one or both parents were targeted, the targeted behavior, and the social influence mechanisms.

In Phase 2, data extraction was based on coding the full text of studies, following standards for qualitative research [20], to code social influence mechanisms. Different interventions leveraged diverse activities and behaviors, underlying the need for an organizing framework to categorize the different social influence pathways used in each study. We therefore coded interventions for three core social influence mechanisms [21, 22]: 1) a supportive social environment; 2) modeling healthy eating and activity patterns; and 3) praise and encouragement for desirable behaviors. Any disagreement or concern in the extracted data was discussed by the reviewers until consensus was reached. A third, senior reviewer oversaw the design and conducting the reviews.

Causal pathway diagram
We also developed a causal pathway diagram to map out social influence mechanisms that affect childhood obesity. The diagram builds on the social ecological model (SEM) for understanding childhood obesity [23, 24] and highlights the intermediate processes that regulate the causal mechanisms between intervention and outcomes hypothesized in various studies. The causal pathway diagramming method is adopted from systems modeling toolbox [25-27] and has diverse applications, including literature reviews (e.g., [28]). These diagrams provide a graphical summary of the key mechanisms identified in the literature, facilitate teasing out the empirical support for alternative pathways, highlight the areas in need of further empirical research, and set the stage for future quantitative statistical and systems modeling as well as meta-analyses.

Quality assessment
Quality assessment was carried out by two reviewers independently, using the methodological quality rating scale (MQRS). The MQRS was originally developed by Miller, et al. [29] and we used the version adapted for family-based obesity interventions by Sung-Chan, et al. [30]. The quality attributes in the MQRS cover a wide range of quality aspects in key stages of interventions, such as design, implementation and maintenance. The measure contains 10 attributes, including study design (randomization and control group), treatment integrity (standardization, procedures, and fidelity check), measures (reliability and validity), treatment intensity (duration), length of follow-up, attrition rate, statistical analyses, sample size, multisite, and generalizability. Study design, treatment integrity, treatment intensity, and length of
follow-up have the highest score of 2 (0, 1, or 2), while the other attributes are dichotomous (0 or 1); for more information about the definition of each attribute and measure, see [30]. Each paper is assessed based on the MQRS attributes and scored between 0 and a maximum of 14.

Outcome score
We used treatment effect scoring [30] to evaluate the effectiveness of interventions on weight-related outcomes. Treatment effect scoring compares weight reduction or changes in weight-related behaviors of the treatment group(s) vs. the control group at the end of the intervention and after the follow-up. This method provides one of the following scores for each study: 1=changes were not significant at the end of the intervention; 2=changes were partially/marginally better at the end of the intervention; 3=changes were significant at the end of the intervention but not at the follow-up, or no follow-up results reported; and 4=changes were significant at the end of the intervention and at the follow-up.

Results

Search results and description of studies
The flow diagram for literature search is illustrated in Figure 1. Using our search strategy, we identified 1,455 papers from PubMed and 2,375 papers from the Web of Science. After removing 1,400 duplicate papers, titles and abstracts of 4,300 papers were collected and screened. After excluding non-obesity interventions, review papers, and studies not implemented within the family setting (1,652 papers), 778 papers remained. We then focused on study purpose, design, and results; when compared with our inclusion criteria, 685 papers were subsequently excluded (e.g., studies in which the effect of social influence could not be traced to specific family members; studies that did not measure the effect of the intervention on targeted family members). Consequently, we reviewed the full text of 93 papers and also identified an additional 63 papers by tracking the citations of the first group, to be included in full text review.

Of 156 reviewed full-text papers, we excluded 124 papers because they did not provide any measure of the effect of intervention on children, or the effect of social influence could not be traced to specific family members. Table 1 presents examples of excluded papers in full-text review. Finally, 32 papers satisfied our inclusion criteria, which presented the effects of parent-led interventions on children (mean child age equal to eight years). Both treatment interventions (23 papers) and prevention (9 papers) are included.

Twenty-eight studies targeted both parents, four focused on mothers, and no studies focused on fathers alone. Eleven studies are implemented in the United States, ten in Australia, four in Israel, two in the United Kingdom, four in Belgium, Germany, Switzerland, and the Netherlands, and one in the United States and Canada. Summaries of the interventions are included in Table 2 and the Online Supplementary Table S1. The analysis focuses on teasing out components of interventions, mechanisms of impact, and outcomes to inform social influence processes and future intervention designs. The Online Supplementary Table S1 provides a detailed review of the studies, including study objective, intervention type and duration, participants, study design, findings, and quantitative outcomes.

During the search process, we also looked for interventions that directly targeted any family member to influence the weight outcomes of another family member. We found only one paper [31] that presented the effects of targeting a spouse on the untreated spouse's behavior. We did not include this study in our review to avoid increasing the heterogeneity of our sample.
**Figure 1** Flow diagram for literature search

**Table 1** Examples of excluded studies in the full text review

<table>
<thead>
<tr>
<th>Study</th>
<th>Reasons for exclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kingsley and Shapiro [32], Israel, et al. [33], Israel, et al. [34], Israel, et al. [35], McGarvey, et al. [36], Klohe-Lehman, et al. [37]</td>
<td>Non-randomized trials</td>
</tr>
<tr>
<td>Brownell, et al. [38], Klesges, et al. [39], Epstein, et al. [40], Epstein, et al. [41], Epstein [42], De Bourdeaudhuij, et al. [43], Klesges, et al. [44], De Bock, et al. [45]</td>
<td>Children are directly involved in the intervention.</td>
</tr>
<tr>
<td>Fisher, et al. [46], Arredondo, et al. [47], Campbell, et al. [48], Jones, et al. [49], Sanders [50], De Bock, et al. [51]</td>
<td>Not an intervention (i.e., study protocol, analysis only based on a questionnaire, etc.)</td>
</tr>
</tbody>
</table>
Table 2 Characteristics of 32 reviewed studies

<table>
<thead>
<tr>
<th>Paper</th>
<th>Type</th>
<th>Age of child</th>
<th>Age of parent</th>
<th>Target behavior</th>
<th>Behavior change (see Table 3 for more descriptions)</th>
<th>Family composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Israel et al. 1985 [52]</td>
<td>T</td>
<td>N/A²</td>
<td>N/A</td>
<td>EB, PA, PS</td>
<td>I, VI</td>
<td>Both parents</td>
</tr>
<tr>
<td>Israel et al. 1994 [53]</td>
<td>T</td>
<td>10.92 (1.17)</td>
<td>N/A</td>
<td>EB, PA, PS</td>
<td>I, IV, VI</td>
<td>Both parents (at least one parent willing to attend sessions)</td>
</tr>
<tr>
<td>Golan et al. 1998 [54, 55]</td>
<td>T</td>
<td>8.9 (0.3)</td>
<td>Mothers: 37.5 (1.0)</td>
<td>EB, PA, PS</td>
<td>I, V</td>
<td>Both parents</td>
</tr>
<tr>
<td>Epstein et al. 2001 [56]</td>
<td>T</td>
<td>IF&amp;V: 8.8 (1.8)</td>
<td>39.1 (4.1)</td>
<td>EB</td>
<td>I, V, VI</td>
<td>IF&amp;V: 12 mothers and a father</td>
</tr>
<tr>
<td>Golan et al. 2004 [60]³</td>
<td>T</td>
<td>16 (0.5)</td>
<td>N/A</td>
<td>EB, PA, PS</td>
<td>I, IV, V</td>
<td>Both parents</td>
</tr>
<tr>
<td>Golan et al. 2006 [61]</td>
<td>T</td>
<td>8.7 (1.9)</td>
<td>38.3 (4.7)</td>
<td>EB, PA, PS</td>
<td>I, IV, V</td>
<td>PO (14 families): 13 fathers and 14 mothers</td>
</tr>
<tr>
<td>Golley et al. 2007 [62]</td>
<td>T</td>
<td>8.2 (1.1)</td>
<td>N/A</td>
<td>EB, PA, PS</td>
<td>IV, V</td>
<td>Both parents/caregivers</td>
</tr>
<tr>
<td>Burrows et al. 2008 and 2010 [63, 64]</td>
<td>T</td>
<td>8.0 (1.5)</td>
<td>N/A</td>
<td>EB</td>
<td>I, IV, V, VI</td>
<td>Both parents/caregivers</td>
</tr>
<tr>
<td>Haire-Joshu et al. 2008 [65]</td>
<td>P</td>
<td>[2-5]</td>
<td>[20-59]</td>
<td>EB</td>
<td>V, VI</td>
<td>95% are mothers. 70.4% of subjects in intervention group (n=605) are married or living with partner.</td>
</tr>
<tr>
<td>Janicke et al. 2008 and 2009 [66, 67]</td>
<td>T</td>
<td>11.0 (1.5)</td>
<td>41.0 (7.3)</td>
<td>EB, PA</td>
<td>IV, V⁷</td>
<td>Both parents</td>
</tr>
<tr>
<td>Munsch et al. 2008 [68]</td>
<td>T</td>
<td>10.6 (1.5)</td>
<td>38.8 (6.0)</td>
<td>EB, PA</td>
<td>I, IV, V, VI</td>
<td>Only mothers. Four fathers eligible for the treatment are excluded.</td>
</tr>
<tr>
<td>Resnick et al. 2009 [69]</td>
<td>T</td>
<td>8.5</td>
<td>N/A</td>
<td>EB, PA</td>
<td>I, II</td>
<td>Both parents</td>
</tr>
<tr>
<td>Okely et al. 2010 [70]</td>
<td>P</td>
<td>8.2 (1.2)</td>
<td>N/A</td>
<td>EB</td>
<td>I, IV, V, VI, VII</td>
<td>Both parents/care providers</td>
</tr>
<tr>
<td>Paper</td>
<td>Type</td>
<td>Age of child</td>
<td>Age of parent</td>
<td>Target behavior</td>
<td>Behavior change (see Table 3 for more descriptions)</td>
<td>Family composition</td>
</tr>
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<tr>
<td>West et al. 2010 [71]</td>
<td>T</td>
<td>8.6 (1.7)</td>
<td>39.1 (5.2)</td>
<td>EB, PA, PS</td>
<td>IV, V, VI, VII</td>
<td>Intervention group (n=52): Original biological parents: 42; One original, one step-parent: 1; Sole parent: 9</td>
</tr>
<tr>
<td>Boutelle et al. 2011 [72]</td>
<td>T</td>
<td>10.8 (1.3)</td>
<td>44.6 (4.7)</td>
<td>EB, PA, PS</td>
<td>I, II, IV, V</td>
<td>Both parents</td>
</tr>
<tr>
<td>Collins et al. 2011 [73]</td>
<td>T</td>
<td>8.2 (1.2)</td>
<td>N/A</td>
<td>EB</td>
<td>IV, V, VI</td>
<td>Both parents/caregivers</td>
</tr>
<tr>
<td>Golley et al. 2011 [74]</td>
<td>T</td>
<td>8.2 (1.1)</td>
<td>N/A</td>
<td>EB, PA, PS</td>
<td>IV, V</td>
<td>Both parents/caregivers</td>
</tr>
<tr>
<td>Jansen et al. 2011 [75]</td>
<td>T</td>
<td>9.72 (1.6)</td>
<td>Moth. 40.31 (5.16) Father. 43.18 (5.62)</td>
<td>EB, PA, PS</td>
<td>I, IV, V, VI</td>
<td>For 63 families, both parents participated. In addition, 35 single-parent families took part in the study (24 mothers and 11 fathers). In total, 87 mothers and 74 fathers participated.</td>
</tr>
<tr>
<td>Magarey et al. 2011 [76]</td>
<td>T</td>
<td>8.2 (1.2)</td>
<td>N/A</td>
<td>EB, PA, PS</td>
<td>I, IV</td>
<td>Most children (74%) from dual-parent families</td>
</tr>
<tr>
<td>Wyse et al. 2011 [77]</td>
<td>P</td>
<td>4.5 (0.8)</td>
<td>36.3 (5.2)</td>
<td>EB</td>
<td>I, IV, V, VII</td>
<td>97% of parents (n=34) are female</td>
</tr>
<tr>
<td>Moens and Braet 2012 [78]</td>
<td>T</td>
<td>S:\ 9.1 (1.3) S:\ 9.2 (1.4)</td>
<td>N/A</td>
<td>EB, PA, PS</td>
<td>I, II, IV, V, VI, VII</td>
<td>Both parents</td>
</tr>
<tr>
<td>Ostbye et al. 2012 [79]</td>
<td>P</td>
<td>3.06 (1.0)</td>
<td>&lt;30: 29.5 (n=59) 30-35: 31.0 (n=62) 35-39: 39.5 (n=79)</td>
<td>EB, PA, PS</td>
<td>I, IV, V, VI, VII</td>
<td>400 mothers</td>
</tr>
<tr>
<td>De Bock et al. 2013 [80]</td>
<td>P</td>
<td>5.0 (0.2)</td>
<td>N/A</td>
<td>PA</td>
<td>IV, V</td>
<td>Both parents along with grandparents.</td>
</tr>
<tr>
<td>Fletcher et al. 2013 [81]</td>
<td>F</td>
<td>4.3 (0.6)</td>
<td>35.2 (5.6)</td>
<td>EB</td>
<td>I, II, III, IV, V, VI, VII</td>
<td>Intervention group: mostly mothers (95.2%)</td>
</tr>
<tr>
<td>Janicke 2013 [82]</td>
<td>T</td>
<td>12 (n=1)</td>
<td>N/A</td>
<td>EB, PS</td>
<td>I, III, IV</td>
<td>A girl with her overweight mother</td>
</tr>
<tr>
<td>McGowan et al. 2013 [83]</td>
<td>P</td>
<td>3.4 (1.2)</td>
<td>35.7 (7.7)</td>
<td>EB</td>
<td>V</td>
<td>Biological mothers (91%), fathers (5%), and step/adoptive parents (4%)</td>
</tr>
</tbody>
</table>

\(^1\) T: treatment, P: prevention; \(^2\) mean(standard deviation) or [range] from parent-targeted groups, WRO: weight reduction only, PT: parent training, IF&V: increase fruit and vegetable intake, DF&S: decrease fat and sugar intake, S:\ study one, S:\ study two; \(^3\) mean(standard deviation) or [range] from parent-targeted groups; \(^4\) EB: eating behavior, PA: physical activity, PS: parenting style; \(^5\) not available; \(^6\) ages and family composition are extracted from [84]; \(^7\) extracted from [82]; \(^8\) extracted from [62].


Behavior change techniques
Within each core social influence mechanism, we identified specific behavior change techniques distilled from Abraham and Michie’s taxonomy [85]. For additional external validity, we mapped these techniques onto Kelman’s variants of social influence [21, 86] (see Table 3). Seven behavior change techniques summarized in Table 3 were utilized to varying degrees in the studies we reviewed—Table 3 presents the descriptions of these techniques and their associations with the core social influence mechanisms. For each intervention, the behavior change techniques used are identified (see ‘behavior change’ column in Table 2, and Figure 2).

Among the techniques that targeted supportive social environments, the behavior change techniques of plan social support or social change and prompt intention formation were the most prevalent, being observed in 69% (22 papers) and 75% (24 papers) of the interventions, respectively (see Figure 2). Two other techniques were not widely utilized: provide instruction and guidance (16%, 5 papers), provide feedback on performance (6%, 2 papers). It should also be noted that a supportive social environment needs proper and effective parenting style (see [87-89] for more discussion), while only 50% of the interventions (16 papers) focused specifically on parenting style (see PS in ‘target behavior’ column in Table 2).

Among the rest of the behavior change techniques, the potential technique of prompt identification as a role model was observed frequently (78%; 25 papers). Lastly, provide contingent rewards and provide general encouragement were observed in 47% (15 papers) and 25% (8 papers) of the interventions, respectively—see Figure 2.

Table 3 Behavior change through social influence

<table>
<thead>
<tr>
<th>Core Social Influence Mechanisms</th>
<th>Behavior Change Techniques</th>
<th>Descriptions [85]</th>
<th>Kalman’s varieties of social influence [21, 86]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supportive social environment</td>
<td>Plan social support or social change (I)</td>
<td>“Prompting consideration of how others could change their behavior to offer the person help or (instrumental) social support, including ‘buddy’ systems and/or providing social support.”</td>
<td>Internalization, Compliance</td>
</tr>
<tr>
<td></td>
<td>Provide instruction and guidance (II)</td>
<td>“Telling the person how to perform a behavior and/or preparatory behaviors.”</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Provide feedback on performance (III)</td>
<td>“Providing data about recorded behavior or evaluating performance in relation to a set standard or others’ performance, i.e., the person received feedback on their behavior.”</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Prompt intention formation (IV)</td>
<td>“Encouraging the person to decide to act or set a general goal, for example, to make a behavioral resolution such as ‘I will get more exercise next week.’”</td>
<td>Internalization</td>
</tr>
<tr>
<td>Model healthy eating and activity patterns</td>
<td>Prompt identification as a role model (V)</td>
<td>“Indicating how the person may be an example to others and influence their behavior or provide an opportunity for the person to set a good example.”</td>
<td>Identification</td>
</tr>
<tr>
<td>Praise and encouragement for desirable behaviors</td>
<td>Provide contingent rewards (VI)</td>
<td>“Praise, encouragement, or material rewards that are explicitly linked to the achievement of specified behaviors.”</td>
<td>Compliance</td>
</tr>
<tr>
<td></td>
<td>Provide general encouragement (VII)</td>
<td>“Praising or rewarding the person for effort or performance without this being contingent on specified behaviors or standards of performance.”</td>
<td>Compliance</td>
</tr>
</tbody>
</table>
Causal pathway diagram
After reviewing selected papers and extracting the data, we summarized the results using a causal pathway diagram of the social influence mechanisms. Figure 3 captures the distinct causal mechanisms identified in the reviewed papers as potentially moderating the impact of parental interventions on childhood obesity. In other words, insights gained from the reviewed studies are summarized as hypothesized causal mechanisms that connect different interventions to outcomes of interest, improving eating and activity behaviors. Given the level of detail in the Online Supplementary Table S1, Figure 3 also helps illustrate the findings.

We relied on both explicit reports of mechanisms in the original studies (solid lines in Figure 3) and our judgment about likely additional or implicit pathways (dashed lines). Figure 3 is divided into five layers that span the conceptual steps involved in these mechanisms: 1) Components of intervention programs; 2) targeted parental behaviors; 3) intermediate mechanisms (actions that transfer the effects of intervention programs from the parents to the indirectly targeted family members, i.e., children); 4) social influence mechanisms, which include the psychological consequences of the intermediate mechanisms; and 5) outcomes (e.g., improvements in child’s eating and activity behaviors). Below we discuss these five layers in more detail, noting that the causal pathways span these layers and are thus easier to follow along with the Figure 3 diagram.

**Figure 2** Behavior change techniques used in the reviewed papers

<table>
<thead>
<tr>
<th>Technique</th>
<th>Number of Papers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plan social support or social change (I)</td>
<td>32</td>
</tr>
<tr>
<td>Provide instruction and guidance (II)</td>
<td>22</td>
</tr>
<tr>
<td>Provide feedback on performance (III)</td>
<td>18</td>
</tr>
<tr>
<td>Prompt intention formation (IV)</td>
<td>20</td>
</tr>
<tr>
<td>Prompt identification as a role model (V)</td>
<td>21</td>
</tr>
<tr>
<td>Provide contingent rewards (VI)</td>
<td>19</td>
</tr>
<tr>
<td>Provide general encouragement (VII)</td>
<td>17</td>
</tr>
</tbody>
</table>

- **Supportive social environment**
- **Model healthy eating and activity patterns**
- **Praise and encouragement for desirable behaviors**
Layer 1: Components of intervention programs

Three distinct components, education, physical activity, and eating behavior, can be identified as part of the interventions we reviewed (the bottom layer in Figure 3). Some interventions focus more on one component than others, yet they all include these three elements to some extent. These components each activate several additional mechanisms relevant to understanding how social interventions work. We first summarize the intervention components and then discuss the pathways through which they impact children’s obesity outcomes.

Parental education
Parental education is a significant element in many of the interventions, though it is often accompanied by other components [90]. Parental education aims to improve parents’ own weight-related behavior as well as their feeding style. Changes in parental responsibility for child feeding [91], encouraging nutritional variety and balance, and modeling [92] have been reported.

In the reviewed interventions, some educational components enhance parents’ understanding of their own and children’s behaviors [56, 60, 62, 78] and parenting tactics (e.g., teaching parents to ignore...
undesirable behaviors and reward desirable behaviors) [75], and improve parents’ competence in managing children’s behavior [62, 71, 73]. Moreover, some interventions include components related to individual self-control and goal setting to enhance parenting skills, e.g., [66].

**Physical activity and eating behavior**

Many interventions also aimed to change parents’ weight-related behaviors. Interventions with physical activity components attempted to: reduce sedentary behavior [79], increase daily steps [66], get parents involved in sports [71, 80], reduce TV watching time [69, 74], encourage parents to get outside [58], engage parents in active play [71, 80], and promote enjoyment and self-efficacy in physical activity [57].

Interventions with eating behavior components targeted improving parents’ eating habits through modifying recipes [61, 62, 71], planning family meals [61, 81], reading nutrition labels [69, 71], providing a prudent diet [54, 55], increasing water consumption [57], recommending core food servings [62], shopping for more healthful foods at grocery stores [69], categorizing foods based on traffic light (stoplight) or similar programs [57, 63, 66, 67], encouraging decreased intake of high-fat and high-sugar foods [56, 64, 68], increasing fruit and vegetable availability at home [65, 77, 81], and increasing intake of nutritionally dense, healthy foods [56, 57, 59, 70, 83].

Layers 2 and 3: Targeted parental behaviors and intermediate mechanisms

The capabilities, routines, and knowledge resulting from the above components enhance a set of parental behaviors in their relationships with children [71, 76], which together we call quality of parenting style. These include taking responsibility for adopting healthier lifestyle habits at home [71], caring about a healthy home environment [61, 83], parental effort to instill a desire for healthy behavior in children [82], and support for children’s attempts to adopt healthy behaviors [68, 71, 72, 76, 82].

By taking responsibility for adoption of healthy lifestyle habits, parents may become more motivated to participate in intervention components [71]. That responsibility also enhances parents’ caring about children’s weight status [66], leading to better monitoring and feedback to change children’s behavior, one of the social influence mechanisms relevant to children’s outcomes. Moreover, increased quality of parenting may lead to children’s enhanced self-efficacy and increased desire to have healthy behaviors [82] and ultimately result in creating a supportive social environment at home [59-61, 66, 78].

Parental education can increase parents’ competence to manage children’s behavior, improving parents’ confidence in helping children change their habits [62] and enhancing parents’ own motivation to continue participation in the intervention [71]. Motivated parents also show a higher quality of parenting style [71]. In fact, there is a potential virtuous cycle (reinforcing feedback loop) in which parents gain confidence, become more committed to the intervention, and therefore perform better in their parenting style, paving the way for further successes and confidence-building.

Changing parents’ own weight-related behaviors moderates the home environment, access, and children’s modeling of behaviors. Different studies have targeted different subsets of parents’ activities, from reducing TV watching hours to increasing fruit and vegetable availability. Parental education also reinforces parental weight-related behavior change as parents learn more about the importance of their own and children’s behaviors [78]. Once actively pursued, these healthy eating and activity behaviors of parents, together with improved parenting style, lead to healthier home environments [60, 61, 65, 82, 83]. Home environment, as a psychosocial antecedent for children’s obesity [93], has the potential to change children’s attitude toward different foods and activity levels [55, 94]. Through modeling effects as well as access, healthy home environments could also regulate children’s “obesogenic” behaviors, such as regularity of participation in family meals, television viewing habits, and healthy food consumption [61].
Layer 4: Social influence mechanisms
In the preceding section, we identified three core social influence mechanisms that moderate how parental interventions influence children’s behaviors. We discuss these mechanisms below.

Praising and encouraging desirable behaviors
As parental attention increases the monitoring of children’s weight-related behaviors, parents can provide praise and encouragement for desirable behaviors (and potentially punish undesirable ones). This type of social influence, also referred to as compliance [21] (see Table 3), is not typically associated with enduring changes; in the absence of other influences, compliance often requires continued rewards and punishments to sustain the target behavior [95]. Ultimately, children must develop the ability to follow healthy eating and physical activity behaviors without much external feedback.

Modeling of healthy eating and activity patterns
Modeling is one of the main mechanisms by which behaviors transfer through social relations, and has been strongly recommended for obesity interventions [96, 97]. Social modeling occurs because people, often unconsciously, adjust their behaviors to match their valued social ties. This type of social influence (modeling) is also called identification [21, 95] (see Table 3), and provides a pathway to more sustained change in children’s behavior. The key to activating this pathway is parental behavior change, which provides a healthy home environment and opportunities for children to imitate parents’ healthy behaviors [98]. Given the reduction in the amount of time children spend with their parents and the adoption of role models outside of home as children age, identification is likely strongest for younger children [95], leading to the recommendation of using social influence for younger children [95]. However, long-term follow-up studies are needed to track whether the modeled behaviors among younger children last into adulthood and whether this mechanism includes an age effect separate from the amount of time children spend with parents.

Supportive social environment
Providing a social environment supportive of healthy behaviors provides a third pathway to social influence. This mechanism is partially encouraged by a healthy home environment. Moreover, in a supportive environment, parents help children form their values and beliefs so that they actively choose healthy behaviors. This mechanism allows for the internalization (see Table 3) of the target behaviors, and is hypothesized to be the longest-lasting type of social influence and the one best suited for older children [95].

In our sample, parent interventions most frequently targeted building supportive social environments and modeling healthy eating and activity patterns (see items I, IV, and V in Figure 2 and Table 2) to promote healthy child weight.

Layer 5: Outcomes
Our main outcomes of interest are children’s eating and physical activity behaviors, which directly influence obesity outcomes. The reviewed studies showed various levels of impact on children’s obesity outcomes and weight-related behaviors. Due to small sample size and high heterogeneity among the studies (i.e., use of completely different mechanisms of impact and various reported weight-related outcomes), additional synthesis in the form of a quantitative aggregation of results using meta-regression or meta-analysis was ruled out.

Quality assessment and outcome score
The rating of 32 papers by two reviewers led to an overall initial disagreement of 27%. The reviewers reached consensus and all initial disagreement were resolved. The MQRS scores ranged from 6 to 12 with
a mean of 9.1 and median of 9. We considered high methodological quality for studies with a score of more than 70% (MQRS score of 10 and above). 13 studies (41%) received a score of 10 or above, while the 19 remaining studies received an average score of 7.9—see Figure 4 (A).

Figure 4 (B) also presents the treatment effect scores for the reviewed studies. The outcome scores ranged from 2 to 4. Nineteen papers (59%) reported that significant changes were maintained at the last follow-up (score=4), 8 papers (25%) reported significant changes (score=3) at the end of the intervention, and 5 papers (16%) reported marginally better changes (score=2) at the end of the intervention. Detailed quantitative outcomes for each paper are reported in the Online Supplementary Table S1.

Discussion
The choice of direct and indirect change agents within the family has recently received some attention in obesity research, e.g., see [30, 93, 99-102]. A few family-based interventions target parents aiming to induce behavioral change in children. We provided a simple graphical summary (Figure 3) of the key social
influence mechanisms identified in the 32 reviewed papers, in which children are targeted indirectly. We also mapped out three core social mechanisms to seven behavior change techniques and their use in the interventions (Table 2 and Table 3). Analyzing these mechanisms, we identified the provision of a supportive social environment for children as potentially the most beneficial social influence mechanism for older children, and the modeling of healthy behavior as especially useful for younger children [95]. The choice of existing intervention designs, however, is not explicitly connected to these recommendations, and may be better explained by feasibility constraints and other goals the studies have pursued. Therefore, significant diversity can be observed in the current designs and outcomes. The limited number of studies and heterogeneity in the designs and reported outcomes did not allow for insights from quantitative assessment of specific pathways. The reports on these interventions also did not provide enough detail to enable comparative cost-benefits analysis, an important need for designing cost-effective interventions.

In addition to the social influence mechanisms and the causal relations discussed in the analysis section, findings from the included studies provide insights on how to improve the efficacy of interventions. Specific recommendations adopted from the reviewed studies include: targeting families with young children (children younger than 11 years) [61, 66, 76]; starting treatment from early stages of obesity [65, 78], as more intensive interventions are usually required for obese children; focusing on what can be eaten versus what cannot be eaten [56]; and focusing on health-centered rather than weight-centered approaches [56, 60]. These recommendations are in line with focusing on providing a supportive social environment that leads to internalization of healthy behaviors in the family, rather than more narrowly defined obesity treatment goals.

Moreover, additional benefits are observed in treating parents as the direct agents of change in the family setting rather than treating the children directly (for more discussions of the roles of mothers and fathers, see [103, 104] and [105], respectively). These benefits relate more to the logistics and sustainability of interventions than to social influence mechanisms. First, focusing on parents reduces children’s perception of having a health problem and the stigmatization that goes with being “an obese patient” [60]. As a result, children are less likely to resist the lifestyle changes that accompany the intervention [66]. Moreover, parents usually have an easier time attending intervention sessions without children [59, 66], and the sessions are more productive in terms of problem solving and discussion time among participating parents [66]. In addition, including fewer change agents reduces the costs of the interventions [69, 71, 72] and makes the interventions more feasible for some, especially among underserved rural communities [61]. The logistical benefits also enhance parents’ motivation to participate, increasing the sustainability of the interventions and parents’ commitment. Nevertheless, the current literature provides limited cost data to enable a systematic comparison of cost and benefits against alternative interventions.

There is considerable interest among obesity researchers in understanding the influence of systems on nutrition and physical activity behaviors. This goes more “upstream” from the family and addresses the outer levels of the socio-ecological model, including community and organizational (e.g., school, faith-based organizations, community recreation programs) factors as well as policy and environmental change at the local, state, and national levels [24, 106]. However, one can also consider systems change within the family, where parental training/education could lead to structuring the home environment so that the “healthy choice is the easy choice.” Here the influence on children’s behaviors is likely a combination of reinforcement, modeling and internalization, as well as a more direct impact of having access to healthy food and equipment/space promoting physical activity, and not having access to tempting foods and devices that promote sedentary behaviors (TV, computer games, etc.). One can even make the argument that families can have organizational “policies” that create health-promoting environments. Children benefit from both directly experiencing this environment and learning how to structure one for themselves when they are able to make their own decisions.
During the search process, we did not limit our review to studies in which only children are targeted indirectly, but we considered any combination of family members. Interestingly, we found only one paper that presents the effects of a targeted spouse on the untreated partner, and we did not find any other combinations (within our inclusion criteria). This shows a potential research need for exploring the targeting of other combinations of family members, e.g., between spouses, among siblings, extended family members (e.g., grandparents), or even targeting children to change parents’ outcomes.

Our review may be limited by selecting only peer-reviewed studies published in English and focusing on a narrowly defined category of interventions. Nevertheless, the current review suggests that interventions that mainly utilize social influence pathways are potentially promising and offer a template for their mechanisms of impact. Much remains to be understood about the relative impact of such interventions in comparison with alternatives, and the best study designs.

Conflict of Interest Statement
No conflict of interest was declared.

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Online Supplementary for

Social influence in childhood obesity interventions: a systematic review

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<th>Study, country</th>
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<tbody>
<tr>
<td>Epstein et al. 1998 [52] United States</td>
<td><strong>Objective:</strong> Evaluate the effect of training in general child management skills with a behavioral treatment program  <strong>Intervention type:</strong> Treatment, randomized controlled trial  <strong>Intervention duration:</strong> 9 weeks; 1 year follow-up from program inception  <strong>Participants:</strong> Thirty-three overweight children (8-12 years) and their parents  <strong>Study design:</strong> Families assigned to parent training (PT) group and parents assigned to weight reduction only (WRO) group attended nine weekly 90-minute sessions. The treatment was based on CAIR: cue control rules, activity, intake, and rewards. The families participated in separate child and parents groups.</td>
<td>At 1-year follow-up, children in the PT condition had a superior maintenance of improved weight status. There was also a positive correlation between changes in child and parent weight status during the follow-up period.</td>
<td>Importance of parents as change agents  *** Percent Overweight  PT group: Week 1: 50.60 (17.48); Week 9: 43.40 (21.63); Year 1: 40.40 (32.86)  WRO group: Week 1: 46.82 (15.57); Week 9: 33.61 (16.99); Year 1: 45.53 (21.21)</td>
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<td>Israel et al. 1994 [53] United States</td>
<td><strong>Objective:</strong> Examine the effect of a multiple-component self-regulation intervention  <strong>Intervention type:</strong> Treatment, randomized trial  <strong>Intervention duration:</strong> 26 weeks; 1 and 3 years follow-up from program inception  <strong>Participants:</strong> 34 families including obese children (8-13 years) and at least one of the parents  <strong>Study design:</strong> Participants were assigned to standard treatment (ST) and enhanced child involvement (ECI) groups. Parents were given the primary responsibility in the ST group. ECI followed the same intervention with greater emphasis on child self-regulation. Treatment for both groups was based on CAIR. The core of the intervention was a four-component model of self-regulation: goal setting, self-monitoring, self-evaluation, and self-consequation.</td>
<td>Children in ST and ECI achieved a significant reduction in percentage overweight, however most children did not achieve non-obese status at the follow-ups.</td>
<td>The results of ECI group was better than of the results of ST group over the long term.  ***Percent Overweight:  ST group: Week 1: 45.94 (17.11); Week 26: 33.43 (17.00)  Year 1: 45.15 (23.87); Year 3: 52.30 (24.37)  ECI group: Week 1: 48.10 (18.31); Week 26: 32.55 (17.35)  Year 1: 42.32 (22.50); Year 3: 43.29 (21.18)</td>
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<td>Israel et al. 1994 [51] United States</td>
<td><strong>Objective:</strong> Study the reduction in overweight and changes in eating-related behaviors in obese children where the parents were the exclusive agents of change.  <strong>Intervention type:</strong> Treatment, longitudinal randomized prospective study  <strong>Intervention duration:</strong> 12 months; 6 months follow-up  <strong>Participants:</strong> 60 children, parents of 30 children in the experimental group (parents as agents of change) and 30 children in control group (children as agents of change)  <strong>Study design:</strong> Forty-hr-long support and educational group sessions for parents in the experimental group and 30-hr-long group sessions for children in the control group.</td>
<td>Selecting parents as the sole agents of change resulted in more weight reduction and more adherence to the program than selecting children as the main focus of change. Significant differences between the two groups in the reduction of exposure to food stimuli and changes in eating habits were found.</td>
<td>Targeting parents as the exclusive agents of change is more effective than conventional treatments.  ***Experimental group: 79% of children lost more than 10% of their excess weight; 35% of children reached non-obese status (&lt;10% overweight)  Control group: 38% of children lost more than 10% of their excess weight; 14% of children reached non-obese status</td>
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<tr>
<td>Golan et al. 1998 [54, 55] Israel</td>
<td><strong>Objective:</strong> Evaluate the effect of a parent-focused behavioral intervention on parent and child eating changes and on % overweight changes in families that contains at least one obese parent and a non-obese child.  <strong>Intervention type:</strong> Treatment, randomized behavioral weight-control program  <strong>Intervention duration:</strong> 6 months; 6 months follow-up (at months 6 and 12)  <strong>Participants:</strong> 30 families, one obese parent and a non-obese child (6-11 years)  <strong>Study design:</strong> Comprehensive behavioral weight-control program for parents; encourage increased fruit/vegetable intake or decreased intake of high-fat/high-sugar foods.</td>
<td>Focus on what can be eaten (versus what cannot) may increase adherence to caloric restrictions for weight control. Targeting fruit/vegetable intake in children increases intake of nutritionally dense foods and decreases intake of low nutrient dense foods. Reduction in high-fat/high-sugar intake in children can be achieved by focusing on parent change.</td>
<td>Reduction in high-fat/high-sugar food intake in children of both groups; significant change in food patterns  *** Group: Fruits and vegetables (Servings per day): Increase Fruit and Vegetable: 0.72 ± 1.11  Decrease Fat and Sugar: -0.55 ± 1.31 (significant between-group differences over time)  Group: High-fat/high-sugar (Servings per day): Increase Fruit and Vegetable: -4.50 ± 7.97  Decrease Fat and Sugar: -8.50 ± 7.58 (p &lt;0.001)</td>
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<td>Epstein et al. 2001 [56] United States</td>
<td><strong>Objective:</strong> Study the reduction in overweight and changes in eating-related behaviors in obese children where the parents were the exclusive agents of change.  <strong>Intervention type:</strong> Treatment, longitudinal randomized prospective study  <strong>Intervention duration:</strong> 12 months; 6 months follow-up  <strong>Participants:</strong> 60 children, parents of 30 children in the experimental group (parents as agents of change) and 30 children in control group (children as agents of change)  <strong>Study design:</strong> Forty-hr-long support and educational group sessions for parents in the experimental group and 30-hr-long group sessions for children in the control group.</td>
<td>Selecting parents as the sole agents of change resulted in more weight reduction and more adherence to the program than selecting children as the main focus of change. Significant differences between the two groups in the reduction of exposure to food stimuli and changes in eating habits were found.</td>
<td>Targeting parents as the exclusive agents of change is more effective than conventional treatments.  ***Experimental group: 79% of children lost more than 10% of their excess weight; 35% of children reached non-obese status (&lt;10% overweight)  Control group: 38% of children lost more than 10% of their excess weight; 14% of children reached non-obese status</td>
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**Table S1** Summary of 32 reviewed studies
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<tr>
<td>Beech et al. 2003 [57] United States</td>
<td><strong>Objective:</strong> Evaluate the acceptability, feasibility, and outcomes of two family-based interventions in pre-adolescent African-American girls. <strong>Intervention type:</strong> Prevention, randomized controlled pilot trial. <strong>Intervention duration:</strong> 12 weeks; post-assessment follow-up only at week 12. <strong>Participants:</strong> 60 African-American girls (8-10 years) and their parents/caregivers. <strong>Study design:</strong> A culturally tailored and family-based interventions (child targeted intervention with girls only, and parent-targeted intervention with parents only). The program focused on nutrition and physical activity, with a control group that focused on self-esteem.</td>
<td>Girls in both groups demonstrated a trend toward reduced BMI and waist circumference.</td>
<td>The pilot results show that both groups were similarly effective in facilitating the desired changes in the girls’ behavior over the short term. ***Mean differences in BMI (baseline-adjusted) at 12 weeks: Parent-targeted vs control: -0.40 (0.25); Child-targeted vs control: -0.38 (0.25)</td>
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<td>Harvey-Golan and Crow 2004 [60] United Kingdom</td>
<td><strong>Objective:</strong> Assess the effectiveness of maternal participation plus parenting support vs parenting support only in reducing obesity among preschool Native-American children. <strong>Intervention type:</strong> Prevention, randomized pilot trial. <strong>Intervention duration:</strong> 16 weeks; post-assessment follow-up only at week 16. <strong>Participants:</strong> 43 child-mother pairs. <strong>Study design:</strong> Subjects were randomly assigned to parenting support (PS) or obesity prevention plus parenting support (OPPS) group. Subjects in both groups participated in a 16-week intervention conducted by an indigenous peer educator in the home of each participant.</td>
<td>Changes in weight-for-height z (WHZ) scores presented a significant trend, with WHZ scores decreasing in the PS and increasing in the OPPS group. Energy intake was also significantly decreased among children in the OPPS group.</td>
<td>Focusing on changing lifestyle behaviors and improving parenting skills showed promise for obesity prevention in high-risk children. ***Change from week 0 to 16: PS: WHZ score: 0.31±1.1; Weight (kg): 1.5±3.2. OPPS group: WHZ score: -0.27±1.1; Weight (kg): 0.9±2.4</td>
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<td>Wardle et al. 2003 [59] United Kingdom</td>
<td><strong>Objective:</strong> Evaluate effectiveness of in-home parent intervention to increase child preference for previously disliked vegetable. <strong>Intervention type:</strong> Prevention, exposure-based randomized controlled trial. <strong>Intervention duration:</strong> 14 consecutive days taste test; 6 weeks follow-up (no quantitative follow-up). <strong>Participants:</strong> 156 parents of 2 to 6 years old children. <strong>Study design:</strong> Parents assigned to one of three groups: (a) training in ‘exposure’ feeding (encourage tasting target vegetables and not offering a reward), (b) general nutritional information, or (c) no treatment. Target vegetable selected based on low ranking on preference test. Parents assigned to the exposure group given guidance on offering child a taste of target vegetable for 14 consecutive days.</td>
<td>Daily exposure to previously disliked vegetable increases child’s liking and consumption of target vegetable. The effect is strongest in the exposure group (showed a significant increase), weakest in the information group and intermediate in the control group. Anecdotally, parents and children enjoyed the ‘tasting games’ and frequently used the exposure technique for other foods after the study.</td>
<td>Increase children’s liking and consumption of that vegetable. *** Means (SEM) of consumption of target vegetables: Exposure group: Pre-intervention: 4.1 (1.4); Post-intervention: 9.0 (1.7). Information group: Pre-intervention: 5.7 (2.1); Post-intervention: 7.3 (1.8). Control group: Pre-intervention: 5.7 (1.5); Post-intervention: 7.7 (1.6). Effects on preference ranking: Exposure group: 30% ranked their target vegetable as the most liked vs. Control group: 5% vs. Information group: 2%</td>
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<tr>
<td>Golian and Crow 2004 [60] Israel</td>
<td><strong>Objective:</strong> Evaluate long-term change in child overweight in a parent-only vs. child only health-centered intervention. <strong>Intervention type:</strong> Treatment, randomized family-based, health-centered study. <strong>Intervention duration:</strong> 1 year; 7 years follow-up (at years 2, 3, and 8). <strong>Participants:</strong> 2 parent-only groups (15 families each), 2 child-only groups (15 children each). Children age 7-12 in original intervention. <strong>Study design:</strong> Parent-only Group: 14 1-hour support and educational group sessions. Topics included setting limits, nutrition education, eating and activity behavior modification, decreasing stimulus exposure, parental modeling, etc. Child-only Group: 30 1-hour group sessions. Topics included physical activity, eating behavior modification, stimulus control, self-monitoring, etc.</td>
<td>Over the long term, targeting parents improved child weight outcomes better than targeting children. Mean reduction in percent overweight is greater at all follow-up points in children of the parent-only group compared with those in the children-only group.</td>
<td>Reduction in percent overweight in children of the parent-only group after 7 years. *** 7 years after the program terminated, mean reduction in children’s overweight: Parent-only group: 29% (p&lt;0.05); Children-only group: 20.2% (p&lt;0.05).</td>
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<tr>
<td>Country</td>
<td>Study, Year</td>
<td>Objective, Type, Duration, Participants, Study design</td>
<td>Findings</td>
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<td>United States</td>
<td>Burrows et al. 2006 [61]</td>
<td><strong>Objective</strong>: Evaluate relative efficacy of targeting parents alone v. parents and obese children together to treat childhood obesity  <strong>Intervention type</strong>: Treatment, randomized health-centered intervention  <strong>Intervention duration</strong>: 6 months; 1 year follow-up  <strong>Participants</strong>: 32 families, with at least one child age 6 to 11 years more than 20% overweight  <strong>Study design</strong>: Parents encouraged fostering authoritative parenting style. 16 1-hour support/education group sessions for each group. In addition, 40–50 min individual sessions once per month for each family, during the 6 month intervention.</td>
<td>Children (6–11 years) who attended intervention sessions with parents lost less weight than children whose parents were targeted alone. Parents-only produced significant reduction in the child % overweight at 6 and 12 months.</td>
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<td>Israel</td>
<td>Golan et al. 2006 [62]</td>
<td><strong>Objective</strong>: Evaluate relative effectiveness of parenting-skills training as a key strategy for the treatment of overweight children.  <strong>Intervention type</strong>: Treatment, assessor-blinded, randomized controlled trial  <strong>Intervention duration</strong>: 6 months; 6 months follow-up (at months 6 and 12)  <strong>Participants</strong>: 111 overweight, children age 6 to 9 years  <strong>Study design</strong>: 3 Parenting-skills training alone (P): parents participate in the Positive, Parenting Program (Triple P), 4 weekly 2-hour group sessions followed by 4 weekly, then 3 monthly, 15- to 20-minute individual telephone sessions. Parenting-skills training + intensive lifestyle education (P+DA): Complete the Triple P program plus an additional 7 intensive lifestyle support group sessions following completion of the 4 weekly parenting sessions (every 2 weeks at first, then monthly). Children in the P+DA group attend structured activity sessions developed by physical activity experts.</td>
<td>3 groups (P, P+DA, and control group) have a significant reduction in BMI z score over 12 months. Significant reductions in BMI seen in intervention boys, but not intervention girls or waitlisted controls. After 12 months, the BMI z score reduced by ~10% in P+DA versus ~5% P or waitlist controls</td>
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<td>Australia</td>
<td>Geller et al. 2007 [62]</td>
<td><strong>Objective</strong>: To assess the impact of a best practice dietary modification program, Hunter Illawarra Kids Challenge Using Parent Support, on overweight and obese children  <strong>Intervention type</strong>: Treatment, randomized controlled trial  <strong>Intervention duration</strong>: 6 months; 6 and 18 months follow-up  <strong>Participants</strong>: 165 overweight children (5–7 years) in the 2008 study; 159 in the 2010 follow-up study  <strong>Study design</strong>: A multicenter intervention with allocation to one of three arms: (1) parent-centered nutrition lifestyle program; (2) child-centered physical activity skill development program; or (3) both the programs. The dietary modification program was aimed at the parent only, with parents having responsibility for attending sessions and implementing family dietary and eating habit changes.</td>
<td>A significant decrease in child feeding questionnaire domain scores were sustained for 24 months for all groups, in the domain of pressure to eat, with increases in degree of monitoring. The domain of parental restriction of foods high in sugar and/or fat showed significant decreases in dietary intervention groups only.</td>
</tr>
<tr>
<td>Australia</td>
<td>Burrows et al. 2008 [63, 64]</td>
<td><strong>Objective</strong>: Test effectiveness of a home-based intervention for parents to foster a positive fruit–vegetable (FV) environment for their preschool child; examine whether changes in parent behavior are associated with improvements in child intake.  <strong>Intervention type</strong>: Prevention, group randomized nested cohort  <strong>Intervention duration</strong>: 7 months (range of 6 to 11 months)  <strong>Participants</strong>: 1,306 parents and children (ages 2 to 5 years)  <strong>Study design</strong>: High 5 for Kids (H5-KIDS) developed in partnership with Parents As Teachers (PAT). Parent educators deliver a standardized curriculum (social cognitive theory-based) via at least five home visits, on-site group activities, and a tailored newsletters and materials for families.</td>
<td>H5-KIDS parents and normal weight children increased FV intake. Overweight children more likely to consume high calorie snack foods or sweetened drinks which may limit intake and preference for FV.</td>
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<tr>
<td>Study, country</td>
<td>Objective, Type, Duration, Participants, Study design</td>
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<tr>
<td>Janicke et al. 2008 and 2009 [66, 67] United States</td>
<td><strong>Objective:</strong> Assess effectiveness of parent-only vs family-based interventions for pediatric weight management in underserved rural setting in the 2008 study; compare the costs of parent-only and family-based group in the 2009 study.</td>
<td>Both PO and FB interventions demonstrated improvement in weight status compared with control. Children &lt;11 years, those in the PO had about 50% greater decrease in weight status at follow-up relative to those in FB. Parent-only interventions may be more cost-effective, especially for families in medically underserved settings.</td>
<td>Decrease in BMI z score of children in PO group; Not significant difference in weight status change between PO and FB.</td>
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<td>Munsch et al. 2008 [68] Switzerland</td>
<td><strong>Objective:</strong> Investigate whether treatment of mothers only is as effective as a mother-child treatment in a randomized controlled clinical trial to reduce child overweight.</td>
<td>Overweight percentage between baseline and 6-month follow-up is reduced by 1.9% (MC) and 4.5% (MO) based on a linear mixed model. Both treatments are efficacious with respect to the reduction of overweight in children between baseline and 6-month follow-up and that these reductions are similar between the two treatments.</td>
<td>Reduction in child percent overweight; no difference between the parent-only and parent-child interventions.</td>
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<td>Resnick et al. 2009 [69] United States</td>
<td><strong>Objective:</strong> Pilot an easy-to-use parent outreach model that could ultimately be used by school nurses, pediatricians, community health agencies, and community health workers to reduce child overweight/obesity.</td>
<td>About 50% parents reported confidence in knowing ways to improve child’s nutritional habits, and about 66% reported confidence in knowing/talking about ways to increase child’s activity at baseline.</td>
<td>Reduction in BMI for children.</td>
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<td>Okely et al. 2010 [70] Australia</td>
<td><strong>Objective:</strong> To evaluate a child-centered physical activity program and a parent-centered dietary program in preventing unhealthy weight-gain in overweight children.</td>
<td>The Diet and Activity programs, both in isolation and combined, were efficacious in reducing relative BMI in overweight prepubertal children at 1-year follow-up. Compared with the Activity program in isolation, the two programs that included the dietary component resulted in about twice as great a reduction in BMI z-score.</td>
<td>Parent-centered dietary program (Diet) had the greatest effect.</td>
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<td>West et al. 2010 [71] Australia</td>
<td><strong>Objective:</strong> Determine whether a Parent-only (PO) intervention is not inferior to a parent and child (PC) treatment for childhood obesity. <strong>Intervention type:</strong> Treatment, randomized clinical trial <strong>Intervention duration:</strong> 6 months; 12 months follow-up <strong>Participants:</strong> 80 parent-child dyads (overweight/obese children age 8 to 12 years, 40 pairs PO; 40 pairs PC <strong>Study design:</strong> 60-min separate child and parent sessions. Parents in the PO group coached on how to assist children in weight monitoring and behavior change. Program included dietary modification (traffic-light diet), increased physical activity, behavioral change skills, and parenting skills specific for children who are overweight.</td>
<td>Child weight loss and physical activity in PO group not inferior to PC group. PO potentially more cost-effective and easier to disseminate. Weight reductions in both groups were significant at post-treatment (BMI, BMI-Z, and BMI-P) and only BMI-Z at follow-up.</td>
<td>Decrease in BMI-Z score of children in PO and PC groups; PO child weight loss, parent weight loss and child physical activity not inferior to the PC.</td>
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<td>Boudelle et al. 2011 [72] United States</td>
<td><strong>Objective:</strong> Evaluate the impact of a child-centered physical-activity plus parent-centered dietary-modification program on child BMI z score <strong>Intervention type:</strong> Treatment, three-arm assessor-blinded randomized control trial <strong>Intervention duration:</strong> 6 months; 18 months (at months 6, 12, and 24) <strong>Participants:</strong> 165 overweight prepubertal children (68 boys) age 5.5 - 9.9 years <strong>Study design:</strong> 3 arm intervention (1) parent-centered dietary-modification program (Diet); (2) child-centered physical-activity skill-development program (Activity), and a combination of programs (Activity + Diet). Each arm: 1) 10 weekly 2-hour face-to-face session with homework activities; 2) 3-monthly relapse-prevention telephone sessions to review parent goals.</td>
<td>All groups achieved clinically significant reductions in BMI z score and waist circumference at 24 months. Parent Diet program is more efficacious than child Activity program, although not different from Activity + Diet suggesting childhood obesity treatment could focus exclusively on parental modification of child dietary intake.</td>
<td>All groups reduction BMI z score (greatest effects through inclusion of a parent-centered diet program)</td>
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<td>Collins et al. 2011 [73] Australia</td>
<td><strong>Objective:</strong> To describe the impact of a parent-led, family-focused childhood nutrition program on the food intake and activity patterns of pre-pubertal children <strong>Intervention type:</strong> Prevention, an assessor-blinded, randomized controlled trial <strong>Intervention duration:</strong> 6 months; 6 months follow-up <strong>Participants:</strong> 11 (64% female) overweight, pre-pubertal children age 6 to 9 years <strong>Study design:</strong> The parenting-skills training alone (P) and P + activity education (DA) groups attended an eight-week standardized general parenting program. Parents in the P + DA arm attended additional seven lifestyle education sessions based on the Australian food selection guide. Parents in the P and wait list control groups (WLC) received a ‘lifestyle recommendations’ pamphlet.</td>
<td>Intake of extra foods (i.e., energy-dense nutrient-poor foods) was lower in both intervention groups at 6 and 12 months. Intervention achieved a reduction in children’s intake of extra foods without compromising intake of nutrient-rich foods.</td>
<td>Reduction in children’s intake of energy-dense, nutrient-poor foods and an increase in the time reported spent in active play</td>
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<td>Goley et al. 2011 [74] Australia</td>
<td><strong>Objective:</strong> Evaluate the effects on child weight of a parent-only parenting and child weight-related behavior intervention, relative to a waitlist control. <strong>Intervention type:</strong> Treatment, randomized clinical trial <strong>Intervention duration:</strong> 12 weeks; 1 year follow-up <strong>Participants:</strong> 101 families with overweight/obese children age 4 to 11 <strong>Study design:</strong> The lifestyle-specific parenting program consists of nine 90-min group sessions to enhance parents’ commitment to change and three 20-min telephone sessions to review parents’ implementation of strategies, and address challenges. All sessions use an active skills training process within a self-regulation framework (e.g., goals and progress evaluation).</td>
<td>The intervention has significant effects on child body size, weight-related problem behavior, parenting self-efficacy, and ineffective parenting. 25% of parents report reductions in child weight-related problem behavior. 33% of families show significant decreases in ineffective parenting, and 14% children show clinically significant decreases in weight. 10% of children move from obese to overweight.</td>
<td>Reductions in children BMI z score and weight-related problem behavior ***** Intervention group: child BMI z-score: 2.15 (pre) to 2.04 (post) and 1.96 (after 1 year) Control group: child BMI z-score: 2.11 (pre) to 2.10 (post)</td>
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<td>Jansen et al., 2011 [75] Netherlands</td>
<td>Evaluate a healthy lifestyle (HL) intervention to reduce adiposity in children aged 5 to 9 years; assess effect of added parenting skills training.</td>
<td>10% reduction in BMI z scores from baseline to 6 months (maintained at 24 months with no additional intervention.)</td>
<td>Reduction in BMI scores in pre-pubertal children&lt;br&gt;*** Mean BMI z Score:&lt;br&gt;P+HL: Baseline (n=85): 2.77±0.58 After 24 month (n=52): 2.38 ±0.67&lt;br&gt;HL: Baseline (n=84): 2.68±0.65 After 24 month (n=54): 2.26±0.84</td>
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<td>Magarey et al., 2011 [76] Australia</td>
<td>Evaluate a parent-led intervention to reduce child BMI.</td>
<td>Variety and/or frequency of children’s fruit/vegetable consumption significantly increased. Increased vegetable/fruit consumption corresponded with non-significant decrease in the variety and frequency of children’s consumption of non-core foods. Parents willing to receive and continue with an intervention.</td>
<td>Increase of variety and/or frequency of children’s fruit and vegetable consumption&lt;br&gt;*** CDQ, Children’s dietary questionnaire, fruit and vegetable subscale (P=0.027): Pre-intervention: 15.5 (5.1) Post-intervention: 18.1 (4.1)</td>
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<td>Wyse et al., 2011 [77] Australia</td>
<td>Evaluate whether a treatment aimed solely at obese children’s parents results in positive effects on the children’s weight status</td>
<td>Child BMI percentile decreased 2.4% in the treatment group, whereas there was no change in the waiting-list control group.</td>
<td>The parents’ treatment had significant effects on child and parent BMI. *** BMI percentile child:&lt;br&gt;Treatment group (n = 59): Pre-treatment: 96.8±2.93; Post-treatment: 94.5±6.52; 3 Month follow-up: 94.7±6.58&lt;br&gt;WLC group (n = 39): Pre-treatment: 95.9 ±3.38; Post-treatment: 96.0 ±3.64; 3 Month follow-up: 95.7±3.90</td>
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<td>Moens and Braet 2012 [78] Belgium</td>
<td>Evaluate a parent-led intervention to reduce child BMI.</td>
<td>Children in the intervention group: decrease in adjusted BMI of 7% post-intervention; weight loss maintained at the one-year follow-up. For the obese children more intensive treatment is required.</td>
<td>Positive changes in children’s eating behavior and positive increase in familial health principles&lt;br&gt;*** The decrease in adjusted BMI&lt;br&gt;Intervention group: baseline=147.57% and 6-month=142.55%&lt;br&gt;Waitlist group: baseline=139.45% and 6-month=135.92%</td>
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Study design: Parents attended eight sessions spread over 10 weeks. The purpose of the sessions was to teach parents to think of alternatives and possible solutions, rather than to purely present information. A substantial part was devoted to enhancing parenting tactics.

Participants: Parents of 98 overweight or obese children, age 7 to 13 years

Intervention duration: 10 weeks; 3 months

Objective: To educate and support families in incorporating healthy eating habits into their daily life, focusing on increasing the frequency and variety of children’s consumption of non-core foods. Parents willing to receive and continue with an intervention.

Study design: Both arms parent-only: 12 (P+HL group) or 8 (HL group) 90- to 120-minute group sessions (and 4 telephone sessions, delivered over 6 months with tapered frequency (weekly, bimonthly, then monthly). The Positive Parenting Program (Triple P) was delivered in 4 sessions to P+HL parents before the lifestyle (HL) component (to encourage parents to anticipate and manage high-risk situations with respect to a positive energy balance). HL sessions focused on information only.

Participants: 169 pre-pubertal moderately obese children, age 5 to 9 years

Intervention type: Treatment, single-blinded randomized controlled trial

Intervention duration: 6 months; 18 months follow-up (at months 6, 12, 18, and 24)

Objective: Evaluate the efficacy of a brief telephone-based parent intervention to increase fruit/vegetable consumption in children aged 3–5 years’ examine feasibility of intervention delivery and parent acceptability.

Intervention type: Prevention, randomized pilot study with no comparison group

Intervention duration: 4 weeks; 1 week follow-up

Participants: 34 parents of children age 3 to 5 years

Study design: Four 30 minute weekly telephone calls plus instructional resources. Three focus areas: availability and accessibility of foods within the home, role modeling fruit/vegetable consumption, and supportive family eating routines.

Objective: Evaluate a parent-led intervention to reduce child BMI.

Intervention type: Treatment, a clustered-randomized controlled trial

Intervention duration: 6 months; 6 months follow-up (at months 6 and 12)

Participants: 50 families with overweight children, age 6 to 12 years

Study design: Six 2-hour group sessions over 5-months. Dietician and a psychologist provide lifestyle education behavior.
Parents in the intervention group received additional training and documentation of their PA. The external gym trainers in intervention group received additional training and served as intervention facilitators for parents to coordinate parent activities, encouraging participation, and documenting the intervention implementation.

### Objective: To take the immediate post-intervention results of Kids and Adults Now, Defeat Obesity! program to enhance healthy lifestyle behaviors in mother-preschooler dyads.

**Intervention type:** Prevention, randomized controlled trial

**Intervention duration:** 8 months; 14 months follow-up

**Participants:** 308 mother-preschooler (2-5 years) dyads

**Study design:** Subjects in the intervention group received eight monthly mailed interactive kits, followed each month by a telephone coaching session for 20–30 minutes. Kits contained child activities and incentives reinforcing the month’s topic (e.g., a rewards chart, yoga mat, pedometer, portion plate).

**Findings:** Compared to the control arm, mothers in the intervention arm reduced instrumental feeding and TV snacks. Further improvements in emotional feeding, mother’s sugary beverage and fruit/vegetable intake, and dinners eaten in front of TV were also observed. There were no group differences in the primary outcomes, but differences were observed in the parental and maternal outcomes—trends toward improvement in the preschoolers’ diets were observed.

**Results summary / *** Quantitative results:** Mothers as agents of change improved several channels of maternal influence.

### Objective: To assess whether a participatory parent-focused approach using parents as agents of behavioral change enhances the efficacy of a preschool physical activity (PA) intervention.

**Intervention type:** Prevention, a cluster randomized controlled trial

**Intervention duration:** 9 months; 3 months follow-up (at months 6—before the end of the program—and 12)

**Participants:** Parents of 433 preschool children age 4 to 6 years

**Study design:** In control group, parents received a state-sponsored program consisting of twice-weekly 1-hour gym classes over 6 months. In intervention group, parents are motivated to develop and implement their own project ideas for promoting children’s PA. The external gym trainers in intervention group received additional training and served as intervention facilitators helping to coordinate parent activities, encouraging participation, and documenting the intervention implementation.

**Findings:** Compared to children enrolled in the standard, expert-driven program alone, children who received a combination of the participatory intervention and the expert-driven non-participatory program were significantly less sedentary and more physically active after 12 months. Half a year after program termination, children in the participatory arm had 4% more accelerometer counts and spent 11 (1.7%) fewer minutes in sedentary behavior during wake times.

**Results summary / *** Quantitative results:** Promote PA and reduce sedentary behavior in preschoolers.

### Objective: To assess the effectiveness of a telephone-based intervention in reducing child consumption of non-core foods, and to examine parent and home food environment mediators of change in child consumption of non-core foods.

**Intervention type:** Prevention, a clustered randomized controlled trial

**Intervention duration:** 1 month; 5 months follow-up (at months 2 and 6)

**Participants:** 394 parents of preschool-aged children, age 3 to 5 years

**Study design:** In control group received four telephone contacts and print materials targeting parent and home food environment characteristics, while parents in the control group received generic print materials only.

**Findings:** Child consumption of non-core foods was reduced at 2 months, however this was not maintained at 6 months. Child access to non-core foods in the home, and child feeding strategies were significant mediators, which representing the primary causal pathways by which the intervention influenced the consumption of non-core foods.

**Results summary / *** Quantitative results:** Improve short-term dietary behavior in preschool age children.

### Objective: To describe behavioral parent-only intervention to promote healthier lifestyle habits and reduce weight status in an obese 12-year-old female participant.

**Intervention type:** Treatment, case example of a randomized controlled trial

**Intervention duration:** 4 months; 6 months follow-up (at months 4 and 10)

**Participants:** A 12-year-old girl with her mother

**Study design:** The intervention included 12 group sessions over 4 months. Behavioral strategies such as including self-monitoring, goal setting, performance feedback, reinforcement, stimulus control, and instruction in behavioral parenting strategies were applied.

**Findings:** The child lost 17 pounds and grew 1.7 inches in height. Her quality of dietary intake was improved. She also experienced a drop in the number of self-reported unhealthy weight control behaviors.

**Results summary / *** Quantitative results:** Improvement in the child’s quality of dietary intake and a drop in the number of self-reported unhealthy weight control behaviors.

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**Results summary / *** Quantitative results:** Improve short-term dietary behavior in preschool age children.
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| McGowan et al. 2013 [8] United Kingdom | **Objective**: To promote habit formation for three parental feeding behaviors: serving fruit/vegetables, serving healthy snacks, and serving non-sweetened drinks  
**Intervention type**: Prevention, a cluster-randomized, controlled exploratory trial  
**Intervention duration**: 8 weeks; follow-up measures were completed at the final home visit  
**Participants**: 126 parents of children age 2 to 6 years  
**Study design**: The intervention was delivered over the course of 4 visits to the family in home. Researchers worked through an intervention booklet in each visit, lasting about an hour. The booklet introduced the concept of habit formation along with tips for habit formation. | Significant effects on children’s intake of vegetables, healthy snacks and water were reported in all three groups. Changes in parental automaticity of feeding behaviors correlated with children’s food intake. | Modification in parental feeding behaviors, change children’s diets positively, and well acceptance by parents  
*** Change in children’s serving of vegetables per day: Intervention Group: +0.8±1.3; Control Group: +0.1±0.8  
Change in Healthy snack occasions per day: Intervention Group: +1.0±2.1; Control Group: -0.2±2.1  
Change in Water occasions per day: Intervention Group: +0.6±1.0; Control Group: +0.1±0.9 |